PRELIMINARY GEOTECHNICAL INVESTIGATION

BISON HIGHWAY MINOR SUBDIVISION
COUNTY ROAD 12-½ AND HICKORY STREET
HUDSON, COLORADO

Prepared for:

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SCOPE

This report presents the results of our Preliminary Geotechnical Investigation for Lot 1 of the Bison Highway Minor Subdivision in Hudson, Colorado (Fig. 1). The purpose of our investigation was to evaluate the subsurface conditions to assist in due diligence and planning of site development. The scope was described in a Service Agreement dated August 23, 2023 (DN-23-0356).

This report contains descriptions of the subsurface conditions found in our exploratory borings, results of field and laboratory tests, engineering analysis of field and laboratory data, and our experience. The report contains descriptions of the soil, bedrock, and groundwater found in the exploratory borings, site geology and geologic hazards, preliminary discussions of foundations and floor support alternatives, and preliminary design and construction criteria for site development, pavements, and surface and subsurface drainage. The discussions of foundation and floor system alternatives are intended for planning purposes only. Additional investigation will be necessary to delineate areas of sub-excavation (if selected). Site-specific investigations will be required to design building foundations, floor systems and pavements. A summary of our conclusions and recommendations follows, with more detailed discussions in the report.

SUMMARY

1. The site is judged suitable for development. The primary geotechnical concerns are expansive soil and bedrock and shallow groundwater. We believe these concerns can be mitigated with proper planning, engineering, design and construction. We believe there are no geotechnical constraints that would preclude development.

2. Strata found in the borings consisted of nil to about 7 feet of existing fill and nil to about 22 feet of native sandy clay and clayey sand underlain by weathered and comparatively unweathered claystone and sandstone bedrock to the maximum depth explored of 35 feet. Claystone is predominant. Testing indicates the clay and claystone are expansive. Planning and design of the development should consider the

impacts of expansive soil and bedrock as well as potential settlement due to soft/loose soils.

3. Groundwater was encountered during drilling at depths of 4 to 12 feet below existing grades (or approximate elevations 4937 to 4954). When the holes were checked after drilling, water was measured at depths of about 2 to 11 feet (or approximate elevations 4938 to 2956) (Fig. 4). At least 3 feet of separation, and preferably 5 feet, should be provided between foundations and groundwater. Groundwater will be encountered during sub-excavation and deep utility installation. Water levels may fluctuate seasonally and rise in response to development, precipitation, landscape irrigation and changes in land-use.

4. Our investigation indicates expansive soils and bedrock are present at depths likely to influence performance of shallow foundations, flatwork and pavements. We estimate total potential ground heave could range from about 1 inch to 5 inches. Soft/loose soils are also present on portions of the site. Ground improvement will be necessary to allow use of shallow foundations. Measures to control groundwater will be needed if sub-excavation is used. Additional investigation is recommended to further evaluate settlement potential and delineate sub-excavation extent once plans are more developed.

5. Pavements will require mitigation of expansive subgrade with sub-excavation and moisture treatment of 3 to 5 feet. Preliminary data suggest that provided the subgrade passes subsequent proof-rolling, we judge the composite section of 4 inches of asphalt over 6 inches of base course for local residential streets and 5 inches of asphalt over 8 inches of base course for minor collector commercial streets are appropriate. Pavement alternatives are presented in the report. A design level pavement and subgrade evaluation should be completed prior to paving.

6. Control of surface drainage will be critical to the performance of foundations, slabs-on-grade, and pavements. Overall surface drainage should be designed to provide rapid run-off of surface water away from structures and off pavements and flatwork. Water should not be allowed to pond near the crests of slopes, near structures or on pavements and flatwork. Conservative irrigation practices should be used to reduce the risk of excessive subsurface wetting.

SITE CONDITIONS

The site consists of Lot 1 of Bison Highway Minor Subdivision and is located southwest of County Road 12-½ and County Road 43-½ (also known as Hickory Street) in Hudson, Colorado (Fig. 1 and Photo 1). The approximate 10.6-acre site is bordered by County Road 12-½ to the north, County Road 43-½ to the east, Interstate 76 Frontage Road to the southeast and State Highway 52 to the southwest. There is an industrial development to the northeast corner of the site (Lot 4 of Bison Highway Minor Subdivision) and two commercial retail developments to the southeast of the site (Lots 2 and 3 of Bison Highway Subdivision). A gas station is located southeast of Lots 2 and 3. Historical imagery indicates that prior to 2013 the eastern portion of the site was occupied by detention ponds. The ponds appear to have been removed between 2012 and 2013 around the same time as the development of the industrial warehouse to the northeast of the site. The commercial developments were developed between 2016 and 2018. Ground cover consists primarily of grasses and weeds. The ground slopes to the northeast.

Photo 1: Aerial Photograph, Google Earth March 2022.
Approximate site boundaries are outlined in red.

PROPOSED CONSTRUCTION

We were not provided with development or grading plans for this site. We understand the proposed development may include residential uses and/or commercial/retail/mixed-use properties. We anticipate the structures will be one to three-story, wood-framed structures. Basements may be planned, or crawl spaces will be constructed beneath main floor levels unless post-tensioned slab-on-grade foundations are planned. The residences may have partial brick or stone veneer exterior wall treatments.

GEOLOGY

Geologic mapping, prepared by Colton, R.B. (Geologic Map of the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado; U.S. Geological

Survey, Miscellaneous Investigations Series Map I-855-G, scale 1:100,000), indicates the site is underlain by sandy to gravelly Post-Piney Creek alluvium over claystone bedrock of the Denver and Arapahoe Formation from the Upper Cretaceous age.

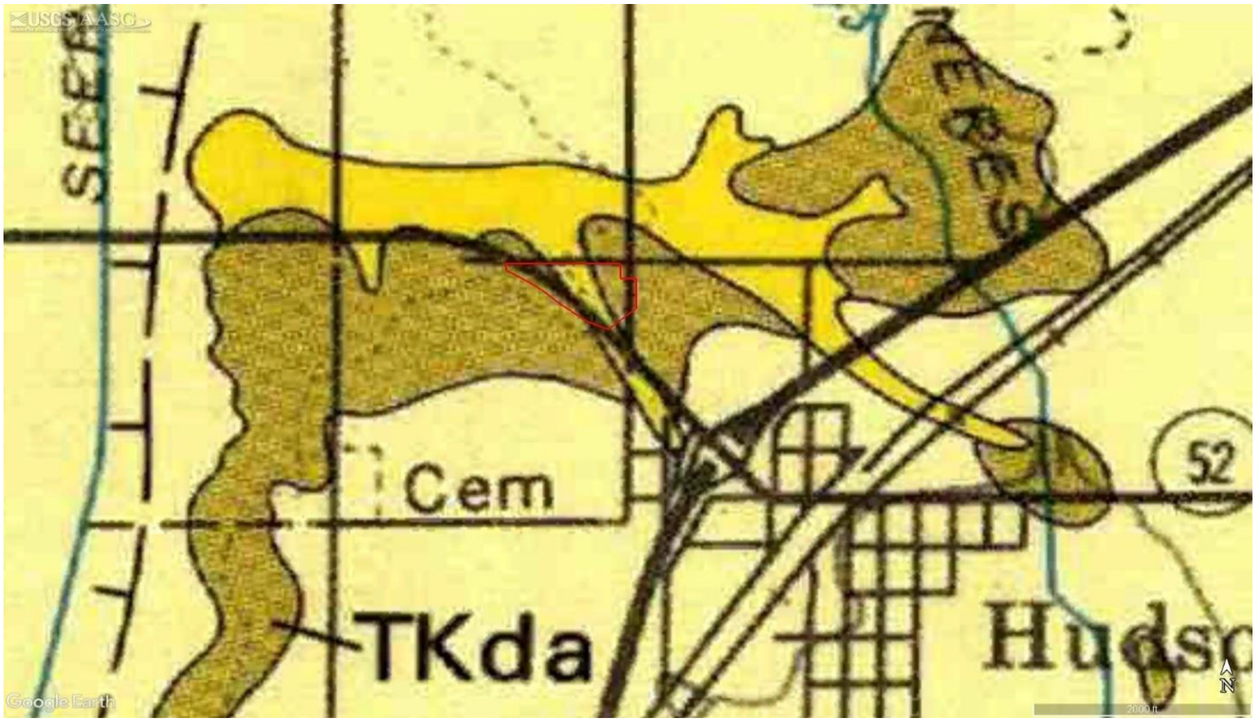


Photo 2 – Geologic Map of The Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado. By: Colton, R.B., 1978. Approximate site boundaries are outlined in red.

INVESTIGATION

We investigated subsurface conditions on September 13, 2023 by drilling and sampling four widely-spaced exploratory borings at the approximate locations shown on Fig. 1. We staked and estimated boring locations and elevations using a Leica GS18 GPS unit referencing the North American Datum of 1983 (NAD83). We contacted the Utility Notification Center of Colorado and local sewer and water districts prior to drilling to identify locations of buried utilities. The borings were drilled to depths of 25 to 35 feet using 4-inch diameter, continuous-flight solid-stem auger and a truck-mounted CME-45 drill rig.

Samples of the soil and bedrock were obtained at approximate 5-foot intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven by blows from an automatic 140-pound hammer falling 30 inches. Our field representative was present to observe drilling, log the strata encountered, and obtain samples. Summary logs of the exploratory borings with results of field penetration resistance tests and a portion of the laboratory test data are presented on Fig. 2.

Samples were returned to our laboratory where they were examined by our engineer. Laboratory tests included dry density, moisture content, percent silt and clay-sized particles (passing the No. 200 sieve), Atterberg limits, swell-consolidation, soil suction and water-soluble sulfate concentration. Swell-consolidation tests were performed by wetting the samples under approximate overburden pressures (the pressure exerted by the overlying soil and bedrock). Results of laboratory tests are presented in Appendix A and summarized in Table A-I.

SUBSURFACE CONDITIONS

Strata found in the borings consisted of nil to about 7 feet of existing fill and nil to about 22 feet of native sandy clay and clayey sand underlain by weathered and comparatively unweathered claystone and sandstone bedrock to the maximum depth explored of 35 feet. Pertinent engineering characteristics of the soil and bedrock are described in the following paragraphs.

Existing Fill

We encountered about 6 and 7 feet of existing fill in two borings (TH-2 and TH-4) which consisted of sandy clay. The fill is likely associated with the backfilling of the previous detention ponds. The fill was stiff based on the results of field penetration resistance tests. One fill sample did not swell and one sample swelled 0.5 percent when wetted. One sample had a soil suction value of 3.86 pF. We were not provided with compaction test records for fill placed on-site.

Native Sand and Clay

Native soils consisted of sandy clay with some clayey sand found at the ground surface or below the fill in three borings. The clay was soft to very stiff and the sand was very loose. One clay sample compressed 0.1 percent and one sample swelled 0.3 percent when wetted. Two clay samples contained 77 and 78 percent fines (passing the No. 200 sieve) and exhibited moderate plasticity. One sand sample contained 37 percent fines.

Bedrock

Bedrock consisted primarily of weathered and comparatively unweathered claystone and was encountered in all borings at depths of about 7 to 22 feet, or approximate elevations 4929 to 4955 feet (Fig. 3). Sandstone was encountered in TH-2. Weathered zones encountered in three borings ranged in thickness from about 9 to 13 feet. The unweathered bedrock is medium hard to hard. Six claystone samples swelled 0.8 to 6.1 percent when wetted, with an average swell of 3.1 percent. Five claystone samples had soil suction values ranging between 3.77 to 4.23 pF and swell pressures ranging from 2,200 to 18,300 psf. One sandstone sample contained 14 percent fines.

Groundwater

Groundwater was encountered during drilling at depths of 4 to 12 feet below existing grades (or approximate elevations 4937 to 4954). When the holes were checked after drilling, water was measured at depths of about 2 to 11 feet (or approximate elevations 4938 to 2956) (Fig. 4). At least 3 feet of separation, and preferably 5 feet, should be provided between foundations and groundwater. Groundwater will likely be encountered during sub-excavation and deep utility installation. Water levels may fluctuate seasonally and rise in response to development, precipitation, landscape irrigation and changes in land-use.

GEOLOGIC HAZARDS AND GEOTECHNICAL CONCERNS

Geologic hazards and geotechnical concerns likely include expansive soil and bedrock, shallow groundwater, existing fill, and regional issues of seismicity and naturally occurring radioactive materials. No geologic hazards or geotechnical concerns that would preclude the proposed development were noted. We believe potential hazards can be mitigated with proper engineering, design, and construction practices, as discussed in this report.

Shallow Groundwater and Soft/Loose Soils

Groundwater was encountered at depths of 2 to 12 feet below existing grades. We recommend providing at least 3 feet, and preferably 5 feet, of separation between foundations and groundwater. Groundwater will be encountered during sub-excavation (if performed) deep utility installation, and temporary construction dewatering, and stabilization efforts may be necessary. Contractors should be prepared to deal with wet soil, flat excavation slopes below groundwater, and temporary dewatering.

Clay and sand soils below groundwater are very soft or loose. These soils may be prone to settlement upon loading from new structures, which could result in damage to the foundations and floor systems. Evaluation of potential settlement should be performed once proposed grades, structure locations, and structure loads are known.

Expansive Soil and Bedrock

The clay and claystone encountered in our borings are expansive. There is risk that ground heave will damage pavements, slabs-on-grade, and foundations. Engineered design of grading, pavements, foundations, slabs-on-grade, and surface drainage can mitigate, but not eliminate, the effects of expansive and collapsible soils.

Existing Fill

Existing fill was encountered in two borings during this investigation. Existing fill is unsuitable to support new foundations. We recommend the existing fill be removed and replaced with moisture-conditioned and compacted fill as discussed in **Site Grading**. Clean portions of the fill can be re-used as fill.

Seismicity

According to the USGS, Colorado's Front Range and eastern plains are considered low seismic hazard zones. The earthquake hazard exhibits higher risk in western Colorado compared to other parts of the state. The Denver Metropolitan area has experienced earthquakes within the past 100 years, shown to be related to deep drilling, liquid injection, and oil/gas extraction. Naturally occurring earthquakes along faults due to tectonic shifts are rare in this area.

The soil and bedrock at this site are not expected to respond unusually to seismic activity. The 2018 International Building Code (Section 16.13.2.2) defers the estimation of Seismic Site Classification to ASCE7-22, a structural engineering publication. Updates from the previous versions of ASCE7 include (1) incorporation of additional Site Classifications BC, CD, and DE, (2) removal of tabulated blow-count and shear-strength correlations to shear wave velocity, and (3) requires the engineer to reduce shear wave velocity values by a factor of 1.3 when empirically estimated or not directly measured. The table below summarizes ASCE7-22 Site Classification Criteria.

ASCE7-22 SITE CLASSIFICATION CRITERIA

Seismic Site Class	$\bar{v}_s$, Calculated Using Measured or Estimated Shear Wave Velocity Profile (ft/s)
A. Hard Rock	>5,000
B. Medium Hard Rock	>3,000 to 5,000
BC. Soft Rock	>2,100 to 3,000
C. Very Dense Sand or Hard Clay	>1,450 to 2,100
CD. Dense Sand or Very Stiff Clay	>1,000 to 1,450
D. Medium Dense Sand or Stiff Clay	>700 to 1,000
DE. Loose Sand or Medium Stiff Clay	>500 to 700
E. Very Loose Sand or Soft Clay	≥500
F. Soils requiring Site Response Analysis	See Section 20.2.1

Based on the results of our investigation, the reduced, empirically estimated average shear wave velocity values for the upper 100 feet range between 770 and 861 feet per second with an average value of 799 feet per second. We judge a Seismic Site Classification of D. The field penetration test results along with the empirical estimates imply that shear-wave velocity seismic tests to directly measure $\bar{v}_s$ could likely result in a better Seismic Site Classification. The subsurface conditions indicate low susceptibility to liquefaction from a materials and groundwater perspective.

Radioactivity

It is normal in the Front Range of Colorado and nearby eastern plains to measure radon gas in poorly ventilated spaces (e.g. full depth residential basements) in contact with soil or bedrock. Radon 222 gas in considered a health hazard and is just one of several radioactive products in the chain of the natural decay of uranium into lead. Radioactive nuclides are common in the soil and bedrock underlying the subject site. Because these sources exist or will exist on most sites in the area, there is a potential for radon gas accumulation in poorly ventilated spaces. The concentration of radon that can develop is a function of many factors, including the radionuclide activity of the soil and bedrock, construction methods and materials, soil gas pathways, and accumulation areas. The only reliable method to determine if a hazard exists is to perform radon testing of completed residential structures to determine the level of radon gas accumulation. Typical mitigation methods consist of sealing soil gas entry areas, ventilation of below-grade spaces, and venting from foundation drain systems. We recommend provision for ventilation of foundation drain systems, if radon is discovered.

Erosion

We observed no evidence of unstable slopes. Erosion potential on this site is considered to be low due to subtle slopes. If steeper slopes exist with sandy soils this potential risk may rise. Erosion potential will increase during construction but should return to pre-construction rates or less if proper grading practices, surface drainage design, and re-vegetation efforts are implemented.

ESTIMATED POTENTIAL HEAVE

Based on the subsurface profiles, swell-consolidation test results and our experience, we calculated the potential heave at the existing ground surface for each boring, as shown in the table below. The analysis involves dividing the soil and bedrock profile into layers and modeling the heave of each layer from representative swell tests. The heave estimates do not consider the planned grading; grading will affect the estimates. We estimated potential ground heave may range from about 1 inch to 5 inches. An estimated relative risk due to expansive soil and bedrock for each boring is presented on Figure 5. A depth of wetting of 24 feet below existing grades was considered for the analysis. It is not certain whether the estimated heave will occur.

ESTIMATED TOTAL POTENTIAL GROUND HEAVE
BASED ON 24 FEET DEPTH OF WETTING

Boring	Estimated Potential Heave at Existing Ground Surface (inches)	Estimated Relative Risk Due to Expansive Soil and Bedrock
TH-1	2 ½	MODERATE
TH-2	2	LOW
TH-3	1	LOW
TH-4	5	HIGH

SITE DEVELOPMENT

The primary geotechnical concerns that we believe will influence development and building construction on this site are shallow groundwater and soft/loose soils, expansive soil and bedrock, and existing fill. These concerns can be mitigated with proper planning, engineering, design, and construction. We believe there are no geologic or geotechnical constraints at this site that would preclude development.

The following sections provide site development recommendations based on our current understanding of the planned construction. Once development and grading plans are available, we can review the data and provide more refined recommendations, particularly related to expansive soil and bedrock mitigation.

Existing Fill

We encountered 6 to 7 feet of existing fill in two borings which was likely placed during previous site development. We have not been provided with compaction records and assume the fill may have not been placed in a controlled manner. The existing fill is considered unsuitable to support improvements and should be completely removed and re-worked within building footprints. Partial removal can be considered in pavement areas provided risk of movement is tolerable. The existing fill can be reused provided it is free of debris, vegetation/organics, and other deleterious material. We anticipate the existing fill removal will be performed in conjunction with sub-excavation. New fill should be moisture-conditioned in accordance with the criteria in **Site Grading**.

Excavation

We believe the soil and bedrock penetrated by our exploratory borings can be excavated with typical heavy-duty equipment. We recommend the owner and 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. Based on our investigation and OSHA standards, we anticipate the clay and claystone will classify as Type B, and the existing fill, sand, and sandstone will classify as Type C soils based on OSHA Standards governing excavations published in 29 CFR, Part 1926. Type B soil requires 1H:1V and Type C requires 1.5H:1V for temporary excavations in dry conditions. Saturated soils may require flatter slopes or bracing. Excavation slopes specified by OSHA are dependent upon soil types and groundwater conditions encountered. The contractor's "competent person" is required to identify the soils encountered in the excavations and refer to OSHA standards to determine appropriate slopes. Stockpiles of soils and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. A professional engineer should design excavations deeper than 20 feet.

Dewatering and Soil Stabilization

Groundwater may be encountered in utility excavations. Temporary construction dewatering systems will likely be needed to properly install deep utilities for some areas of the site. We believe that dewatering for excavations which penetrate less than 3 to 5 feet below groundwater may be accomplished using conventional sump and pump methods in utility trenches. Deeper excavations may require more elaborate dewatering (such as well points).

The Town of Hudson and/or the Colorado Department of Public health may require dewatering permits. Our experience indicates periodic environmental testing is usually required with these permits, with reporting. Permitting requirements may also influence the construction schedule.

Soft/loose, wet soils may be encountered in excavations where shallow water is present and should be removed or stabilized. Excavations of soft soil should be filled with moisture-conditioned and compacted fill. Soft/loose subgrade can likely be stabilized by crowding crushed rock into the excavation bottom so that when compactive effort is applied, the surface does not deform significantly. Acceptable rock materials include, but are not limited to, No. 2 and No. 57 rock. Crushed rock on a layer of geosynthetic grid or woven fabric can also be used, which should reduce the amount of aggregate needed to stabilize the subgrade. Typically, a biaxially woven fabric such as Mirafi 600x (or equal) or geogrid (such as Tensar BX1100 or equal) topped with 8 to 12 inches of 1 to 5-inch crushed rock will provide a stable working surface.

Site Grading

We believe grading can be accomplished using conventional heavy-duty construction equipment. The ground surface in areas to be filled should be stripped of vegetation, scarified, and moisture-conditioned between 1 and 4 percent above optimum for clay or within 2 percent of optimum for sand, and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698). Placement and compaction of fill should be observed and tested by a representative of our firm during construction. If imported fill is necessary for general site grading purposes, it should ideally consist of soil having a maximum particle size of 2-inches, between 20 and 50 percent passing a No.200 sieve, a liquid limit less than 30, and a plasticity index less than 15. Potential fill should be submitted to our office for approval prior to importing to the site.

The properties of fill will affect the performance of foundations, slabs-on-grade, utilities, pavements, flatwork, and other improvements. The on-site soils are suitable for use as site grading fill provided, they are substantially free of debris, organics and other deleterious materials. Fill should be placed in thin loose lifts, moisture-conditioned and compacted prior to placement of the next lift using the criteria presented in the previous paragraph. The placement and compaction of site grading fill should be observed and tested by our representative during construction. Guideline Site Grading Specifications are presented in Appendix B and should be strictly followed.

Our experience indicates fill and backfill can settle, even if properly compacted to criteria provided above. Factors that influence the amount of settlement are depth of fill, material type, degree of compaction, amount of wetting and time. The degree of compression of fill under its own weight will likely range from low for granular soils (½ percent or less), to moderate for clay/sand mixtures (1 to 2 percent).

Ground Improvement

Shallow groundwater, soft/loose soils, and expansive soils and bedrock are present at this site. Soft/loose soils can settle upon additional loading. Heave due to expansive soil and bedrock can also damage foundations and slabs-on-grade. Ground improvement will be necessary to allow use of shallow foundation systems on this site. Typically, sub-excavation is used to mitigate expansive soil and bedrock. The presence of shallow groundwater will complicate this approach and a sub-excavation interceptor drain will be necessary. Other efforts, such as surcharging of building pads prior to construction or use of stone columns, may be necessary to reduce risk of settlement-related problems and improve subgrade support characteristics to allow use of a shallow foundation system. Alternatively, a drilled pier foundation system can be used. More detailed discussions are provided below.

Sub-Excavation

Our investigation indicates variably expansive soils and bedrock are present at depths likely to influence the performance of shallow foundations, concrete flat-work, and pavements. We estimate potential heave up to about 5 inches. Deep foundations and structurally supported floors are typically recommended for sites with significant potential heave. Alternatively, sub-excavation can be considered to reduce potential heave and allow use of shallow foundation systems. Shallow groundwater will complicate sub-excavation efforts, and measures to control groundwater will likely be needed if sub-excavation is used.

Proposed grades were not available at the time of our investigation. Structure locations are also unknown. We anticipate sub-excavation to depths of 10 to 12 feet below lowest foundation element will likely be necessary to allow use of a shallow foundation system. Sub-excavation should extend laterally at least 5 feet beyond the outside edge of foundations. Depth of sub-excavation may be reduced in areas where non-expansive material is present. Additional investigation is recommended once plans are more defined to further evaluate depth and extent of sub-excavation.

Sub-excavation has been used in the Denver area with satisfactory performance for the large majority of the sites where this ground modification method has been completed. We have seen isolated instances where settlement of sub-excavation fill has led to damage to buildings supported on footings. In most cases, the settlement was caused by wetting associated with poor surface drainage or seepage, and/or poorly compacted fill placed at the horizontal limits of excavation. Wetting of the fill may cause softening and settlement.

Interceptor drains will be required if sub-excavation is performed in areas of shallow groundwater. Interceptor drains should consist of Mirafi G200N drain board with two-sided drainage capacity connected to 4-inch diameter perforated PVC pipe or approved equivalent. The drain board should extend vertically at least 3 feet above groundwater. A typical drain detail is provided on Fig. 6. Sub-excavation bottoms should slope to direct water to the drain locations. Drains should slope to a gravity outlet or a wet well where water can be removed with a pump. We should evaluate groundwater levels with additional investigation and after review of proposed grading.

The excavation contractor should be chosen carefully to assure they have experience with fill placement at over-optimum moisture and have the necessary compaction equipment. Special precautions should be taken for compaction of fill at corners, access ramps, and along the perimeters of the sub-excavation as large compaction equipment cannot easily reach these areas. We recommend a surveyor document the actual limits of the treatment and create “as-built” plans.

Guideline sub-excavation specifications are presented in Appendix C. Our representative should observe placement procedures and test compaction of the fill on a full-time basis. The swell of the moisture-conditioned fill should be tested after the fill placement.

If the fill dries excessively prior to construction, it may be necessary to rework the upper drier materials just prior to constructing foundations. We judge the fill should retain adequate moisture for about two years and can check moisture conditions in each excavation as construction progresses, if requested.

Sub-excavation and replacement with moisture conditioned fill will likely reduce potential movements for footing or post-tensioned slab foundations for lightly loaded structures and enhance performance of slab-on-grade floors. Shallower sub-excavation can also be considered to enhance performance of concrete flatwork (driveways and sidewalks) and pavements, potentially reducing maintenance costs. We believe excavation to at least 5 feet below these areas may be necessary to improve performance; deeper excavation can be considered.

Settlement

The presence of soft/loose soils increases risk of settlement. Additional efforts such as surcharging of building pads prior to construction may be merited. Other techniques, such as use of stone columns, may be considered to improve subgrade support characteristics to allow use of shallow foundation systems. Additional investigation is recommended once proposed grades, building locations, and foundation loads are known to further evaluate settlement risk at this site.

Slopes

We recommend permanent cut and fill slopes be designed with a maximum grade of 3:1 (horizontal to vertical), preferably 4H:1V. If site constraints (property boundaries and streets) do not permit construction with recommended slopes, we should be contacted to evaluate the subsurface soils and steeper slopes, or the civil engineer should include retaining walls in the design to provide grade separation and to allow for the recommended slope inclinations. Slopes greater than 20 feet high should be evaluated by our office on a case-by-case basis. Surface drainage should not be allowed to sheet flow across slopes or pond near the crest of slopes. All cut and fill slopes should be designed and re-vegetated as soon as possible after grading to reduce potential for erosion problems. Excavation contractors should evaluate ground conditions and control slopes in accordance with OSHA criteria.

Utilities

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. Trench backfill should be placed in thin (6 inches or less) loose lifts and moisture and compacted to jurisdictional specifications. The placement and compaction of trench fill and backfill should be observed and tested by our firm during construction.

Our experience indicates use of a self-propelled compactor results in more reliable performance compared to backfill “compacted” by a sheepsfoot wheel attachment on a backhoe or track hoe. The upper portion of the trenches should be wide enough to allow the use of a self-propelled compactor. Special attention should be paid to backfill placed adjacent to manholes as we have seen instances where settlement in excess of 2 percent has occurred. Any improvements placed over backfill should be designed to accommodate movement.

Underdrain

With long-term development and subsequent irrigation, groundwater levels could rise. The water could lead to expansive soil related problems and frequent pumping of basement foundation drains in residential portions of the development. We advocate use of underdrains incorporated into the design of sanitary sewer systems in portions of the development where basements are planned to provide a means to control water and allow gravity discharge from basement foundation drains. Conceptual sewer underdrain plans are provided on Figs. 7 through 9. If the underdrains discharge to aa detention pond or drainage, the potential for backflow of water from the discharge point into the under drain or building foundation drains should be evaluated.

PAVEMENTS

Our investigation indicates pavement subgrade will consist of non-expansive sand, expansive clay or claystone, or fill of similar composition. Clay and claystone have poor pavement support characteristics. Pavements can experience heave due to expansive soil. Depending on site grading, mitigation of expansive subgrade consisting of sub-excavation may be necessary. Sub-excavation locations and depths should be based on additional investigation.

The table below presents minimum pavement section alternatives that can be considered for planning and budgeting purposes. A design-level study should be done prior to paving.

SUMMARY OF MINIMUM PAVEMENT ALTERNATIVES

Classification	Hot-Mix Asphalt over Aggregate Base Cours (HMA+ABC)	Concrete (PCC)
Local – Residential	4" HMA + 6" ABC	6" PCC
Minor Collector – Commercial	5" HMA + 8" ABC	7" PCC

The design of a pavement system is as much a function of paving materials as support characteristics of the subgrade. If the pavement system is constructed of inferior material, then the life and serviceability of the pavement will be substantially reduced. Materials and placement methods should conform to the requirements of the Town of Hudson. All materials planned for construction should be tested to confirm their compliance with project specifications. A design level pavement and subgrade evaluation should be completed prior to paving.

BUILDING CONSTRUCTION CONSIDERATIONS

The following discussions are preliminary and are not intended for design or construction. After grading is completed, design-level investigations should be performed on a lot-specific basis.

Foundations

Our investigation indicates non-expansive sand, expansive clay and claystone bedrock, and soft/loose clay and sand are present at depths likely to influence performance of shallow foundations and slabs-on-grade. Drilled piers bottomed in bedrock are the safest foundation system. Footing foundations may be suitable where low swelling soils and bedrock are present, or if sub-excavation is performed.

Further evaluation of potential heave and settlement should be performed if shallow foundation systems are being considered. Additional investigations should be conducted to more fully assess soil conditions.

Floor Systems and Slab Performance Risk

Structurally supported floor should be anticipated in all non-basement finished living spaces in residences unless post-tensioned slab-on-grade foundations are used. Slab-on-grade basement floors may be considered on low and moderate risk sites where potential heave is acceptable to builders and home buyers. Structurally supported basement floors should be used on site with high or very high risk of poor basement slab performance.

Floor systems in commercial and retail buildings largely depend on the building use, size, and owner/operator's tolerance of floor movement. On high and some moderate risk sites owner-operators typically elect to over-excavate expansive soil to reduce potential floor movement and enhance floor performance versus using a structurally supported floor. In rare instances, structurally supported floors are used.

The performance of garage floors, driveways, sidewalks and other surface flatwork will likely be poor at this site, unless sub-excavation is performed. The following precautions will be required to reduce the potential for damage due to movement of slabs-on-grade placed at this site:

1. Isolation of the slabs from foundation walls, columns and other slab penetrations;

2. Voiding of interior partition walls to allow for slab movement without transferring the movement to the structure;

3. Flexible water and gas connections to allow for slab movement. A flexible plenum above furnaces will be required; and

4. Proper surface grading and foundation drain installation to reduce water availability to sub-slab and foundation soils.

Below Grade Areas

Surface water can penetrate relatively permeable loose backfill soils located adjacent to structures and collect at the bottom of relatively impermeable basement or crawl space excavations, causing wet or moist conditions after construction. Basement and crawl space foundation walls should be designed to resist lateral earth pressures. Interior or exterior foundation drains should be constructed around the lowest excavation levels of basement or crawl space areas. These drains could be connected to a sump pit where water can be removed by pumping if an under-drain is not provided.

Subsurface and Surface Drainage

The performance of foundations, floors, pavements and other improvements are affected by moisture changes within the soil and bedrock. This is largely influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each structure, landscaping near the structures, ballasts and the pavements. The ground surface around buildings should be sloped to provide positive drainage away from the foundations. We recommend a slope of at least 5 percent for the first 10 feet in landscaped areas surrounding each building. Roof downspouts and other water collection systems should discharge well beyond the limits of all backfill around structures.

Proper control of surface runoff is also important to control the erosion of surface soils. Sheet flow should not be directed over unprotected slopes. Water should not be allowed to pond at the crest of slopes. Permanent slopes should be prepared to reduce erosion.

Surface water can penetrate relatively permeable loose backfill soils located adjacent to buildings and collect at the bottom of crawl space and basement excavations, causing wet or moist conditions after construction. Foundation walls and grade beams should be designed to resist lateral earth pressures. If basements or crawl spaces are used, foundation drains should be constructed around the perimeter to help reduce the risk of excessive wetting. Foundation drains are not typically constructed with post-tensioned slab-on-grade foundations unless any portion of a floor will be below exterior grade.

Attention should be paid to compact the soils behind curb and gutter adjacent to streets and in utility trenches during the development. If surface drainage between preliminary development and construction phases is neglected, performance of the roadways, flatwork and foundations may be poor.

CONCRETE

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentrations of 0.01 and 0.30 percent in two samples from this study. As indicated in our tests and ACI 332-20, the sulfate exposure class ranges from *Not Applicable* or *RS0* to *Severe or RS2.* Deviations from the exposure class may occur as a result of additional sampling and testing.

SULFATE EXPOSURE CLASSES PER ACI 332-20

Exposure Classes		**Water-Soluble Sulfate (SO_4) in Soil[A] (%)**
Not Applicable	RS0	< 0.10
Moderate	RS1	0.10 to 0.20
Severe	RS2	0.20 to 2.00
Very Severe	RS3	> 2.00

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

For this level of sulfate concentration, ACI 332-20 *Code Requirements for Residential Concrete* indicates there are special cement type requirements for sulfate resistance as indicated in the table below. Additional sulfate testing is recommended during the design-level phase.

CONCRETE DESIGN REQUIREMENTS FOR SULFATE EXPOSURE PER ACI 332-20

Exposure Class	Maximum Water/Cement Ratio	Minimum Compressive Strength[A] (psi)	Cementitious Material Types[B]			Calcium Chloride Admixtures
			ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	
RS0	N/A	2500	No Type Restrictions	No Type Restrictions	No Type Restrictions	No Restrictions
RS1	0.50	2500	II	Type with (MS) Designation	MS	No Restrictions
RS2	0.45	3000	V[C]	Type with (HS) Designation	HS	Not Permitted
RS3	0.45	3000	V + Pozzolan or Slag Cement[D]	Type with (HS) Designation plus Pozzolan or Slag Cement[E]	HS + Pozzolan or Slag Cement[E]	Not Permitted

A) Concrete compressive strength specified shall be based on 28-day tests per ASTM C39/C39M
B) Alternate combinations of cementitious materials of those listed in ACI 332-20 Table 5.4.2 shall be permitted when tested for sulfate resistance meeting the criteria in section 5.5.
C) Other available types of cement such as Type III or Type I are permitted in Exposure Classes RS1 or RS2 if the C3A contents are less than 8 or 5 percent, respectively.
D) 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 slab to be used shall not be less than the amount tested in accordance with ASTM C1012/C1012M and meeting the criteria in section 5.5.1 of ACI 332-20.
E) Water-soluble chloride ion content that is contributed from the ingredients including water aggregates, cementitious materials, and admixtures shall be determined on the concrete mixture ASTM C1218/C1218M between 29 and 42 days.

Superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. 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 (including the inside and outside faces of garage and crawl space grade beams).

RECOMMENDED FUTURE INVESTIGATIONS

We recommend the following investigations and services:

1. Additional investigations to further evaluate settlement potential, delineate potential sub-excavation extent;

2. Construction testing and observation during site development, including compaction testing of grading fill, utility trench backfill, and pavements;

3. Subgrade investigation and pavement designs after grading;

4. Design-level investigations for structures; and

5. Foundation installation observations.

CONSTRUCTION OBSERVATIONS

This report has been prepared for the exclusive use of Carlson Associates, Inc. and your design team for planning for the proposed project. The information, conclusions, and recommendations presented herein are based upon consideration of many factors including, but not limited to, the type of structures 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 evolve in geotechnical engineering. The recommendations provided are appropriate for about three years. If the site is not developed within about three years, we should be contacted to determine if we should update this report.

We recommend that CTL|Thompson, Inc. provide construction observation services to allow us the opportunity to verify whether soil conditions are consistent with those found during this 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 structures will perform satisfactorily. It is critical that all recommendations in this report are followed during construction.

LIMITATIONS

Our borings were widely spaced to provide a general picture of subsurface conditions for preliminary planning of development and residential construction. Variations from our borings should be anticipated. We believe this investigation was conducted in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or analysis of the influence of subsurface conditions on the project, please call.

CTL|THOMPSON, INC.

COLORADO LICENSED
ERIN CHRISTINE BOUCHET
0054368
PROFESSIONAL ENGINEER

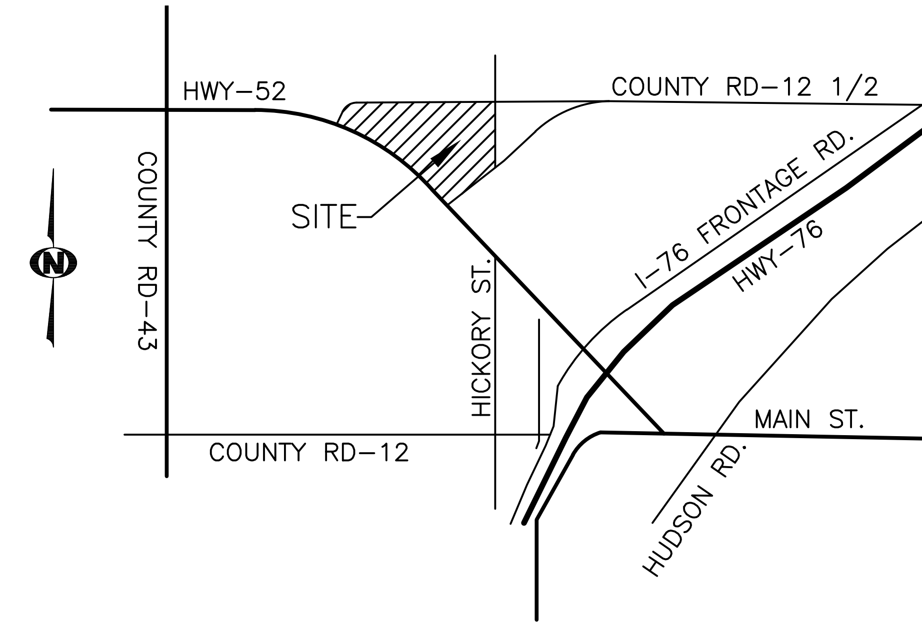
Javier Avitia-Herrera, E.I.T.
Staff Engineer

Reviewed by:

Erin Bouchet
Nov 1 2023 4:53 PM

Erin C. Bouchet, P.E., P.G.
Associate Engineer | Denver Engineering Manager

Via e-mail: ryancarlson@carlsonland.net



VICINITY MAP
NOT TO SCALE

LEGEND:

TH-1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING

0 75 150

SCALE: 1" = 150'

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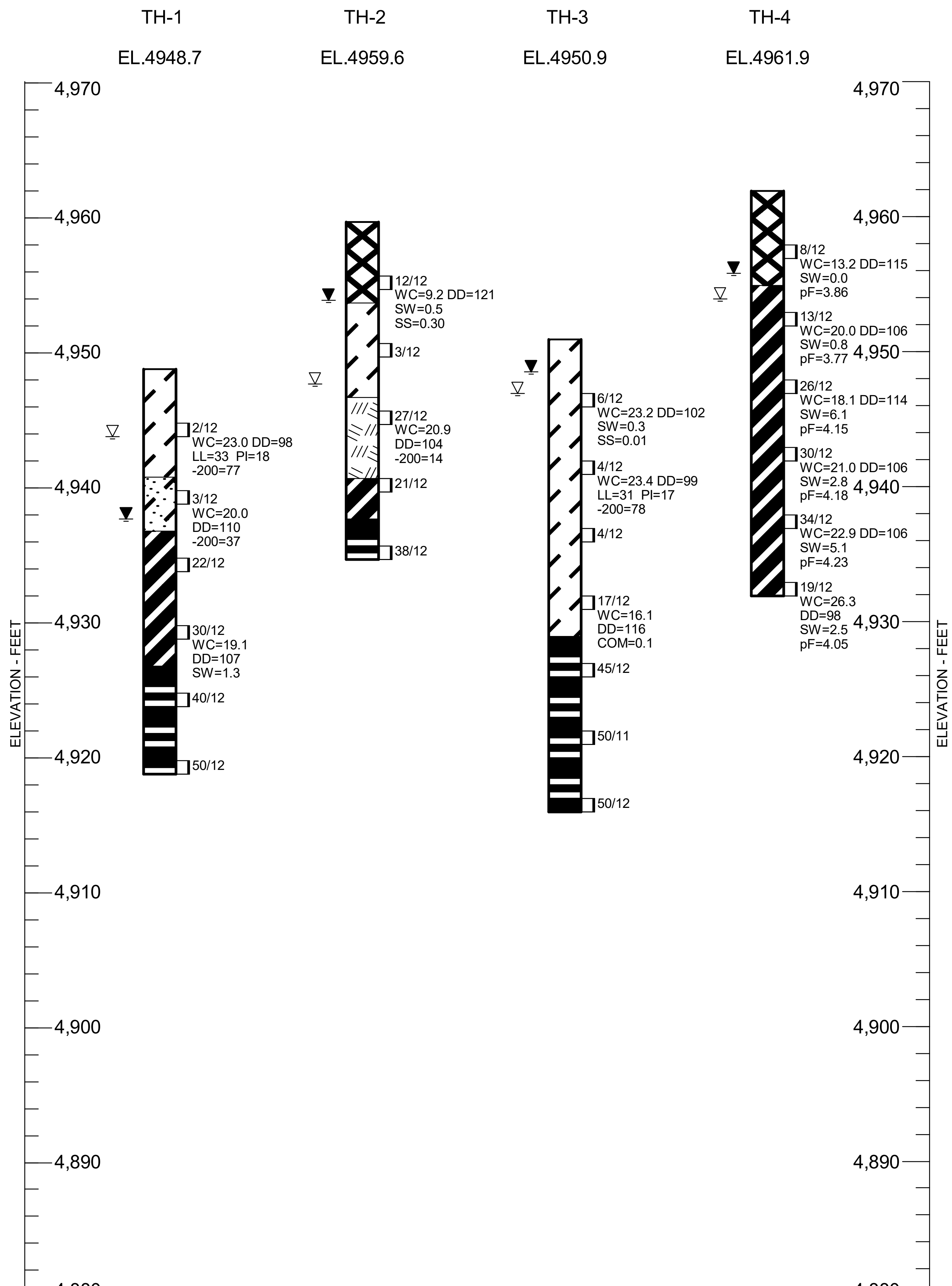
BISON HIGHWAY MINOR SUBDIVISION
CTL|T Project No. DN52,053-115-R1

Locations of Exploratory Borings

Fig. 1



SUMMARY LOGS OF EXPLORATORY BORINGS

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CTL|T PROJECT NO. DN52,053-115-R1

LEGEND:

FILL, CLAY, SANDY, STIFF, MOIST TO VERY MOIST, BROWN, WHITE, BLACK.

CLAY, SANDY, SOFT TO VERY STIFF, VERY MOIST TO WET, BROWN, TAN, WHITE (CL).

SAND, CLAYEY, VERY LOOSE, WET, BROWN, GRAY, RUST (SC).

WEATHERED CLAYSTONE, MOIST, BROWN, GRAY, WHITE, RUST.

WEATHERED SANDSTONE, WET, TAN, BLACK, RUST.

BEDROCK, CLAYSTONE, MEDIUM HARD TO HARD, MOIST, BROWN, TAN, GRAY, RUST.

DRIVE SAMPLE. THE SYMBOL 2/12 INDICATES 2 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

WATER LEVEL MEASURED AT TIME OF DRILLING.

WATER LEVEL MEASURED AFTER DRILLING ON

NOTES:

1. THE BORINGS WERE DRILLED SEPTEMBER 13, 2023 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A CME-45 TRUCK-MOUNTED DRILL RIG.

2. BORING LOCATIONS AND ELEVATIONS ARE APPROXIMATE AND WERE DETERMINED BY A REPRESENTATIVE OF OUR FIRM USING A LEICA GS18 GPS UNIT REFERENCING THE NORTH AMERICAN DATUM OF 1983 (NAD83).

3. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (PCF).
   SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
   COM - INDICATES COMPRESSION WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
   LL - INDICATES LIQUID LIMIT.
   PI - INDICATES PLASTICITY INDEX.
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT (%).
   pF - INDICATES SOIL SUCTION VALUE (PSF).

4. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.

FIG. 2

LEGEND:

TH-1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING

(12) INDICATES ESTIMATED DEPTH TO BEDROCK (FEET)

[4937] INDICATES APPROXIMATE BEDROCK ELEVATION (FEET)

NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS.

0 75 150

SCALE: 1" = 150'

CARLSON ASSOCIATES, INC.
BISON HIGHWAY MINOR SUBDIVISION
CTL|T Project No. DN52,053-115-R1

Approximate Depth and Elevation of Bedrock

Fig. 3

LEGEND:

TH-1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING

(5) INDICATES ESTIMATED DEPTH TO GROUNDWATER (FEET)

[4944] INDICATES APPROXIMATE GROUNDWATER ELEVATION (FEET)

NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS AND SEASONAL FLUCTUATIONS.

0 75 150

SCALE: 1" = 150'

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CTL|T Project No. DN52,053-115-R1

Approximate Depth and Elevation of Groundwater

Fig. 4

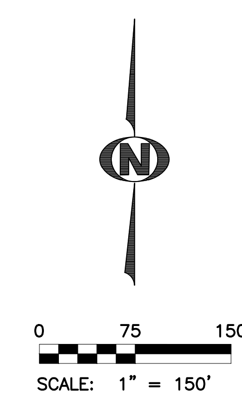
LEGEND:

TH-1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING

LOW RISK

MODERATE RISK

HIGH RISK



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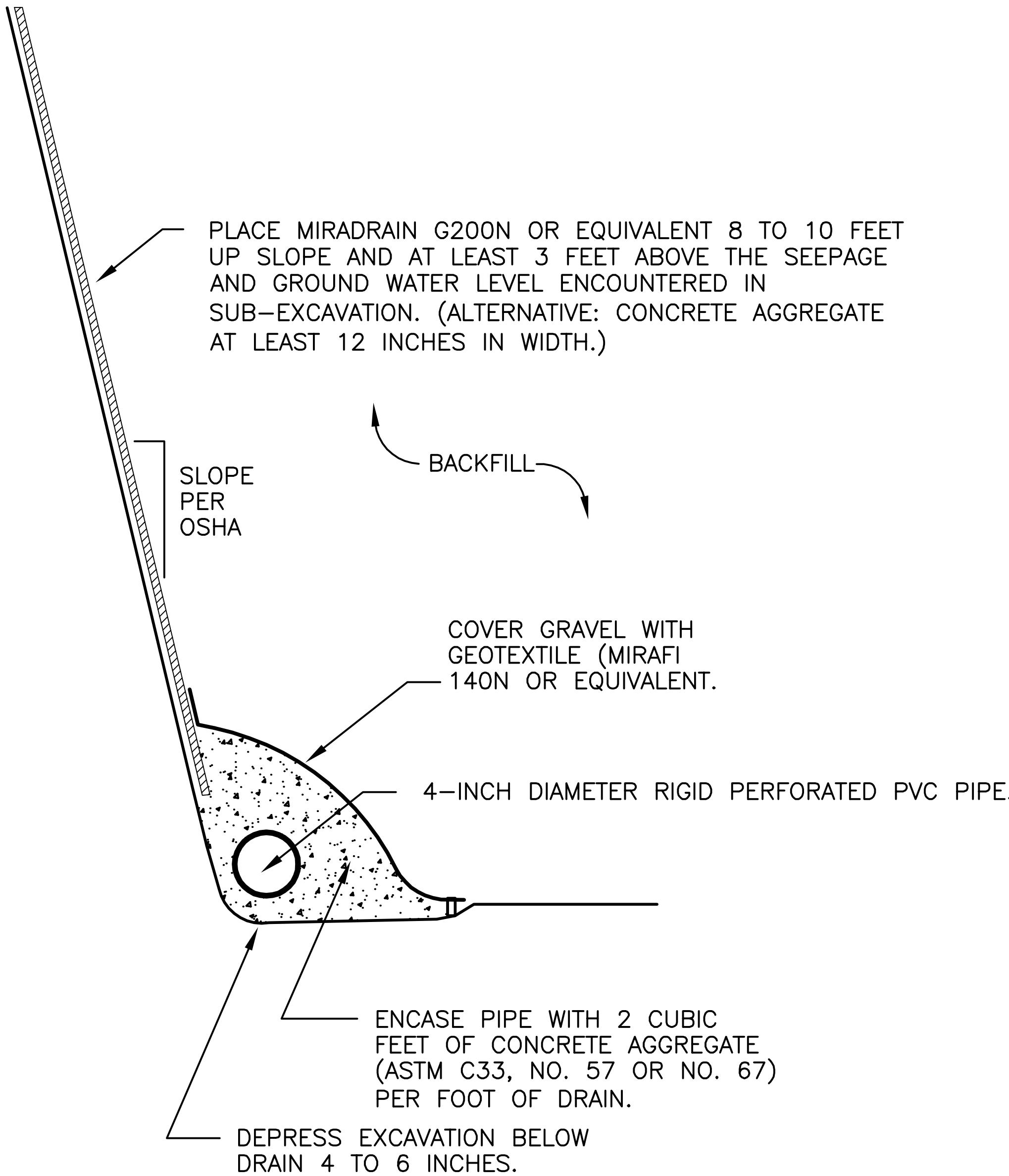
Preliminary Risk Assessment Due to Expansive Soil and Bedrock

Fig. 5



NOTE:
THE BOTTOM OF THE DRAIN SHOULD SLOPE TO A POSITIVE GRAVITY OUTLET WITH A MINIMUM SLOPE OF 0.5 PERCENT.

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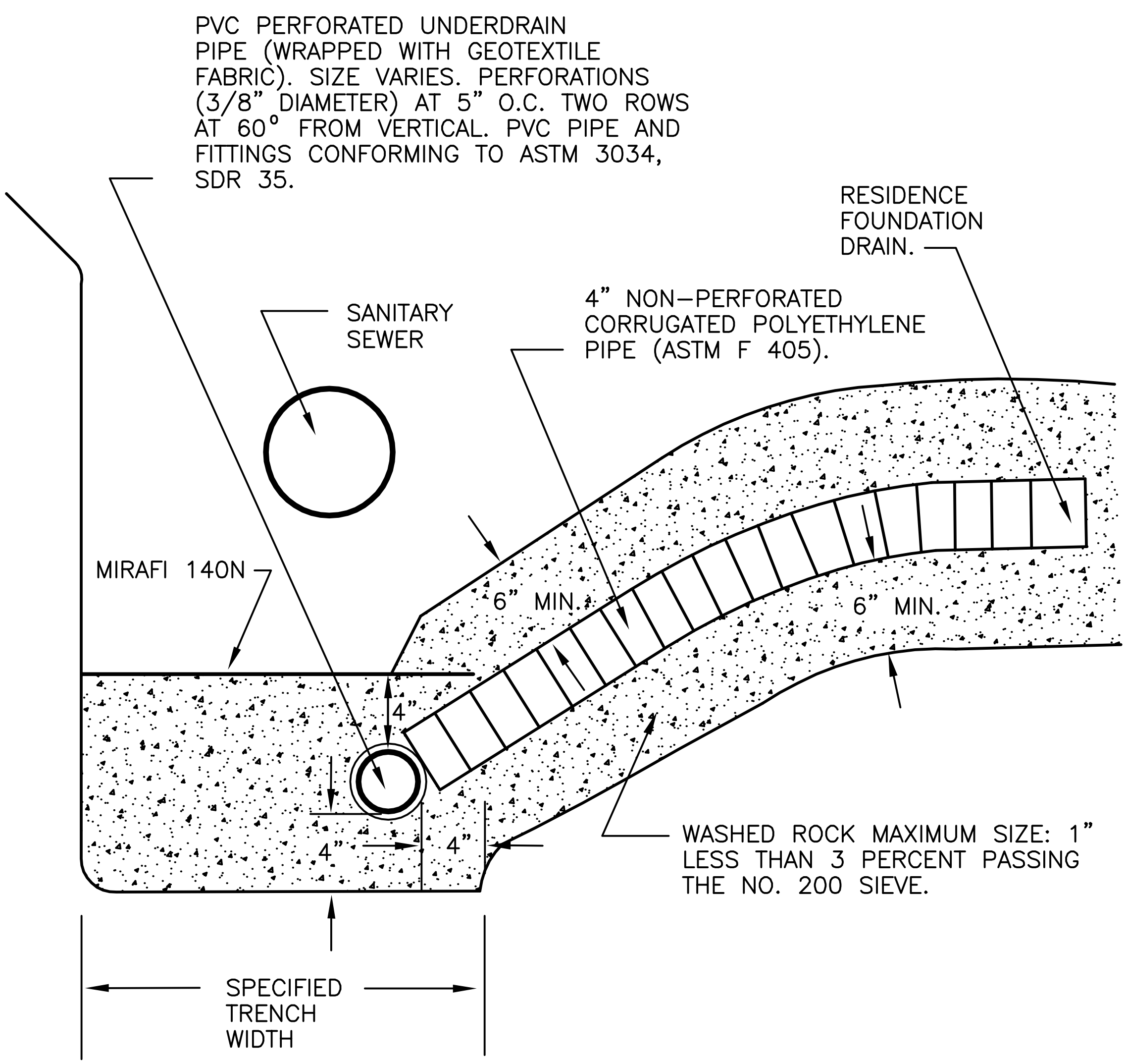
Sub-Excavation Interceptor Drain

Fig. 6



NOTE: NOT TO SCALE.

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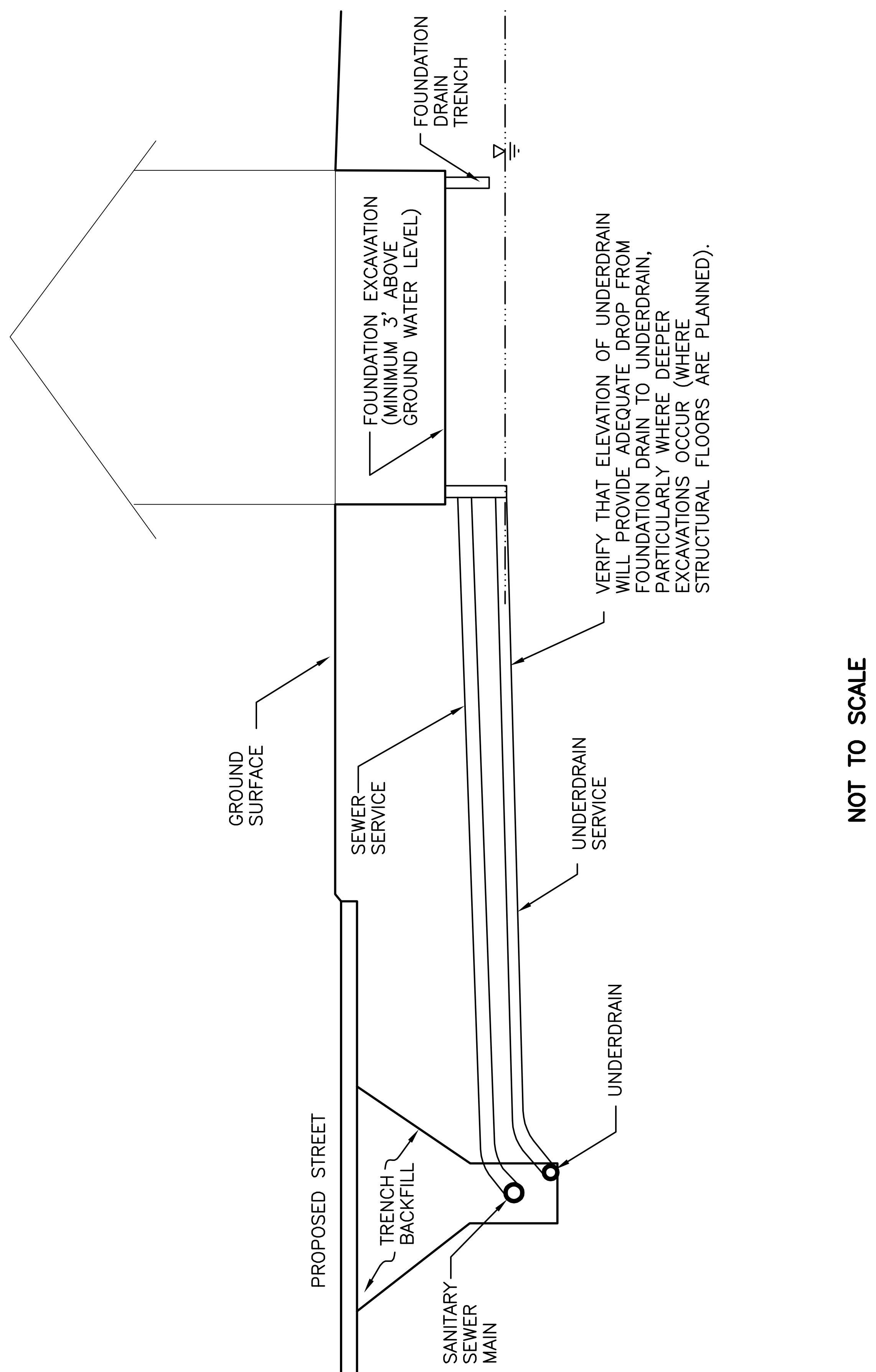
Sewer Underdrain Detail

Fig. 7

50-UNDERDRAIN_06



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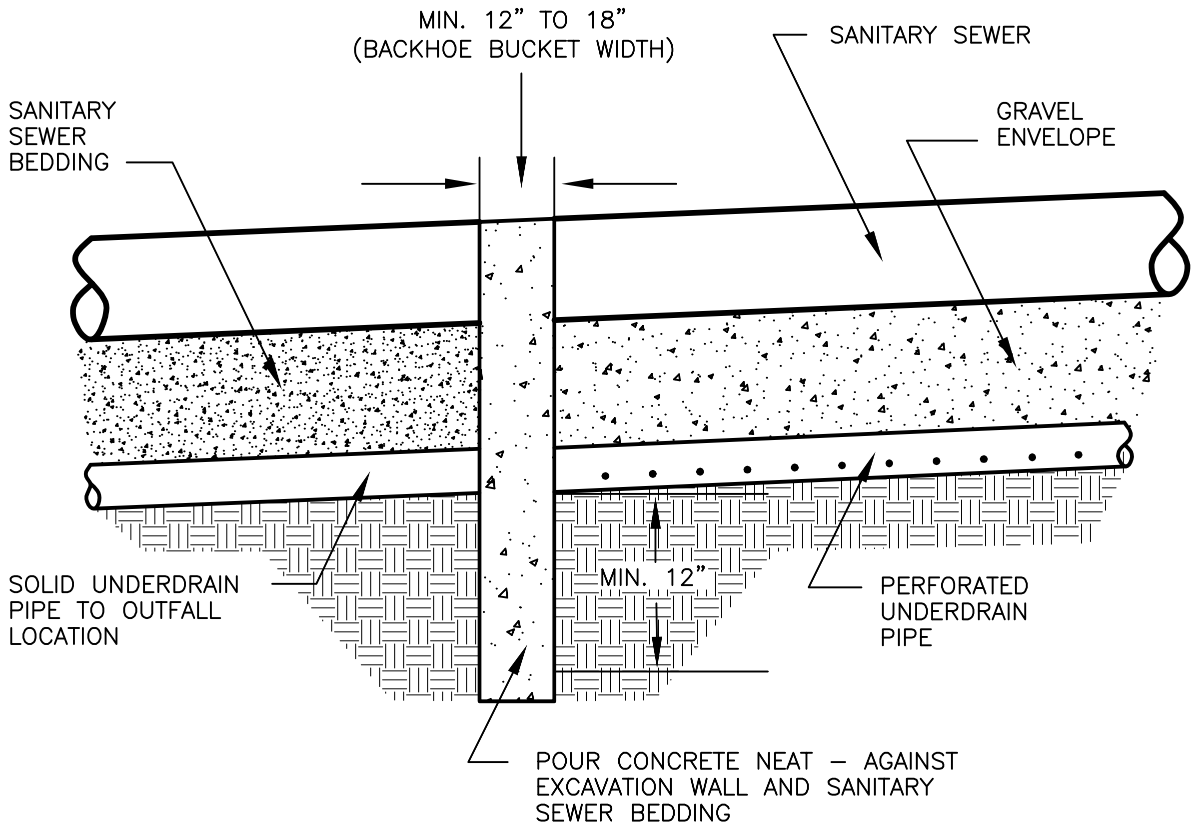
Conceptual Underdrain Service Profile

Fig. 8



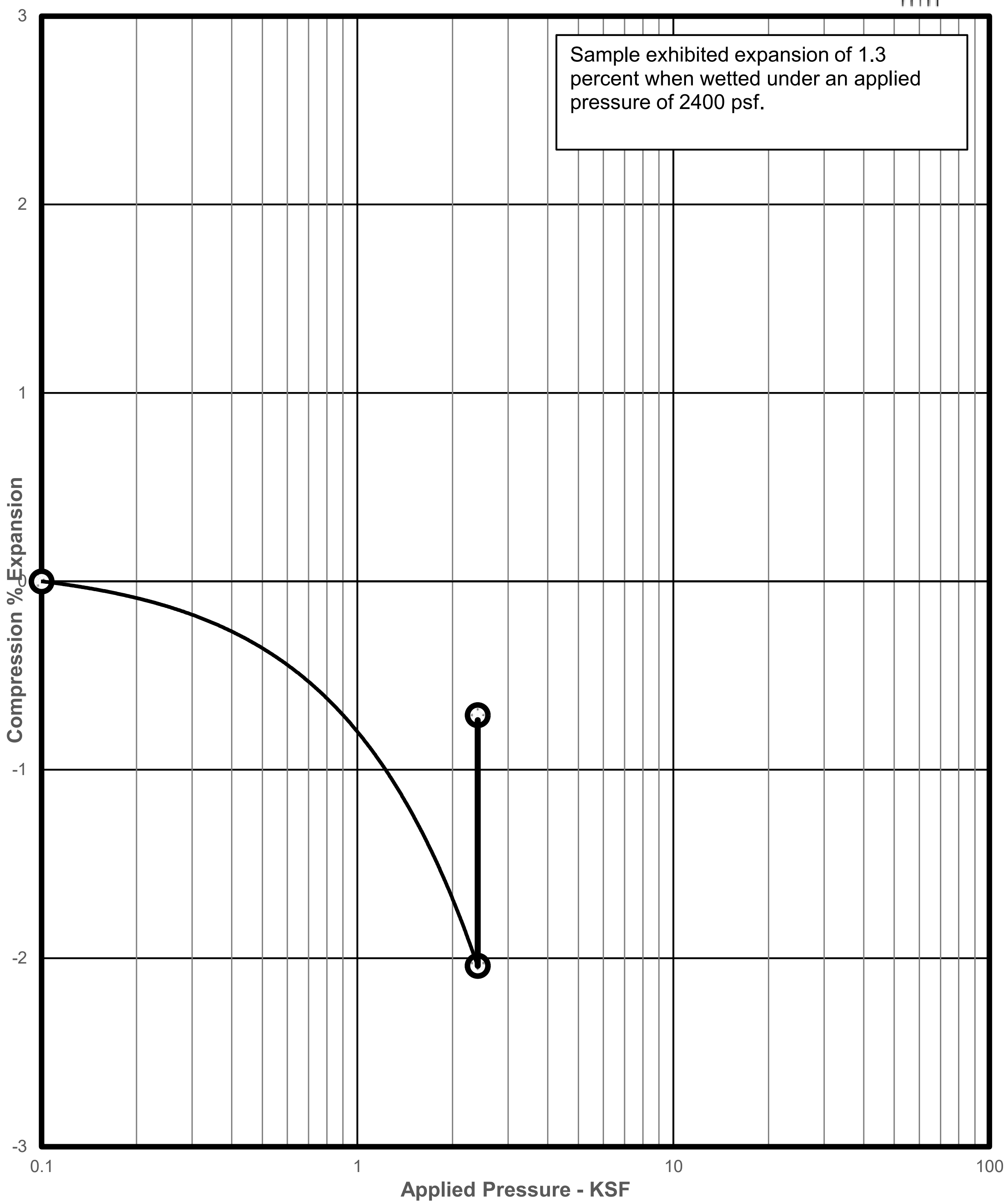
NOTE:
THE CONCRETE CUTOFF WALL SHOULD EXTEND INTO THE UNDISTURBED SOILS OUTSIDE THE UNDERDRAIN AND SANITARY SEWER TRENCH A MINIMUM DISTANCE OF 12 INCHES.

Underdrain Cutoff Wall Detail

Fig. 9

APPENDIX A

LABORATORY TEST RESULTS
TABLE A-I – SUMMARY OF LABORATORY TESTING



SAMPLE OF WEATHERED CLAYSTONE
FROM: TH-1 AT 19 FEET

DRY UNIT WEIGHT: 107 pcf
MOISTURE CONTENT: 19.1 %

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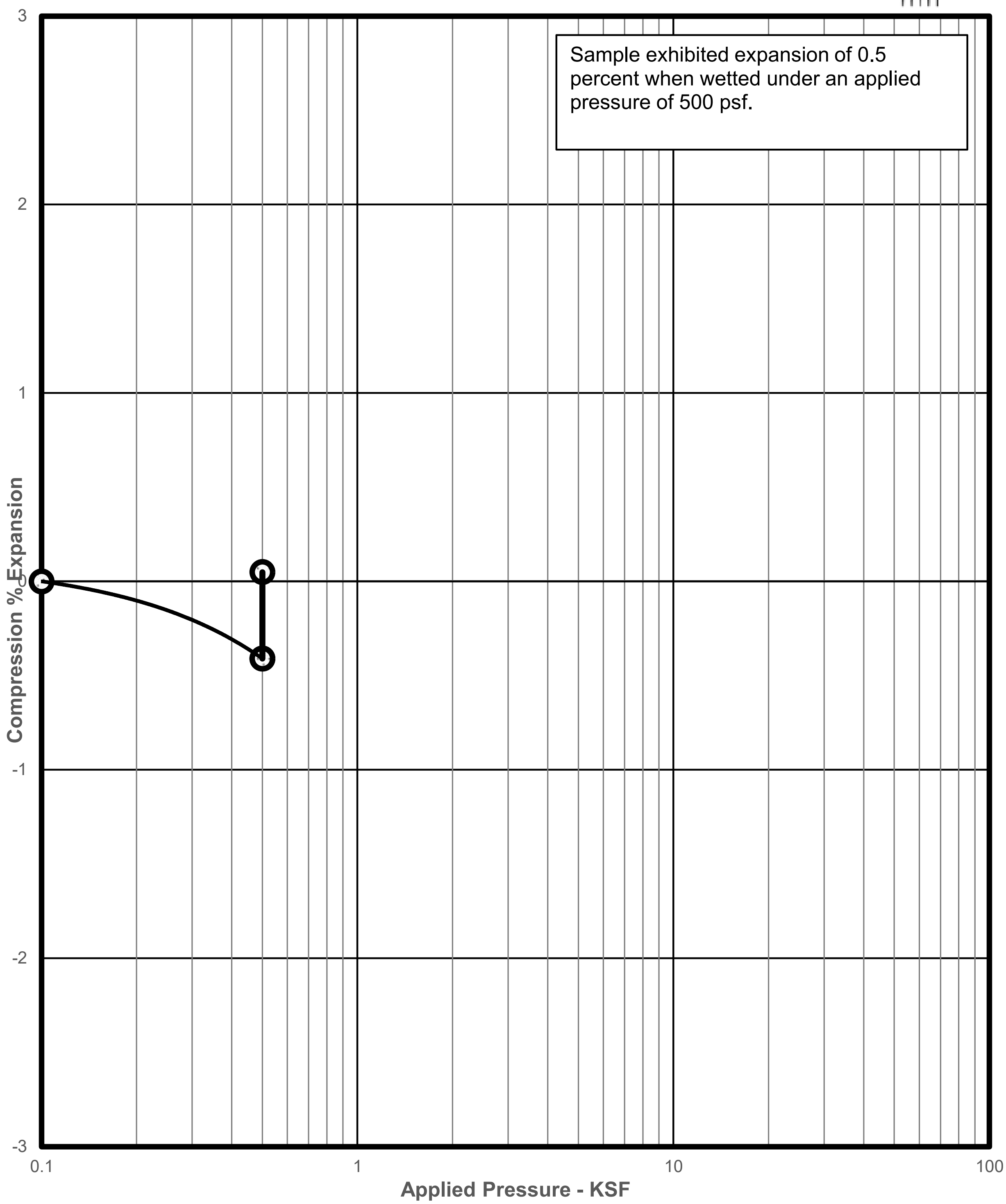
Swell Consolidation Test Results FIG. A- 1



SAMPLE OF FILL, CLAY, SANDY
FROM: TH-2 AT 4 FEET

DRY UNIT WEIGHT: 121 pcf
MOISTURE CONTENT: 9.2 %

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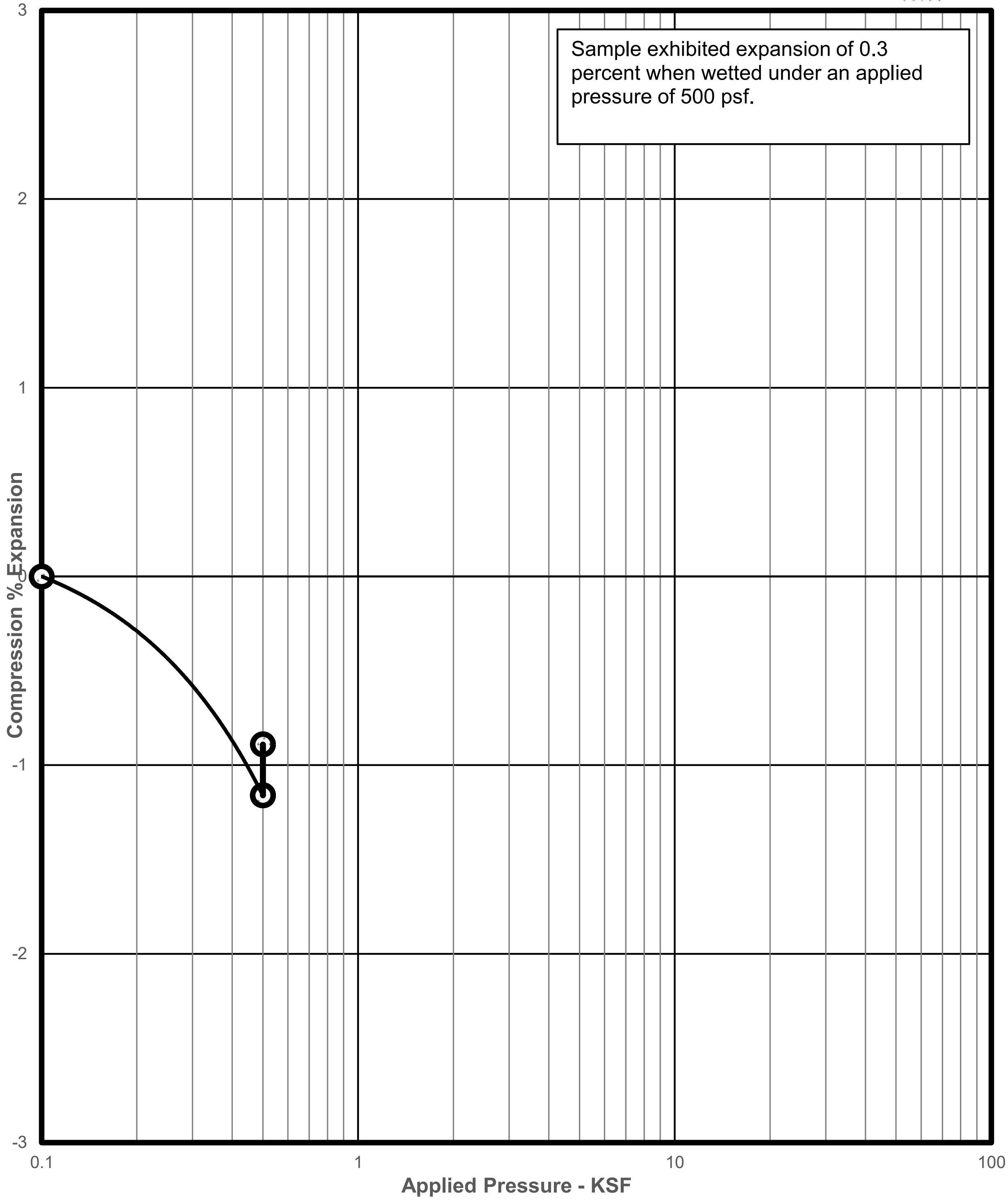
Swell Consolidation Test Results FIG. A- 2



SAMPLE OF CLAY, SANDY (CL)
FROM: TH-3 AT 4 FEET

DRY UNIT WEIGHT: 102 pcf
MOISTURE CONTENT: 23.2 %

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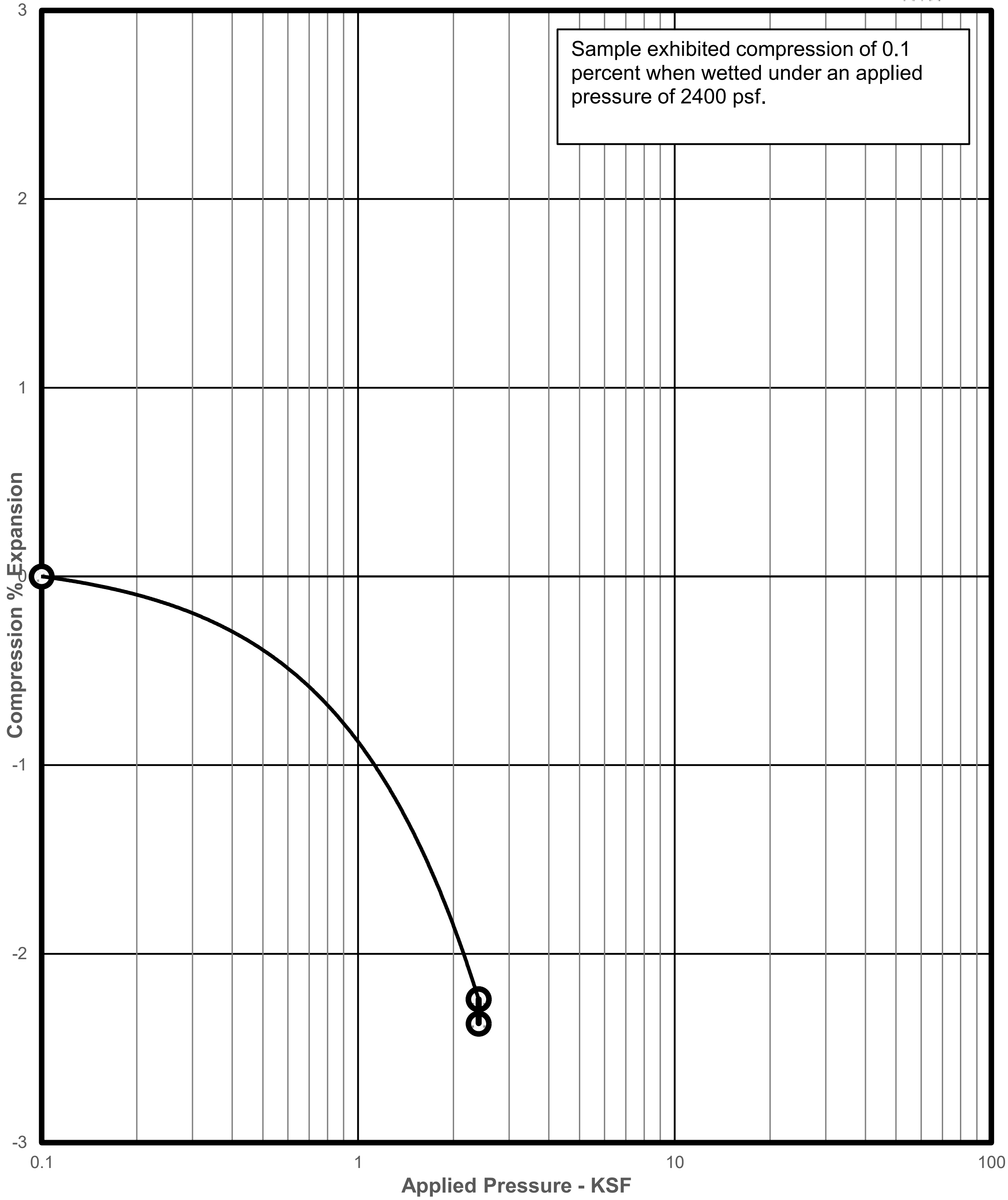
Swell Consolidation Test Results FIG. A- 3



SAMPLE OF CLAY, SANDY (CL)
FROM: TH-3 AT 19 FEET

DRY UNIT WEIGHT: 116 pcf
MOISTURE CONTENT: 16.1 %

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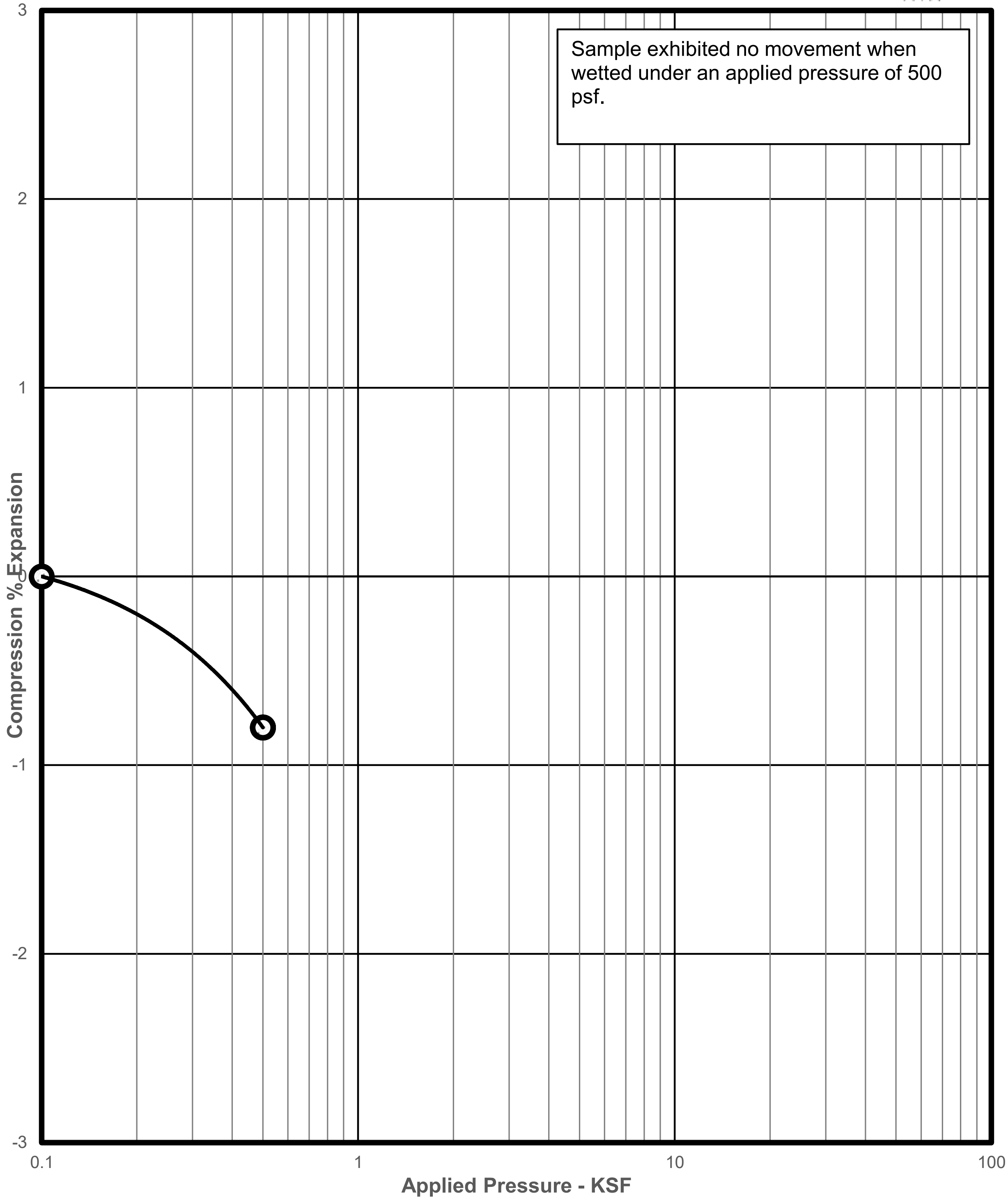
Swell Consolidation Test Results FIG. A- 4



SAMPLE OF FILL, CLAY, SANDY

FROM: TH-4 AT 4 FEET

DRY UNIT WEIGHT: 115 pcf

MOISTURE CONTENT: 13.2 %

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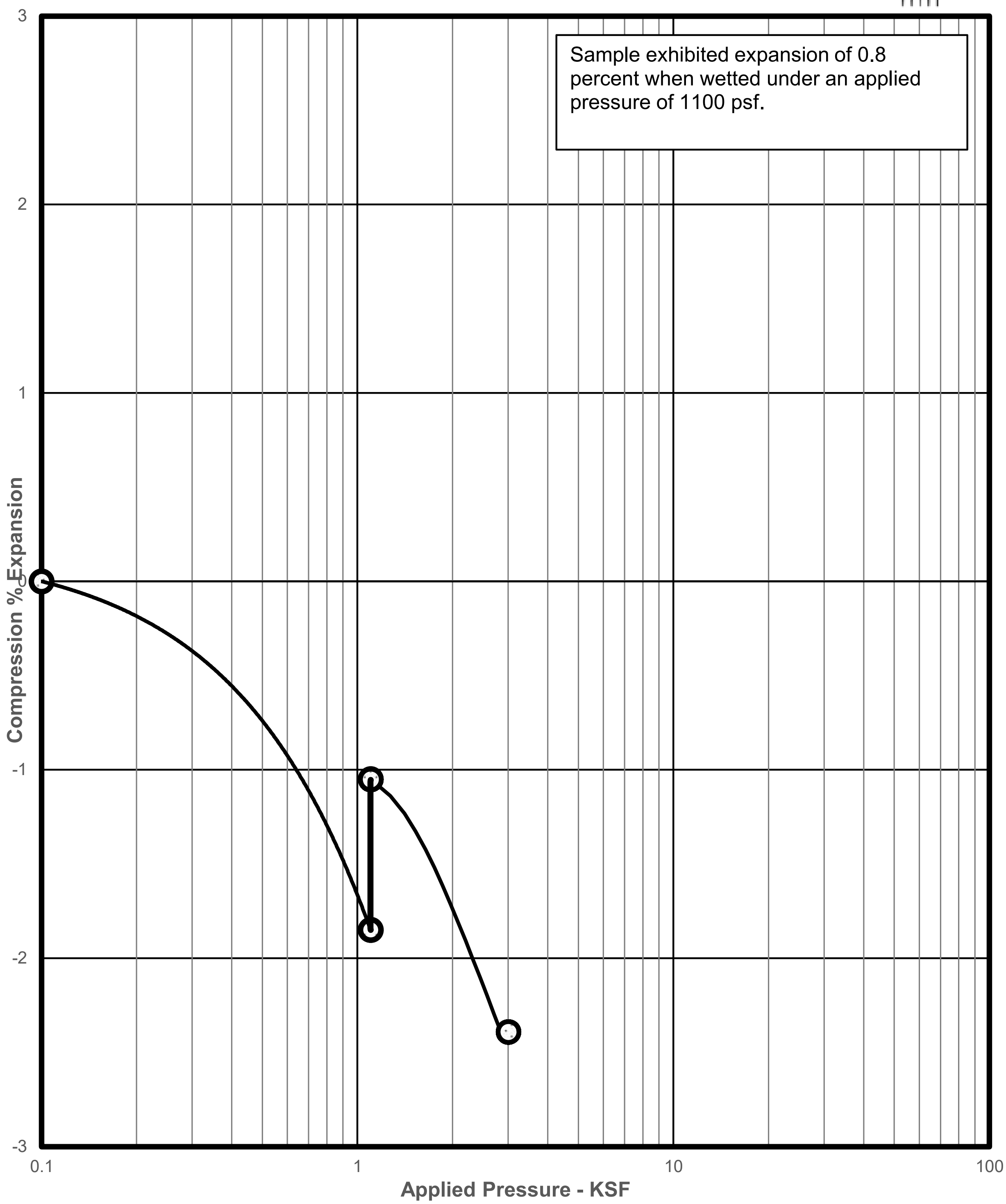
Swell Consolidation Test Results FIG. A- 5



SAMPLE OF	WEATHERED CLAYSTONE	DRY UNIT WEIGHT:	106	pcf
FROM:	TH-4 AT 9 FEET	MOISTURE CONTENT:	20.0	%

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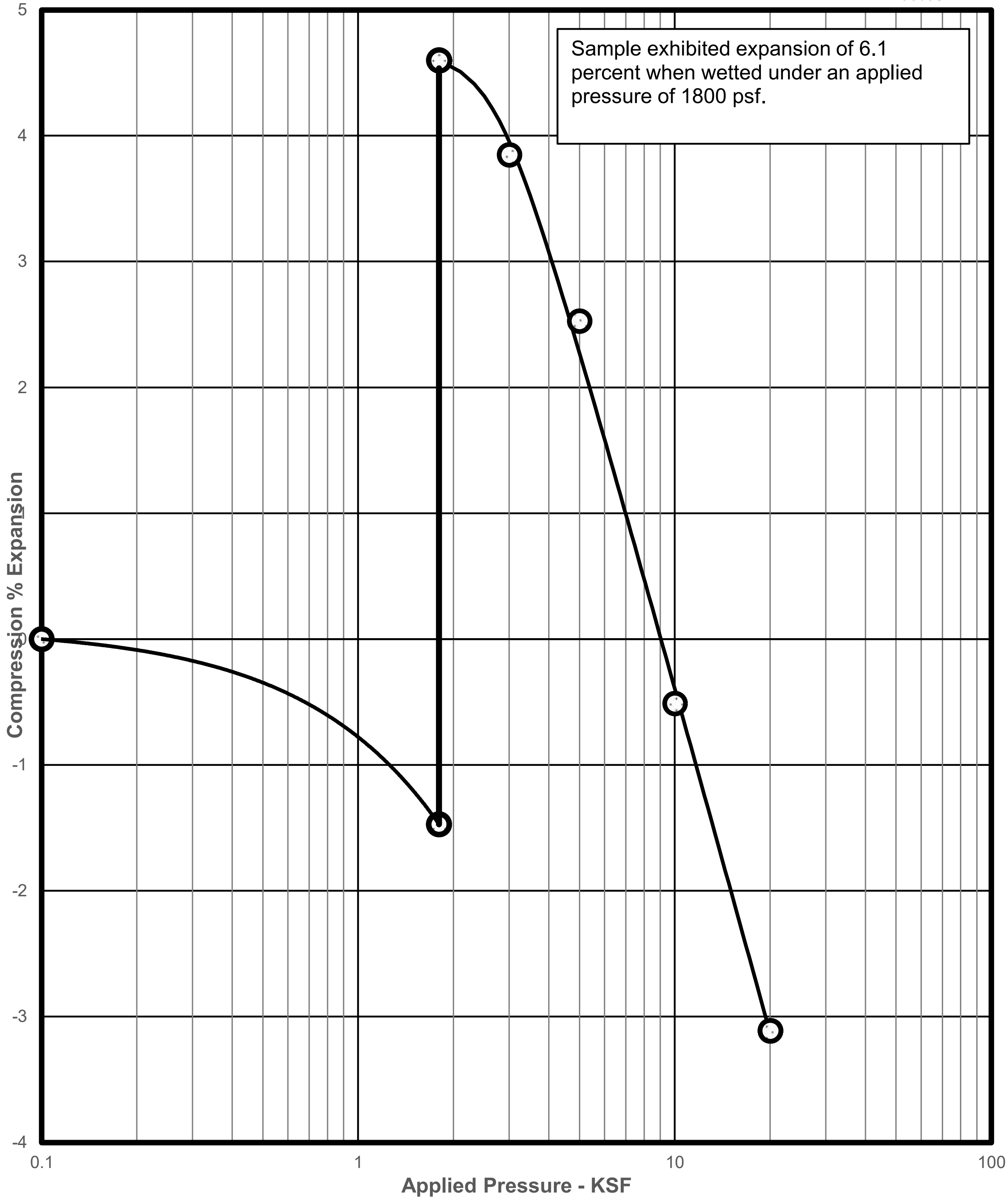
CTL|T PROJECT NO. DN52,053-115-R1

Swell Consolidation Test Results FIG. A- 6



SAMPLE OF WEATHERED CLAYSTONE

FROM: TH-4 AT 14 FEET

DRY UNIT WEIGHT: 114 pcf

MOISTURE CONTENT: 18.1 %

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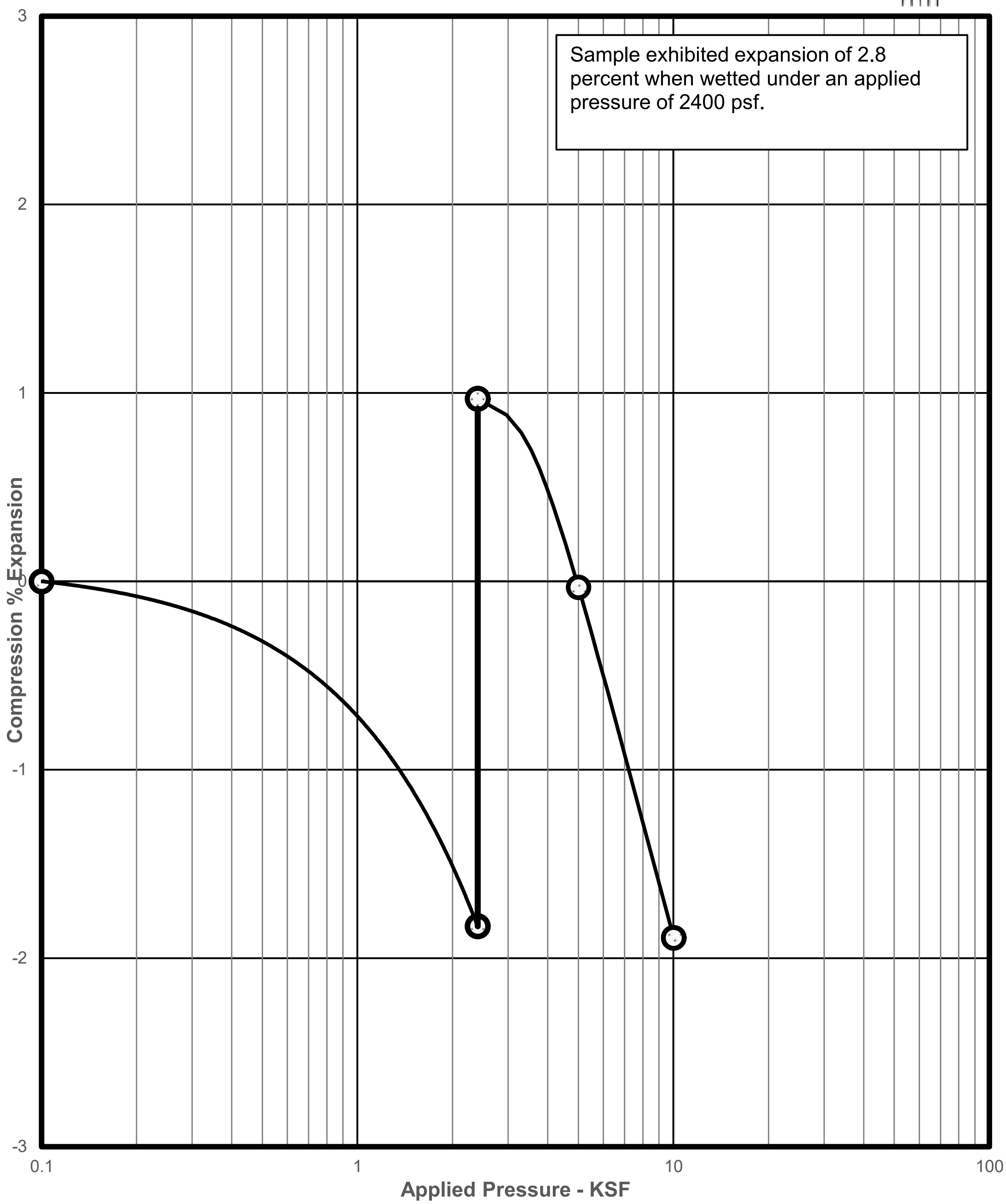
Swell Consolidation Test Results FIG. A- 7



SAMPLE OF WEATHERED CLAYSTONE

FROM: TH-4 AT 19 FEET

DRY UNIT WEIGHT: 106 pcf

MOISTURE CONTENT: 21.0 %

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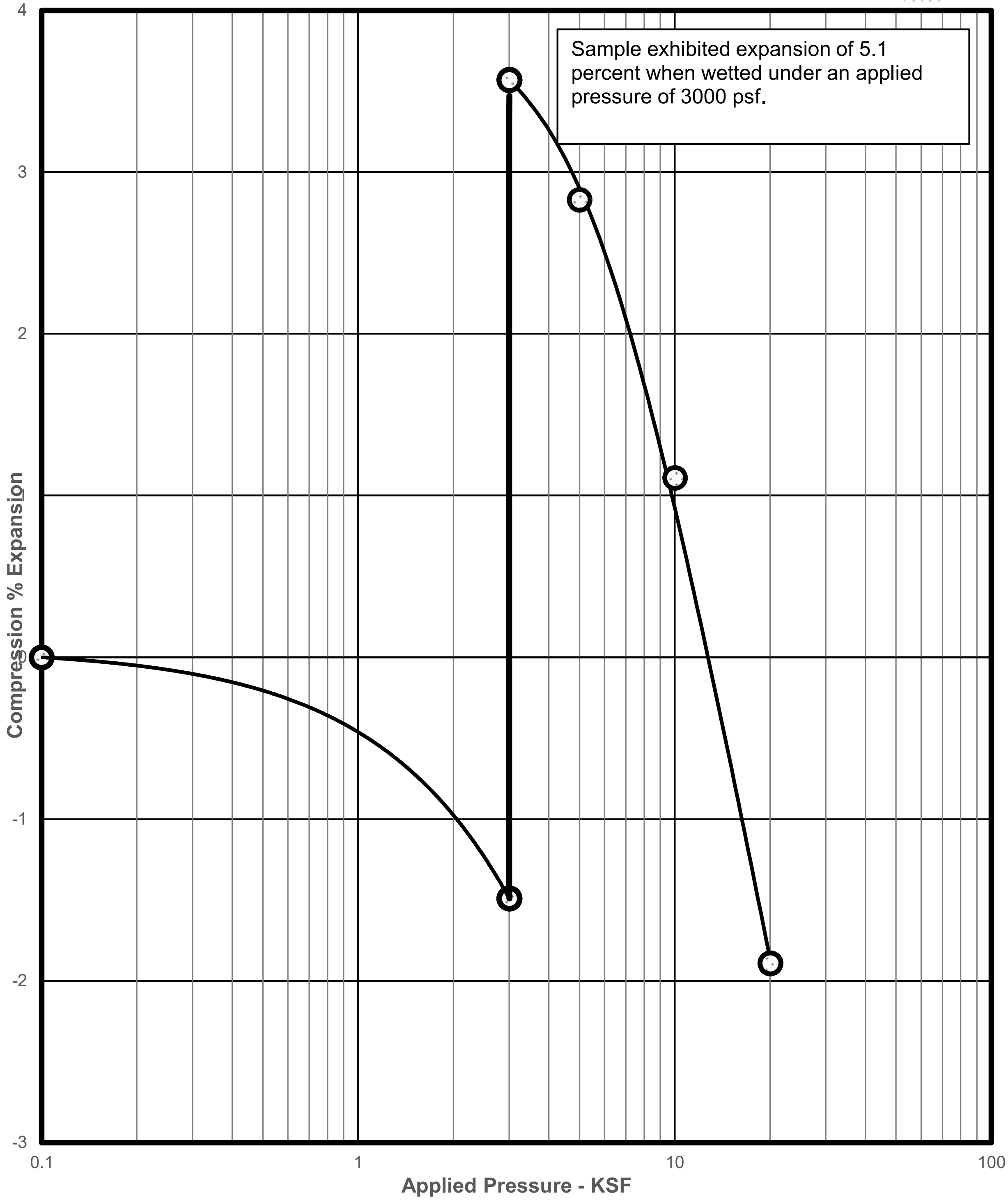
Swell Consolidation Test Results FIG. A- 8



SAMPLE OF WEATHERED CLAYSTONE
FROM: TH-4 AT 24 FEET

DRY UNIT WEIGHT: 106 pcf
MOISTURE CONTENT: 22.9 %

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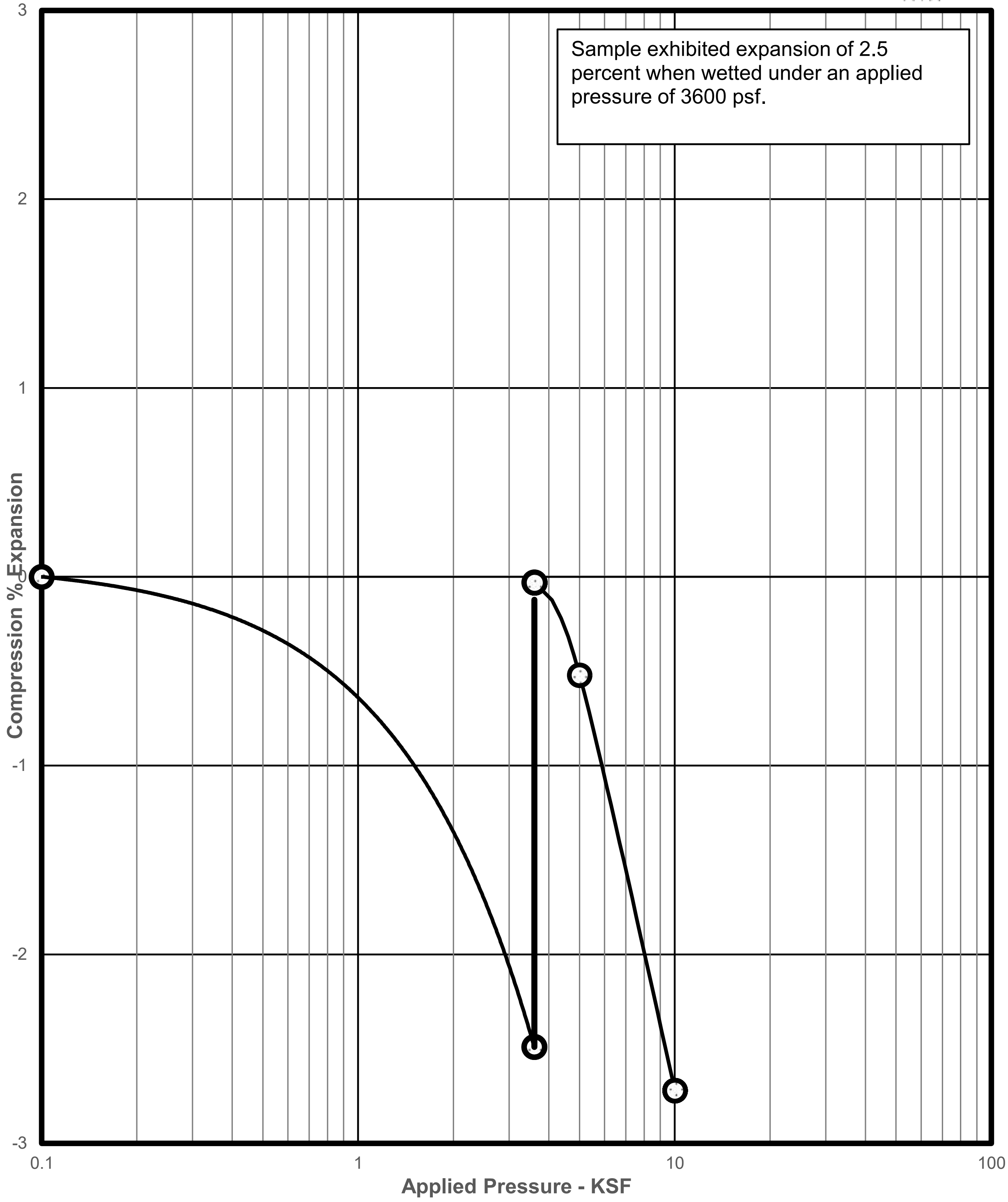
Swell Consolidation Test Results FIG. A- 9



SAMPLE OF WEATHERED CLAYSTONE
FROM: TH-4 AT 29 FEET

DRY UNIT WEIGHT: 98 pcf
MOISTURE CONTENT: 26.3 %

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CTL|T PROJECT NO. DN52,053-115-R1

Swell Consolidation Test Results FIG. A- 10

TABLE A - I

SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	SWELL TEST DATA: SWELL (%)	COMPRESSION (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)	SOIL SUCTION VALUE (pF)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTICITY INDEX	SOLUBLE SULFATE CONTENT (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
TH-1	4	23.0	98						33	18		77	CLAY, SANDY (CL)
TH-1	9	20.0	110									37	SAND, CLAYEY (SC)
TH-1	19	19.1	107	1.3		2,400							WEATHERED CLAYSTONE
TH-2	4	9.2	121	0.5		500					0.30		FILL, CLAY, SANDY
TH-2	14	20.9	104									14	WEATHERED SANDSTONE
TH-3	4	23.2	102	0.3		500					0.01		CLAY, SANDY (CL)
TH-3	9	23.4	99						31	17		78	CLAY, SANDY (CL)
TH-3	19	16.1	116		0.1	2,400							CLAY, SANDY (CL)
TH-4	4	13.2	115	0.0		500		3.86					FILL, CLAY, SANDY
TH-4	9	20.0	106	0.8		1,100	2,200	3.77					WEATHERED CLAYSTONE
TH-4	14	18.1	114	6.1		1,800	13,400	4.15					WEATHERED CLAYSTONE
TH-4	19	21.0	106	2.8		2,400	9,600	4.18					WEATHERED CLAYSTONE
TH-4	24	22.9	106	5.1		3,000	18,300	4.23					WEATHERED CLAYSTONE
TH-4	29	26.3	98	2.5		3,600	9,300	4.05					WEATHERED CLAYSTONE

APPENDIX B

GUIDELINE SITE GRADING SPECIFICATIONS

Bison Highway Minor Subdivision
Hudson, Colorado

GUIDELINE SITE GRADING SPECIFICATIONS

Bison Highway Minor Subdivision
Hudson, Colorado

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of excess cut materials that may be placed outside of the development boundaries.

2. GENERAL

The Soils Representative shall be the Owner's representative. The Soils Representative shall approve fill materials, method of placement, moisture contents and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. AREA TO BE FILLED

All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction.

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content (1 to 4 percent above optimum moisture content for clays and within 2 percent of optimum moisture content for sands) and compacted to not less than 95 percent of maximum dry density as determined in accordance with ASTM D 698.

5. FILL MATERIALS

Fill soils shall be free from organics, debris or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than six (6) inches. Bedrock should be broken down to three (3) inches or smaller in size. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SW, SP, GP, GC and GM are acceptable. Concrete, asphalt, organic matter and other deleterious materials or debris shall not be used as fill.

6. MOISTURE CONTENT

Fill material classifying as CH and CL shall be moisture conditioned to between 1 to 4 percent above optimum moisture content. Granular soils classifying as SC, SM, SW, SP, GP, GC and GM shall be moisture conditioned to within 2 percent of optimum moisture content as determined from Proctor compaction tests. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Representative, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disc the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Representative, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

7. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill shall be compacted to at least 95 percent of the maximum density as determined in accordance with ASTM D 698. At the option of the Soils Representative, soils classifying as SW, GP, GC, or GM may be compacted to 95 percent of maximum density as determined in accordance with ASTM D 1557 or 70 percent relative density for cohesionless sand soils. Fill materials shall be placed such that the thickness of loose materials does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.

Compaction as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other approved equipment. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

8. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is no appreciable amount of loose soils on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to 5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

9. PLACEMENT OF FILL ON NATURAL SLOPES

Where natural slopes are steeper than 20 percent in grade and the placement of fill is required, benches shall be cut at the rate of one bench for each 5 feet in height (minimum of two benches). Benches shall be at least 10 feet in width. Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

10. DENSITY TESTS

Field density tests shall be made by the Soils Representative at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is not within specification, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

11. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Representative indicates that the moisture content and density of previously placed materials are as specified.

12. NOTICE REGARDING START OF GRADING

The Contractor shall submit notification to the Soils Representative and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

13. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Representative, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, and percentage compaction shall be reported for each test taken.

14. DECLARATION REGARDING COMPLETED FILL

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, and was placed in general accordance with the specifications.

APPENDIX C

GUIDELINE SITE GRADING SPECIFICATIONS
(SUB-EXCAVATION)

Bison Highway Minor Subdivision
Hudson, Colorado

GUIDELINE SITE GRADING SPECIFICATIONS
(SUB-EXCAVATION)

Bison Highway Minor Subdivision
Hudson, Colorado

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of materials that may be placed outside of the development boundaries.

2. GENERAL

The Soils Engineer shall be the Owner's representative. The Soils Engineer shall observe fill materials, method of placement, moisture content and percent compaction, and shall provide written opinions of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil and vegetable matter shall be removed from the ground surface where fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features that would prevent uniform compaction.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content, (1 to 4 percent above optimum for clay or within 2 percent of optimum for sand) and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698.

6. FILL MATERIALS

Fill soils shall be free from vegetable matter or other deleterious substances, and shall not contain clay and claystone having a diameter greater than three (3) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SP, GP, GC and GM are acceptable. Concrete, asphalt, and other deleterious materials or debris shall not be used as fill.

7. MOISTURE CONTENT

Fill materials shall be moisture-conditioned to within limits of optimum moisture content specified in “Moisture Content and Density Criteria”. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas or imported to the site.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor will be required to rake or disc the fill to provide uniform moisture content throughout the fill.

The application of water to embankment materials shall be made with any type of watering equipment that will give the desire results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL MATERIALS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density given in “Moisture Content and Density Criteria”. Fill materials shall be placed such that the thickness of loose material does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of suitable equipment. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

9. MOISTURE CONTENT AND DENSITY CRITERIA

Fill material shall be substantially compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T 99) dry density at 1 to 4 percent above optimum moisture content for clay or within 2 percent of optimum for sand. Additional criteria for acceptance are presented in DENSITY TESTS.

10. DENSITY TESTS

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof not within specifications, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

Allowable ranges of moisture content and density given in MOISTURE CONTENT AND DENSITY CRITERIA are based on design considerations. The moisture shall be controlled by the Contractor so that moisture content of the compacted earth fill, as determined by tests performed by the Soils Engineer, shall be within the limits given. The Soils Engineer will inform the Contractor when the placement moisture is less than or exceeds the limits specified and the Contractor shall immediately make adjustments in procedures as necessary to maintain placement moisture content within the specified limits, to satisfy the following requirements.

A. Moisture

1. The average moisture content of clay material tested each day shall not be less than 1.5 percent over optimum moisture content.

2. Material represented by samples tested having moisture lower than 1 percent over optimum will be rejected. Such rejected materials shall be reworked until moisture equal to or greater than 1 percent above optimum is achieved.

B. Density

1. The average dry density of material tested each day shall not be less than 95 percent of standard Proctor maximum dry density (ASTM D 698).

2. No more than 10 percent of the material represented by the samples tested shall be at dry densities less than 95 percent of standard Proctor maximum dry density (ASTM D 698).

3. Material represented by samples tested having dry density less than 93 percent of standard Proctor maximum dry density (ASTM D 698) will be rejected. Such rejected materials shall be reworked until a dry density equal to or greater than 95 percent of standard Proctor maximum dry density (ASTM D 698) is obtained.

11. OBSERVATION AND TESTING OF FILL

Observation by the Soils Engineer shall be sufficient during the placement of fill and compaction operations so that they can declare the fill was placed in general conformance with specifications. All observations necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates the moisture content and density of previously placed materials are as specified.

13. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content and percentage compaction shall be reported for each test taken.