

**GEOLOGIC HAZARDS EVALUATION AND  
GEOTECHNICAL INVESTIGATION  
THE LAUNCHPAD – YOUTH HOUSING  
810 NORTH 19<sup>th</sup> STREET  
COLORADO SPRINGS, COLORADO**

Prepared for:

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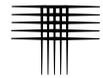
CTL|T Project No. CS19543-125

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FIG. 1 – LOCATION OF EXPLORATORY BORINGS

FIG. 2 – ENGINEERING GEOLOGIC CONDITIONS

REFERENCES

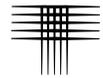
APPENDIX A – SUMMARY LOGS OF EXPLORATORY BORINGS

APPENDIX B – LABORATORY TEST RESULTS

TABLE B-1 – SUMMARY OF LABOATORY TEST RESULTS

APPENDIX C – DIRECT SHEAR TEST RESULTS

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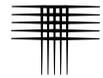
## SCOPE

This report presents the results of our Geologic Hazards Evaluation and Geotechnical Investigation for an approximate 1.4-acre site located at 810 North 19th Street in Colorado Springs, Colorado. The investigated parcel is planned for development of a youth housing facility. Our purpose was to evaluate the property for the occurrence of geologic hazards and assess their potential effect on the planned development. This report includes descriptions of our interpretation of site geology, our engineering analysis of the potential impact of geologic conditions on development, a summary of subsurface and groundwater conditions found in our exploratory borings, a description of our engineering analysis of the geologic conditions at the site, and geotechnical design and construction recommendations.

The report was prepared based on conditions interpreted from field reconnaissance of the site, conditions found in our exploratory borings, results of laboratory tests, engineering analysis, and our experience. The criteria presented are for the development as described. Revision in the scope of the project could influence our recommendations. If changes occur, we should be retained to review these plans and update geotechnical recommendations and our slope stability analyses included in this report, as necessary. Evaluation of the property for the possible presence of potentially hazardous materials (Environmental Site Assessment) was beyond the scope of this investigation. The following section summarizes the report. A more complete description of the conditions found, our interpretations, and our recommendations are included in the report.

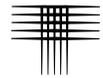
## SUMMARY

1. We did not identify geologic hazards we believe will preclude development of the site for its intended use. The most significant conditions identified during the study that will affect the proposed development include a potentially unstable slope at the west side of the site, existing fill and very highly expansive clay and claystone bedrock.
2. There is a very high risk that the expansive material will heave and damage slabs-on-grades, foundations, and exterior site improvements. Our



analysis indicates the proposed construction should maintain suitable factors of safety for the slope at the west side of the site. We believe the recommendations presented in this report will help to control risk of damage; they will not eliminate that risk.

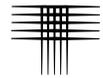
3. Subsurface conditions encountered in our borings drilled at the site consisted of areas of surficial clay fill up to approximately 12 feet thick and areas of natural, very clayey sand and slightly sandy to sandy clay. The existing fill is of suspect quality and highly expansive in its current condition. The fill should be removed from the building area to expose the natural materials. The surficial soils were underlain by claystone bedrock at depths ranging between 6 and 19 feet. Samples of the clay fill and claystone bedrock exhibited moderate to very high measured swell values.
4. At the time of drilling, groundwater was encountered in one of the borings at a depth of 29 feet below the existing ground surface. When checked several days after the completion of drilling, groundwater was measured in one of the borings at a depth of 23 feet. Groundwater levels will fluctuate seasonally and rise in response to precipitation and landscape irrigation.
5. We understand a post-tensioned slab-on-grade foundation is the desired foundation type. The post-tensioned slab-on-grade should be underlain by at least 6 feet of moisture conditioned, sub-excavation fill measured from the lowest exterior footing elevation.
6. Based on subsurface conditions encountered in our borings and the results of laboratory testing, we believe a very high risk of differential movement and damage will exist for slabs-on-grade underlain by the onsite soils in their present condition. Sub-excavation and construction of a moisture conditioned fill prism beneath the structure will reduce the risk.
7. We believe the parking areas and drive aisles can be paved with 6.5 inches of asphalt or 4 inches of asphalt over 8 inches of aggregate base course. Further discussions of the pavements including pavement sub-excavation and subgrade preparation are included in the report.
8. Surface drainage should be designed and maintained to provide the rapid removal of runoff away from the building to reduce potential subsurface wetting. Water should not be allowed to pond adjacent to the structure or over flatwork and pavement areas. Conservative irrigation practices should be employed to avoid excessive subsurface wetting.
9. The design and construction criteria presented in this report were compiled with the expectation that all other recommendations presented related to surface and subsurface drainage, landscaping irrigation, backfill compaction, etc. will be incorporated into the project and that the property manager will maintain the structure, use prudent irrigation practices, and maintain surface drainage. It is critical that all recommendations in this report are followed.



## SITE CONDITIONS

The investigated parcel is located immediately west of the intersection of North 19th Street and Dale Street in Colorado Springs, Colorado. The general vicinity of the property is shown in Fig. 1. The site consists of approximately 1.4 acres of vacant land. The site is bordered to the north, south, and west by existing single-family residences and to the east by North 19<sup>th</sup> Street.

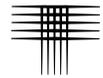
The site is dominated by a steep slope within the western half that descends from the adjacent residential community to the west. Photographs of the slope are presented below. The high point of the slope is located in the northwest corner of the site at approximately 6174 feet above mean sea level (msl). The slope descends steeply to the east and southeast at gradients between approximately 1:1 (horizontal to vertical) and 3:1. The slope appears to have been partially excavated. Aerial photography and previous mapping confirm the slope formerly descended at a gentler gradient and extended further into the parcel. Below the slope, a generally level area is present before becoming gently sloping as the site approaches North 19<sup>th</sup> Street. Vegetation consists of scattered shrubs and grasses and a couple trees around the perimeter.



**Photo 1 - View to the west toward steep slope**



**Photo 2 - View to the north toward steep slope**



1966 Aerial Photo

The 1966 aerial photo shown above indicates a structure was present at the site. We believe it was likely a single-family residence. The structure is not shown on the September 1999 Google Earth® aerial image.

## PROPOSED DEVELOPMENT

Based on the architectural concept plans prepared by Shop Works Architecture and meetings with the project team, the project will consist of a 4-story, youth housing building with a total of 50 dwelling units and an interior amenity and office area. The building will be constructed along the east side of the parcel adjacent to North 19<sup>th</sup> Street. We understand the planned ground level finish floor elevation will be approxi-



mately 6136 feet msl in the northern portion of the building and 6135 feet in the southern portion of the building. A site retaining wall is planned along the lower portion of the slope. Other exterior improvements will include a paved entrance driveway and parking area, exterior concrete flatwork, underground utilities, and a water quality pond.

## **SUBSURFACE INVESTIGATION**

Subsurface conditions at the site were investigated by drilling three exploratory borings on April 14, 2022, to depths of 20 to 30 feet using 4-inch diameter, continuous-flight, solid-stem auger and a truck-mounted drilling rig. Two additional borings were drilled on July 30, 2022, to depths of 25 and 40 feet using a track-mounted drill rig. Following the change to the site plan, we returned to the site again on October 22, 2022, to advance two more borings. The approximate locations of our borings are shown in Fig. 1.

Samples of the soils were obtained at 5-foot intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven by blows from a 140-pound hammer falling 30 inches. Our field representative was present to observe drilling operations, log the soils and bedrock encountered, and obtain samples for laboratory tests. Graphical logs of the conditions found in our exploratory borings, the results of field penetration resistance tests, and some laboratory data are shown in Appendix A. Swell-consolidation and gradation test results are presented in Appendix B. Laboratory test data are summarized in Table B-1. Results of direct shear testing are presented in Appendix C.

Soil samples obtained during this study were returned to our laboratory and visually classified. Laboratory testing was then assigned to representative samples. Testing included moisture content and dry density, swell-consolidation, direct shear, gradation analysis, Atterberg limits, and water-soluble sulfate content tests. The swell test samples were wetted under applied pressures that approximated the overburden pressure (the weight of overlying soil).



## **SUBSURFACE CONDITIONS**

The soils encountered in the seven exploratory borings drilled at the site consisted of areas of surficial, undocumented fill material and natural, very clayey sand and slightly sandy to very sandy clay. Claystone bedrock was found in each of the seven borings. Some of the pertinent engineering characteristics of the soils encountered and groundwater conditions are discussed in the following paragraphs.

### **Undocumented Fill**

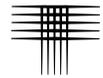
Existing fill consisting of sandy to very sandy, gravelly clay was encountered in five of our borings extending from the surface to depths of about 3 to 12 feet. Based on field penetration resistance testing the fill was very stiff. Three samples of the fill contained 64 to 75 percent silt and clay-sized particles (passing the No. 200 sieve). Two samples exhibited measured swell of 2.7 and 15.4 percent swell when wetted under estimated overburden pressures.

### **Natural Soils**

Natural soils were encountered beneath existing fill material in TH-3 and at the surface in TH-4 and TH-5 and extended to depths of 7.5 to 19 feet. The natural soils consisted of very clayey sand and slightly sandy to very sandy clay. The sand was medium dense to dense and the clay was very stiff based on field penetration resistance testing. Three samples of the sand contained 36 to 46 percent silt and clay-sized particles. Two samples of the clay contained 65 and 90 percent silt and clay-sized particles. Our experience indicates the very clayey sand exhibits low to moderate expansion potential and the slightly sandy to very sandy clay exhibits moderate to very high expansion potential.

### **Bedrock**

Claystone bedrock was encountered in each of our borings underlying fill and/or natural soils at depths ranging from 6 to 19 feet. The claystone was hard to very hard based on results of field penetration resistance testing. Four samples of the claystone



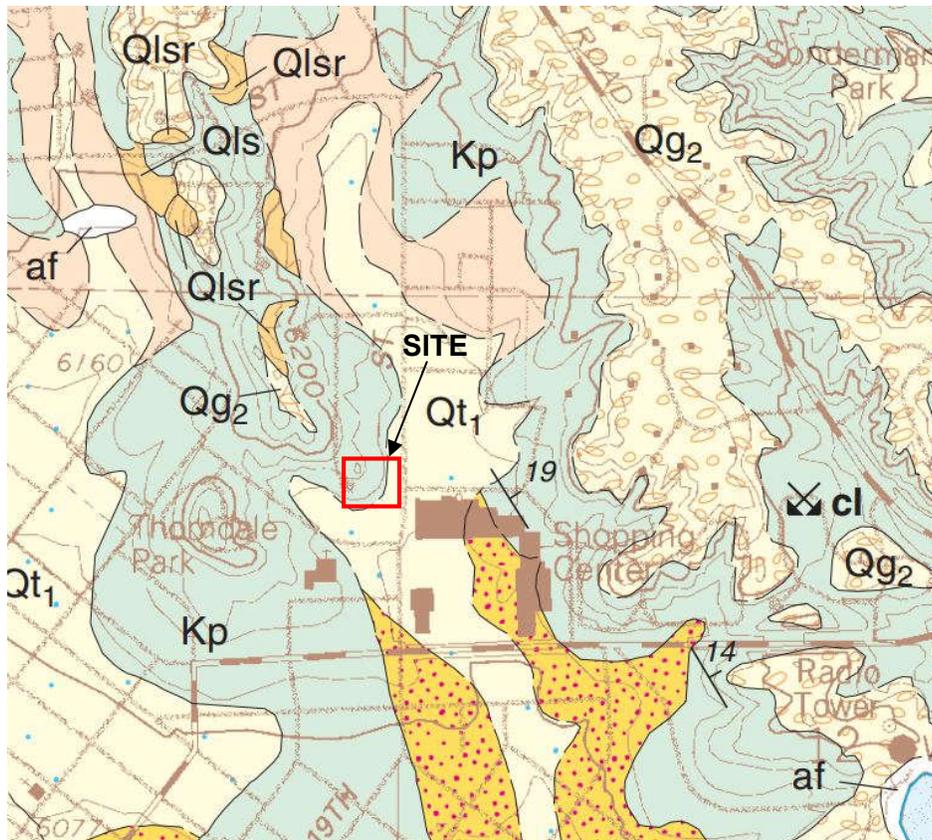
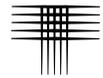
exhibited 4.9 to 9.5 percent measured swell when wetted under estimated overburden pressures. Three samples of the claystone tested in our laboratory contained 99 percent silt and clay sized particles. A sample of the claystone was subjected to direct shear testing and results indicated a peak friction angle of 21 degrees and cohesion of 1120 psf.

### **Groundwater**

At the time of drilling, groundwater was found in TH-4 at a depth of 29 feet. When checked several days after drilling groundwater was measured in TH-5 at a depth of 23 feet. Groundwater levels will fluctuate seasonally in response to seasonal precipitation and irrigation of landscaping. A seasonal rise of 3 to 5 feet is considered typical for this area.

### **SITE GEOLOGY**

The geology of the site was evaluated by reviewing geologic maps, aerial photographs, conditions found in our borings, and observing field conditions. The native conditions have been disturbed by excavation into the slope and placement of fill material. The site has been mapped by Carroll and Crawford (2000) as part of the Colorado Springs Quadrangle for the Colorado Geological Survey. The mapping indicates the majority of the site is underlain by Pierre Shale (map unit "Kp"). The Pierre Shale consists of gray to dark-gray shale that weathers to brown and olive-green gray. The formation has a high potential for shrink-swell and heaving bedrock problems due to the presence of smectite claystone and bentonite beds.



Excerpt from Geologic Map

The eastern portion of the site adjacent to North 19<sup>th</sup> Street is mapped as Qt<sub>1</sub>, denoted as Terrace alluvium one. This map unit is comprised of Holocene-age, poorly to moderately sorted, unconsolidated, matrix-supported cobble gravel in a sandy, silty, or clayey matrix.

## POTENTIAL GEOLOGIC HAZARDS AND ENGINEERING CONSTRAINTS

We did not identify geologic hazards we believe preclude development of the site for its intended use. Conditions we identified at the site that pose constraints to development include the occurrence of expansive soils and a potentially unstable slope. Regional geologic conditions that may affect the site include seismicity and radioactivity (radon). We believe these conditions can be mitigated with engineering design and construction methods commonly employed in this area. The engineering conditions map presented in Fig. 2 uses a modified version of the system developed by Robinson (1977). These conditions are discussed in greater detail in the following sections.



## **Potentially Unstable Slopes**

The Landslide Susceptibility Map of Colorado Springs (by White & Wait) indicates the western half of the site lies within a landslide susceptible zone. The Colorado Geological Survey notes that for locations that lie within the susceptible area, the designation does not imply that landslides will occur during the life of the proposed structure, only that a higher risk exists compared to areas not mapped as susceptible.

The site lies outside of the Hillside Overlay Zone of Colorado Springs as shown on zoning layers on the Cityview webpage as prepared by the GIS Division of the Planning, Development, and Finance Department; however, a steep slope is present in the western portion of the site. The slope descends steeply to the east and southeast at gradients between approximately 1:1 (horizontal to vertical) and 3:1. The slope appears to have been partially excavated.

Our analysis (Section A-A') indicates the current condition of the slope is stable from the standpoint of global stability; however, the slope is susceptible to erosion and surficial sloughing that may cause the slope to become unstable. Our analysis (Section B-B') indicates the proposed grading and retaining walls will result in an acceptable factor of safety. Further discussion of our analysis is included in the slope stability section of our report.

## **Expansive Soil and Bedrock**

The existing fill material and natural soils are judged to have a low to very high potential for swell. Samples of these surficial materials exhibited 2.7 to 15.4 percent measure swell when wetted under estimated overburden pressure. Claystone bedrock lies beneath the natural soils. Test results and our experience indicates the claystone exhibits moderate to very high expansion potential.

## **Shallow Groundwater**

Groundwater was found in two of our borings at depths of 23 and 29 feet. Our experience indicates the groundwater is likely flowing through fractures in the bedrock.



We understand no below-grade levels are currently planned. If plans change, we should be contacted to provide recommendations for subsurface drainage.

### **Steeply Dipping Bedrock**

The site is not located within the Steeply Dipping Bedrock Overlay District outlined by the Colorado Geological Survey in their Map Series 32.

### **Mine Subsidence**

The site is not included in the Colorado Springs Subsidence Investigation, State of Colorado, Division of Mined Land Reclamation, prepared by Dames & Moore, dated April 1985. The study was conducted specifically for known or suspected areas of underground coal mining in Colorado Springs. We did not observe evidence of subsurface mining at the site.

### **Hard Bedrock**

The claystone within the Pierre Shale Formation is medium hard to very hard and may require aggressive excavation techniques including rock teeth and rock buckets.

### **Seismicity**

This area, like most of central Colorado, is subject to a degree of seismic activity. Geologic evidence indicates that movement along some Front Range faults has occurred during the last two million years (Quaternary). This includes the Rampart Range and Ute Pass Faults, which are located about 1 and 3 miles west of the site, respectively. We believe the soils on the property classify as Site Class C (soft rock profile) according to the 2015 International Building Code (2015 IBC).

### **Radioactivity / Radon**

We believe no unusual hazard exists from naturally occurring sources of radioactivity on this site. However, the materials found in our borings are often associated with the production of radon gas and concentrations in excess of those currently accepted by



the EPA can occur. Passive and active mitigation procedures are commonly employed in this region to effectively reduce the buildup of radon gas. Measures that can be taken after a structure is enclosed during construction include installing a blower connected to the foundation drain and sealing the joints and cracks in concrete floors and foundation walls. If the occurrence of radon is a concern, we recommend the structure be tested after it is enclosed and commonly utilized techniques be employed to minimize the risk.

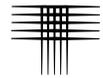
### **Flooding and Streamside Overlay Zone**

The site is outside of the areas mapped as the Streamside Overlay as shown on zoning layers on the Cityview webpage as prepared by the GIS Division of the Planning, Development, and Finance Department. The site is outside of the 500-year flood plain, as shown on Flood Insurance Rate Map Number 08041C0513G with an effective date of December 7, 2018.

### **SLOPE STABILITY ANALYSIS**

We conducted slope stability analyses for the steeper portion of the slope located at the west side of the site. Our analyses are based on the grading plan prepared by Ware Malcomb, dated December 2, 2022. Cross-section (A-A') considers what we interpret as the critical cross section extending down the steep portion of the slope. We evaluated the existing conditions, as well as an excavation condition for the proposed retaining wall. We also conducted slope stability analyses extending through the proposed retaining wall and building (B-B'). The approximate locations of the cross-sections are presented on Fig. 1. Our analysis also considered the temporary excavations into the slope and in the building pad area that will be necessary during construction.

The on-site materials were assigned unit weights and conservative shear strength parameters based on the results of our laboratory testing and our experience with similar materials in the site vicinity. The relevant shear strength parameters used in our slope stability analysis for different material types are presented in the analyses in Appendix D.



Groundwater was encountered at depths of 23 and 29 feet. Groundwater was modeled in the slope at a higher elevation (depth of around 10 feet) to evaluate impacts of a hypothetical and conservative increased groundwater level of the post-construction condition due to heavy precipitation. Factors of safety of 1.15 and 1.5 are usually considered appropriate by Geotechnical Engineers for temporary and permanent slopes, respectively. The results of our slope stability analysis indicate a factor of safety of about 1.5 for the existing slope in its current condition and 1.4 for the temporary cut condition at section A-A'. A factor of safety of 2.1 for a temporary construction condition and 1.5 for the post-construction condition were calculated for section B-B'. The results of our slope stability analyses are presented in Appendix D. This slope stability evaluation is limited to the specific portion of the site. Based on the results of our analysis and our site reconnaissance, we believe the slope should exhibit an acceptable factor of safety during and after construction. Global stability should be evaluated for critical wall sections during design.

## **SITE DEVELOPMENT CONSIDERATIONS**

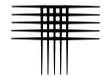
The project is technically feasible from a geotechnical standpoint; however, design and construction will be significantly complicated due to the presence of a steep slope adjacent to the outdoor amenity area, highly expansive soils and bedrock, and undocumented fill material.

### **Existing Fill**

Existing fill was identified throughout the proposed building area and extended to depths of up to 12 feet. The fill is undocumented and highly expansive. The fill is not suitable for construction of slab-on-grade floors or shallow foundations in its current condition. The existing fill should be over-excavated to natural materials.

### **Sub-Excavation**

The site is underlain by up to 12 feet of undocumented fill, consisting of very highly expansive, sandy to very sandy clay with occasional gravel as well as expansive



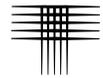
claystone. These materials are well below optimum moisture content. We calculated potential ground heave of up to about 11 inches with normal post-construction wetting.

We believe sub-excavation below the building and placement of the excavated soils as new, moisture conditioned, compacted fill should be performed to reduce settlement and/or heave and enhance performance of foundations, slabs-on-grade, and flatwork. Sub-excavation to a depth of at least 6 feet below the lowest exterior footing elevation will allow the use of a post-tension, slab-on-grade (PTS) foundation with reduced potential for differential movement. Removal of the undocumented fill below the minimum sub-excavation depth will result in greater depths of moisture conditioned fill beneath portions of the building, as indicated in TH-7, where the undocumented fill extended to a depth of about 12 feet.

Excavation and fill placement should be completed per the Excavation and Fill Placement sections of this report. The extent and depth of sub-excavation should be mapped by a surveyor and an “as-built” plan of the sub-excavated area is recommended. The sub-excavation area should extend at least 6 feet outside the building limits.

The earth work contractor should be chosen based on experience with moisture conditioning, processing, and compacting clay fill and have the necessary compaction equipment. Special attention should be paid to compaction in the corners and along the edges of the excavation, as large equipment cannot easily access these areas. In order for the procedure to perform properly, close control of fill placement is required. Sub-excavation fill should be moisture conditioned and compacted to the specifications contained in the Fill Placement section. Our representative should observe the bottom of the excavation and observe and test compaction of fill during placement.

Once fill is placed, it is important that measures be planned to reduce drying of near-surface materials. If fill dries excessively prior to building construction, it may be necessary to rework the upper, drier materials just prior to construction of foundations.



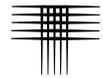
## **Excavation**

We believe the soils encountered in the exploratory borings can be excavated with conventional, heavy-duty excavation equipment. Zones of hard bedrock may require more aggressive excavation techniques. We recommend the contractor become familiar with applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards, to determine appropriate excavation slopes. We anticipate the near-surface clays and clayey sands will classify as Type B materials. Temporary excavations in Type B materials require a maximum slope inclination of 1:1 (horizontal to vertical), unless the excavation is shored or braced. The claystone bedrock will classify as Type A materials. Temporary excavations in Type A materials require a maximum slope inclination of 0.75:1, unless the excavation is shored or brace. If groundwater seepage occurs, flatter slopes will likely be required. The contractor's "competent person" should review excavation conditions and refer to OSHA standards when worker exposure is anticipated. Stockpiles and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. Excavations deeper than 20 feet should be designed by a registered professional engineer.

## **Fill Placement**

The on-site, natural soils and excavated bedrock are suitable for use during site grading. The existing fill material may be suitable provided it is free of debris and deleterious material. Prior to placement of new fill, topsoil, vegetation, and organic materials should be removed from the ground surface. The ground surface in areas to receive fill should be scarified, moisture conditioned to near optimum moisture content, and compacted to a high density to establish a stable subgrade for fill placement.

Imported fill, if needed, should ideally consist of soil having a maximum particle size of 2 inches and 30 to 50 percent passing the No. 200 sieve. The import material should exhibit a Liquid Limit of less than 30 and a Plasticity Index of less than 15. A sample of any potential imported fill material should be submitted to our office for testing, prior to its use at the site.



The properties of the fill will affect the performance of surficial improvements such as pavements and concrete flatwork. As stated in the Sub-Excavation section, the existing undocumented fill soils are below optimum moisture content. Significant mixing, addition of water, and mellowing (allowing water to be absorbed) will be required to achieve uniform moisture contents above optimum. We recommend water be added to soils during stockpiling to help incorporate the water into the soil matrix. This process is complicated by freezing temperatures in winter months.

We recommend site grading fill be placed in thin, loose lifts, moisture conditioned to between 1 and 4 percent above optimum moisture content and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698). We recommend the moisture content be reduced to within 2 percent of optimum in the upper two feet of pavement areas, to reduce problems associated with unstable subgrade materials. Fill should not be placed on top of frozen soils. The frozen soils should be removed or allowed to thaw prior to the placement of fill. Placement and compaction of the grading fill should be observed and tested by our representative during construction.

During construction, the site should be graded such that surface water can drain readily away from the building area. Water that accumulates in excavations should be promptly pumped out or otherwise removed before resuming construction. Berms, ditches, and similar means should be used to decrease stormwater entering the work area and to efficiently convey it off site. Failure to control surface drainage during construction could result in construction delays, require reworking of materials, and/or cause slope instability of excavations.

### **Buried Utilities**

Water and sewer lines are often constructed beneath slabs and pavements. Compaction of utility trench backfill can have a significant effect on the life and serviceability of floor slabs, pavements, and exterior flatwork. We recommend utility trench backfill be placed in compliance with City of Colorado Springs specifications. Our experience indicates the use of a self-propelled compactor results in more reliable performance compared to trench backfill compacted by a sheepsfoot wheel attachment on a



backhoe or trackhoe. The upper portion of the trenches should be widened to allow the use of a self-propelled compactor. Personnel from our firm should periodically observe utility trench backfill placement and test the density of the backfill materials during construction.

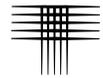
## FOUNDATIONS

Our investigation indicates existing fill material, natural sand and clay soils, and claystone bedrock are present at depths that will impact construction of shallow foundations. We understand a post-tensioned, slab-on-grade (PTS) foundation is the preferred foundation system. PTS foundations may be utilized for support of the proposed structure, provided the remedial grading and sub-excavation recommendations set forth previously are performed. Design and construction criteria are presented below.

PTS foundation design is based on a method developed by the Post-Tensioning Institute (PTI, 3rd Edition, 2004 with 2008 Supplement). Various climate and relevant soil factors are required to evaluate the PTI design criteria. The PTI slab design includes evaluation of two mechanisms of soil movement (edge lift and center lift) based on assumptions that the wetting and drying of the foundation soils are primarily affected by the climate. These values were calculated using software titled VOLFLO 1.5 and the parameters presented below.

| PTI Parameters                       |                                  |
|--------------------------------------|----------------------------------|
| Parameter                            | Design Value                     |
| Thornthwaite Moisture Index          | -20                              |
| Constant Soil Suction                | 3.6 pF                           |
| Depth of Seasonal Moisture Variation | 15 feet                          |
| Percent Finer than 2 Microns         | 40 for fill and 60 for claystone |
| Soil Fabric Factor                   | 1.0                              |

Our experience indicates that the foundation soils will normally undergo a significant increase in moisture content due to covering of the ground surface by the buildings and pavements, and irrigation around the structures. Depending on the surface drain-



age or the amount of available water, the movement mechanism, which controls the design, could be as high as total heave. The edge moisture variation distance can also be more than the design values provided in the PTI manual. Considering the limitations of the current PTI design, we believe a conservative approach with reasonable engineering judgment is necessary to prepare geotechnical recommendations for PTS foundation design.

The PTI design method estimates movements for a depth of wetting of 9 feet below the ground surface. Based on our experience in the area, field data, and experience with the proposed development the depth of wetting will likely be 12 to 15 feet below the ground surface. It is possible wetting will not penetrate this deep; however, we believe it is a reasonable design assumption. The PTI design procedure does not predict soil movements that result from site conditions such as irrigation or poor surface drainage that may lead to deeper wetting. If deeper wetting of the foundation soils occurs, the foundation movement may exceed the design movements predicted in the PTI procedure. If surface drainage is properly designed and maintained, it is unlikely the total calculated heave would occur and manifest at the surface. We expect total heave or settlement will be on the order of 1 to 2 inches. PTS foundation design is based on the potential differential movement of the slabs due to both settlement and heave of the subsoils. The estimated differential soil movement ( $y_m$ ) were evaluated for two cases: post-equilibrium and post-construction. In our opinion, the post-construction case is considered more appropriate due to the magnitude of potential movement and our experience with the local climate.

Design criteria for PTS foundations developed from analysis of field and laboratory data and our experience are presented below.

### **Post-Tensioned, Slabs-On-Grade (PTS)**

1. PTS foundations should be constructed on newly placed, sub-excavation fill that is moisture conditioned and compacted according to the recommendations provided.
2. The foundations should be designed for a maximum allowable soil pressure of 2,000 psf.



3. For the PTI design method, we recommend a differential movement ( $y_m$ ) of 2.0 inches for the edge lift condition and -1.3 inches for the center lift condition.
4. Based on the Thornthwaite Moisture Index (PTI Manual, Edition 3), an edge moisture variation distance ( $e_m$ ) of 4.1 feet for the edge lift condition and 8.0 feet for the center lift condition should be used in design.
5. We understand the PTI design method assumes the slab is somewhat flexible. Some of the above-grade construction may not be flexible, such as drywall, brick, and stucco. We are aware of situations where minor differential slab movement has caused distress in finish materials. One way to enhance performance would be to place reinforcing steel in the bottoms of the stiffening beams. The structural engineer should evaluate the merits of this approach and other potential alternatives.
6. Stiffening beams may be poured “neat” into trenches excavated in the building pads. Soils may cave or slough during trench excavation for the stiffening beams. Disturbed soils should be removed from trench bottoms prior to placement of concrete. Formwork or other methods may be required for proper stiffening beam installation.
7. Exterior stiffening beams must be protected from frost action. Normally, 30 inches of frost cover is provided in the Colorado Springs area.
8. For slab tensioning design, a coefficient of friction value of 0.75 or 1.0 can be assumed for slabs on polyethylene sheeting or a sand layer, respectively. A coefficient of friction of 2 should be used for slabs on clay or clay fill.
9. A representative of our firm should observe the completed excavations. A representative of the structural engineer should observe the placement of the reinforcing tendons and reinforcement prior to placing the slabs and beams.

## FLOOR SYSTEMS

Our investigation indicates the materials near the anticipated first floor levels of the proposed apartment buildings will consist predominantly of natural sandy clay and silty to clayey sand, new, grading fill and sandstone. For the PTS system, the foundations are structurally integrated with the floor slab and should exhibit more reliable long-term performance provided the remedial grading and sub-excavation recommendations set forth previously are performed. Underslab utilities such as water and sewer lines should be pressure tested prior to installing slabs. Utilities that penetrate slabs should be provided with sleeves and flexible connections that allow for independent movement



of the slab and reduce likelihood of damaging buried pipes. We recommend these details allow at least 2 inches of differential movement between the slabs and pipes.

## **SITE RETAINING WALLS**

Site retaining walls are currently planned at the slope in the western portion of the site and also along the south and east sides of the building. The walls vary in height with a maximum height of about 7 feet. Site retaining walls may be designed for a maximum allowable bearing pressure of 2,000 psf. For gravity block wall design or MSE wall design, we recommend an angle of friction of 24 degrees and a moist unit weight of 125 pcf be assigned to the retained soils.

For cast-in-place walls, design should consider lateral earth loads which are dependent on the height of the wall, soil type, and backfill configuration. Backfill behind site retaining walls is expected to be sloped in portions of the site. We expect site retaining walls will be subject to “active” earth pressures where walls are free to rotate and the soil moves toward the wall away from the soil mass. The active pressures are fully mobilized at horizontal movements of about 0.5 percent of the wall height for cohesionless soils, such as sands and gravels. Passive stresses exist when the wall moves toward the soil mass. Passive resistance requires relatively more movement than active, at-rest, or base friction to generate resistance. Passive pressures should only be used when movement is tolerable, and the soils is well compacted and will not be removed. For frictional resistance to lateral loads, we recommend that a coefficient of friction of 0.3 be used between soil and concrete contacts. The recommended equivalent fluid densities provided in the following table assume no surcharge loads next to the top of the wall and free-draining, granular backfill such as CDOT Class 1, with an angle of internal friction ( $\phi$ ) of 34 degrees, and a unit weight of 125 pounds per cubic foot (pcf).



| <b>Lateral Earth Pressure Values (Equivalent Fluid Density), pcf</b> |               |                |                |
|--|---------------|----------------|----------------|
| <b>Retained Slope</b>  | <b>Active</b> | <b>At-Rest</b> | <b>Passive</b> |
| Level  | 35            | 55             | 400            |
| 1.5H:1V  | 77            | -              | 250            |
| 2H:1V  | 52            | -              | 250            |
| 3H:1V  | 44            | -              | 250            |

Care must be exercised when compacting backfill against retaining walls. To reduce temporary construction loads on the walls, heavy equipment should not be used for placing and compacting fill within a region as determined by a 0.5H:1V line drawn upward from the bottom of the wall. Granular backfill behind any new site retaining walls should be compacted to 90 percent of the maximum modified Proctor dry density (ASTM D 1557) but should not be compacted to more than approximately 92 percent to minimize pressure against the walls. Thinner lifts should be used when utilizing smaller compaction equipment.

Adequate drainage is essential to the performance of retaining walls. New walls should include installation of a drainpipe that discharges away from the wall. For site retaining walls drainage measures could include free-draining granular backfill and perforated drainpipes leading to a positive gravity outlet and granular backfill.

## **PAVEMENTS**

Our exploratory borings and understanding of the proposed construction suggest the subgrade soils within the planned access driveway and parking area will consist predominantly of sandy clay and very clayey sand. A sample of the sandy clay tested in our laboratory classified as A-7-6 materials according to the American Association of State Highway Transportation Officials (AASHTO) classification system. This type of material generally exhibits poor pavement support characteristics. Based on our laboratory classification testing (Atterberg Limits and gradation analysis), a Hveem Stabilometer ("R") value of 5 was assigned to the subgrade materials for design purposes.

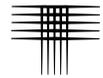


We anticipate the access driveways could be subjected to occasional heavy vehicle loads such as trash trucks and moving vans. We considered a daily traffic number (DTN) of 5, which corresponds to an 18-kip Equivalent Single-Axle Loads (ESAL) of 36,500, for a 20-year pavement design life. Based on the estimated design traffic and pavement design input parameters, we recommend a pavement section of 6.5 inches of asphalt or 4 inches of asphalt over 8 inches of aggregate base. A plain portland cement concrete pavement section of 6 inches can also be considered.

It should be understood that the pavements may perform poorly due to the presence of moderately to very highly expansive soils. If the owner is unwilling to accept the high risk of damaging heave to pavements caused by swelling soils, the more reliable alternative to mitigate the risk is sub-excavation. We recommend at least 4 feet of the subgrade soils be sub-excavated and recompacted to at least 95 percent of maximum standard Proctor (ASTM D 698) at moisture contents between 0 and 4 percent above the optimum moisture content. Placement of the sub-excavation fills at high moisture contents results in soils that are more prone to pumping and rutting. We recommend the moisture content be reduced to within 2 percent of optimum in the upper two feet of pavement areas, to reduce problems associated with unstable subgrade materials. Due to high water-soluble sulfate contents, chemical stabilization with cement or lime are not recommended.

We recommend a concrete pad be provided at the trash dumpster site. The pad should be at least 8 inches thick and long enough to support the entire length of the trash truck and dumpster. Joints between concrete and asphalt pavements should be sealed with a flexible compound.

Our design considers pavement construction will be completed in accordance with the City of Colorado Springs "Standard Specifications" and the Pikes Peak Region Asphalt Paving Specifications. The specifications contain requirements for the pavement materials (asphalt, base course, and concrete) as well as the construction practices used (compaction, materials sampling, and proof-rolling). Of particular importance are those recommendations directed toward subgrade and base course compaction and



proof-rolling. During proof-rolling, attention should be directed toward the areas of confined backfill compaction. Soft or loose subgrade or areas that pump excessively should be stabilized prior to pavement construction. A representative of our office should be present at the site during placement of fill and construction of pavements to perform density testing.

## CONCRETE

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentration 0.4 percent in a sample from this site. As indicated in our tests and ACI 318-19, the sulfate exposure class is *Severe* or S2.

SULFATE EXPOSURE CLASSES PER ACI 318-19

| Exposure Classes |    | Water-Soluble Sulfate (SO <sub>4</sub> ) in Soil <sup>A</sup> (%) |
|------------------|----|---|
| Not Applicable   | S0 | < 0.10  |
| Moderate         | S1 | 0.10 to 0.20  |
| Severe           | S2 | 0.20 to 2.00  |
| Very Severe      | S3 | > 2.00  |

A) Percent sulfate by mass in soil determined by ASTM C1580

For this level of sulfate concentration, ACI 318-19 *Code Requirements* indicates there are special cement type requirements for sulfate resistance as indicated in the table below.



CONCRETE DESIGN REQUIREMENTS FOR SULFATE EXPOSURE PER ACI 318-19

| Exposure Class | Maximum Water/Cement Ratio | Minimum Compressive Strength (psi) | Cementitious Material Types <sup>A</sup> |  |  | Calcium Chloride Admixtures               |               |
|----------------|----------------------------|------------------------------------|--|--|--|---|---------------|
|                |                            |                                    | ASTM C150/C150M                          | ASTM C595/C595M                          | ASTM C1157/C1157M  |   |               |
| S0             | N/A                        | 2500                               | No Type Restrictions                     | No Type Restrictions                     | No Type Restrictions   | No Restrictions                           |               |
| S1             | 0.50                       | 4000                               | II <sup>B</sup>                          | Type with (MS) Designation               | MS   | No Restrictions                           |               |
| S2             | 0.45                       | 4500                               | V <sup>B</sup>                           | Type with (HS) Designation               | HS   | Not Permitted                             |               |
| S3             | Option 1                   | 0.45                               | 4500                                     | V + Pozzolan or Slag Cement <sup>C</sup> | Type with (HS) Designation plus Pozzolan or Slag Cement <sup>C</sup> | HS + Pozzolan or Slag Cement <sup>C</sup> | Not Permitted |
| S3             | Option 2                   | 0.4                                | 5000                                     | V <sup>D</sup>                           | Type with (HS) Designation   | HS  | Not Permitted |

- A) Alternate combinations of cementitious materials shall be permitted when tested for sulfate resistance meeting the criteria in section 26.4.2.2(c).
- B) Other available types of cement such as Type III or Type I are permitted in Exposure Classes S1 or S2 if the C3A contents are less than 8 or 5 percent, respectively.
- C) The amount of the specific source of pozzolan or slag to be used shall not be less than the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag to be used shall not be less than the amount tested in accordance with ASTM C1012 and meeting the criteria in section 26.4.2.2(c) of ACI 318.
- D) If Type V cement is used as the sole cementitious material, the optional sulfate resistance requirement of 0.040 percent maximum expansion in ASTM C150 shall be specified.

Superficial damage may occur to the exposed surfaces of highly permeable concrete. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious materials ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high-water tables. Concrete should have a total air content of 6 percent ± 1.5 percent. We advocate damp-proofing of all foundation walls and grade beams in contact with the subsoils.

## SURFACE DRAINAGE AND IRRIGATION

Proper surface drainage cannot be overemphasized for this project. The performance of structures, flatwork, and pavements within the development will be influenced



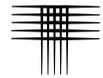
by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around the structure and pavement area. Drainage should be planned such that surface runoff is directed away from foundations and is not allowed to pond adjacent to or between structures, over pavements, or at the crest of permanent slopes. Ideally, slopes of at least 6 inches in the first 10 feet should be planned for the landscaped areas surrounding buildings, where possible. Roof downspouts and other water collection systems should discharge onto paved surfaces or well beyond the limits of all backfill around the structures.

Proper control of surface runoff is also important to prevent the erosion of surface soils. Concentrated flows must not be directed over unprotected slopes. Permanent slopes, including the existing steep slope in the western portion of the site, should be seeded or mulched to reduce the potential for erosion. Backfill soils behind the curb and gutter adjacent to access roads and parking lots, and in utility trenches should be compacted. If surface drainage is neglected, performance of the pavements, flatwork, and foundations may be compromised.

Landscaping concepts should consider a xeriscape scheme and concentrate on plantings that require little or no supplemental irrigation after the vegetation is established. Irrigated sod, irrigation mainlines, above-surface spray heads, rotors, and other above-surface irrigation spray devices should not be located or discharge within 10 feet of the building. Irrigation should be set at the lowest level necessary for plant growth.

## **CONSTRUCTION OBSERVATIONS**

We recommend that CTL|Thompson, Inc. provide observation and testing services during construction to allow us the opportunity to verify whether soil conditions are consistent with those found during our investigation. If others perform these observations, they must accept responsibility to judge whether the recommendations in this report remain appropriate.



## **GEOTECHNICAL RISK**

The concept of risk is an important aspect with any geotechnical evaluation primarily because the methods used to develop geotechnical recommendations do not comprise an exact science. We never have complete knowledge of subsurface conditions. Our analysis must be tempered with engineering judgment and experience. Therefore, the recommendations presented in any geotechnical evaluation should not be considered risk-free. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the structure will perform satisfactorily. It is critical that all recommendations in this report are followed during design and construction.

## **LIMITATIONS**

This report has been prepared for the exclusive use of the Cohen Esrey and the project design team for the purpose of providing geotechnical design and construction criteria for the proposed building additions. The information, conclusions, and recommendations presented herein are based upon consideration of many factors, but not limited to, the type of structure proposed, the geologic setting, and the subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice continuously evolve in the area of geotechnical engineering. The recommendations are appropriate for about three years. If the project is not constructed within about three years, we should be contacted to determine if we should update this report.

Our borings were located to obtain a reasonably accurate indication of subsurface foundation conditions. The borings are representative of conditions encountered at the exact boring location only. Variations in subsurface conditions not indicated by the borings are possible. We recommend a representative of our office observe the completed foundation excavations. Representatives of our firm should be present during construction to perform construction observation and materials testing services.



We believe this investigation was conducted with that level of skill and care normally used by geotechnical engineers practicing under similar conditions. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of the subsoil conditions on design of the structure from a geotechnical engineering point-of-view, please call.

CTL | THOMPSON, INC

Jeffrey M. Jones, P.E.  
Associate Engineer

JMJ:TAM:cw



Reviewed by:

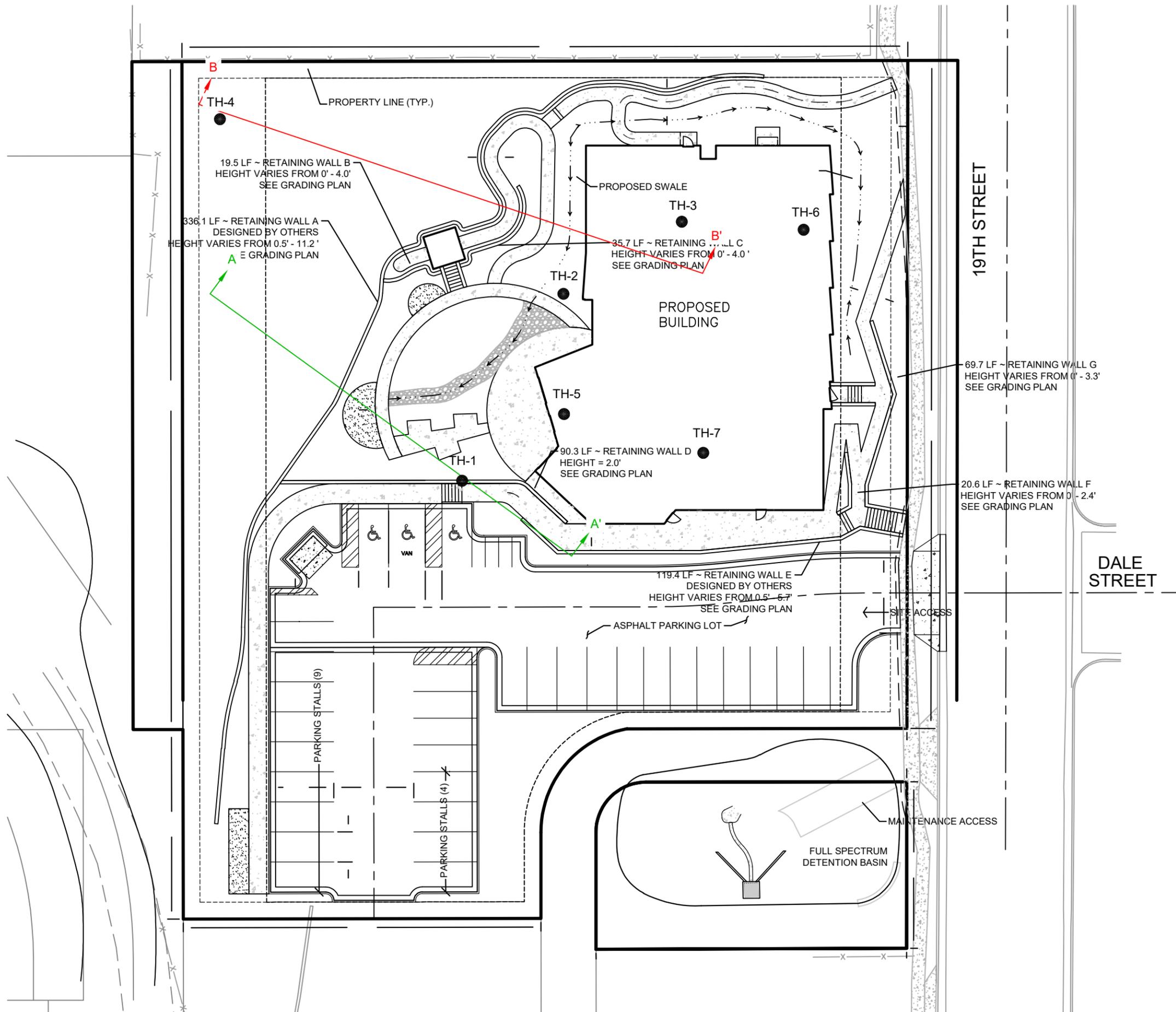
Timothy A. Mitchell, P.E.  
Principal Engineer

Via email: [lsorensen@cohenesrey.com](mailto:lsorensen@cohenesrey.com); [kervin@cohenesrey.com](mailto:kervin@cohenesrey.com)



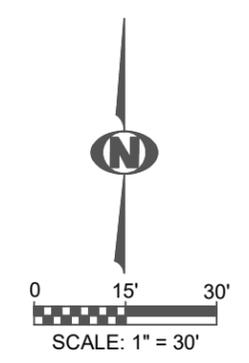
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**VICINITY MAP**  
(NOT TO SCALE)

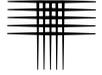
- LEGEND:**
- TH-1 APPROXIMATE LOCATION OF EXPLORATORY BORING.
  - - - PROJECT BOUNDARY
  - ▲ A SLOPE STABILITY CROSS-SECTION (EXISTING CONDITION)
  - ▲ B SLOPE STABILITY CROSS-SECTION (PROPOSED CONSTRUCTION)



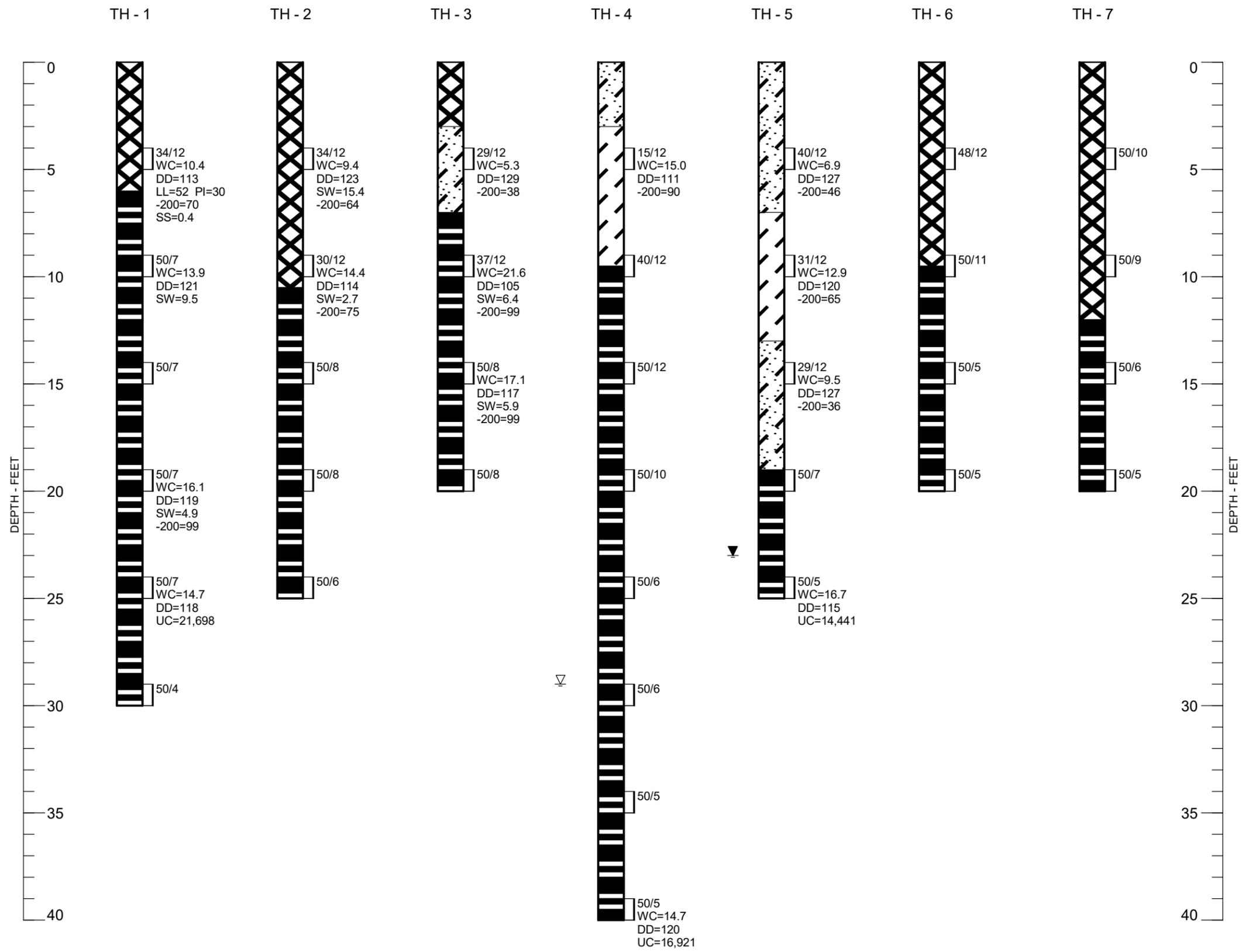
**NOTE:**  
BASE DRAWING WAS PROVIDED BY SHOP WORKS ARCHITECTURE (THE LAUNCHPAD - YOUTH HOUSING).

**Location of Exploratory Borings**





**APPENDIX A**  
SUMMARY LOGS OF EXPLORATORY BORINGS



**LEGEND:**

- FILL, CLAY, SANDY TO VERY SANDY, GRAVELLY, VERY STIFF, SLIGHTLY MOIST, LIGHT BROWN.
- SAND, VERY CLAYEY, GRAVELLY, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST, LIGHT TO DARK BROWN (SC).
- CLAY, SLIGHTLY SANDY TO SANDY, VERY STIFF, MOIST, REDDISH BROWN TO LIGHT BROWN (CL).
- BEDROCK, CLAYSTONE, SANDY, MEDIUM HARD TO VERY HARD, SLIGHTLY MOIST, MEDIUM BROWN.
- DRIVE SAMPLE. THE SYMBOL 34/12 INDICATES 34 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- GROUNDWATER LEVEL MEASURED AT TIME OF DRILLING.
- GROUNDWATER LEVEL MEASURED AFTER DRILLING ON AUGUST 11, 2022.

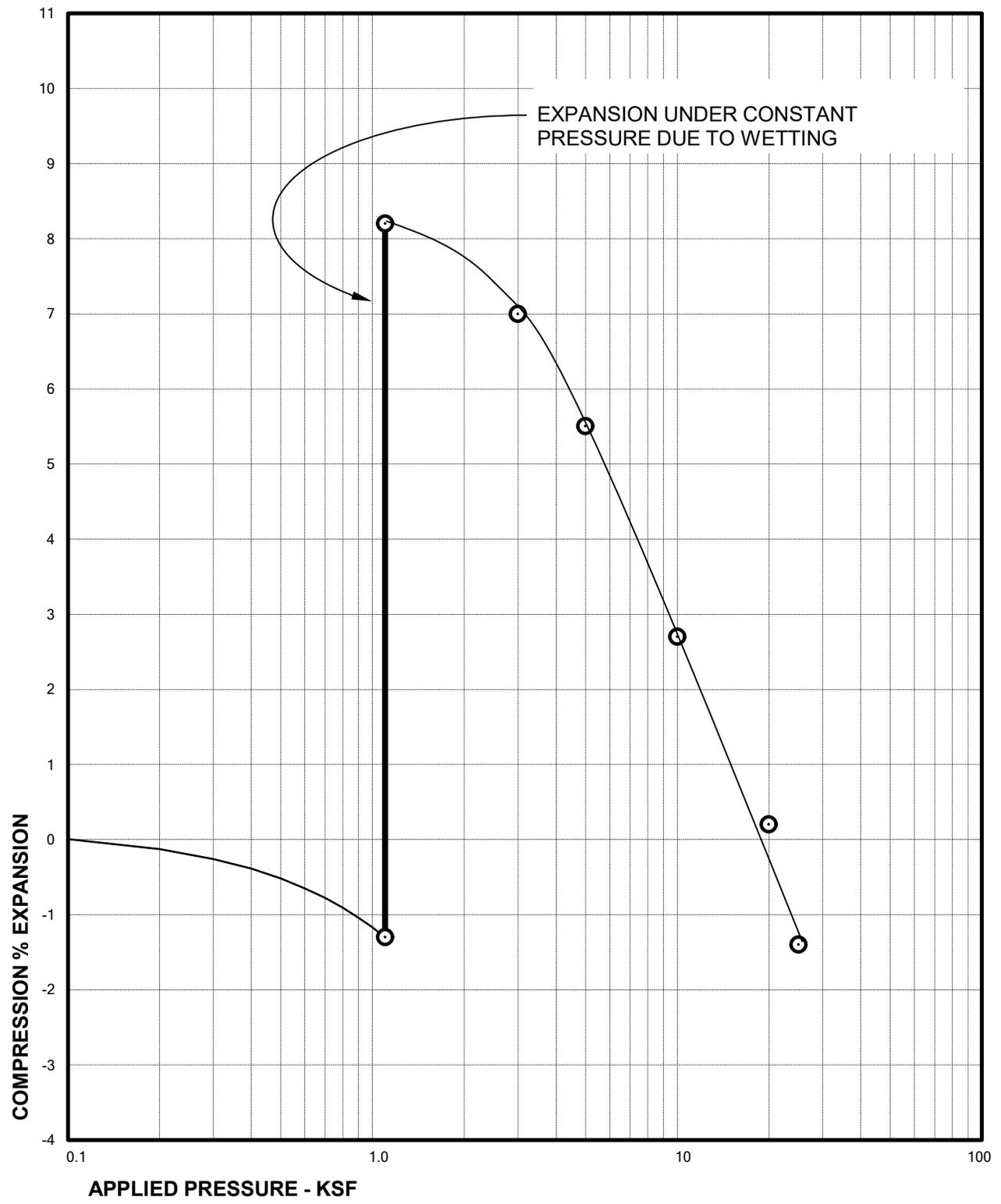
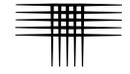
**NOTES:**

1. THE BORINGS WERE DRILLED APRIL 14, JULY 30, AND OCTOBER 21, 2022 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A CME-45, AND A DIEDRICH D-90, TRUCK-MOUNTED DRILL RIGS.
2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.
3. WC - INDICATES MOISTURE CONTENT. (%)  
 DD - INDICATES DRY DENSITY. (PCF)  
 SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE. (%)  
 LL - INDICATES LIQUID LIMIT.  
 (NV : NO VALUE)  
 PI - INDICATES PLASTICITY INDEX.  
 (NP : NON-PLASTIC)  
 -200 - INDICATES PASSING NO. 200 SIEVE. (%)  
 SS - INDICATES WATER-SOLUBLE SULFATE CONTENT. (%)  
 UC - INDICATES UNCONFINED COMPRESSIVE STRENGTH. (PSF)



## **APPENDIX B**

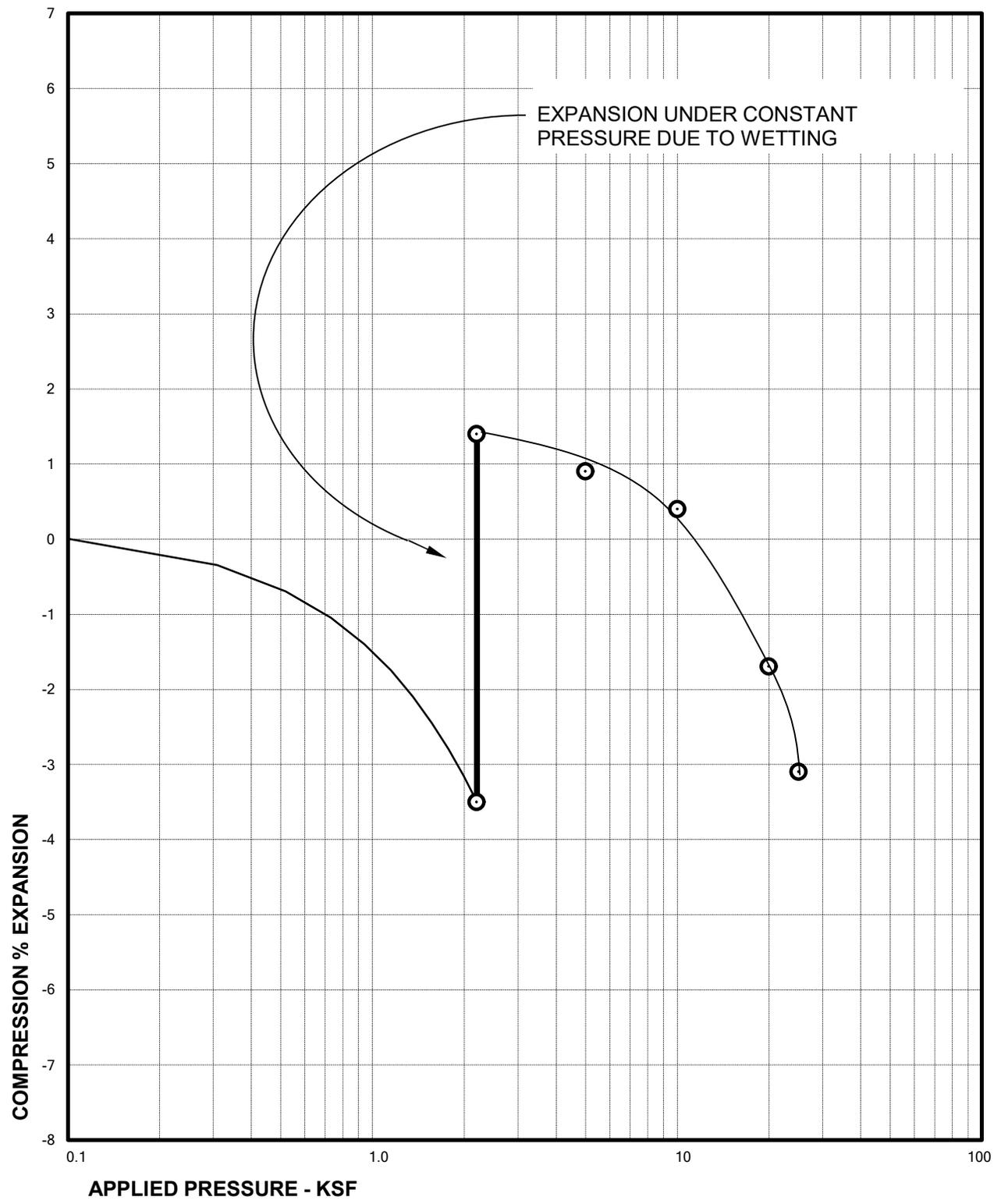
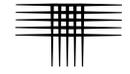
### **LABORATORY TEST RESULTS TABLE B-1: SUMMARY OF LABORATORY TESTING**



Sample of CLAYSTONE  
From TH-1 AT 9 FEET

DRY UNIT WEIGHT= 121 PCF  
MOISTURE CONTENT= 13.9 %

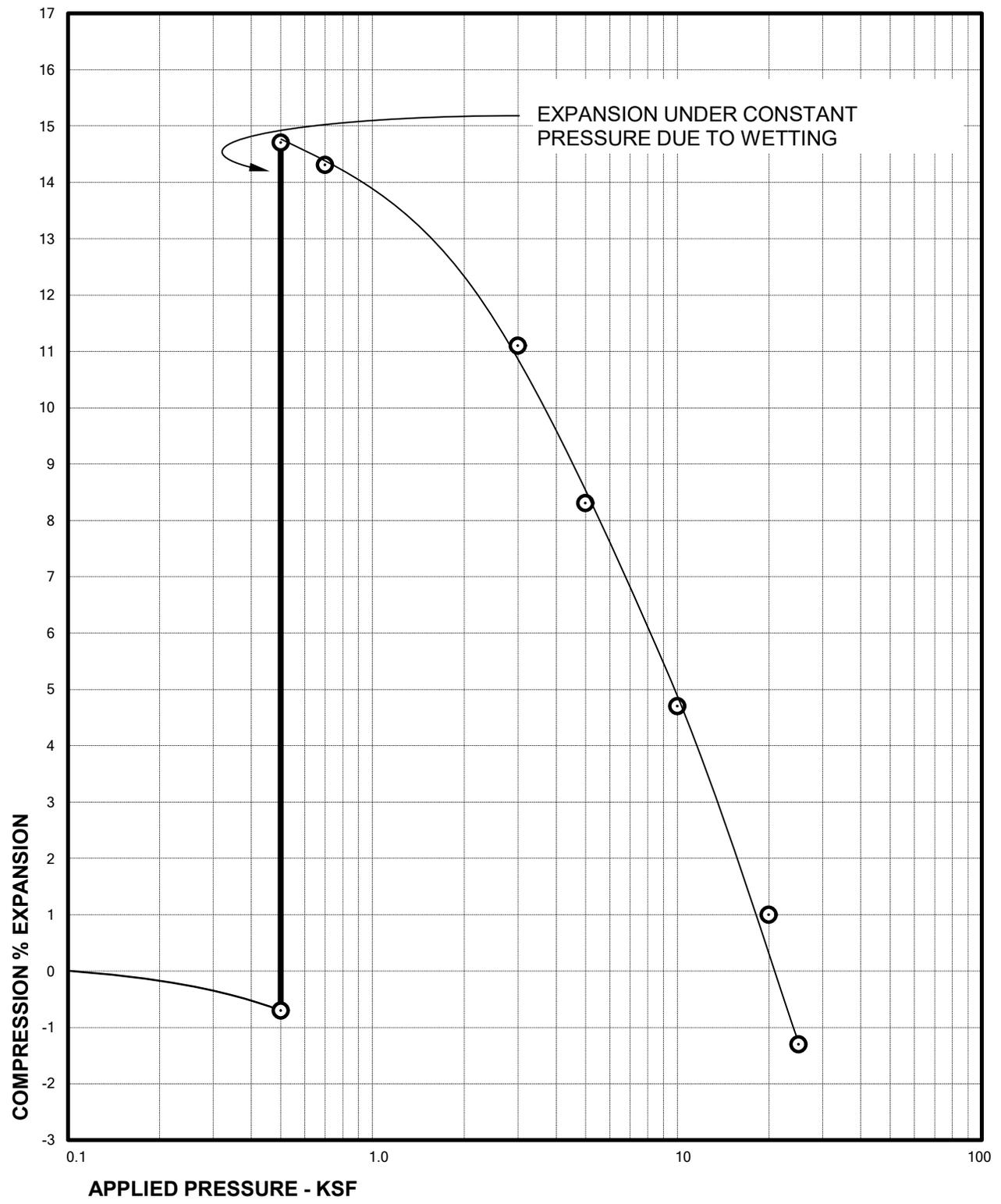
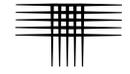
### Swell Consolidation Test Results



Sample of CLAYSTONE  
From TH-1 AT 19 FEET

DRY UNIT WEIGHT= 119 PCF  
MOISTURE CONTENT= 16.1 %

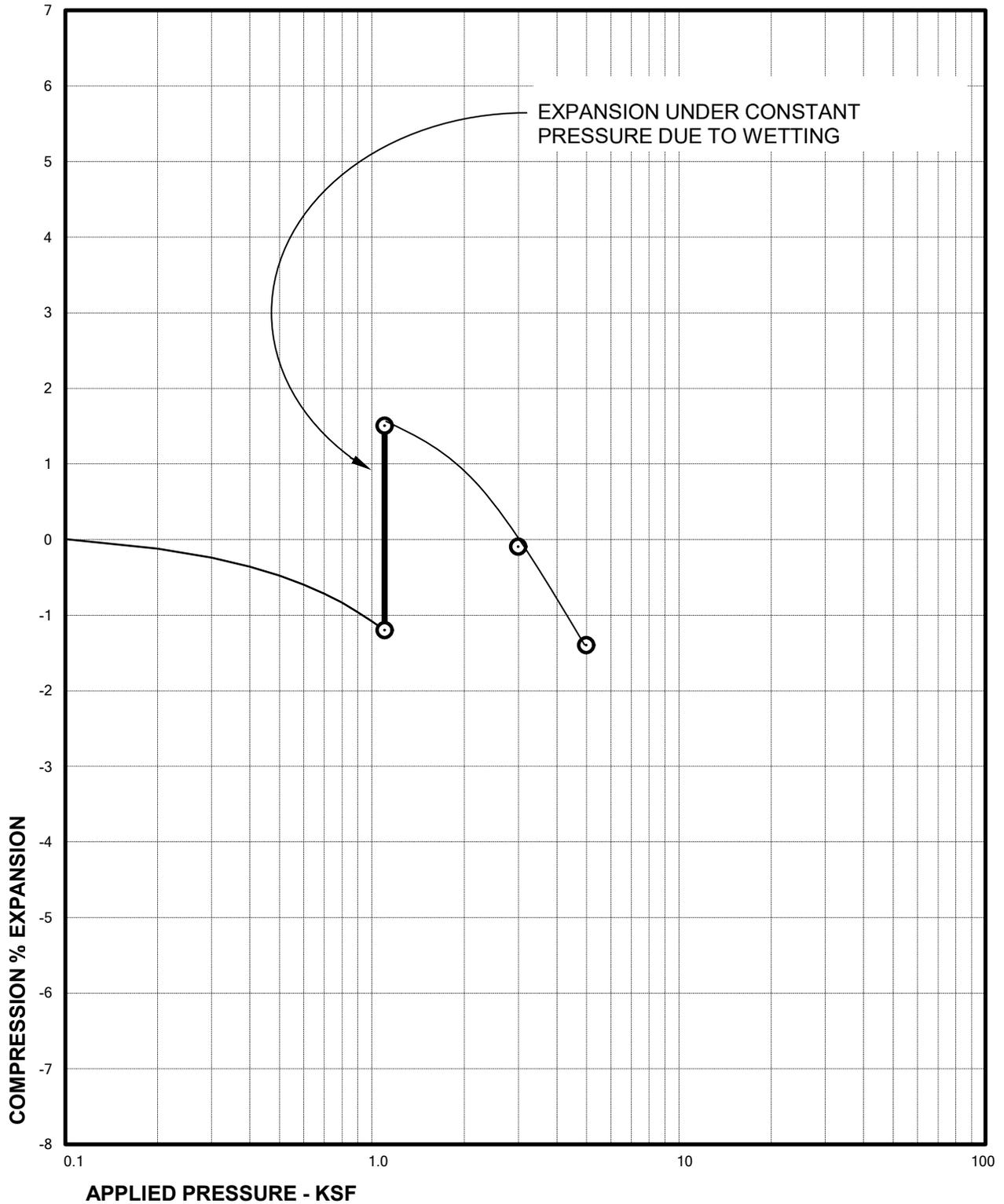
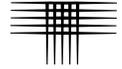
### Swell Consolidation Test Results



Sample of FILL, CLAY, VERY SANDY  
From TH-2 AT 4 FEET

DRY UNIT WEIGHT= 123 PCF  
MOISTURE CONTENT= 9.4 %

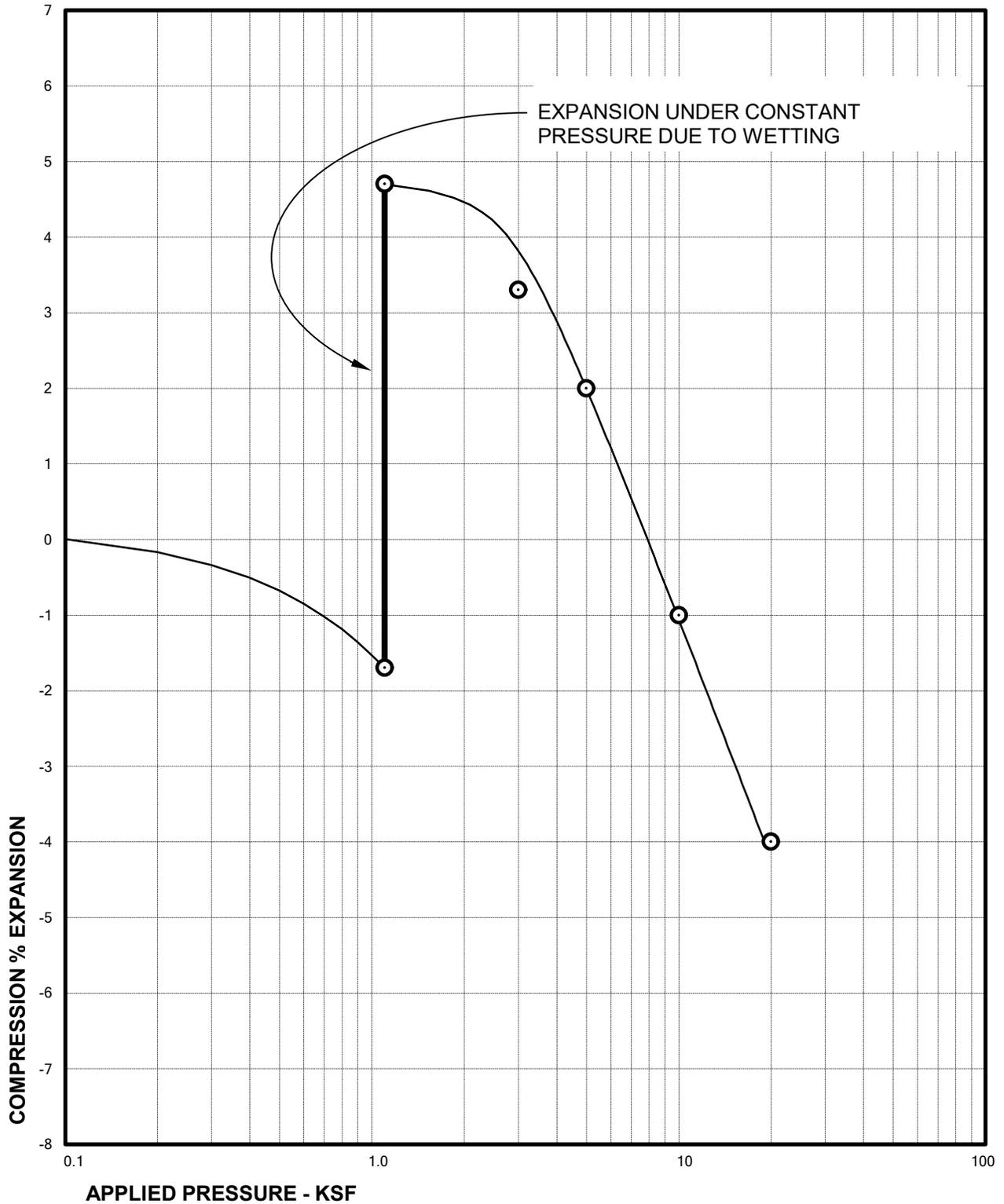
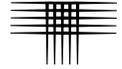
### Swell Consolidation Test Results



Sample of FILL, CLAY, SANDY  
From TH-2 AT 9 FEET

DRY UNIT WEIGHT= 114 PCF  
MOISTURE CONTENT= 14.4 %

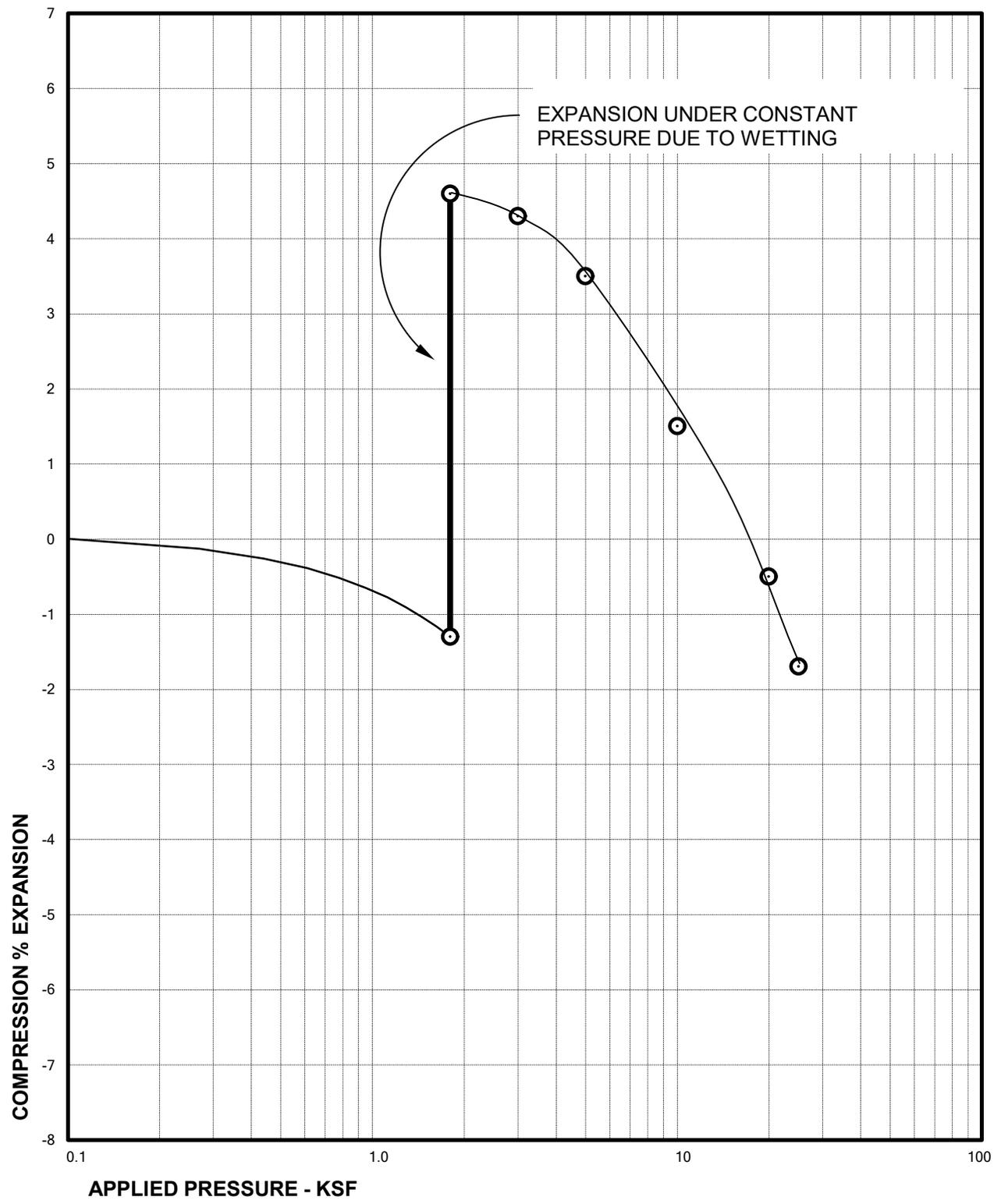
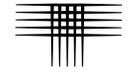
## Swell Consolidation Test Results



Sample of CLAYSTONE  
From TH-3 AT 9 FEET

DRY UNIT WEIGHT= 105 PCF  
MOISTURE CONTENT= 21.6 %

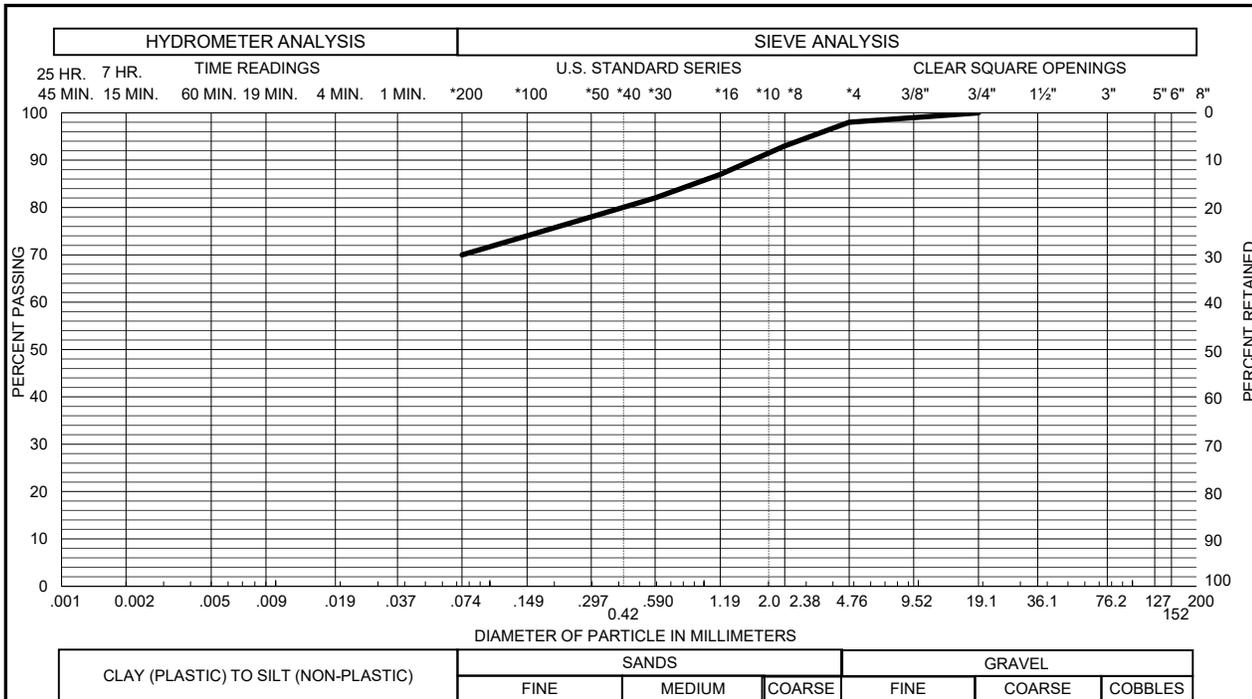
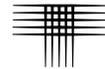
### Swell Consolidation Test Results



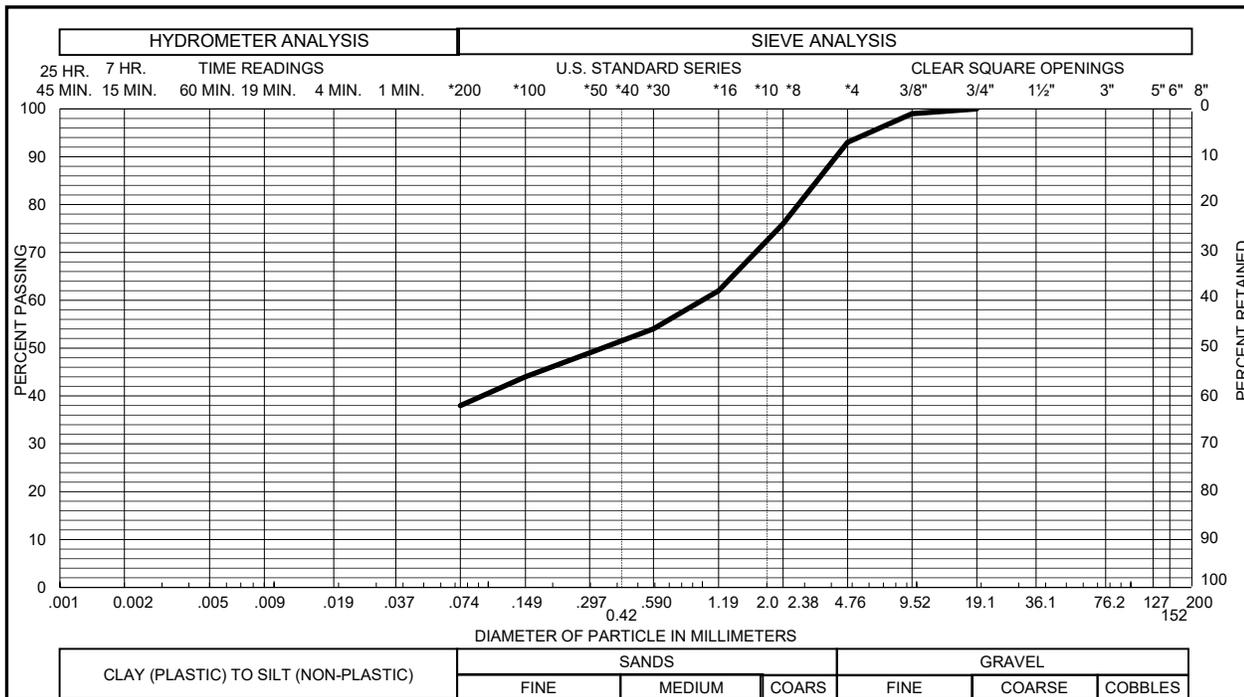
Sample of CLAYSTONE  
From TH-3 AT 14 FEET

DRY UNIT WEIGHT= 117 PCF  
MOISTURE CONTENT= 17.1 %

### Swell Consolidation Test Results

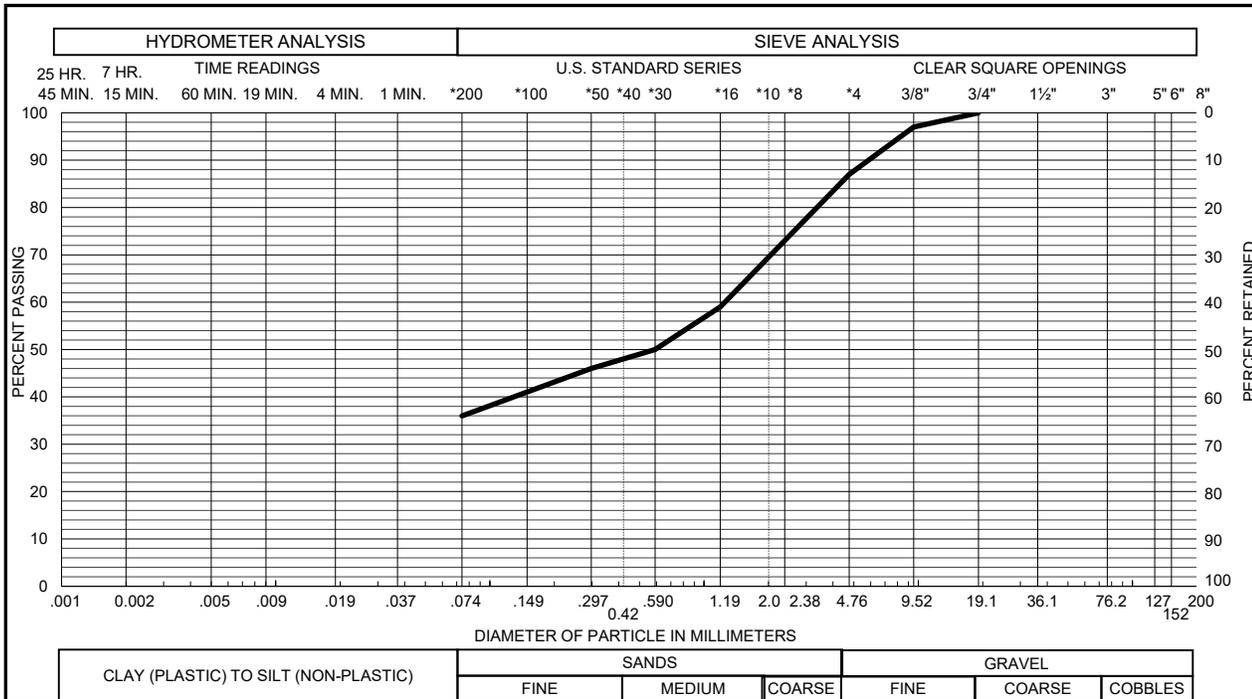
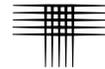


Sample of FILL, CLAY, SANDY GRAVEL 2 % SAND 28 %  
 From TH - 1 AT 4 FEET SILT & CLAY 70 % LIQUID LIMIT 52 %  
 PLASTICITY INDEX 30 %

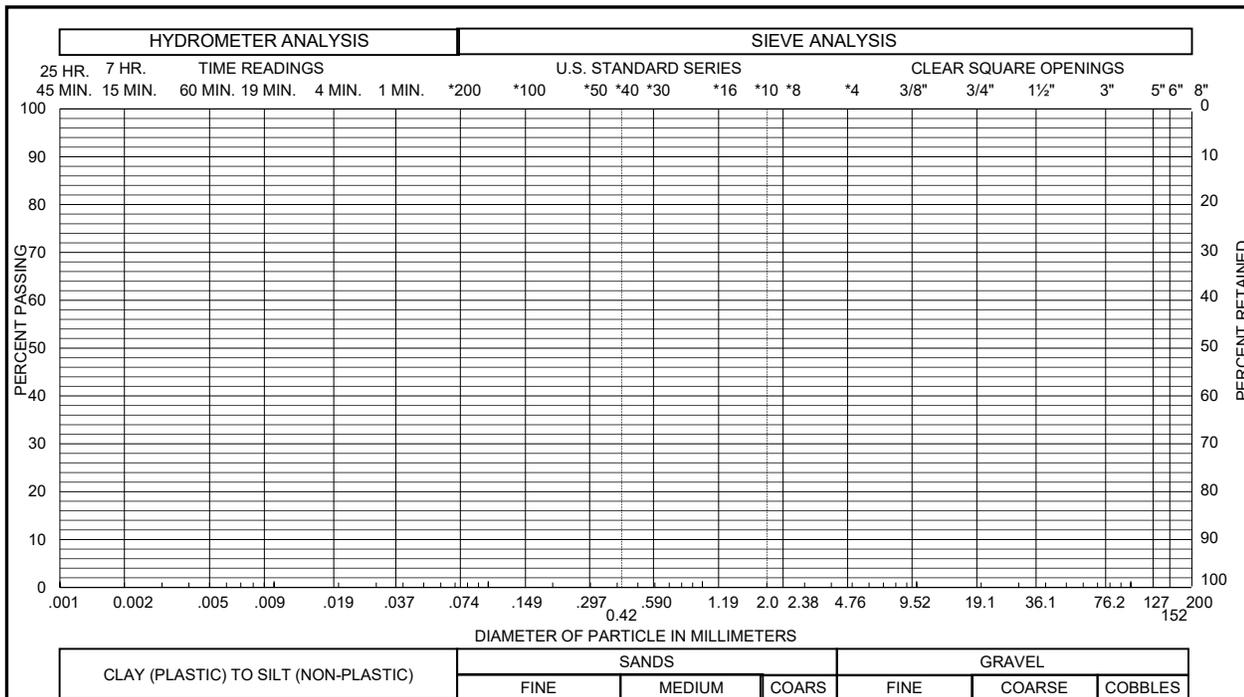


Sample of SAND, VERY CLAYEY (SC) GRAVEL 7 % SAND 55 %  
 From TH - 3 AT 4 FEET SILT & CLAY 38 % LIQUID LIMIT     %  
 PLASTICITY INDEX     %





Sample of SAND, VERY CLAYEY (SC) GRAVEL 13 % SAND 51 %  
 From TH - 5 AT 14 FEET SILT & CLAY 36 % LIQUID LIMIT \_\_\_\_\_ %  
 PLASTICITY INDEX \_\_\_\_\_ %



Sample of \_\_\_\_\_ GRAVEL \_\_\_\_\_ % SAND \_\_\_\_\_ %  
 From \_\_\_\_\_ SILT & CLAY \_\_\_\_\_ % LIQUID LIMIT \_\_\_\_\_ %  
 PLASTICITY INDEX \_\_\_\_\_ %





**APPENDIX C**  
**DIRECT SHEAR TEST RESULTS**

**Direct Shear**

**ASTM D 3080**

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

**Direct Shear Results**

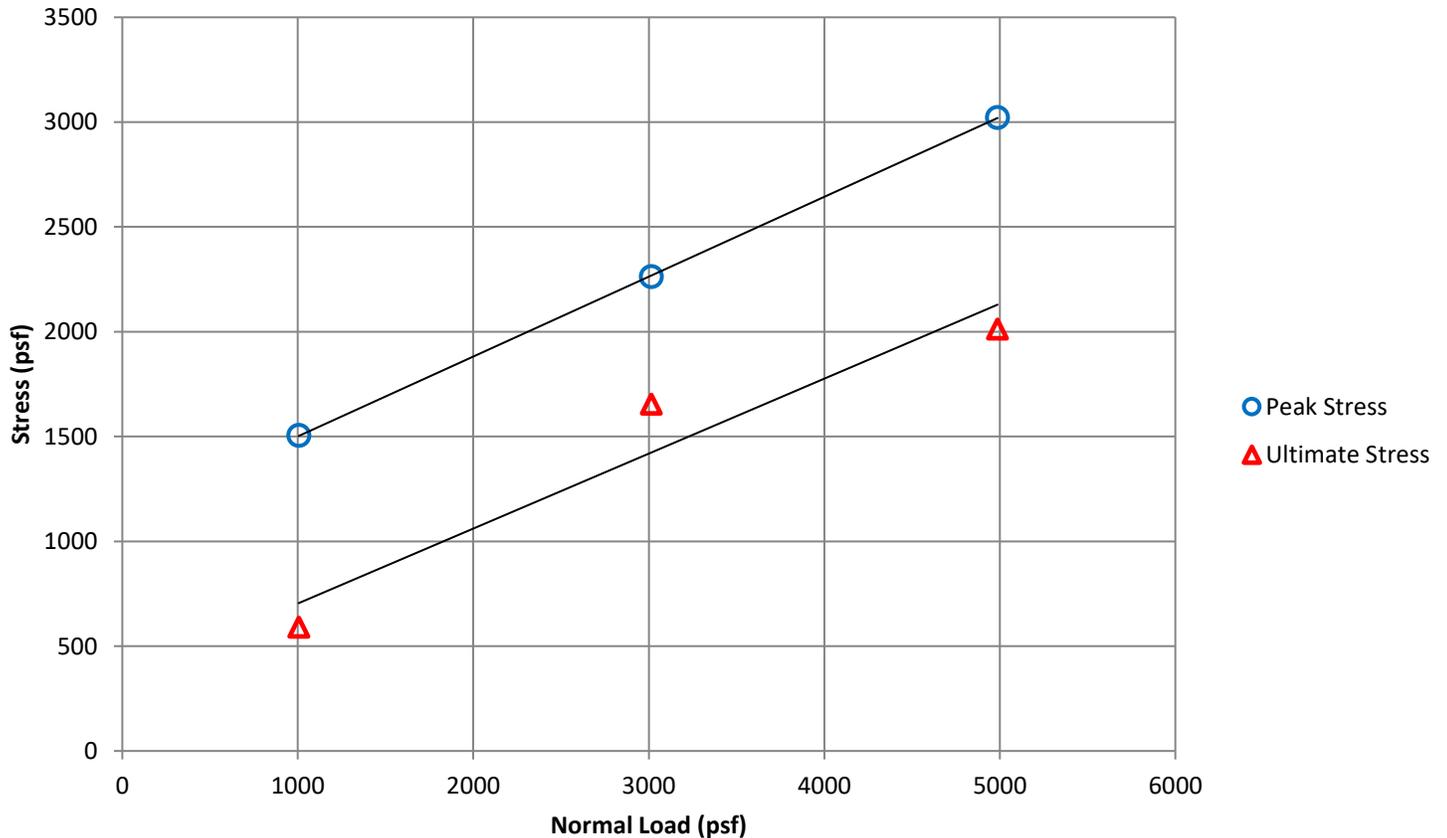
| Point:                   | A     | B     | C    |
|--------------------------|-------|-------|------|
| Normal Load (psf):       | 4987  | 3015  | 1005 |
| Normal Load (kPa):       | 238.8 | 144.4 | 48.1 |
| Peak Strength (psf):     | 3022  | 2263  | 1505 |
| Ultimate Strength (psf): | 2013  | 1654  | 591  |
| Peak Strength (kPa):     | 144.7 | 108.3 | 72.1 |
| Ultimate Strength (kPa): | 96.4  | 79.2  | 28.3 |

**Peak Strength**

**Ultimate Strength**

|                 |      |                 |      |
|-----------------|------|-----------------|------|
| Friction Angle: | 20.9 | Friction Angle: | 19.7 |
| Cohesion (psf): | 1120 | Cohesion (psf): | 346  |
| Cohesion (kPa): | 53.7 | Cohesion (kPa): | 16.6 |

**Normal Load vs. Stress**



Data entry by: AC  
 Checked by: JL  
 File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm

Date: 08/25/22  
 Date: 08/25/22

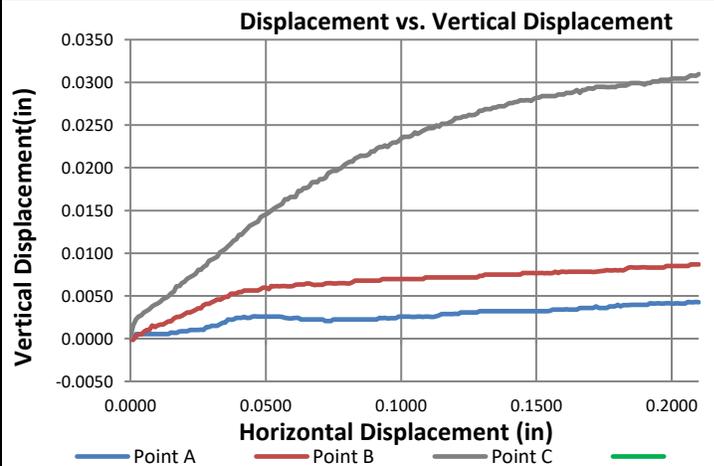
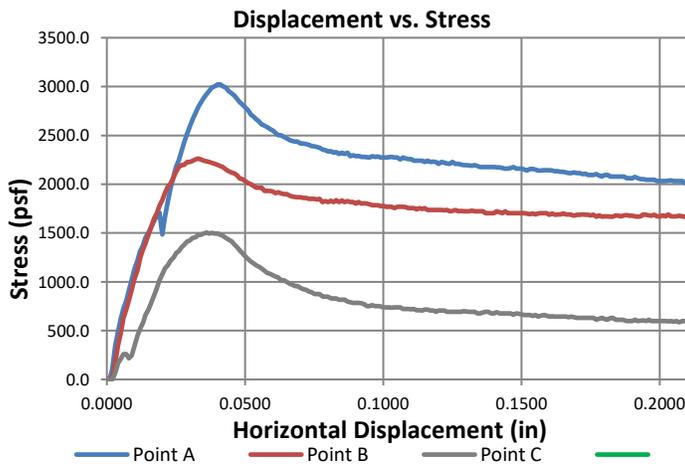
|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

**Test Parameters**

Displacement Rate (in/min): 0.0001458      Displacement Rate (cm/min): 0.000370332

Raw Data Files: 2843-014\_TH-4\_DS\_A\_8-19.txt, 2843-014\_TH-4\_DS\_B\_8-22.txt, 2843-014\_TH-4\_DS\_C\_8-23.txt,

|  |         |         |         |
|--|---------|---------|---------|
| Before Test Mass of Wet Soil and Ring (g): | 126.32  | 126.93  | 128.83  |
| After Test Mass of Wet Soil and Pan (g):   | 101.69  | 102.78  | 106.55  |
| Mass of Ring (g):                          | 27.94   | 28.00   | 28.00   |
| Mass of Wet Soil and Pan (g):              | 54.49   | 54.49   | 61.43   |
| Mass of Dry Soil and Pan (g):              | 46.88   | 46.88   | 52.84   |
| Mass of Pan (g):                           | 6.89    | 6.89    | 6.75    |
| Diameter (in):                             | 1.94    | 1.94    | 1.94    |
| Initial Height (in):                       | 1.00    | 1.00    | 1.00    |
| Height Change (in):                        | 0.00496 | -0.0088 | -0.0462 |
| Area (in <sup>2</sup> ):                   | 2.95    | 2.95    | 2.95    |
| Initial Wet Density (pcf):                 | 127.1   | 127.8   | 130.2   |
| Initial Dry Density (pcf):                 | 106.7   | 107.3   | 109.8   |
| Initial Wet Density (kg/m <sup>3</sup> ):  | 2035    | 2047    | 2086    |
| Initial Dry Density (kg/m <sup>3</sup> ):  | 1710    | 1719    | 1758    |
| Initial Moisture (%):                      | 19.0    | 19.0    | 18.6    |
| Final Wet Density (pcf):                   | 132.0   | 131.6   | 131.5   |
| Final Dry Density (pcf):                   | 107.3   | 106.4   | 104.9   |
| Final Wet Density (kg/m <sup>3</sup> ):    | 2114    | 2108    | 2107    |
| Final Dry Density (kg/m <sup>3</sup> ):    | 1718    | 1704    | 1681    |
| Final Moisture (%):                        | 23.0    | 23.7    | 25.4    |



**NOTES:**

Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points.

**Direct Shear Data  
ASTM D3080**

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

| Point A           |              |                            | Point B           |              |                            | Point C           |              |                            |
|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|
| Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) |
| 0.0000            | 0.6          | 0.0000                     | 0.0000            | 0.0          | 0.0000                     | 0.0000            | 0.6          | 0.0002                     |
| 0.0010            | 0.9          | 0.0000                     | 0.0010            | 10.4         | -0.0002                    | 0.0010            | 0.0          | 0.0016                     |
| 0.0020            | 110.6        | 0.0005                     | 0.0021            | 22.3         | 0.0003                     | 0.0021            | 1.5          | 0.0023                     |
| 0.0030            | 339.4        | 0.0005                     | 0.0030            | 171.9        | 0.0005                     | 0.0030            | 66.3         | 0.0026                     |
| 0.0041            | 489.3        | 0.0005                     | 0.0040            | 349.5        | 0.0005                     | 0.0040            | 163.9        | 0.0027                     |
| 0.0050            | 616.0        | 0.0005                     | 0.0051            | 482.1        | 0.0008                     | 0.0050            | 212.6        | 0.0031                     |
| 0.0060            | 729.1        | 0.0005                     | 0.0060            | 629.8        | 0.0010                     | 0.0060            | 259.1        | 0.0032                     |
| 0.0070            | 808.3        | 0.0005                     | 0.0070            | 718.4        | 0.0010                     | 0.0070            | 258.5        | 0.0034                     |
| 0.0080            | 910.4        | 0.0005                     | 0.0080            | 810.5        | 0.0015                     | 0.0080            | 216.5        | 0.0038                     |
| 0.0090            | 1020.7       | 0.0005                     | 0.0091            | 919.9        | 0.0014                     | 0.0090            | 246.0        | 0.0040                     |
| 0.0101            | 1134.5       | 0.0005                     | 0.0101            | 1035.2       | 0.0015                     | 0.0100            | 349.0        | 0.0041                     |
| 0.0111            | 1216.2       | 0.0005                     | 0.0111            | 1115.6       | 0.0017                     | 0.0111            | 449.9        | 0.0043                     |
| 0.0120            | 1311.8       | 0.0005                     | 0.0121            | 1249.2       | 0.0017                     | 0.0121            | 524.3        | 0.0046                     |
| 0.0131            | 1370.8       | 0.0005                     | 0.0130            | 1330.0       | 0.0018                     | 0.0131            | 585.2        | 0.0048                     |
| 0.0140            | 1453.8       | 0.0005                     | 0.0140            | 1392.5       | 0.0020                     | 0.0140            | 661.3        | 0.0050                     |
| 0.0150            | 1499.7       | 0.0007                     | 0.0150            | 1478.0       | 0.0020                     | 0.0150            | 712.4        | 0.0053                     |
| 0.0160            | 1559.1       | 0.0007                     | 0.0160            | 1559.1       | 0.0024                     | 0.0160            | 783.4        | 0.0055                     |
| 0.0170            | 1621.6       | 0.0007                     | 0.0171            | 1647.4       | 0.0026                     | 0.0170            | 860.1        | 0.0061                     |
| 0.0180            | 1669.4       | 0.0008                     | 0.0181            | 1701.8       | 0.0025                     | 0.0181            | 938.1        | 0.0062                     |
| 0.0190            | 1709.6       | 0.0009                     | 0.0191            | 1777.2       | 0.0027                     | 0.0190            | 1014.8       | 0.0065                     |
| 0.0200            | 1485.5       | 0.0009                     | 0.0200            | 1835.3       | 0.0029                     | 0.0200            | 1078.4       | 0.0067                     |
| 0.0210            | 1662.2       | 0.0009                     | 0.0210            | 1907.0       | 0.0031                     | 0.0210            | 1136.9       | 0.0070                     |
| 0.0220            | 1817.1       | 0.0010                     | 0.0220            | 1973.6       | 0.0031                     | 0.0220            | 1168.8       | 0.0072                     |
| 0.0230            | 1961.0       | 0.0010                     | 0.0231            | 2005.0       | 0.0032                     | 0.0231            | 1218.1       | 0.0074                     |
| 0.0241            | 2079.2       | 0.0010                     | 0.0240            | 2060.0       | 0.0034                     | 0.0241            | 1246.5       | 0.0076                     |
| 0.0251            | 2174.7       | 0.0010                     | 0.0250            | 2126.6       | 0.0036                     | 0.0251            | 1294.8       | 0.0081                     |
| 0.0261            | 2248.3       | 0.0011                     | 0.0260            | 2174.4       | 0.0036                     | 0.0260            | 1316.9       | 0.0081                     |
| 0.0270            | 2336.9       | 0.0010                     | 0.0270            | 2193.9       | 0.0039                     | 0.0270            | 1352.7       | 0.0084                     |
| 0.0280            | 2431.8       | 0.0014                     | 0.0280            | 2199.9       | 0.0041                     | 0.0280            | 1379.6       | 0.0086                     |
| 0.0290            | 2517.0       | 0.0014                     | 0.0290            | 2226.9       | 0.0041                     | 0.0290            | 1411.6       | 0.0091                     |
| 0.0301            | 2597.7       | 0.0015                     | 0.0300            | 2228.8       | 0.0043                     | 0.0300            | 1423.2       | 0.0092                     |
| 0.0311            | 2671.9       | 0.0015                     | 0.0311            | 2240.7       | 0.0044                     | 0.0310            | 1449.8       | 0.0094                     |
| 0.0321            | 2727.5       | 0.0015                     | 0.0321            | 2254.9       | 0.0046                     | 0.0321            | 1456.6       | 0.0096                     |
| 0.0331            | 2793.2       | 0.0017                     | 0.0331            | 2262.7       | 0.0046                     | 0.0331            | 1481.1       | 0.0101                     |
| 0.0342            | 2841.3       | 0.0019                     | 0.0340            | 2254.9       | 0.0047                     | 0.0340            | 1481.7       | 0.0103                     |
| 0.0350            | 2882.5       | 0.0019                     | 0.0350            | 2241.4       | 0.0049                     | 0.0350            | 1495.2       | 0.0105                     |
| 0.0360            | 2921.7       | 0.0022                     | 0.0360            | 2234.1       | 0.0049                     | 0.0360            | 1505.3       | 0.0108                     |
| 0.0370            | 2956.0       | 0.0022                     | 0.0370            | 2227.2       | 0.0053                     | 0.0370            | 1495.2       | 0.0111                     |
| 0.0380            | 2989.3       | 0.0022                     | 0.0380            | 2217.2       | 0.0053                     | 0.0381            | 1501.7       | 0.0115                     |
| 0.0391            | 3003.8       | 0.0024                     | 0.0390            | 2207.1       | 0.0053                     | 0.0390            | 1495.2       | 0.0116                     |
| 0.0401            | 3022.3       | 0.0024                     | 0.0400            | 2200.2       | 0.0054                     | 0.0401            | 1495.2       | 0.0122                     |
| 0.0410            | 3022.3       | 0.0024                     | 0.0410            | 2184.2       | 0.0054                     | 0.0410            | 1481.7       | 0.0122                     |
| 0.0420            | 3004.1       | 0.0026                     | 0.0420            | 2174.4       | 0.0056                     | 0.0420            | 1470.7       | 0.0125                     |

**Direct Shear Data  
ASTM D3080**

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

| Point A           |              |                            | Point B           |              |                            | Point C           |              |                            |  |
|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|--|
| Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) |  |
| 0.0430            | 2989.3       | 0.0024                     | 0.0431            | 2148.3       | 0.0056                     | 0.0430            | 1449.8       | 0.0129                     |  |
| 0.0440            | 2956.0       | 0.0024                     | 0.0441            | 2133.9       | 0.0056                     | 0.0441            | 1431.9       | 0.0132                     |  |
| 0.0451            | 2932.1       | 0.0026                     | 0.0451            | 2119.1       | 0.0056                     | 0.0450            | 1415.1       | 0.0133                     |  |
| 0.0461            | 2908.2       | 0.0026                     | 0.0461            | 2111.6       | 0.0056                     | 0.0460            | 1386.5       | 0.0135                     |  |
| 0.0470            | 2874.9       | 0.0026                     | 0.0471            | 2089.9       | 0.0056                     | 0.0471            | 1354.2       | 0.0137                     |  |
| 0.0480            | 2841.3       | 0.0026                     | 0.0480            | 2059.7       | 0.0058                     | 0.0480            | 1323.2       | 0.0142                     |  |
| 0.0490            | 2817.1       | 0.0026                     | 0.0490            | 2050.6       | 0.0060                     | 0.0490            | 1295.1       | 0.0144                     |  |
| 0.0500            | 2786.9       | 0.0026                     | 0.0500            | 2031.1       | 0.0060                     | 0.0500            | 1263.5       | 0.0145                     |  |
| 0.0511            | 2760.5       | 0.0026                     | 0.0511            | 2012.6       | 0.0058                     | 0.0510            | 1233.6       | 0.0147                     |  |
| 0.0521            | 2712.8       | 0.0026                     | 0.0521            | 1998.4       | 0.0062                     | 0.0521            | 1207.4       | 0.0150                     |  |
| 0.0531            | 2689.2       | 0.0026                     | 0.0531            | 1981.1       | 0.0061                     | 0.0531            | 1187.1       | 0.0152                     |  |
| 0.0541            | 2665.0       | 0.0026                     | 0.0541            | 1963.9       | 0.0062                     | 0.0541            | 1168.8       | 0.0154                     |  |
| 0.0550            | 2644.6       | 0.0026                     | 0.0550            | 1964.2       | 0.0061                     | 0.0550            | 1155.7       | 0.0156                     |  |
| 0.0560            | 2612.5       | 0.0026                     | 0.0560            | 1964.5       | 0.0062                     | 0.0560            | 1135.4       | 0.0158                     |  |
| 0.0571            | 2598.4       | 0.0024                     | 0.0571            | 1931.5       | 0.0062                     | 0.0571            | 1113.6       | 0.0163                     |  |
| 0.0580            | 2584.5       | 0.0024                     | 0.0581            | 1930.5       | 0.0061                     | 0.0580            | 1091.5       | 0.0163                     |  |
| 0.0591            | 2565.1       | 0.0024                     | 0.0591            | 1930.5       | 0.0061                     | 0.0591            | 1081.4       | 0.0166                     |  |
| 0.0600            | 2551.9       | 0.0024                     | 0.0601            | 1923.9       | 0.0062                     | 0.0600            | 1069.1       | 0.0166                     |  |
| 0.0611            | 2524.2       | 0.0024                     | 0.0610            | 1907.3       | 0.0063                     | 0.0610            | 1056.0       | 0.0166                     |  |
| 0.0620            | 2503.1       | 0.0024                     | 0.0620            | 1917.3       | 0.0063                     | 0.0620            | 1046.1       | 0.0173                     |  |
| 0.0630            | 2503.1       | 0.0022                     | 0.0630            | 1906.7       | 0.0063                     | 0.0630            | 1015.1       | 0.0173                     |  |
| 0.0640            | 2484.0       | 0.0022                     | 0.0641            | 1897.5       | 0.0063                     | 0.0641            | 1015.1       | 0.0176                     |  |
| 0.0651            | 2469.8       | 0.0022                     | 0.0651            | 1897.9       | 0.0064                     | 0.0651            | 1000.8       | 0.0176                     |  |
| 0.0661            | 2451.3       | 0.0022                     | 0.0661            | 1882.8       | 0.0065                     | 0.0660            | 984.0        | 0.0178                     |  |
| 0.0671            | 2443.7       | 0.0022                     | 0.0671            | 1874.0       | 0.0063                     | 0.0671            | 969.7        | 0.0183                     |  |
| 0.0681            | 2436.2       | 0.0022                     | 0.0680            | 1869.6       | 0.0063                     | 0.0680            | 955.4        | 0.0183                     |  |
| 0.0690            | 2436.2       | 0.0022                     | 0.0690            | 1865.2       | 0.0063                     | 0.0690            | 955.7        | 0.0183                     |  |
| 0.0700            | 2417.7       | 0.0022                     | 0.0700            | 1865.2       | 0.0063                     | 0.0700            | 938.4        | 0.0187                     |  |
| 0.0710            | 2415.8       | 0.0022                     | 0.0710            | 1861.1       | 0.0063                     | 0.0711            | 924.3        | 0.0187                     |  |
| 0.0721            | 2411.1       | 0.0021                     | 0.0720            | 1859.2       | 0.0064                     | 0.0721            | 917.5        | 0.0188                     |  |
| 0.0730            | 2403.5       | 0.0021                     | 0.0730            | 1850.1       | 0.0065                     | 0.0731            | 899.8        | 0.0194                     |  |
| 0.0740            | 2390.6       | 0.0021                     | 0.0742            | 1850.1       | 0.0065                     | 0.0740            | 894.5        | 0.0195                     |  |
| 0.0750            | 2388.7       | 0.0022                     | 0.0750            | 1850.1       | 0.0065                     | 0.0751            | 874.2        | 0.0197                     |  |
| 0.0760            | 2382.1       | 0.0022                     | 0.0760            | 1843.2       | 0.0064                     | 0.0760            | 874.5        | 0.0197                     |  |
| 0.0770            | 2369.9       | 0.0022                     | 0.0770            | 1850.1       | 0.0065                     | 0.0770            | 874.2        | 0.0198                     |  |
| 0.0780            | 2355.7       | 0.0022                     | 0.0781            | 1816.8       | 0.0065                     | 0.0781            | 847.9        | 0.0200                     |  |
| 0.0790            | 2348.5       | 0.0022                     | 0.0791            | 1826.2       | 0.0065                     | 0.0791            | 847.9        | 0.0204                     |  |
| 0.0801            | 2336.3       | 0.0022                     | 0.0801            | 1817.4       | 0.0065                     | 0.0800            | 845.5        | 0.0205                     |  |
| 0.0810            | 2337.5       | 0.0022                     | 0.0810            | 1830.9       | 0.0065                     | 0.0812            | 829.1        | 0.0207                     |  |
| 0.0820            | 2323.1       | 0.0022                     | 0.0820            | 1817.4       | 0.0066                     | 0.0820            | 829.1        | 0.0207                     |  |
| 0.0830            | 2328.1       | 0.0022                     | 0.0830            | 1835.3       | 0.0068                     | 0.0830            | 829.1        | 0.0211                     |  |
| 0.0840            | 2308.0       | 0.0022                     | 0.0840            | 1817.1       | 0.0068                     | 0.0840            | 815.6        | 0.0213                     |  |
| 0.0851            | 2323.1       | 0.0022                     | 0.0851            | 1832.8       | 0.0068                     | 0.0851            | 815.9        | 0.0214                     |  |

**Direct Shear Data  
ASTM D3080**

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

| Point A           |              |                            | Point B           |              |                            | Point C           |              |                            |
|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|
| Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) |
| 0.0861            | 2308.0       | 0.0022                     | 0.0860            | 1816.8       | 0.0068                     | 0.0861            | 815.9        | 0.0214                     |
| 0.0871            | 2321.8       | 0.0022                     | 0.0871            | 1826.2       | 0.0068                     | 0.0871            | 797.7        | 0.0214                     |
| 0.0880            | 2288.2       | 0.0022                     | 0.0880            | 1817.1       | 0.0068                     | 0.0881            | 790.6        | 0.0216                     |
| 0.0890            | 2295.7       | 0.0022                     | 0.0890            | 1817.1       | 0.0068                     | 0.0890            | 784.0        | 0.0219                     |
| 0.0900            | 2288.2       | 0.0022                     | 0.0900            | 1802.3       | 0.0068                     | 0.0900            | 784.3        | 0.0219                     |
| 0.0910            | 2289.1       | 0.0022                     | 0.0911            | 1817.1       | 0.0068                     | 0.0910            | 783.4        | 0.0223                     |
| 0.0921            | 2281.6       | 0.0024                     | 0.0920            | 1802.3       | 0.0068                     | 0.0921            | 780.4        | 0.0224                     |
| 0.0931            | 2280.0       | 0.0024                     | 0.0931            | 1802.6       | 0.0070                     | 0.0931            | 771.2        | 0.0224                     |
| 0.0940            | 2278.4       | 0.0024                     | 0.0940            | 1802.3       | 0.0070                     | 0.0940            | 752.4        | 0.0226                     |
| 0.0951            | 2275.0       | 0.0024                     | 0.0950            | 1795.7       | 0.0070                     | 0.0950            | 752.4        | 0.0224                     |
| 0.0960            | 2287.9       | 0.0024                     | 0.0960            | 1784.1       | 0.0070                     | 0.0960            | 761.9        | 0.0228                     |
| 0.0970            | 2281.6       | 0.0024                     | 0.0971            | 1784.1       | 0.0070                     | 0.0970            | 752.4        | 0.0230                     |
| 0.0981            | 2281.9       | 0.0024                     | 0.0980            | 1783.2       | 0.0070                     | 0.0980            | 752.4        | 0.0229                     |
| 0.0991            | 2274.4       | 0.0026                     | 0.0991            | 1775.9       | 0.0070                     | 0.0991            | 749.4        | 0.0231                     |
| 0.1000            | 2274.0       | 0.0026                     | 0.1000            | 1779.1       | 0.0070                     | 0.1000            | 738.9        | 0.0234                     |
| 0.1011            | 2274.7       | 0.0026                     | 0.1010            | 1769.6       | 0.0070                     | 0.1010            | 738.0        | 0.0236                     |
| 0.1020            | 2276.9       | 0.0026                     | 0.1020            | 1769.6       | 0.0070                     | 0.1020            | 738.3        | 0.0236                     |
| 0.1030            | 2280.3       | 0.0026                     | 0.1030            | 1769.3       | 0.0070                     | 0.1030            | 734.1        | 0.0236                     |
| 0.1040            | 2274.7       | 0.0026                     | 0.1040            | 1756.4       | 0.0070                     | 0.1040            | 738.6        | 0.0238                     |
| 0.1051            | 2274.7       | 0.0025                     | 0.1050            | 1769.3       | 0.0070                     | 0.1051            | 738.0        | 0.0242                     |
| 0.1061            | 2255.5       | 0.0026                     | 0.1061            | 1769.6       | 0.0070                     | 0.1061            | 738.0        | 0.0240                     |
| 0.1071            | 2275.0       | 0.0026                     | 0.1071            | 1769.6       | 0.0070                     | 0.1071            | 720.7        | 0.0242                     |
| 0.1081            | 2264.9       | 0.0026                     | 0.1082            | 1763.7       | 0.0070                     | 0.1081            | 720.7        | 0.0243                     |
| 0.1090            | 2255.8       | 0.0026                     | 0.1090            | 1754.6       | 0.0072                     | 0.1090            | 721.0        | 0.0245                     |
| 0.1100            | 2255.8       | 0.0026                     | 0.1100            | 1754.6       | 0.0072                     | 0.1100            | 719.8        | 0.0246                     |
| 0.1110            | 2240.7       | 0.0025                     | 0.1111            | 1754.6       | 0.0072                     | 0.1110            | 721.0        | 0.0246                     |
| 0.1121            | 2241.4       | 0.0025                     | 0.1121            | 1742.6       | 0.0072                     | 0.1120            | 708.5        | 0.0247                     |
| 0.1130            | 2240.7       | 0.0026                     | 0.1131            | 1754.6       | 0.0072                     | 0.1131            | 710.6        | 0.0250                     |
| 0.1141            | 2241.0       | 0.0027                     | 0.1140            | 1745.1       | 0.0072                     | 0.1140            | 707.0        | 0.0248                     |
| 0.1150            | 2227.5       | 0.0029                     | 0.1150            | 1754.6       | 0.0072                     | 0.1150            | 714.4        | 0.0251                     |
| 0.1160            | 2241.7       | 0.0029                     | 0.1160            | 1736.0       | 0.0072                     | 0.1160            | 717.1        | 0.0251                     |
| 0.1170            | 2227.5       | 0.0029                     | 0.1171            | 1735.4       | 0.0072                     | 0.1170            | 707.0        | 0.0251                     |
| 0.1181            | 2230.7       | 0.0029                     | 0.1181            | 1735.4       | 0.0072                     | 0.1181            | 707.0        | 0.0253                     |
| 0.1191            | 2229.1       | 0.0029                     | 0.1191            | 1736.0       | 0.0072                     | 0.1191            | 692.9        | 0.0255                     |
| 0.1200            | 2207.7       | 0.0029                     | 0.1201            | 1735.4       | 0.0072                     | 0.1200            | 707.0        | 0.0258                     |
| 0.1211            | 2227.5       | 0.0029                     | 0.1211            | 1736.6       | 0.0072                     | 0.1211            | 707.0        | 0.0258                     |
| 0.1220            | 2222.5       | 0.0031                     | 0.1220            | 1732.2       | 0.0072                     | 0.1220            | 707.3        | 0.0259                     |
| 0.1230            | 2212.8       | 0.0031                     | 0.1230            | 1735.7       | 0.0072                     | 0.1230            | 692.6        | 0.0260                     |
| 0.1240            | 2208.0       | 0.0031                     | 0.1240            | 1721.9       | 0.0072                     | 0.1240            | 693.5        | 0.0260                     |
| 0.1250            | 2227.5       | 0.0031                     | 0.1250            | 1727.2       | 0.0072                     | 0.1251            | 693.8        | 0.0262                     |
| 0.1260            | 2208.0       | 0.0031                     | 0.1261            | 1736.0       | 0.0072                     | 0.1260            | 693.5        | 0.0262                     |
| 0.1271            | 2207.4       | 0.0031                     | 0.1270            | 1723.8       | 0.0072                     | 0.1271            | 692.9        | 0.0262                     |
| 0.1281            | 2201.1       | 0.0031                     | 0.1280            | 1726.0       | 0.0072                     | 0.1280            | 693.5        | 0.0264                     |

**Direct Shear Data  
ASTM D3080**

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |

| Point A           |              |                            | Point B           |              |                            | Point C           |              |                            |
|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|
| Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) |
| 0.1290            | 2195.8       | 0.0032                     | 0.1290            | 1721.9       | 0.0073                     | 0.1290            | 700.1        | 0.0267                     |
| 0.1300            | 2194.2       | 0.0032                     | 0.1301            | 1721.9       | 0.0073                     | 0.1300            | 696.8        | 0.0267                     |
| 0.1310            | 2193.6       | 0.0032                     | 0.1310            | 1721.9       | 0.0075                     | 0.1310            | 693.8        | 0.0269                     |
| 0.1321            | 2187.6       | 0.0032                     | 0.1320            | 1728.5       | 0.0075                     | 0.1321            | 693.8        | 0.0269                     |
| 0.1331            | 2193.9       | 0.0032                     | 0.1330            | 1721.9       | 0.0075                     | 0.1331            | 692.6        | 0.0269                     |
| 0.1341            | 2186.0       | 0.0032                     | 0.1341            | 1721.9       | 0.0075                     | 0.1340            | 677.4        | 0.0270                     |
| 0.1350            | 2177.2       | 0.0032                     | 0.1350            | 1721.9       | 0.0075                     | 0.1350            | 678.0        | 0.0270                     |
| 0.1360            | 2174.7       | 0.0032                     | 0.1360            | 1721.9       | 0.0075                     | 0.1360            | 686.4        | 0.0272                     |
| 0.1370            | 2174.7       | 0.0032                     | 0.1370            | 1702.1       | 0.0075                     | 0.1370            | 694.4        | 0.0272                     |
| 0.1381            | 2174.7       | 0.0032                     | 0.1381            | 1702.1       | 0.0075                     | 0.1380            | 693.8        | 0.0272                     |
| 0.1391            | 2174.7       | 0.0032                     | 0.1391            | 1701.8       | 0.0075                     | 0.1390            | 675.6        | 0.0274                     |
| 0.1401            | 2174.7       | 0.0032                     | 0.1401            | 1702.1       | 0.0075                     | 0.1401            | 675.9        | 0.0276                     |
| 0.1411            | 2171.0       | 0.0032                     | 0.1410            | 1721.9       | 0.0075                     | 0.1410            | 691.2        | 0.0276                     |
| 0.1420            | 2173.2       | 0.0032                     | 0.1420            | 1712.4       | 0.0075                     | 0.1420            | 675.6        | 0.0277                     |
| 0.1430            | 2165.3       | 0.0032                     | 0.1430            | 1702.4       | 0.0075                     | 0.1430            | 675.3        | 0.0277                     |
| 0.1440            | 2159.6       | 0.0032                     | 0.1441            | 1721.9       | 0.0075                     | 0.1440            | 675.6        | 0.0279                     |
| 0.1451            | 2160.0       | 0.0032                     | 0.1450            | 1701.8       | 0.0077                     | 0.1451            | 675.3        | 0.0279                     |
| 0.1461            | 2167.2       | 0.0032                     | 0.1461            | 1702.1       | 0.0077                     | 0.1461            | 675.9        | 0.0279                     |
| 0.1471            | 2174.7       | 0.0032                     | 0.1470            | 1702.1       | 0.0077                     | 0.1470            | 663.1        | 0.0279                     |
| 0.1482            | 2159.6       | 0.0032                     | 0.1480            | 1703.0       | 0.0077                     | 0.1481            | 675.9        | 0.0279                     |
| 0.1490            | 2159.6       | 0.0032                     | 0.1490            | 1702.1       | 0.0077                     | 0.1490            | 672.0        | 0.0281                     |
| 0.1501            | 2159.6       | 0.0032                     | 0.1500            | 1702.1       | 0.0077                     | 0.1500            | 667.0        | 0.0282                     |
| 0.1511            | 2150.8       | 0.0032                     | 0.1511            | 1701.8       | 0.0077                     | 0.1511            | 661.6        | 0.0282                     |
| 0.1520            | 2141.4       | 0.0032                     | 0.1521            | 1695.5       | 0.0077                     | 0.1521            | 661.6        | 0.0284                     |
| 0.1531            | 2157.1       | 0.0032                     | 0.1531            | 1692.0       | 0.0077                     | 0.1531            | 661.6        | 0.0284                     |
| 0.1540            | 2155.2       | 0.0032                     | 0.1540            | 1700.2       | 0.0077                     | 0.1540            | 652.0        | 0.0284                     |
| 0.1550            | 2150.5       | 0.0032                     | 0.1550            | 1689.2       | 0.0077                     | 0.1550            | 661.6        | 0.0284                     |
| 0.1560            | 2141.4       | 0.0034                     | 0.1560            | 1698.9       | 0.0077                     | 0.1560            | 643.1        | 0.0284                     |
| 0.1570            | 2141.4       | 0.0034                     | 0.1570            | 1701.8       | 0.0078                     | 0.1571            | 655.0        | 0.0284                     |
| 0.1581            | 2141.7       | 0.0034                     | 0.1581            | 1701.8       | 0.0077                     | 0.1580            | 659.5        | 0.0286                     |
| 0.1591            | 2142.0       | 0.0034                     | 0.1591            | 1701.8       | 0.0078                     | 0.1590            | 652.6        | 0.0286                     |
| 0.1601            | 2141.7       | 0.0034                     | 0.1601            | 1687.6       | 0.0078                     | 0.1601            | 645.2        | 0.0286                     |
| 0.1612            | 2141.1       | 0.0034                     | 0.1610            | 1700.5       | 0.0078                     | 0.1610            | 646.1        | 0.0288                     |
| 0.1620            | 2134.5       | 0.0034                     | 0.1620            | 1688.2       | 0.0078                     | 0.1620            | 643.1        | 0.0288                     |
| 0.1630            | 2134.2       | 0.0034                     | 0.1630            | 1689.8       | 0.0078                     | 0.1630            | 643.1        | 0.0288                     |
| 0.1640            | 2127.0       | 0.0034                     | 0.1640            | 1689.2       | 0.0078                     | 0.1640            | 643.4        | 0.0289                     |
| 0.1650            | 2127.0       | 0.0034                     | 0.1651            | 1699.9       | 0.0078                     | 0.1650            | 643.4        | 0.0291                     |
| 0.1661            | 2121.0       | 0.0036                     | 0.1661            | 1688.6       | 0.0078                     | 0.1661            | 643.1        | 0.0288                     |
| 0.1670            | 2112.8       | 0.0036                     | 0.1670            | 1688.9       | 0.0079                     | 0.1670            | 636.5        | 0.0291                     |
| 0.1680            | 2112.5       | 0.0036                     | 0.1680            | 1687.9       | 0.0078                     | 0.1680            | 643.1        | 0.0291                     |
| 0.1690            | 2119.1       | 0.0036                     | 0.1690            | 1678.5       | 0.0078                     | 0.1690            | 638.0        | 0.0293                     |
| 0.1700            | 2112.5       | 0.0036                     | 0.1700            | 1687.9       | 0.0078                     | 0.1700            | 632.3        | 0.0293                     |
| 0.1711            | 2112.5       | 0.0036                     | 0.1710            | 1687.9       | 0.0078                     | 0.1711            | 630.5        | 0.0293                     |

**Direct Shear Data  
ASTM D3080**

CLIENT CTL Thompson  
 JOB NO. 2843-014  
 PROJECT The Launchpad  
 PROJECT NO. CS19243-125  
 LOCATION --  
 DATE TESTED 08/18/22  
 TECHNICIAN JL

BORING NO. TH-4  
 DEPTH 14-19'  
 SAMPLE NO. --  
 DATE SAMPLED --  
 DESCRIPTION --

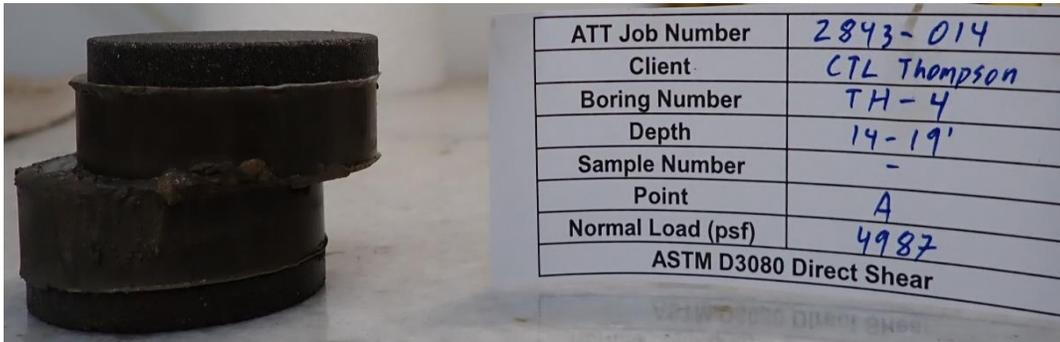
| Point A           |              |                            | Point B           |              |                            | Point C           |              |                            |
|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|-------------------|--------------|----------------------------|
| Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) | Displacement (in) | Stress (psf) | Vertical Displacement (in) |
| 0.1720            | 2103.1       | 0.0038                     | 0.1721            | 1688.6       | 0.0078                     | 0.1721            | 630.5        | 0.0295                     |
| 0.1731            | 2106.5       | 0.0036                     | 0.1731            | 1687.9       | 0.0079                     | 0.1730            | 630.2        | 0.0295                     |
| 0.1740            | 2093.3       | 0.0036                     | 0.1740            | 1687.9       | 0.0079                     | 0.1741            | 630.5        | 0.0295                     |
| 0.1750            | 2094.3       | 0.0036                     | 0.1750            | 1678.8       | 0.0080                     | 0.1750            | 629.7        | 0.0295                     |
| 0.1760            | 2094.3       | 0.0036                     | 0.1760            | 1687.9       | 0.0080                     | 0.1760            | 630.5        | 0.0294                     |
| 0.1770            | 2103.1       | 0.0038                     | 0.1771            | 1668.1       | 0.0080                     | 0.1770            | 611.4        | 0.0294                     |
| 0.1780            | 2086.4       | 0.0038                     | 0.1781            | 1681.0       | 0.0080                     | 0.1780            | 620.7        | 0.0295                     |
| 0.1790            | 2079.2       | 0.0038                     | 0.1791            | 1668.8       | 0.0080                     | 0.1791            | 630.2        | 0.0295                     |
| 0.1801            | 2094.0       | 0.0040                     | 0.1801            | 1669.1       | 0.0080                     | 0.1801            | 618.6        | 0.0296                     |
| 0.1812            | 2094.3       | 0.0038                     | 0.1810            | 1669.1       | 0.0080                     | 0.1811            | 612.0        | 0.0296                     |
| 0.1821            | 2079.2       | 0.0039                     | 0.1820            | 1668.4       | 0.0080                     | 0.1820            | 628.2        | 0.0296                     |
| 0.1830            | 2079.2       | 0.0039                     | 0.1830            | 1668.8       | 0.0081                     | 0.1830            | 630.2        | 0.0296                     |
| 0.1840            | 2079.2       | 0.0039                     | 0.1840            | 1678.8       | 0.0083                     | 0.1840            | 611.4        | 0.0298                     |
| 0.1850            | 2079.2       | 0.0040                     | 0.1850            | 1678.2       | 0.0083                     | 0.1851            | 612.0        | 0.0299                     |
| 0.1861            | 2079.2       | 0.0040                     | 0.1860            | 1669.1       | 0.0083                     | 0.1861            | 611.4        | 0.0299                     |
| 0.1871            | 2079.2       | 0.0039                     | 0.1871            | 1678.8       | 0.0083                     | 0.1871            | 609.1        | 0.0299                     |
| 0.1880            | 2062.5       | 0.0040                     | 0.1880            | 1682.9       | 0.0083                     | 0.1880            | 598.9        | 0.0299                     |
| 0.1890            | 2060.3       | 0.0040                     | 0.1890            | 1678.5       | 0.0083                     | 0.1890            | 597.4        | 0.0298                     |
| 0.1900            | 2060.0       | 0.0040                     | 0.1900            | 1678.2       | 0.0083                     | 0.1900            | 598.3        | 0.0297                     |
| 0.1910            | 2074.2       | 0.0040                     | 0.1911            | 1669.1       | 0.0083                     | 0.1911            | 611.4        | 0.0299                     |
| 0.1921            | 2060.3       | 0.0041                     | 0.1921            | 1666.9       | 0.0083                     | 0.1921            | 598.0        | 0.0299                     |
| 0.1931            | 2052.5       | 0.0041                     | 0.1931            | 1669.4       | 0.0083                     | 0.1930            | 601.3        | 0.0301                     |
| 0.1941            | 2053.4       | 0.0041                     | 0.1940            | 1688.9       | 0.0083                     | 0.1941            | 605.2        | 0.0301                     |
| 0.1951            | 2045.6       | 0.0041                     | 0.1950            | 1687.6       | 0.0083                     | 0.1951            | 598.9        | 0.0301                     |
| 0.1960            | 2045.3       | 0.0041                     | 0.1960            | 1678.8       | 0.0083                     | 0.1960            | 611.7        | 0.0303                     |
| 0.1970            | 2046.5       | 0.0041                     | 0.1970            | 1676.6       | 0.0083                     | 0.1970            | 598.3        | 0.0303                     |
| 0.1980            | 2045.3       | 0.0041                     | 0.1981            | 1687.9       | 0.0085                     | 0.1980            | 597.4        | 0.0303                     |
| 0.1991            | 2031.4       | 0.0041                     | 0.1991            | 1669.1       | 0.0085                     | 0.1990            | 597.4        | 0.0303                     |
| 0.2001            | 2031.4       | 0.0041                     | 0.2001            | 1669.1       | 0.0085                     | 0.2001            | 598.6        | 0.0305                     |
| 0.2010            | 2031.7       | 0.0041                     | 0.2010            | 1678.8       | 0.0085                     | 0.2011            | 598.0        | 0.0305                     |
| 0.2021            | 2031.4       | 0.0041                     | 0.2022            | 1669.1       | 0.0085                     | 0.2022            | 598.3        | 0.0305                     |
| 0.2030            | 2037.1       | 0.0041                     | 0.2030            | 1688.6       | 0.0085                     | 0.2032            | 595.9        | 0.0305                     |
| 0.2040            | 2038.3       | 0.0041                     | 0.2041            | 1669.1       | 0.0085                     | 0.2040            | 598.0        | 0.0305                     |
| 0.2050            | 2031.4       | 0.0041                     | 0.2050            | 1669.1       | 0.0085                     | 0.2050            | 592.0        | 0.0305                     |
| 0.2060            | 2031.4       | 0.0043                     | 0.2061            | 1669.1       | 0.0085                     | 0.2061            | 598.9        | 0.0306                     |
| 0.2070            | 2031.4       | 0.0043                     | 0.2070            | 1675.7       | 0.0087                     | 0.2070            | 585.2        | 0.0308                     |
| 0.2081            | 2031.4       | 0.0043                     | 0.2081            | 1669.1       | 0.0087                     | 0.2081            | 598.3        | 0.0308                     |
| 0.2091            | 2013.2       | 0.0043                     | 0.2090            | 1668.8       | 0.0087                     | 0.2090            | 598.9        | 0.0308                     |
| 0.2100            | 2012.9       | 0.0043                     | 0.2100            | 1654.3       | 0.0087                     | 0.2100            | 591.1        | 0.0310                     |



**Direct Shear  
ASTM D3080  
(Point A Picture 1)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



|       |  |
|-------|--|
| NOTES | Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points. |
|-------|--|

Picture File: P8220931.JPG  
File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm



**Direct Shear  
ASTM D3080  
(Point A Picture 2)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



NOTES

Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points.

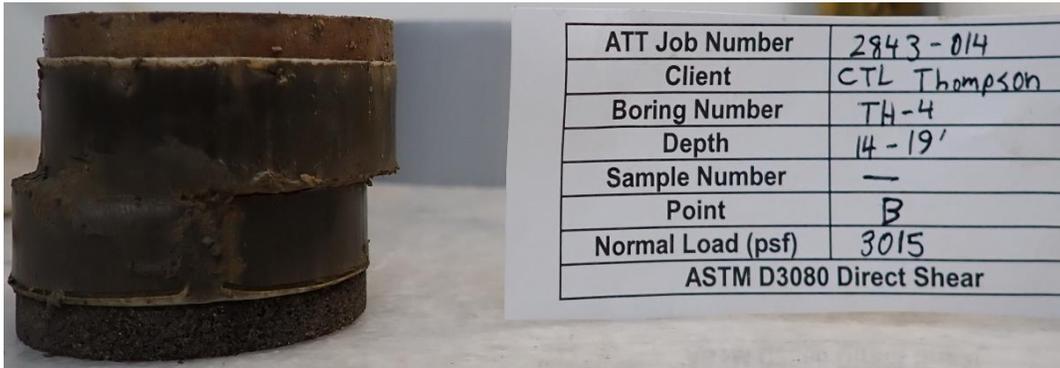
Picture File: P8220933.JPG  
File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm



**Direct Shear  
ASTM D3080  
(Point B Picture 1)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



|       |  |
|-------|--|
| NOTES | Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points. |
|-------|--|

Picture File: P8230942.JPG  
File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm



**Direct Shear  
ASTM D3080  
(Point B Picture 2)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



NOTES

Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points.

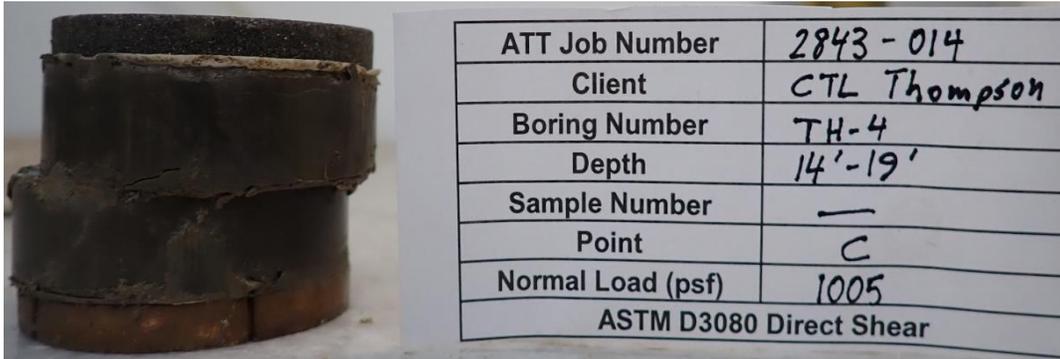
Picture File: P8230943.JPG  
File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm



**Direct Shear  
ASTM D3080  
(Point C Picture 1)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



NOTES      Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points.

Picture File:      P8240957.JPG  
File name:        2843014\_\_Direct Shear ASTM D3080\_0.xlsm



**Direct Shear  
ASTM D3080  
(Point C Picture 2)**

ADVANCED TERRA TESTING

|             |               |              |        |
|-------------|---------------|--------------|--------|
| CLIENT      | CTL Thompson  | BORING NO.   | TH-4   |
| JOB NO.     | 2843-014      | DEPTH        | 14-19' |
| PROJECT     | The Launchpad | SAMPLE NO.   | --     |
| PROJECT NO. | CS19243-125   | DATE SAMPLED | --     |
| LOCATION    | --            | DESCRIPTION  | --     |
| DATE TESTED | 08/18/22      |              |        |
| TECHNICIAN  | JL            |              |        |



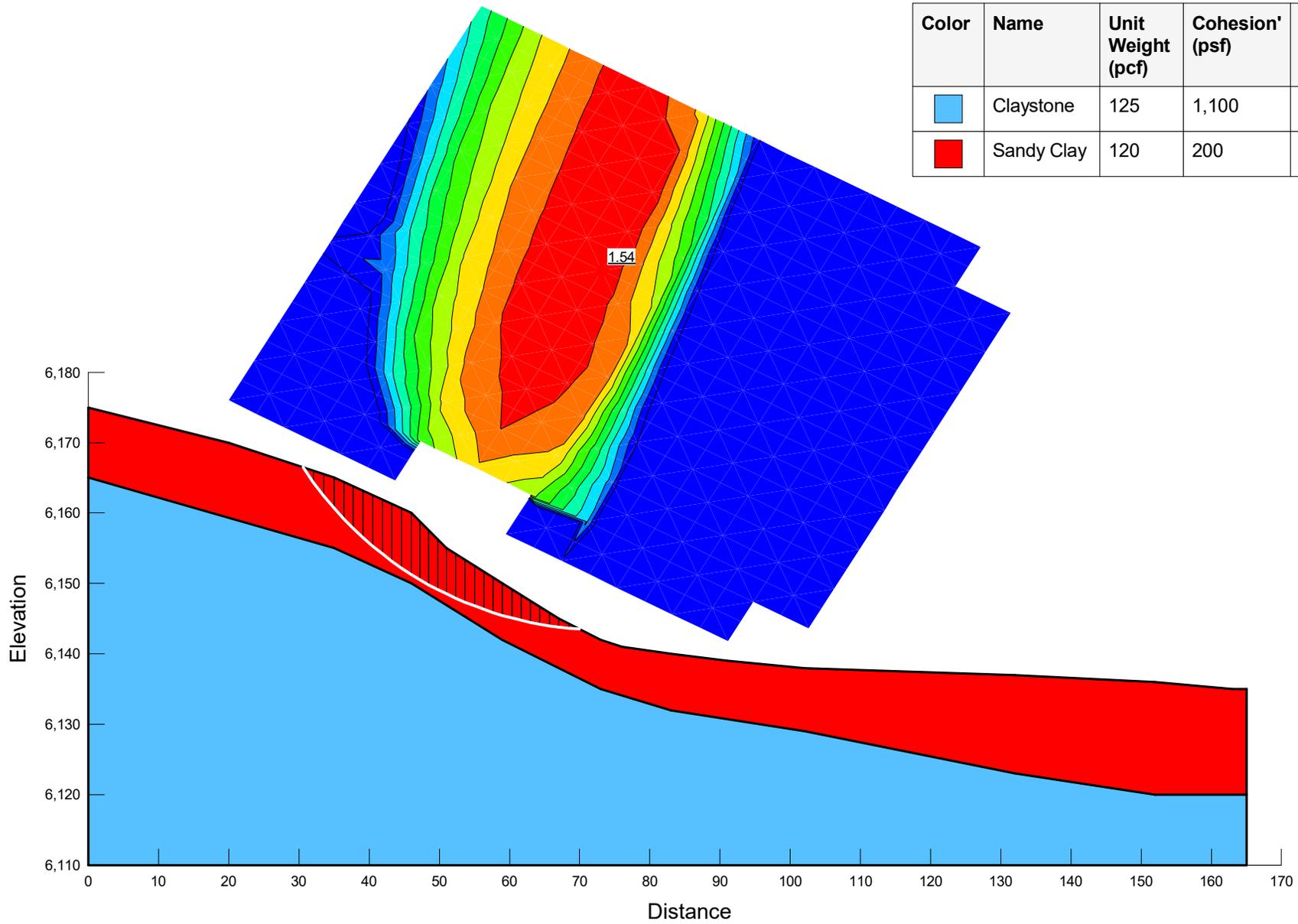
NOTES

Sample swelled during consolidation, shear rate calculated for 24 hour shear per ASTM D3080. Single moisture content taken for A and B points.

Picture File: P8240958.JPG  
File name: 2843014\_\_Direct Shear ASTM D3080\_0.xlsm



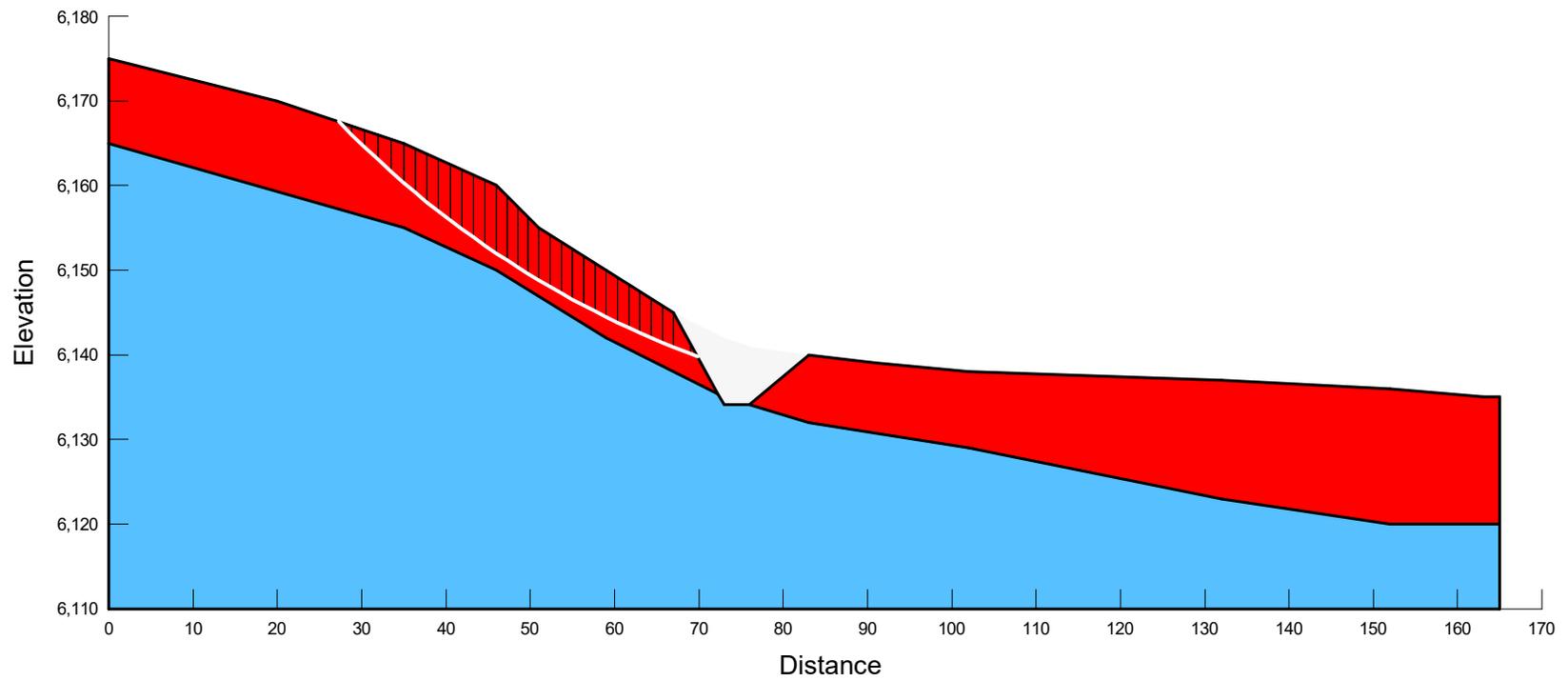
**APPENDIX D**  
**RESULTS OF SLOPE STABILITY ANALYSIS**



| Color                                    | Name       | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|--|------------|-------------------|-----------------|----------|
| <span style="color: lightblue;">■</span> | Claystone  | 125               | 1,100           | 21       |
| <span style="color: red;">■</span>       | Sandy Clay | 120               | 200             | 22       |

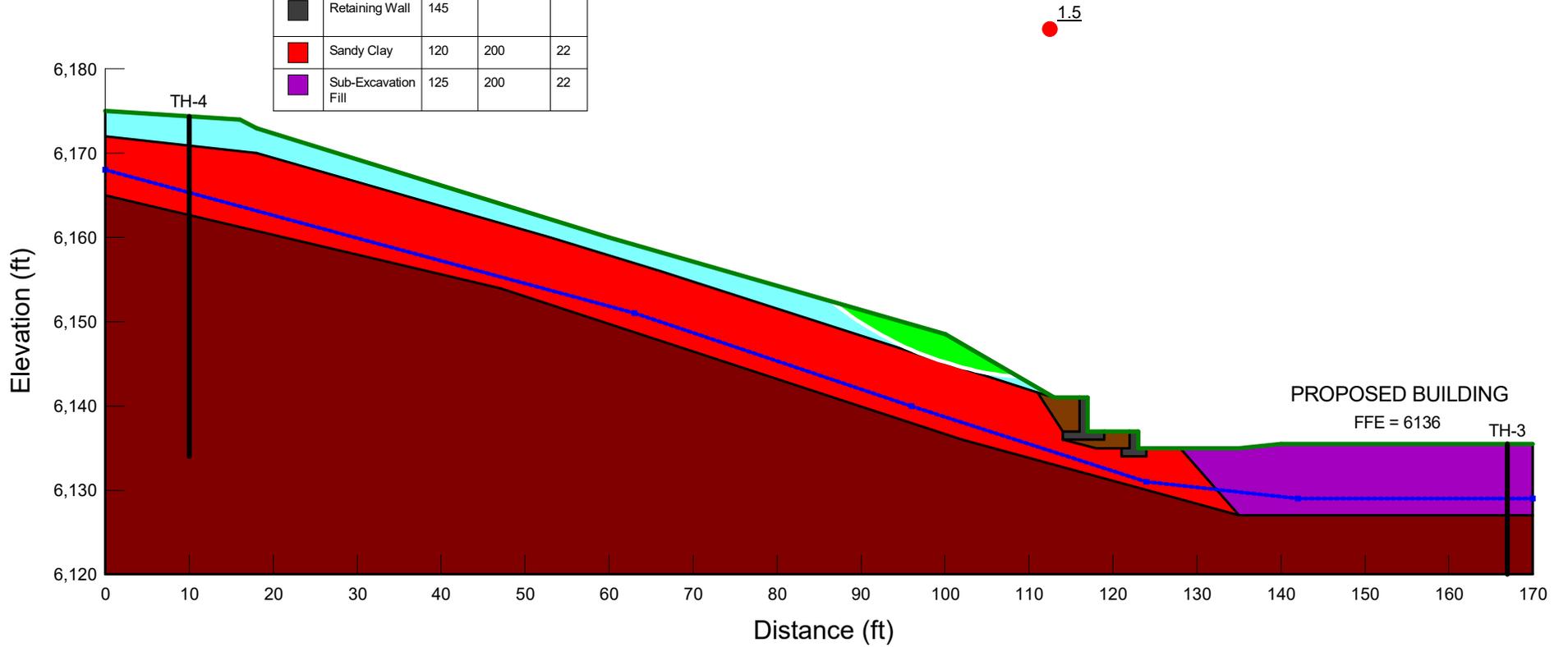
EXISTING CONDITIONS (SECTION A-A')

| Color | Name       | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|-------|------------|-------------------|-----------------|----------|
| ■     | Claystone  | 125               | 1,100           | 21       |
| ■     | Sandy Clay | 120               | 200             | 22       |



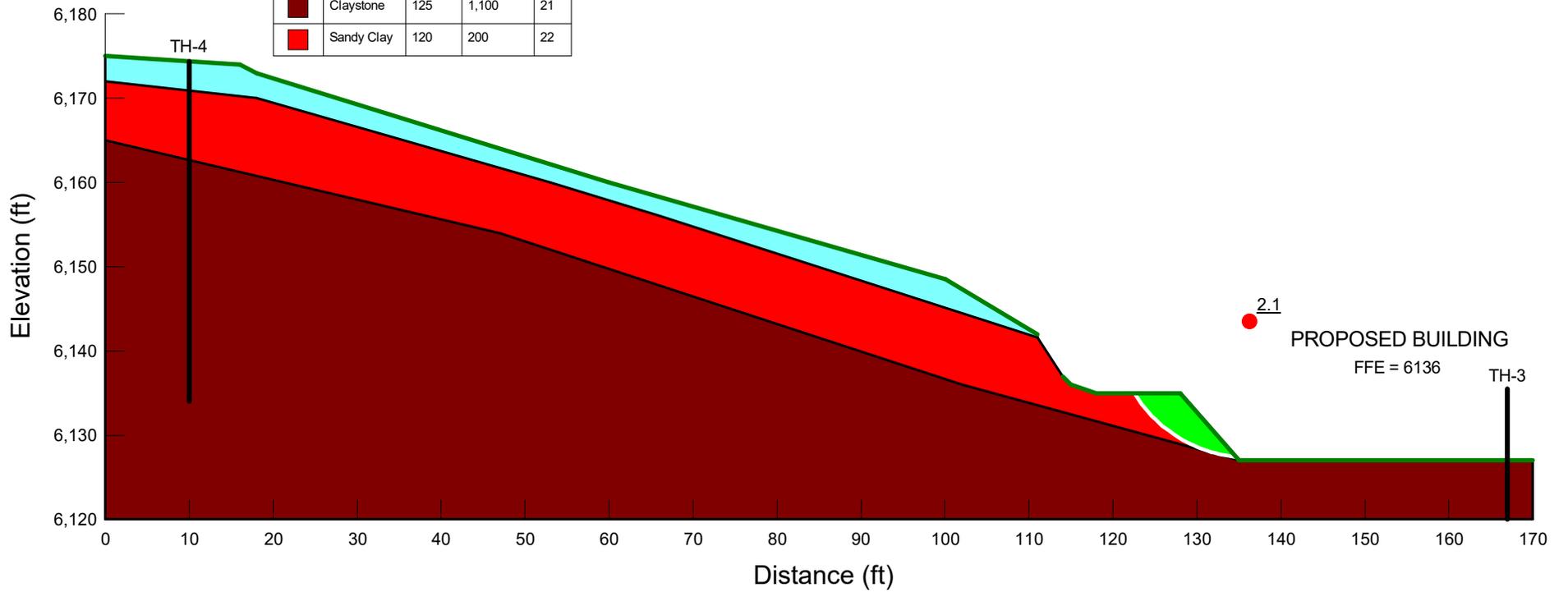
TEMPORARY CONSTRUCTION CONDITION (SECTION A-A')

| Color | Name                | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|-------|---------------------|-------------------|-----------------|----------|
| ■     | Backfill            | 125               | 0               | 34       |
| ■     | Clayey Sand         | 125               | 20              | 26       |
| ■     | Claystone           | 125               | 1,100           | 21       |
| ■     | Retaining Wall      | 145               |                 |          |
| ■     | Sandy Clay          | 120               | 200             | 22       |
| ■     | Sub-Excavation Fill | 125               | 200             | 22       |



PROPOSED CONSTRUCTION (SECTION B-B')

| Color   | Name        | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) |
|---|-------------|-------------------|-----------------|----------|
|  | Clayey Sand | 125               | 20              | 26       |
|  | Claystone   | 125               | 1,100           | 21       |
|  | Sandy Clay  | 120               | 200             | 22       |



TEMPORARY CONSTRUCTION CONDITION (SECTION B-B')