SOIL AND FOUNDATION INVESTIGATION
PROPOSED DUPLEX
3966 VRAIN STREET
DENVER, COLORADO

Prepared for:

G.J. GARDNER HOMES
ATTN: DAVE PAGANO
7660 RALEIGH STREET
WESTMINSTER, COLORADO 80030

PROJECT NO. 1090 OCTOBER 14, 2010

TABLE OF CONTENTS

SCOPE

This report presents the results of a soils and foundation investigation for a proposed duplex to be located at 3966 Vrain Street in Denver, Colorado. A single family residence with a basement exists at the site. The residence is to be removed and replaced with a new duplex with a basement and a detached garage. The test borings were located as indicated on Figure 1. A site specific house plan was not available at the time of our report preparation. The purpose of our investigation was to evaluate subsurface conditions at the site and provide geotechnical recommendations for the proposed construction. The report presents a description of subsurface conditions encountered at the site, recommended foundation system, and design and construction criteria influenced by the subsurface conditions. The report is based on data developed during the field and laboratory investigations and our experience. A summary of our findings and recommendations is presented below.

CONCLUSIONS

1. Subsurface materials encountered in Test Hole 1 (TH-1) consisted of a thin topsoil/root zone layer, underlain to 9 feet by sandy clay, underlain by sandy claystone bedrock with interbedded sandstone lenses to the maximum depth explored of 25 feet. Subsurface materials encountered in Test Hole 2 (TH-2) consisted of sandy clay to a depth of 9 feet underlain by sandy claystone bedrock with interbedded sandstone lenses to the maximum depth explored of 20 feet. The soils encountered at proposed foundation elevations consist of sandy clay and sandy claystone bedrock.

2. No free water was encountered at the time of drilling. The borings were checked three days after drilling and ground water was measured at a depth of 11 feet in TH-1 and 16 feet in TH-2.

3. The proposed duplex can be constructed with either a drilled pier foundation system or a spread footing foundation system bottomed a minimum of 3 feet (slab elevation) above ground water. Helical piers may be utilized in lieu of drilled piers. Design and construction criteria are presented in the body of the report. If very moist soil is encountered or soils are too soft for heavy equipment access, a minimum of 1 foot of soil over-excavation below foundation elevations and replacement with gravel to stabilize soft, very moist to wet sub-soils and to create a subsurface drainage system for ground water may be utilized.

4. The soils are suitable for support of slab-on-grade construction with a low risk of movement or cracking due to expansive soils and/or soil settlement. Any slabs supported on grade should be free to move vertically, and not tied to the structure.

5. An interior foundation drain should be installed below basement slab elevations. as indicated on Figures 7-8. A vapor barrier is recommended below the slab due to shallow ground water.

7. Positive drainage down and away from all foundation walls should be established and maintained at all times.

PROPOSED CONSTRUCTION

A duplex with a basement is proposed and a detached garage is proposed in the eastern portion of the site. The proposed duplex is assumed to consist of concrete and wood frame construction and relatively light construction loads are anticipated. Detailed plans for the proposed construction were not provided at the time of this investigation. The basement slab depth is anticipated at 8 feet below existing grade due to ground water.

SITE CONDITIONS

The site has an existing residence to be removed, and is located in an established residential area of northwest Denver, Colorado. The locations of the exploratory borings are presented on Figure 1. The site has little to no slope. The lot has a moderate cover of grasses with some large, mature trees.

INVESTIGATION

Subsurface conditions were investigated on October 4, 2010 by drilling two exploratory borings at the locations indicated on Figure 1. The borings were advanced using a 4-inch diameter continuous flight auger powered by a CME-45 drilling rig. Samples were taken at select intervals using a California sampler, which was driven into the soil by dropping a 140-pound hammer through a free fall of 30 inches. The number of blows required to drive the sampler into the soil is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches is evaluated and gives an indication of the consistency or relative density of the soils and bedrock. The results of the penetration tests and logs of the material encountered are presented on the Logs of Exploratory Borings, Figure 2. Samples were returned to the laboratory where they were visually classified and testing was assigned to evaluate the engineering properties of the soil layers. Laboratory testing consisted of swell-consolidation testing and moisture-density determinations. The results of the laboratory tests are presented on Figures 2 - 6.

SUBSURFACE CONDITIONS

Subsurface materials encountered in TH-1 consisted of a thin topsoil/root zone layer, underlain to 9 feet by sandy clay, underlain by sandy claystone bedrock with interbedded sandstone lenses to the maximum depth explored of 25 feet. Subsurface materials encountered in TH-2 consisted of sandy clay to a depth of 9 feet underlain by sandy claystone bedrock with interbedded sandstone lenses to the maximum depth explored of 20 feet. No free water was encountered at the time of drilling. The test borings were checked three days after drilling and water was present at a depth of 11 feet in TH-1 and 16 feet in TH-2. Additional subsurface details are presented on Figure 2.

The geotechnical practice in the Denver and surrounding area uses a relative scale to evaluate swelling potentials. When the sample is wetted under a surcharge pressure of 1000 pounds per square foot (PSF), the measured swell is classified as low, moderate, high, or very high. It is important to note that measured swell is not the only criteria for slab-on-grade recommendations and additional factors are considered by the geotechnical engineer when evaluating the risk for slab-on-grade construction. The following table presents the relative classification criteria. The classification criteria is in conformance with guidelines established by the Colorado Association of Geotechnical Engineers (CAGE).

Risk Category	Percent Swell Under A 1000 PSF Surcharge Pressure
Low	0 – <2
Moderate	2 - <4
High	4 – <6
Very High	Greater than 6

Swell-consolidation test results for samples of sandy clay and claystone obtained from TH-1 and TH-2 exhibited a low expansion potential when wetted under a surcharge pressure of 1000 PSF (0.4% from TH-1 at 9 feet, 0.9% from TH-1 at 14 feet, 1.6% from TH-2 at 4 feet and 0.2% swell from TH-2 at 9 feet). Swell-consolidation test results are presented on Figures 3-6.

EXCAVATIONS AND SHORING

Excavations should not remain open for extended periods of time, permitting wetting or drying of the bearing materials. Moisture changes of the bearing materials may increase the risk for movement. The materials encountered within the depth of excavations on site are categorized as Type A according to the Occupational Safety and Health Administration (OSHA). Based on published OSHA guidelines, the temporary excavations in the Type C soils can have a maximum temporary slope of 0.75:1.0 horizontal:vertical (H:V) or 53 degrees. These inclinations are reasonable for the conditions at the site. Exceeding these inclinations will increase the chance of deformation, especially over a long time period. Some localized deformation of the bank may occur, especially during wet weather, loading or with vibrations. Care should be taken when working near the sides of the excavation at all times, and the slopes should be monitored by onsite personnel during construction for evidence of sloughing, bulging or toppling of the sidewalls or cracking at the ground surface. Surcharge loading at the top of the cut by equipment, materials, or vehicles must be avoided, since surcharge loading will increase the risk of caving. Spoils of the excavation must be placed a minimum of 2 horizontal feet from the edge of the excavation. A geotechnical engineer should observe the completed excavation prior to foundation installation.

Where the recommended excavation inclination crosses property boundaries or is within the influence (0.75:1) of the bottom of shallow foundations on adjacent properties, we recommend slopes be stabilized by shoring the adjacent excavation. Our office may be contacted to prepare a shoring design.

SITE PREPARATION

Organic material and debris should be removed from the foundation area and wasted off site or used for non-structural purposes. Where required, structural fill should be placed in 8-inch uncompacted thickness lifts and compacted to 95 percent of the standard Proctor maximum dry density (MPD) within 2 percent of the optimum moisture content (OMC). Structural fill is a material that classifies as sand according to the Unified Soil Classification System possessing a silt and clay fraction less than 25 percent, a liquid limit less than 40 and a plasticity index less than 20. Coarse-grained material larger than 3 inches in diameter should not be utilized. Structures supported by insufficiently compacted structural fill may settle. Any fill not utilized for structural purposes should be compacted to 90 percent MPD within 2 percent of the OMC. A geotechnical engineer should review earthwork placement activities.

BUILDING FOUNDATIONS

The soil below the anticipated residence foundation elevation of 8 feet below the ground surface elevation at the time of this investigation consists of a thin layer of sandy clay and claystone with a low swell potential. Based on the swell results, a drilled pier foundation system represents the lowest risk for foundation movement. A shallow footing foundation can also be used, also with a low risk for movement (less than 1 inch anticipated). While swell test results indicated structural fill is not required below footing foundations to maintain a minimum potential movement of less than 1 inch, a minimum of 3 feet of properly compacted structural fill may be placed between the footing foundation elevation and the clay or claystone for a reduction in movement potential for the footing foundation as well as the slab. Due to the presence of shallow ground water, placement of more than 3 feet of structural fill may be problematic from a construction standpoint. Spread footing foundation recommendations are presented below. Drilled pier or helical pier recommendations are as follows:

DRILLED PIERS - The drilled straight shaft pier system should be designed and constructed in accordance with the following criteria.

1. Drilled piers should have a minimum length of 16 feet with a minimum of 6 feet of penetration into the competent bedrock. Piers should be designed for a maximum allowable end bearing pressure of 25,000 PSF and an allowable skin friction (side shear) of 2,000 PSF for the portion in bedrock. Piers should be designed for a minimum deadload pressure of 5,000 PSF times pier end area. If minimum deadloads can not be obtained, the piers should be lengthened using 2,000 PSF in side shear for the portion of the pier in bedrock.

2. All piers should be reinforced full length to resist uplift forces of 24,000 pounds for 12-inch piers and 20,000 pounds for 10-inch piers. Dead loads can be subtracted from these uplift forces. Reinforcement should extend into grade beams of foundation walls. A minimum 4-inch void forming material should be placed between the piers to concentrate dead loads and avoid contact with potentially expansive soils. Sonotubes must be used to form the top of the pier and avoid "mushrooming" the tops of piers.

3. Groundwater was encountered in both test holes during drilling or and was observed after three days at depths ranging from 11 to 16 feet. Therefore, dewatering should be anticipated during drilled pier installation. Concrete should be onsite at the time of drilling and placed immediately after the pier is drilled and inspected. If groundwater enters the boring (which is likely), tremie (underwater) concrete placement will be necessary. Concrete should not be placed in more than 3 inches of water without tremie placement.

4. The installation of the piers should be observed by a representative of our office to observe piers are bottomed in suitable material and holes are properly cleaned.

5. Very moist soil may be encountered in the basement excavation due to shallow ground water at the site. If excavations are too moist for drill rig access, 1-foot or more of 1.5 inch gravel may be placed in the excavation to stabilize soft soils.

Steel helical piers are an acceptable alternative to drilled piers for this site, and may be desirable due to shallow ground water encountered at the site. In this case, the helical pier contractor uses information from this report and loading information from the structural engineer to determine the type and size or helical pier needed for the project. These piers should be installed into bedrock. At this site, it is recommended the piers be installed into the bedrock encountered at the site with a minimum length of 16 feet and per minimum torque requirements for prescribed loads.

FOOTINGS - A suitable alternative to drilled piers is a spread footing foundation system. A spread footing foundation system bottomed on natural soil below any uncontrolled fill soils may be utilized for the structures. Removal and replacement of 3 feet of soil below shallow foundations for the duplex and garage will reduce the risk for movement for both the foundation and the slab. The structural fill should be selected and placed per the recommendations in the Site Preparation portion of this report. The detached garage may utilize spread footings or a monolithic slab with turned down edges. Basement slabs should be bottomed a minimum of 3 feet above ground water on natural soil or properly compacted structural fill. Basement footings, garage footings, or monolithic slab should be designed for a maximum allowable bearing capacity of 3000 pounds per square foot (PSF). Basement footings must have a minimum dead load requirement of 1000 PSF. For the garage, thickened edges should be turned down to a minimum depth of 30 inches and footings (if utilized) covered with a minimum of 3 feet of soil for frost protection. Spread footing foundations should be designed and constructed to meet the following criteria.

1. All footings must be supported by native soil or properly compacted structural fill. Any soils loosened by the excavation or forming process should be removed from the footing areas prior to structural fill and/or concrete. Soils in the footing excavation should not be allowed to dry excessively. Drying of the soil can increase the movement potential. The footing excavations should be observed by a geotechnical engineer to confirm subsurface conditions.

2. We recommend minimum footing widths of at least 16 inches for continuous footings, and 24 inches square for concrete pads supporting columns. Larger sized or interrupted footings may be necessary depending on structure loads.

3. Continuous foundation walls should be reinforced to span local anomalies in the subsoil. Walls should be reinforced to span an unsupported length of 10 feet. Structural steel reinforcement should satisfy the appropriate building codes and the structural design.

4. Footings must be protected from frost action. Footings should be covered with a minimum of 3 feet of soil for frost protection.

SLAB-ON-GRADE CONSTRUCTION

The soils encountered include sandy clay and claystone with a low swell potential. Movement of slabs is possible. We recommend construction of a structural floor system with a minimum 12 inch void below the floor in finished living areas if the owner is not willing to accept the risk of slab movement. A structural floor system is the only means of preventing floor movement. We do not recommend slab-on-grade construction be used in finished living areas if the owner is unwilling to accept the risk of slab movement. If the owner is willing to accept the risk of slab movement, the slabs can be constructed as "floating" slabs which are free to move in a vertical direction. The slabs should not be attached to interior or exterior bearing members. Risk for slab movement can be reduced by removal and replacement of subsoils with properly compacted structural fill, as indicated previously in this report. The following design and construction details should be used for slab-on-grade construction.

1. Slabs should be separated from exterior walls and interior bearing members. Vertical movement of the slabs should not be restricted.

2. Slab bearing partitions should be minimized. Where such partitions are necessary, a slip joint should be constructed to allow free vertical movement of the partitions. Slip joints should allow at least 2.5 inches of vertical movement.

3. Underslab plumbing should be eliminated where feasible. Where such plumbing is unavoidable it should be thoroughly pressure tested during construction.

4. Plumbing and utilities, which pass through the slab, should be isolated from the slab.

5. If a forced air heating system is used and the furnace is located on the slab, we recommend provision of a collapsible connection between the furnace and the ductwork.

The above design and construction criteria will not prevent movement, but will reduce damage if movement occurs.

LATERAL LOADS AND SUBSURFACE DRAINAGE

Below grade walls must be designed for lateral loads. For "active" conditions, the walls should be designed for an equivalent fluid pressure of 45 pounds per cubic foot (PCF). For "at rest" conditions, equivalent fluid pressures of 55 PCF should be used. These loads do not include swelling pressures, hydrostatic loads or surcharge loads such as sloping backfill or vehicles. Expansive soil should not be used for backfill. In the basement of the structure, a foundation drain should be installed as presented on Figures 7 and 8. The foundation drain will reduce the risk of "wet basement" conditions and the buildup of hydrostatic pressures. The foundation drain should lead to a positive gravity outlet or a sump where water can be removed by pumping. A vapor barrier above the structural fill or soil layer is recommended due to very moist to wet underlying soils.

SURFACE DRAINAGE

The risk for wetting of foundation soils can be reduced by carefully planned and maintained surface drainage. The following precautions should be observed during construction and be maintained at all times after the structure(s) are completed.

1. Excessive wetting or drying of open foundation excavations should be avoided as much as possible during construction.

2. Backfill adjacent to foundation walls should be moistened and compacted. Any settlement of backfill after completion of the structure should be repaired and positive drainage reestablished.

3. The ground surface surrounding the structure should be sloped to drain away from the structure in all directions. A minimum slope of 12 inches in the first 10 feet should be achieved and maintained after construction.

4. Roof downspouts and drains for the structure should discharge to the surface well beyond the limits of all backfill. Irrigated landscaping should not be placed within 10 feet of the foundation walls.

5. Plastic membranes should not be used to cover the ground surface immediately surrounding the structure. These membranes trap moisture and prevent normal evaporation from occurring. Geotextile fabrics are a suitable option to control weed growth and allow some evaporation.

LIMITATIONS

Although the borings were located to obtain a reasonably accurate determination of foundation conditions, variations in the subsoil conditions are possible. If subsurface conditions or the proposed construction differs from those described herein, we should be notified. Excavations should be observed by a representative of our office. The cost of construction observations is not included in this investigation and is billed separately per the service agreement/proposal. An environmental assessment of the site is outside our scope of work for this project.

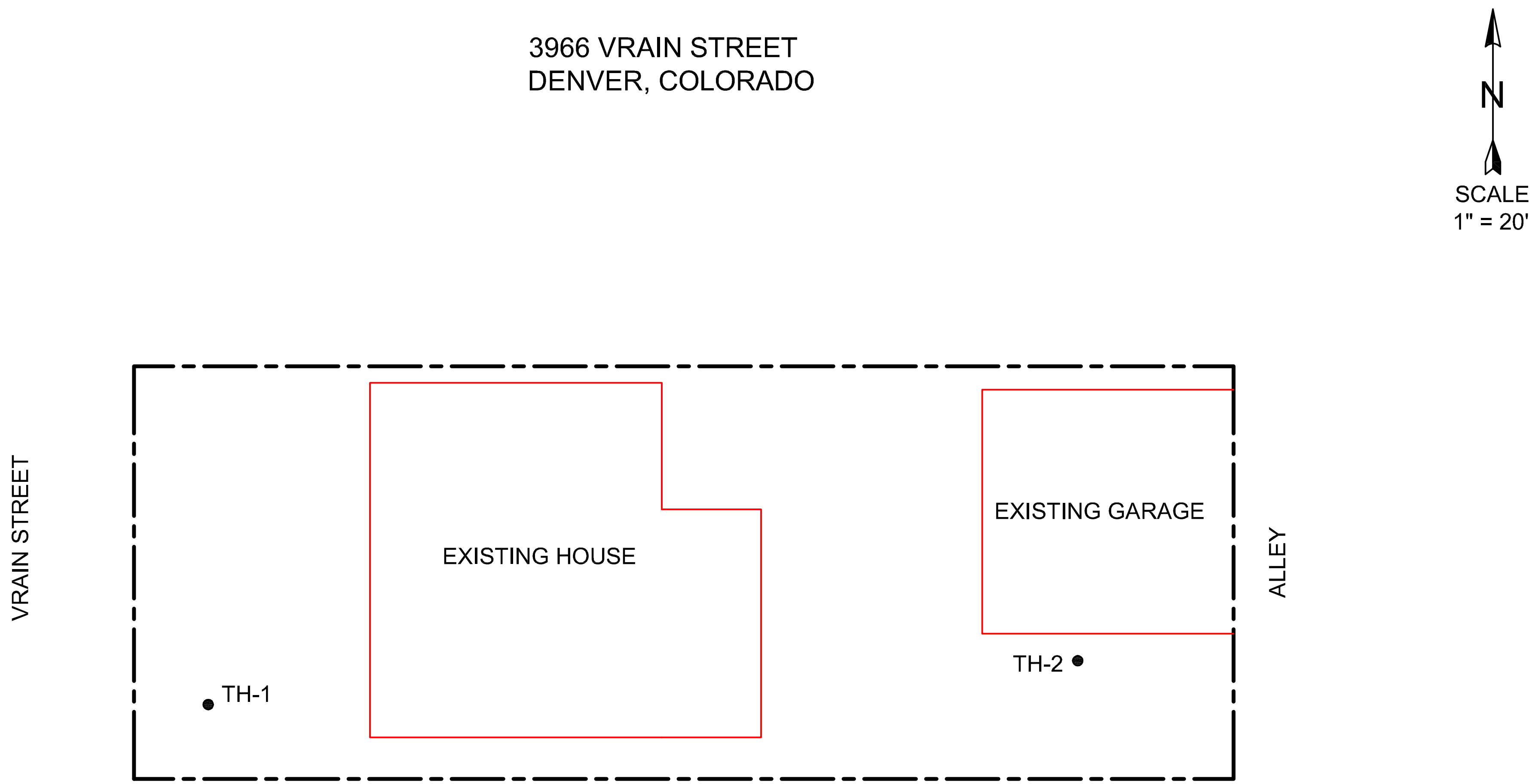
If we can be of further service in discussing the contents of this report, or in the analysis of the influence of subsurface conditions on the design of the structures, please call.

Sincerely,

Kordziel Engineering, Inc.

Joseph C. Kordziel, P.E.
3 copies sent

3966 VRAIN STREET
DENVER, COLORADO



NOTE: HOUSE AND GARAGE TO BE REMOVED AND REPLACED WITH DUPLEX AND NEW GARAGE

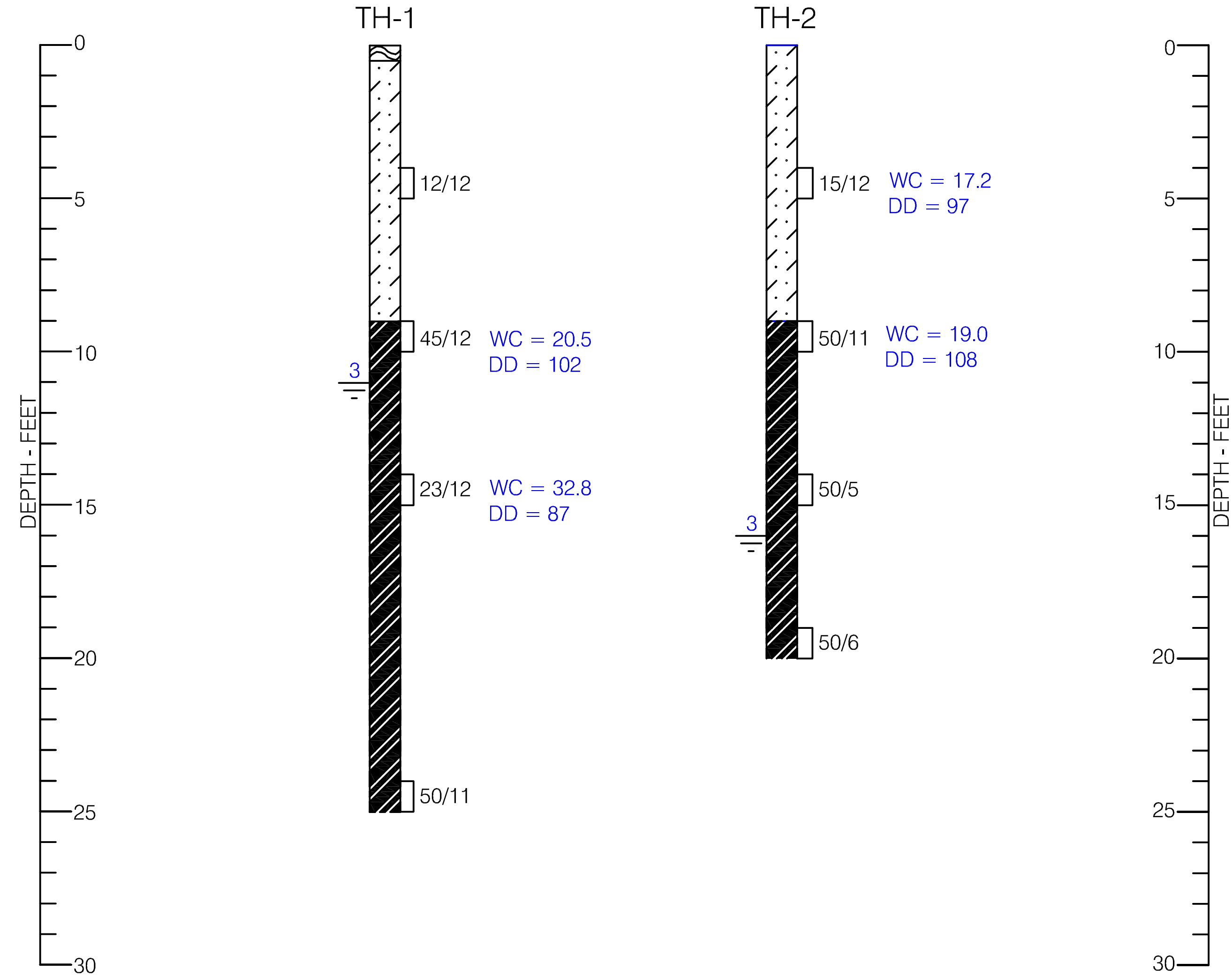
KORDZIEL ENGINEERING, INC.

SCALE: 1" = 20'
DATE: 10-12-10
REV. DATE:
DES. BY: JCK
DRAWN BY: JCK

SITE PLAN AND LOCATION OF EXPLORATORY BORINGS

PROJECT NO. 1090

FIGURE 1



EXPLANATIONS:

SOD/ROOT ZONE

CLAY, SANDY, STIFF, MOIST, BROWN WITH CALCAREOUS DEPOSITS (CL)

CLAYSTONE BEDROCK, SANDY WITH SANDSTONE LENSES, MEDIUM HARD TO VERY HARD, VERY MOIST, LIGHT BROWN TO GRAY

12/12 INDICATES THAT 12 BLOWS OF A 140 POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5 INCH O.D. SAMPLER 12 INCHES

3 INDICATES DEPTH TO FREE WATER AND THE NUMBER OF DAYS AFTER DRILLING THE MEASUREMENT WAS TAKEN

NOTES:
1. THE EXPLORATORY BORINGS WERE DRILLED ON 10-4-10 USING A 4-INCH DIAMETER CONTINUOUS FLIGHT AUGER POWERED BY A CME 45 DRILLING RIG.
2. NO FREE WATER WAS ENCOUNTERED AT THE TIME OF DRILLING. THE BORINGS WERE CHECKED 3 DAYS AFTER DRILLING AND FREE WATER WAS MEASURED AT 11 FEET IN TH-1 AND AT 16 FEET IN TH-2.
3. WC = WATER CONTENT(%) DD = DRY DENSITY (PCF)
   -200 = PERCENT OF FINES PASSING THE NUMBER 200 SIEVE.

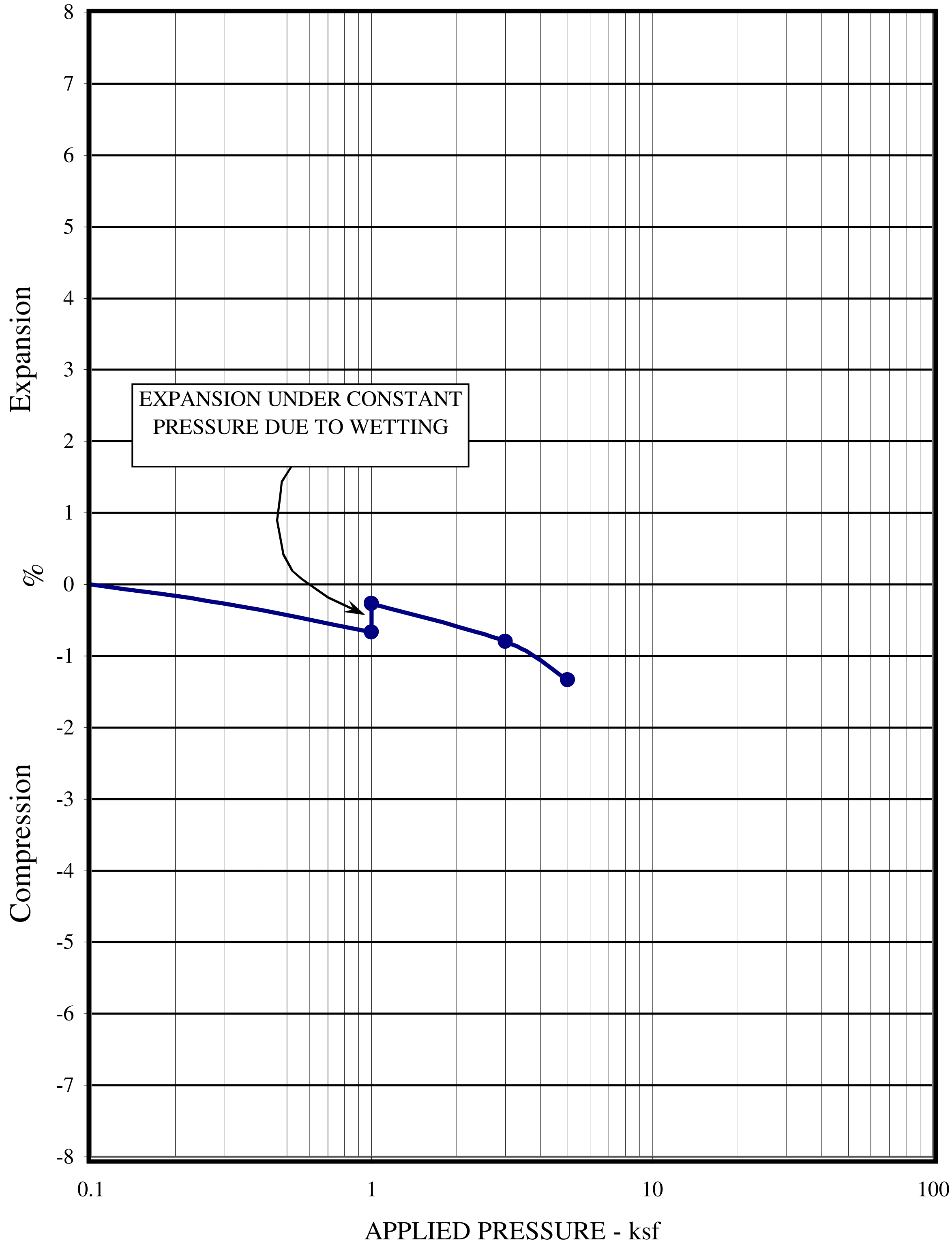
KORDZIEL ENGINEERING, INC.

SCALE: NTS
DATE: 10-12-10
REV. DATE:
DES. BY: JCK
DRAWN BY: JCK

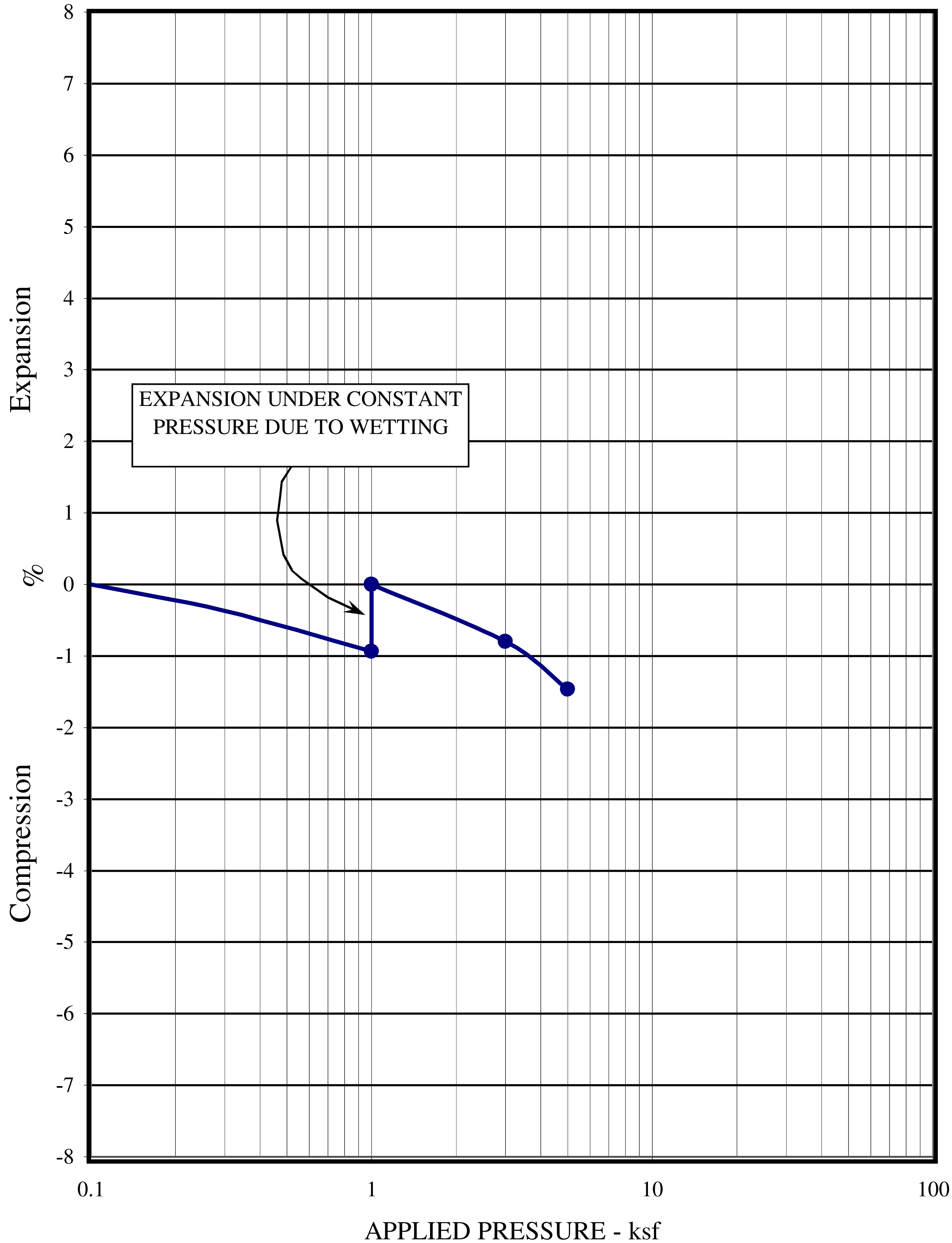
LOGS OF EXPLORATORY BORINGS

PROJECT NO. 1090

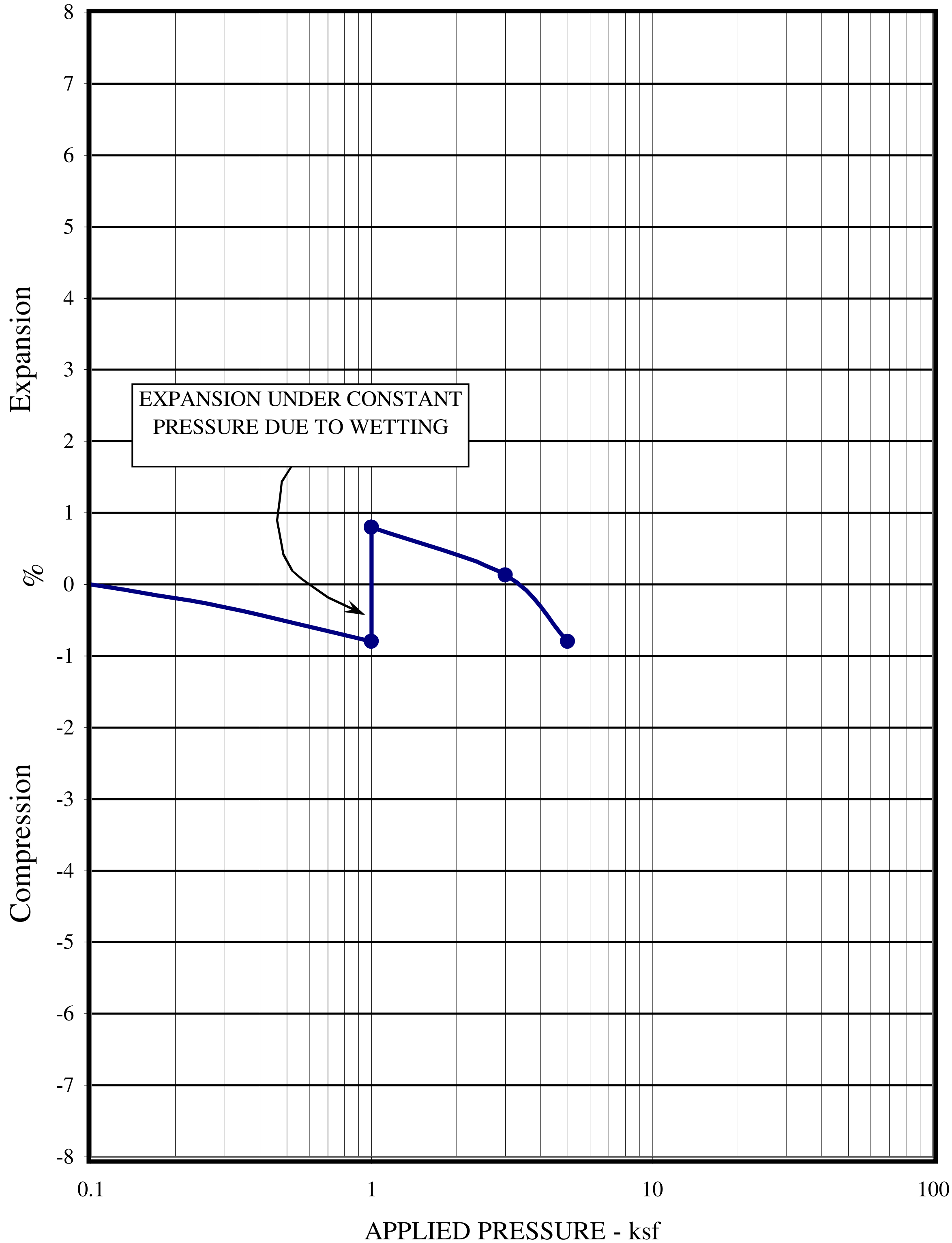
FIGURE 2



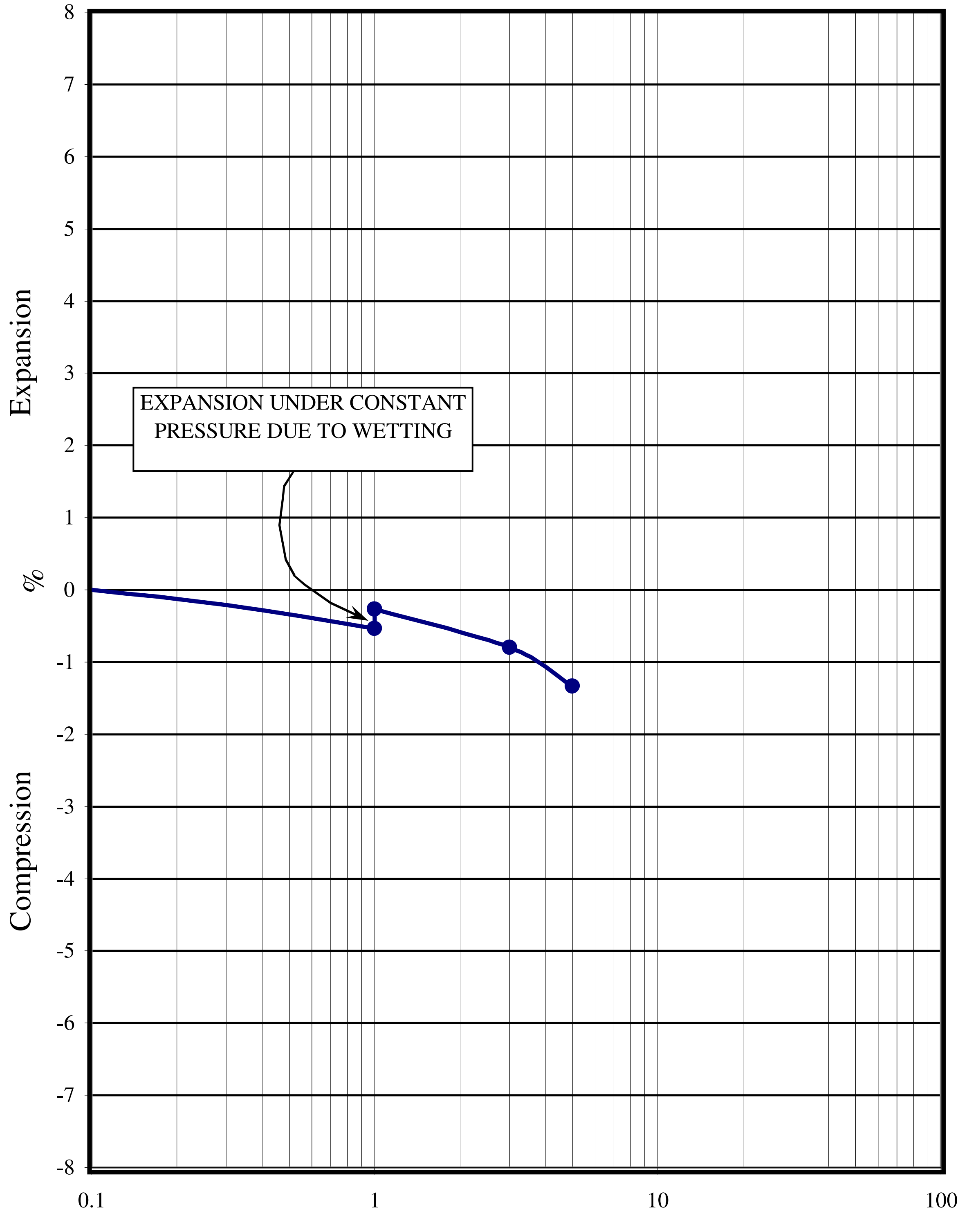
Sample of sandy claystone from TH-1 @ 9'
Natural Dry Unit Weight = 102 PCF
Natural Moisture Content = 20.5%



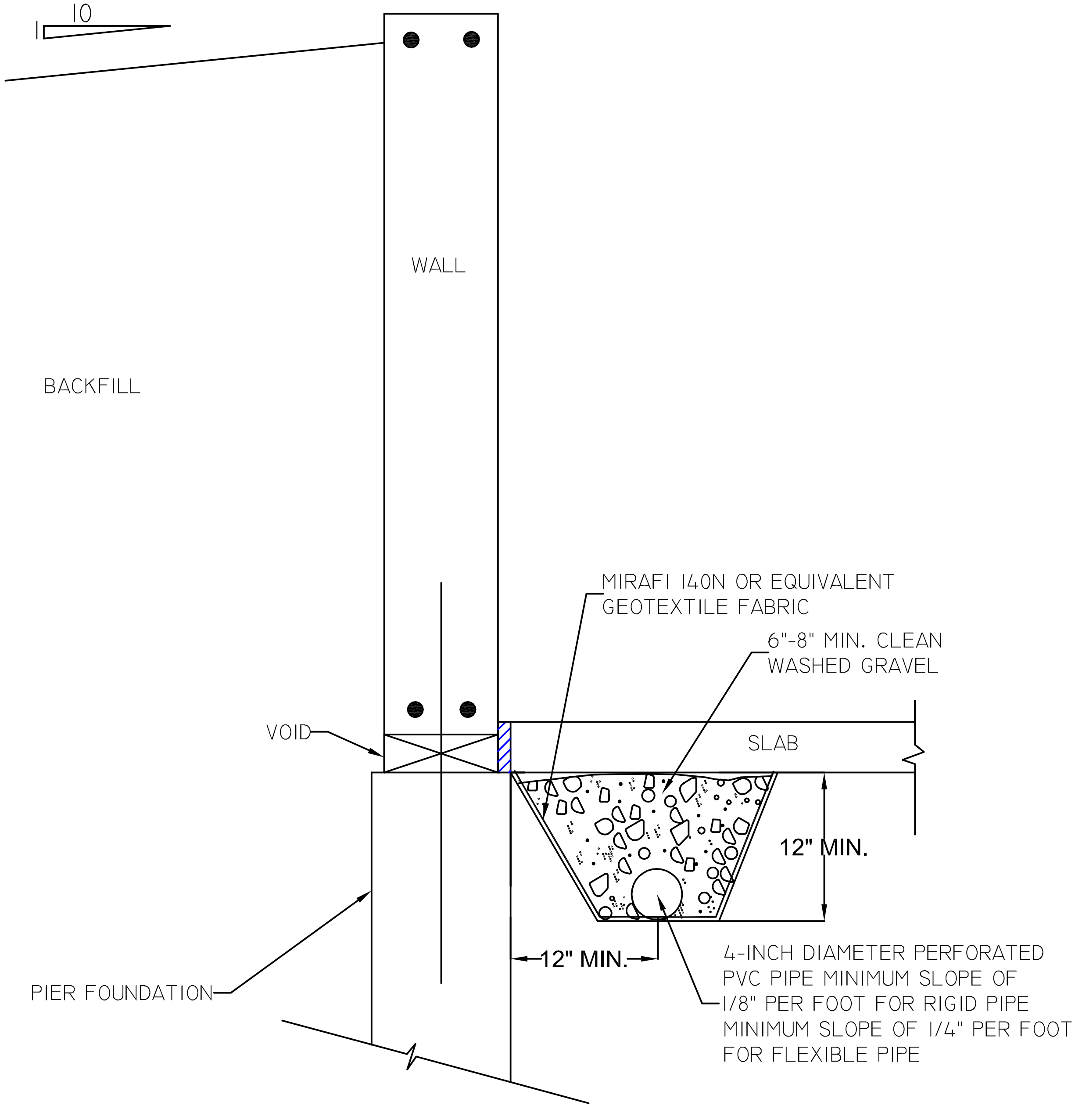
Sample of sandy claystone from TH-1 @ 14'
Natural Dry Unit Weight = 87 PCF
Natural Moisture Content = 32.8%



Sample of sandy clay from TH-2 @ 4'
Natural Dry Unit Weight = 97 PCF
Natural Moisture Content = 17.2%



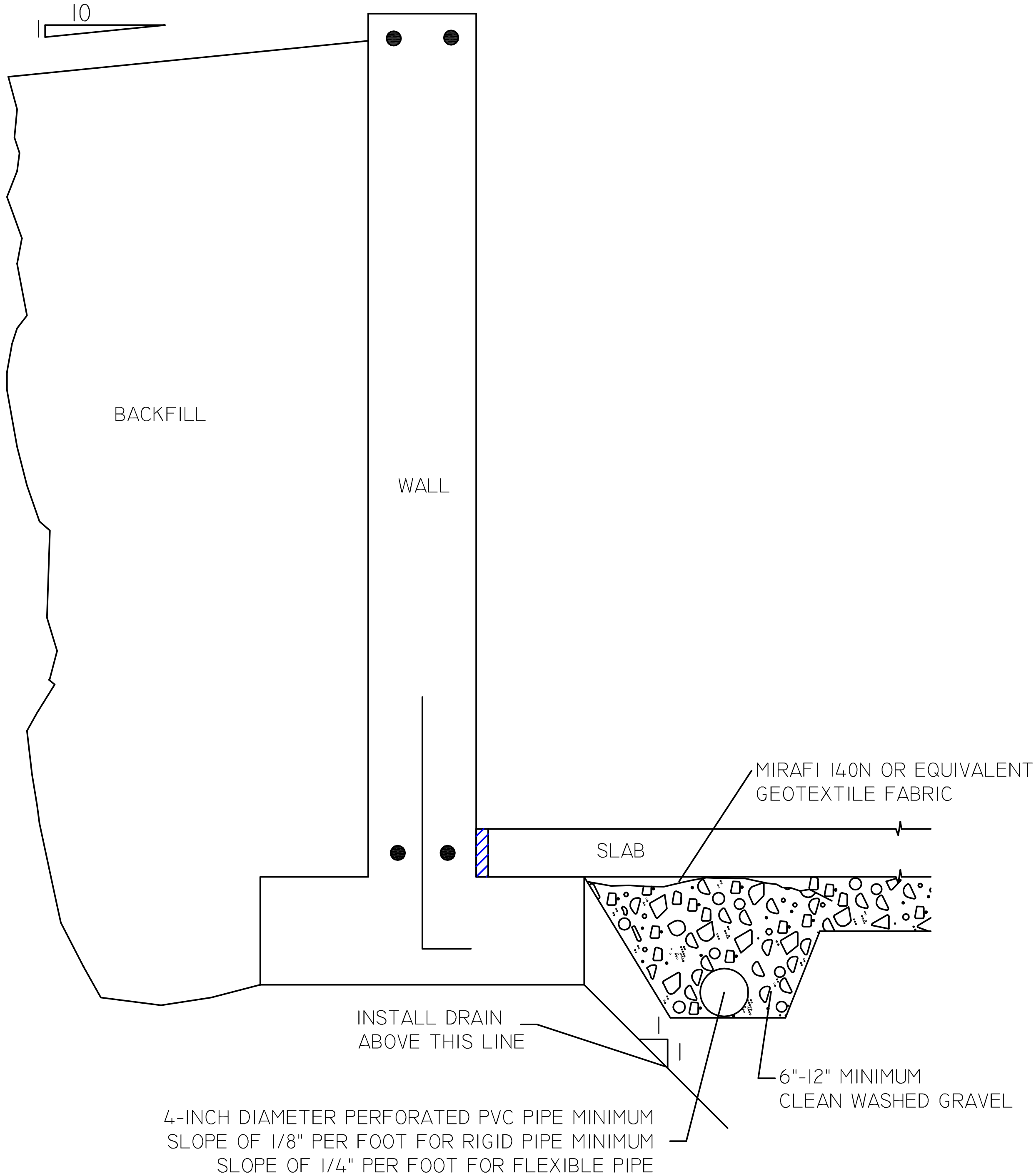
Sample of sandy claystone from TH-2 @ 9'
Natural Dry Unit Weight = 108 PCF
Natural Moisture Content = 19.0%



NOTES:

1. DRAIN PIPE SHOULD LEAD TO SUMP OR POSITIVE GRAVITY DISCHARGE.
2. LINE DRAINAGE TRENCH WITH MIRAFI 140N OR EQUIVALENT GEOTEXTILE FABRIC IN SANDY OR SILTY SOILS.
3. BOTTOM OF DRAIN SHOULD BE A MINIMUM OF 12 INCHES BELOW TOP OF SLAB AT HIGH POINT.
4. GRAVEL SPECIFICATIONS: CLEAN WASHED GRAVEL, 100 % PASSING 1.5", 60-100% RETAINED #4, <3% PASSING #200

KORDZIEL ENGINEERING, INC.	SCALE: NTS DATE: 10-12-10 REV. DATE: DES. BY: JCK DRAWN BY: JCK	TYPICAL INTERIOR BASEMENT WALL DRAIN PROJECT NO. 1090 FIGURE 7



NOTES:

1. DRAIN PIPE SHOULD LEAD TO SUMP OR POSITIVE GRAVITY DISCHARGE.
2. COVER GRAVEL COMPLETELY WITH GEOTEXTILE IN SANDY OR SILTY SOILS.
3. BOTTOM OF DRAIN SHOULD BE A MINIMUM OF 12 INCHES BELOW TOP OF SLAB AT HIGH POINT.
4. GRAVEL SPECIFICATIONS: CLEAN WASHED GRAVEL, 100% PASSING 1.5", 60-100% RETAINED #4, <3% PASSING #200

KORDZIEL
ENGINEERING, INC.

SCALE: NTS
DATE: 10-12-10
REV. DATE:
DES. BY: JCK
DRAWN BY: JCK

TYPICAL INTERIOR BASEMENT WALL DRAIN

PROJECT NO. 1090

FIGURE 8