AGEC
Applied GeoTech

GEOTECHNICAL INVESTIGATION

BELLA SOL SUBDIVISION, PHASES 2-7

SANTA CLARA, UTAH

PREPARED FOR:

BELLA SOL DEVELOPMENT, LLC
299 SOUTH MAIN STREET, SUITE 2250
SALT LAKE CITY, UTAH 84111

ATTENTION: ROBERT SMITH

PROJECT NO. 2130401

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SUMMARY

1. The subsurface profile observed within the borings drilled at the site generally consists of silty sand and interbedded layers of clayey sand overlying expansive mudstone bedrock to the maximum depth investigated, approximately 30½ feet. The expansive mudstone bedrock was encountered in at depths ranging from 8½ to greater than 30½ feet below existing grade. Following the proposed grading, the depth to mudstone ranges in depth from approximately 10½ to great than 33½ feet.

2. Subsurface water was encountered within all the borings at depths ranging from approximately 6 to 16 feet below the existing ground surface. Fluctuations in the groundwater level may occur over time. An evaluation of such fluctuations is beyond the scope of this report. We anticipate that groundwater exists in a perched condition on top of the underlying mudstone bedrock due to infiltration of surface water related to the drainages and nearby developments.

3. The on-site soils in their existing condition are not suitable to support the proposed construction. The site is suitable for the proposed construction provided recommendations within this report are followed.

4. Laboratory tests, observations and our experience in the area indicate the near surface sand on the site is relatively loose, dry and potentially collapsible are generally moderately collapsible (moisture-sensitive) when wetted under a constant pressure of approximately 1,000 psf. The loose/dry zone varies from on the order of 1 to 2 feet thick.

5. In order to address concerns for post construction settlement of the proposed residences due to the near surface potentially collapsible soils, we recommend the building pads be properly prepared. Subsequent to grubbing, the exposed subgrade beneath building areas should be overexcavated at least 2 feet below the existing grade or 2 feet below final grades, which ever is greater. Prior to placing site grading fill, the exposed subgrade should be scarified to a depth of at least 8 inches moisture condition and compacted to meet the recommendations in the Compaction section of this report.

6. Groundwater was encountered throughout the proposed development. Portions of the site contained shallow groundwater. In areas where shallow groundwater is present, we anticipate that loose and unstable soil conditions will exist in this area. If an unstable subgrade is observed during grading, stabilization of the subgrade may be accomplished using geogrid and crushed aggregate as provided in the Subgrade Stabilization section of this report.

7. We anticipate excavation and compaction of the on-site soils may be accomplished with typical excavation equipment. If soft soil conditions/instability due to high moisture content are encountered, pumping conditions may be reduced by accomplishing as much grading as possible using track mounted equipment. Track mounted equipment may consist of a track mounted excavator with a smooth blade attached to the bucket or a small wide tracked dozer.

Rubber tired equipment or other compaction equipment (sheepsfoot roller or steel drum roller) will still be required to achieve compaction after sufficient fill is placed on top of a "stabilized" subgrade.

8. The proposed residences may be supported on conventional spread footings bearing on properly compacted structural fill underlain by a properly prepared subgrade as recommended in the Subgrade Preparation section of this report.

   As a minimum, in areas where groundwater exists over the mudstone, we recommend a minimum of 15 feet of separation is to be maintained below pad grade and the underlying mudstone. If groundwater doesn't exist perched over the mudstone, this separation should be increased to 17 feet.

9. Due to the presence of relatively shallow groundwater and the underlying expansive mudstone, the construction of pools or below grade structures will require additional evaluation and possibly additional exploration. These items should not be allowed without further consultation.

10. Detailed recommendations for subgrade preparation, materials, foundations, and drainage are included in the report.

11. The information provided in this summary should not be used independent of that provided within the body of this report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed Bella Sol Subdivision, Phases 2 through 7 to be located in Santa Clara, Utah, as shown in Figure 1. This report presents the subsurface conditions encountered, laboratory test results, and recommendations for the project.

Field exploration was conducted to obtain information on the subsurface conditions and to obtain samples for laboratory testing. Information obtained from the field and laboratory was used to define conditions at the site and to develop recommendations for the proposed development.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

REFERENCED REPORTS

The following reports were referenced as part of this investigation.

1. "Preliminary Geotechnical Investigation, Knoll Pasture Area", prepared by AGEC, Inc., project No. 2021116, dated November 18, 2002.

2. "Geotechnical Investigation, Sugar Plum at Santa Clara Heights, Phase 1", prepared by AGEC, Inc., project No. 2120851, dated August 8, 2012.

3. "Geotechnical Investigation, Sugar Plum at Santa Clara Heights, Phase 1(revised)", prepared by AGEC, Inc., project No. 2120907, dated September 18, 2012.

SITE CONDITIONS

The subject site consists of approximately 21 acres of undeveloped property. The property is bounded on the north by residential development, on the west by Rachel Drive and by Phase 1 of the Bella Sol subdivision to the south. The Tuachan wash, which traverses the site from the north to the south, bounds the property on the east. Vegetation at the site consists of desert brush and weeds. The general slope of the property is down from the northwest to the southeast towards the Tuachan wash.

FIELD STUDY

On May 22, 23, and 28 of 2013, and on August 20 of 2013, an engineer from AGEC visited the site and observed the excavation of 21 borings at the approximate locations shown on the Site Plan, Figure 2. The borings were drilled with utilizing a truck mount drilled rig equipped with 8-inch hollow stem augers. The subsurface soil profile was logged and soil samples were obtained at this time for laboratory testing.

SUBSURFACE SOIL CONDITIONS

The subsurface profile observed within the borings drilled at the site generally consists of silty sand and interbedded layers of clayey sand overlying expansive mudstone bedrock to the maximum depth investigated, approximately 30½ feet. The expansive mudstone bedrock was encountered in at depths ranging from 8½ to greater than 30½ feet below existing grade. Following the proposed grading, the depth to mudstone ranges in depth from approximately 10½ to greater than 33½ feet.

Detailed descriptions of the soil and bedrock types encountered follow.

Fill - The fill consists of silty sand interbedded with clayey sand. It is poorly compacted, moist, fine-grained, and red in color.

Laboratory tests conducted on samples of the fill indicate an in-place moisture content ranging from 3 to18 percent, in-place dry densities ranging from 93 to 113 pounds per cubic foot (pcf), and fines contents (percent passing the No. 200 sieve) ranging from 35 to 96 percent.

A One-dimensional consolidation/collapse test conducted on a sample of the fill indicates that the material is moderately moisture sensitive (collapsible) when wetted under a constant pressure of approximately 1,000 psf and moderately compressible under additional loading. A collapse potential of approximately 4 percent was measured.

Silty sand - The silty sand is loose to dense, moist (near surface) to wet, fine-grained, low plastic, and red in color.

Laboratory tests conducted on samples of the silty sand indicate in-place moisture contents ranging from 3 to 14 percent, in-place dry densities ranging from 104 to 110 pcf, and fines contents ranging from 16 to 41percent.

One-dimensional consolidation/collapse tests conducted on samples of the silty sand indicates the material is slightly to moderately moisture sensitive (collapsible) when wetted under a constant pressure of approximately 1,000 psf and slightly compressible under additional loading. A collapse potential ranging from approximately 0.04 to 4.15 percent were measured.

Clayey sand - The clayey sand is loose to dense, moist to wet, fine to medium-grained, low plastic, and dark red to brown in color.

Laboratory tests conducted on samples of the clayey sand indicate in-place moisture contents ranging from 12 to 13 percent, in-place dry densities ranging from 111 to 118 pcf, and fines contents ranging from 68 to 79 percent. Atterberg limits tests conducted on sample of the clayey sand indicate a liquid limit of ranging from 21 to 26 percent and plasticity indexes ranging from 7 to 10 percent.

One-dimensional consolidation/collapse tests conducted on samples of the clayey sand indicates that the material is slightly moisture sensitive (collapsible) when wetted under a constant pressure of approximately 1,000 psf and slightly compressible under additional loading. A collapse potential ranging from approximately 0.04 to 0.16 percent were measured.

Mudstone bedrock - The mudstone bedrock is soft, moist, high plastic, and purple in color.

Laboratory tests conducted on samples of the mudstone bedrock indicate in-place moisture contents ranging from 8 to 26 percent, in-place dry densities ranging from 91 to 117 pcf, and fines contents ranging from 68 to 79 percent. Atterberg limits tests conducted on samples of the mudstone bedrock indicate the mudstone is highly plastic with liquid limits ranging from 39 to 66 percent and plasticity indexes ranging from 21 to 42 percent.

One-dimensional consolidation/swell tests conducted on samples of the mudstone bedrock indicates the material is slightly to highly expansive when wetted under a constant pressure of approximately 1,000 psf. Swell potentials ranging from approximately 0.22 to 3.21 percent were measured.

The Logs of Exploratory Borings are shown on Figures 3-6 with the Legend and Notes of Exploratory Borings shown on Figure 7. Results of the laboratory tests are also shown on Figures 3 through 6 and are summarized in the Summary of Laboratory Test Results, Table 1. The consolidation/collapse/swell test results are shown graphically on Figures 8-22.

SUBSURFACE WATER

Subsurface water was encountered within the majority of the borings at depths ranging from approximately 6 to 16 feet below the existing ground surface. Several of the borings in Phase 7 along the northern portion of the site, where the mudstone was shallow did not encounter groundwater. Fluctuations in the groundwater level may occur over time. An evaluation of such fluctuations is beyond the scope of this report. We anticipate that groundwater exists in a perched condition on top of the underlying mudstone bedrock due to infiltration of surface water related to the drainages and nearby developments.

PROPOSED CONSTRUCTION

We understand it is proposed to develop Phases 2-7 into 91 lots. Based on the existing topography and the proposed grading plan, we anticipate grading will require cut on the order of 1 to 7 feet and fills up to approximately 15 feet deep. The site will likely require import material from off-site. Portions of the pads have been recently graded.

We understand it is proposed to construct single-family, slab on grade residences on the subject lots which will typically consist of single and multi-story construction. We anticipate the residences will be constructed using conventional spread footings with slab-on-grade floors. The residences will likely be constructed with wood framing, stucco or rock veneer, and tile roofs. For design purposes, we have assumed wall loads of up to 2 kips per linear foot and column loads to 30 kips. As part of the development, we understand that roadways, utilities and city improvements will also be included.

Due to the presence of relatively shallow groundwater and the underlying expansive mudstone, we do not recommend construction of pools or below grade structures without further evaluation and specific recommendations for each below grade structure.

We understand the interior roadways will have 34 foot right of ways. North Town Road will be 40 foot right-of-way. For design purposes, we have utilized a traffic index of 5 for the 40 foot right-of-ways and a traffic index of 7 for the 80 foot right-of-way in accordance with the Santa Clara City standards.

If the proposed construction, or building loads are significantly different from those listed, we should be notified so that we can reevaluate our recommendations.

RECOMMENDATIONS

Based on our experience in the area, the subsurface conditions encountered, laboratory test results, and the proposed construction, the following recommendations are given:

A. Site Grading

Based on the subsurface conditions and proposed grading provided by Rosenberg Associates, the following recommendations are provided:

1. Subgrade Preparation

   a. *General Subgrade Preparation*

   Prior to placing fill or concrete, existing vegetation and soil containing significant roots and organics should be removed. We anticipate this will require the removal of on the order of 2 to 6 inches of soil across the site. The soil may be stockpiled for use in landscaped areas.

b. *Building Pads*

Subsequent to grubbing and prior to placing fill or concrete, the exposed subgrade beneath building areas should be overexcavated at least 2 feet below the existing grade or 2 feet below pad grade, whichever is greater, to address concerns for post construction settlement of the proposed residences due to the near surface potentially collapsible soils.

Relatively shallow groundwater was encountered throughout the development. Due to the presence of the shallow groundwater, we anticipate that loose and unstable soil conditions will exist in this area. If an unstable subgrade is observed during proof rolling, stabilization of the subgrade should be accomplished using geogrid and crushed aggregate as provided in the Subgrade Stabilization section of this report.

The limits of overexcavation should extend at least 5 feet beyond the perimeter of the proposed construction. Subsequent to overexcavation and prior to placing fill, the exposed subgrade should be scarified to a depth of 8 inches, moisture condition and properly compacted. The removed material may then be replaced in properly moisture conditioned and compacted lifts.

Additional overexcavation may be necessary for lots in the north central portion of Phase 7 due to expansive clay. Recommendations are provided in the Foundations section of this report.

d. *Pavement, flatwork and improvements*

Prior to constructing improvements (roadways, flatwork, block walls, etc), the exposed subgrade should be properly prepared by overexcavating at least 1 foot below the existing grade. Subsequent to overexcavation and prior to placing fill, the exposed subgrade should be scarified to a depth of 8 inches, moisture condition and properly compacted. The removed material may then be replaced in properly moisture conditioned and compacted lifts. Overexcavation is not necessary in the area mapped as containing shallow groundwater on Figure 2.

2. Subgrade Stabilization

The subgrade should be stabilized by placement of biaxial geogrid (TENSAR BX1200 or TX160) on the exposed subgrade below fill areas following removal of soft, disturbed or rutted soil to assist in obtaining compaction during fill placement above the soft subgrade. The geogrid should be placed on a smooth, level surface. This should be accomplished by cutting the subgrade with a trackhoe bucket with a smooth blade, preferably from outside or "in front of" the excavation. The geogrid should be rolled and stretched taught/free of wrinkles. The layers of geogrid should be overlapped at least 2 feet. The layers should be "zip-tied" together to reduce movement. The geogrid should be secured in place with wood stakes or piles of gravel so as to prevent wrinkles. The stakes may be left in-place and buried with the gravel/base course.

We recommend placing on the order of 18 to 24 inches of angular gravel and/or compacted (angular) base course over the geogrid in soft areas to assist in stabilizing the subgrade. Gravel is the preferred aggregate if groundwater is shallow. The gravel and base course layers should each be placed in one pre-moisture conditioned (base course) lift and spread over the geogrid with track mounted equipment. We recommend spreading the gravel by pushing the material in front of the equipment (wide tracked dozer or trackhoe) so the equipment is being supported on top of the full thickness of gravel.

After the full thickness of the gravel or base course layer are placed, each material should be compacted with a steel drum roller (gravel) or rubber tired equipment (base course). A rolling pattern should be established to determine the minimum number of passes which are required to achieve compaction. If excessively soft areas are exposed, a separation layer of geosynthetic, such as Mirafi 600X, may be necessary below the geogrid. If excessively soft soil conditions are encountered, a representative of AGEC should be notified to provide guidance in the field for the appropriate stabilization process.

3. <u>Excavation</u>

We anticipate excavation and compaction of the on-site soils may be accomplished with typical excavation equipment.

Soil instability due to high moisture conditions may be reduced by accomplishing as much grading as possible using track mounted equipment. Track mounted equipment may consist of a track mounted excavator with a large smooth blade attached to the bucket or a small wide tracked dozer. If soft or wet areas are encountered, excavation with rubber tired equipment should be terminated. An engineer from AGEC should be contacted to observe the conditions and provide guidance during excavation.

Rubber tired equipment or other compaction equipment (sheepsfoot roller or steel drum roller) will still be required to achieve compaction if fill is placed on top of a relatively stable or "stabilized" subgrade using the method previously described.

4. Grading Slopes and Trenches

Excavations which extend below the groundwater level should be filled with clean, free-draining gravel to at least 1 foot above the highest anticipated groundwater level. Filter fabric (Mirafi 160 N or equivalent) should be placed over the gravel prior to placing backfill.

Permanent cut slopes excavated into the overburden soils should be cut no steeper than 2:1 (horizontal to vertical). Unretained fill slopes constructed with properly compacted on-site soil should be graded no steeper than 2½:1 (horizontal to vertical). Slopes should include benches in accordance with the 2009 IBC. The granular fill slopes will be highly susceptible to erosion. To reduce erosion, the fill slopes may be flattened to 3:1 (horizontal to vertical) or they may be retained. Fill slopes may also be protected from erosion with an appropriate geotextile or riprap underlain with filter fabric. More detailed recommendations for riprap erosion control can be provided if requested.

Fill slopes should be graded by overbuilding and then cutting them back to the desired grade to provide a compacted slope face. Fill placed on existing slopes steeper than 3:1 (horizontal to vertical) should be placed using a benching procedure to "key" the fill into the existing slope. Benches should be of sufficient width to allow adequate area for the compaction equipment.

Utility trenches excavated in the on-site soils above the groundwater level should be excavated in accordance with OSHA requirements using a OSHA Soil Class C (1½:1 Horizontal:Vertical). Steeper trenches or trenches below the groundwater level will likely require the use of shoring or a trench box to provide as safe work environment.

Based on the water levels measured in the borings, the water level may need to be lowered to place utilities. The actual quantity of water required to dewater the excavations may vary significantly due to variations soil conditions and the length of time which dewatering is conducted. A pump test could be conducted to better estimate dewatering quantities. Dewatering methods will depend on contractor preference, but may consist of well points, secondary trenches, or sump holes.

5. Materials

Import materials should be non-expansive, non-gypsiferous, granular soil and should be approved by AGEC prior to use at the site. Listed below are the materials recommended for imported fill.

Area	Fill Type	Recommendations
Foundations/slabs	Site grading/ structural fill	**-200** <35%, **LL** <30% Maximum size: 4 inches Solubility < 1%
Underslab/Pavement/ Flatwork/Stabilization	Base course	4≤**-200** ≤12%; Solubility < 1% Maximum aggregate size: ¾ inch **CBR**≥50% (for paved areas)

-200 = Percent Passing the No. 200 Sieve
LL = Liquid Limit

The on-site sand, free of organics, debris and material greater than 6 inches in size, is suitable for use as site grading fill, structural fill, wall backfill and utility trench backfill. The on-site clay and mudstone may be used as utility trench back fill or site grading fill in non-structural areas.

6. Compaction

Compaction of materials placed at the site should equal or exceed the following minimum densities when compared to the maximum dry density as determined by ASTM D-1557:

Area	Percent Compaction
Subgrade	90
Footings/building pad	95
Site grading	95
Utility trenches	95
Utility trenches - Pipezone	90
Wall backfill	95
Roadway subgrade	90
Roadway fill	95
Base course	95

To facilitate the compaction process, the fill should be moisture conditioned to within 2 percentage points of the optimum moisture content as determined by ASTM D-1557 prior to placement. Fill should be placed in loose lift thicknesses which do not exceed the capacity of the equipment being utilized. Generally, 6 to 8-inch loose lifts are adequate. Lift thicknesses should be reduced to 4-inches for hand compaction equipment.

7. <u>Drainage</u>

Drainage of surface water away from the buildings should be maintained through the course of construction and during the lives of the structures. In no case should water be allowed to accumulate and pond adjacent to foundations. We recommend a minimum slope of 6 inches in the first 10 feet away from the perimeter of the structures. Proper drainage will be critical in areas where moisture sensitive (collapsible) soil is present, but not removed beneath site improvements.

Roof drains should be utilized as needed and roof downspouts should discharge out away from foundations or on to hard surfaces to decrease potential for infiltration of water into the underlying soils.

We also recommend that desert landscaping, which requires little to no water, be used adjacent to foundations and masonry walls or other cement containing elements to reduce salt migration and the subsequent salt weathering and sulfate attack on cement containing elements. Further, the below grade portions of walls/fences which are backfilled with soil should be protected with an impermeable membrane. A gravel covered, perforated PVC pipe should also be placed at the base of the wall to carry water to a discharge point. This is intended to reduce the potential for salt weathering and sulfate attack on concrete/masonry.

B. Foundations

Based on our subsurface investigation, engineering analysis and proposed finished pad grades provided by Rosenberg Associates, the expansive mudstone will be present at approximately 10 ½ to greater than 30½ feet below the proposed finished grade. Due to the presence of the underlying potentially expansive mudstone bedrock, AGEC conducted analysis to estimate the potential surface heave. The following table summarizes the estimated potential surface heave and corresponding depths are to the expansive mudstone from the ground surface:

Depth to Expansive Bedrock Below Finished Grade (feet)	Estimated Potential Differential Surface Heave Estimate (inches)*
15	< ¾ to 1"
17	½ to ¾"
20	< ½"

* The heave estimates assume that groundwater exists perched over the mudstone. If groundwater does not exist perched on the mudstone, the estimates should be increased.

The heave estimates assume slab-on-grade construction without a below grade structure. If experienced, differential heave will likely result in cosmetic distress and potential structural damage. Our experience has shown that differential upward foundation movement of approximately ½ or greater of an inch will likely result in cosmetic distress to building.

Cosmetic distress would likely include potential drywall cracking, cracking of tile/concrete slabs, doors/windows becoming out of square and cracking/distress to exterior finishes, etc. Heave amounts greater than 1 inch may result in structural damage. As a minimum, we recommend the at least 15 feet and preferably 17 feet of non-expansive overburden soil over the mudstone. Based on the analysis by AGEC, the proposed slab on grade residences may be supported on conventional spread footings bearing on compacted structural fill underlain by a properly prepared subgrade as recommended in the Subgrade Preparation section of this report.

Recommendations for design of conventional spread footing are provide below.

1. <u>Bearing Material</u>

   The proposed residences may be supported on conventional spread footings bearing on properly compacted structural fill underlain by a properly prepared subgrade. The subgrade should be prepared during site grading by overexcavating and compacting the entire building pad as recommended in the Subgrade Preparation section of this report.

   As a minimum, we recommend at least 1 foot of properly compacted structural fill below foundations to properly support the proposed residences.

2. <u>Bearing Pressure</u>

   Footings bearing on properly compacted structural fill may be designed for a net allowable bearing pressure of 2,000 psf.

3. Footing Width and Embedment

Footings should have a minimum width of 18 inches and should be embedded at least 12 inches below the lowest adjacent grade.

4. Temporary Loading Conditions

The allowable bearing pressures may be increased by one-half for temporary loading conditions such as wind or seismic loads.

5. Settlement

The subdivision construction will require placement of site grading fill up to approximately 15 feet above the existing grade. Placement of the fill to construct the development will induce a significant load on the underlying support soils which will result in a significant amount of settlement. Based on the subsurface conditions and engineering analysis, we estimate the settlement in the deep fill area be approximately 1 to 2½inches (depending on the fill depth) due to densification of the underlying sandy soils. We anticipate most of this settlement will occur during construction of the development. Therefore, monitoring of the settlement is not necessary.

We estimate that foundation settlement will be approximately 1 inch for footings designed as indicated above due to the load of the structure. Differential settlement is estimated to be approximately ½ inch.

6. Foundation Base

The base of all excavations should be cleared of loose or deleterious material prior to placement of fill or concrete.

C. Concrete Slab-on-Grade

1. Slab Support

Concrete slabs may be supported on a zone of properly prepared (overexcavated) and compacted fill as stated in the Subgrade Preparation section of this report. Fill placed in slab areas should be tested frequently to verify compaction meets the recommendations provided within this report.

2. Underslab Base Course

A 4-inch layer of properly compacted base course should be placed below slabs to provide a firm and consistent subgrade and promote even curing of the concrete.

3. Vapor Barrier

A vapor barrier should be placed below slabs in areas which will receive sensitive floor coverings or coverings which are impermeable. In addition, vapor barriers should also be considered beneath slabs to provide protection from sulfate attack (on the concrete slab) due to the potentially high water soluble sulfates which exist in the underlying soil.

D. **Lateral Earth Pressures**

1. Lateral Resistance for Footings

Lateral resistance for spread footings is controlled by sliding resistance developed between the footing and the subgrade soil or rock. An ultimate friction value of 0.45 may be used in design for ultimate lateral resistance of footings bearing on properly compacted structural fill (on-site sand).

2. Retaining Structures

The following equivalent fluid weights are given for design of subgrade walls and retaining structures. The active condition is where the wall moves away from the soil. The passive condition is where the wall moves into the soil and the at-rest condition is where the wall does not move. We recommend the basement walls be designed in an at-rest condition.

The values listed below assume a horizontal surface adjacent the top and bottom of the wall.

Soil Type	Active	At-Rest	Passive
On-site sand	35 pcf	55 pcf	325 pcf
Earth pressure coefficient	0.29	0.46	-

It should be recognized that the above values account for the lateral earth pressures due to the soil and level backfill conditions and do not account for hydrostatic pressures or surcharge loads.

Lateral loading should be increased to account for surcharge loading (using the appropriate earth pressure coefficient) and a rectangular distribution if structures are placed above the wall and are within a horizontal distance equal to the height of the wall. If the ground surface slopes up away from the wall, the equivalent fluid weights should also be increased.

Care should be taken to prevent percolation of surface water into the backfill material adjacent to the retaining walls. The risk of hydrostatic buildup can be reduced by placing a subdrain behind the walls consisting of free-draining gravel wrapped in a filter fabric.

3. Seismic Conditions

Under seismic conditions, the equivalent fluid weight should be modified as follows assuming a level backfill condition:

Lateral Earth Pressure Condition	Seismic Modification (2% PE in 50 yrs)
Active	10 pcf increase
At-rest	No increase
Passive	24 pcf decrease

The seismic increases and decrease assume a short period spectral response acceleration of 0.19g which represents a 2 percent probability of exceedance in a 50 year period (IBC, 2009).

E. Seismicity, Liquefaction and Faulting

1. Seismic design parameters are provided below:

Description	Seismic Parameter
	2,500 yr event (≈2% PE in 50 yrs)
2009 IBC	D
Site Latitude	37.1559°
Site Longitude	-113.6632°
PGA - Site Class B	0.19g
S_s (0.2 second period) - Site Class B	0.47g
S_1 (1 second period) - Site Class B	0.14g
F_a - Site Class Factor	1.428
F_v - Site Class Factor	2.225
F_{PGA} - Site Class Factor	1.423

2. Liquefaction

Liquefaction is a condition where a soil loses strength due to an increase in soil pore water pressures during a dynamic event such as an earthquake. Research indicates that the soil type most susceptible to liquefaction during a severe seismic event is loose, clean sand. For the sand to liquefy, it must be located beneath the groundwater level. The liquefaction potential for soil tends to decrease with an increase in fines content and density.

Based on subsurface conditions encountered in the borings, there is a low to very low risk of liquefaction of the subsurface soils (located below the groundwater level) during a seismic event. Our analysis indicates the potential liquefaction induced settlement would be less than ½ inch.

3. Faulting

Based on a review of available geologic literature, there are no mapped faults extending near or through the site.

F. **Soil Corrosion**

Based the test results associated with the referenced projects and on our experience in the area, the soils contain water soluble sulfates in sufficient concentration to be corrosive to concrete. Therefore, we recommend concrete that will be exposed to the on-site soils be designed in accordance with provisions provided in the American Concrete Institute Manual of Concrete Practice (ACI) 318 Section 4.3 and the 2009 International Building Code. Table 4.3.1 of ACI 318-08 should be referenced utilizing a Sulfate Exposure Category of S1 and a sulfate exposure Class of "moderate".

Consideration should also be given to cathodic protection of buried metal pipes. We recommend utilizing PVC pipes where local building codes allow.

G. Pavement

Based on the subsoil conditions encountered and the laboratory test results, the following recommendations are given:

1. Analysis

a. Asphaltic Concrete: The flexible pavement analysis is based on AASHTO design methods and a 20 year design life. The following parameters were considered for our analysis:

- A base course that meets Santa Clara City specifications which would correspond to a Structural Coefficient (a_2) of at least 0.12. Asphalt that provides a Structural Coefficient (a_1) of at least 0.40.

- Drainage Coefficient = 1.0.

- We anticipate the subgrade materials will consist of properly compacted sand. We have assumed CBR value of 7 percent for a silty sand subgrade. Prior to placing base course or pavement area grading fill, the subgrade should grubbed and prepared as recommended in the Subgrade Preparation section of this report. A M_R value of 10,500 psi was used for the subgrade based upon the CBR value and the relationship between CBR and Resilient Modulus (M_R).

- Serviceability Index: $P_o=4.2$, $P_t=2.5$, therefore, $\Delta PSI=1.7$.

- Reliability of 90 percent.

- Standard Deviation (S_o) = 0.45.

2. Subgrade Support

Our design assumes a properly prepared subgrade as recommended in the Subgrade Preparation section of this report. The subgrade preparation varies depending on the location on the site. Prior to placing sub-base, base course or pavement or grading fill, the subgrade should be prepared as recommended in the Subgrade Preparation section of this report.

3. Pavement Thickness

Based on the anticipated traffic, a 20 year design life, UDOT and AASHTO design methods, the following pavement sections are recommended.

	Flexible Pavement	
Area	**Asphaltic concrete (inches)**	**Base Course (inches)**
Interior Local Roads	2½	6
North Town Road	3	6

4. Pavement Materials

The pavement materials should meet AASHTO and Santa Clara City specifications for gradation and quality. The pavement thicknesses indicated above assume that the base course is a high quality material with a CBR value of 50 percent. Asphalt material should have a Marshal stability of at least 1,800 pounds.

5. Drainage

The collection and diversion of drainage away from the pavement surface is extremely important to the satisfactory performance of the pavement section. Proper drainage should be provided. We further recommend proper pavement maintenance to extend the pavement life.

H. Construction Materials Observation and Testing

A representative of AGEC should observe/test the following during grading and construction so that a final grading report may be issued upon completion of site work:

1. Verify the subgrade is properly prepared prior to placing fill.

2. Verify the overexcavation and replacement of collapsible soil and/or existing fill in areas where it is present.

3. Verify subgrade is properly stabilized in soft or unstable areas, prior to placement of site grading fill.

4. Verify structural and site grading fill materials are placed in proper lift thicknesses for the compaction equipment utilized.

5. Verify fill placed is properly moisture conditioned and compacted. A sufficient number of tests should be taken to verify compaction. We recommend testing each foot of fill placed below foundations and slabs.

6. Conduct construction materials and laboratory testing for city improvements at a frequency which meets or exceeds Santa Clara City specifications.

The recommended testing observations will be conducted by a qualified individuals in accordance with standard test methods ASTM, ICBO, etc.

I. Geotechnical Recommendation Review

The client should familiarize themselves with the information contained in this letter. If specific questions arise or if the client does not fully understand the conclusions/recommendations provided, AGEC should be contacted to provide clarification.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings drilled, the data obtained from laboratory testing, our experience in the area and information from the referenced geotechnical investigation. Variations in the subsurface conditions may not become evident until excavation is conducted. If the subsurface conditions or groundwater level are found to be significantly different from those described above, we should be notified to reevaluate our recommendations.

If you have any questions or if we can be of further service please call.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

LICENSED PROFESSIONAL ENGINEER
7-2-14
No. 177876
G. WAYNE
ROGERS
STATE OF UTAH

Jon Russell Hanson, P.E.

Reviewed by: G. Wayne Rogers, P.E.

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enclosures

BELLA SOL SUBDIVISION,
PHASES 2-5
SANTA CLARA, UTAH

N

2130401	AGEC	Vicinity Map	Figure 1

BELLA SOL SUBDIVISION,
PHASES 2-5
SANTA CLARA, UTAH

- Approximate boring location - This study
- Approximate boring location - From previous study, Project No. 2120851
- Approximate boring location - From previous study, Project No. 2021116
- Approximate boring location - from previous study, Project No. 2120907

Depth to groundwater and mudstone - This study

Boring No.	Elevation (feet)	Approx. depth to groundwater (feet)	Approx. depth to mudstone (feet)
B-1P(2)	2927.8	6	18
B-2P(2)	2928.6	10	23
B-3P(2)	2926.8	7	27
B-1P(3)	2919.7	6	17
B-1P(5)	2939.8	14	20
B-2P(5)	2933.1	9	22
B-1P(6)	2932.3	11	22
B-2P(6)	2936.6	10	>30
B-3P(6)	2936.6	11	>30
B-1P(7)	2939.9	11	8.5
B-2P(7)	2932.9	6	13
B-3P(7)	2937.3	11	>26
B-4P(7)	2936.4	11	13
B-5P(7)	2937.3	11	17
B-6P(7)	2930.5	9	17
B-7P(7)	2939.8	10.5	15.5
B-8P(7)	2939.8	11	10
B-9P(7)	2941.1	12	15.5
B-10P(7)	2936.8	*NA	15
B-11P(7)	2945.7	15.1	>20
B-12P(7)	2943.6	*NA	24

* Not measured, pipe destroyed during grading.

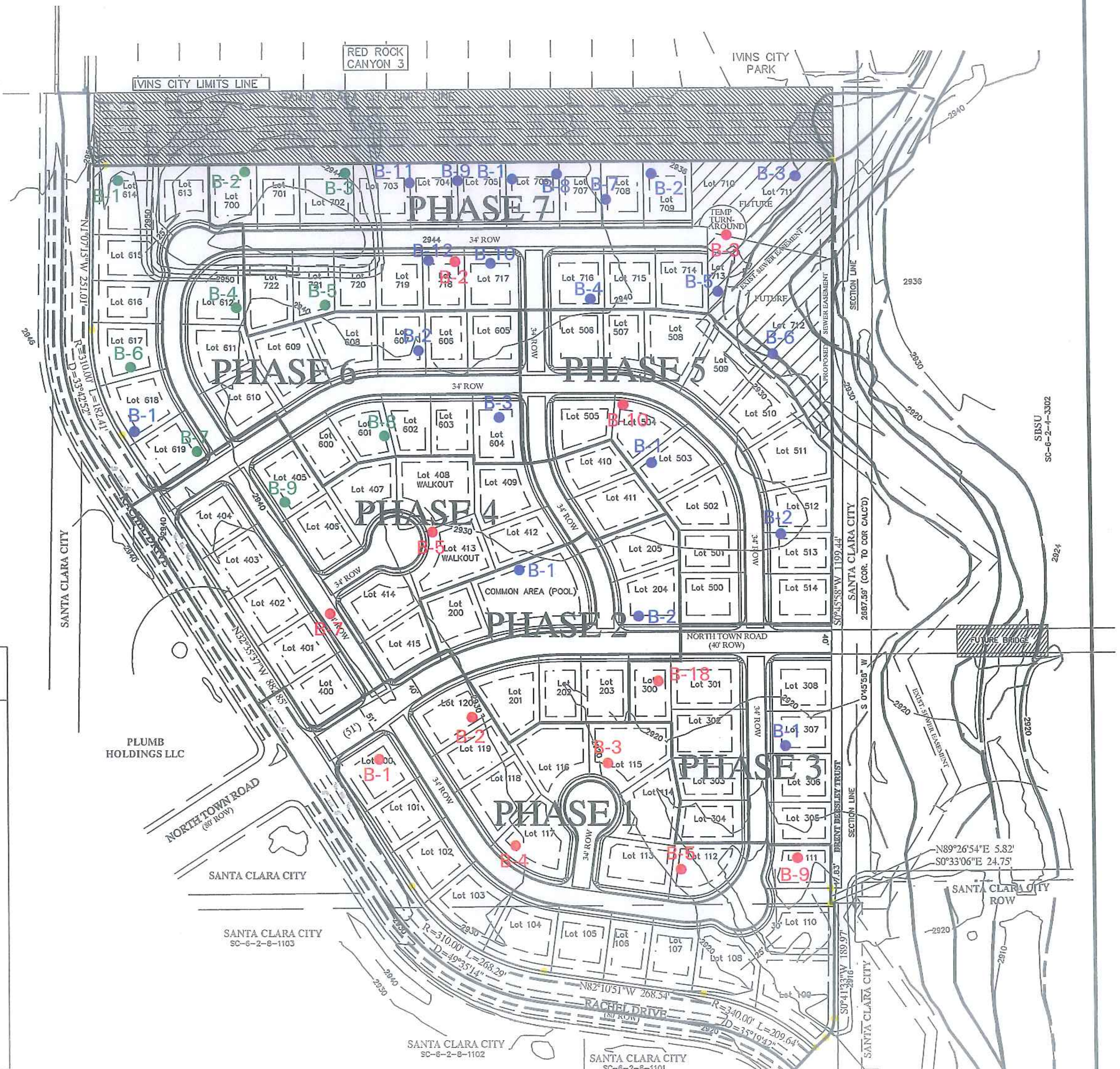
N

0 200 400 feet

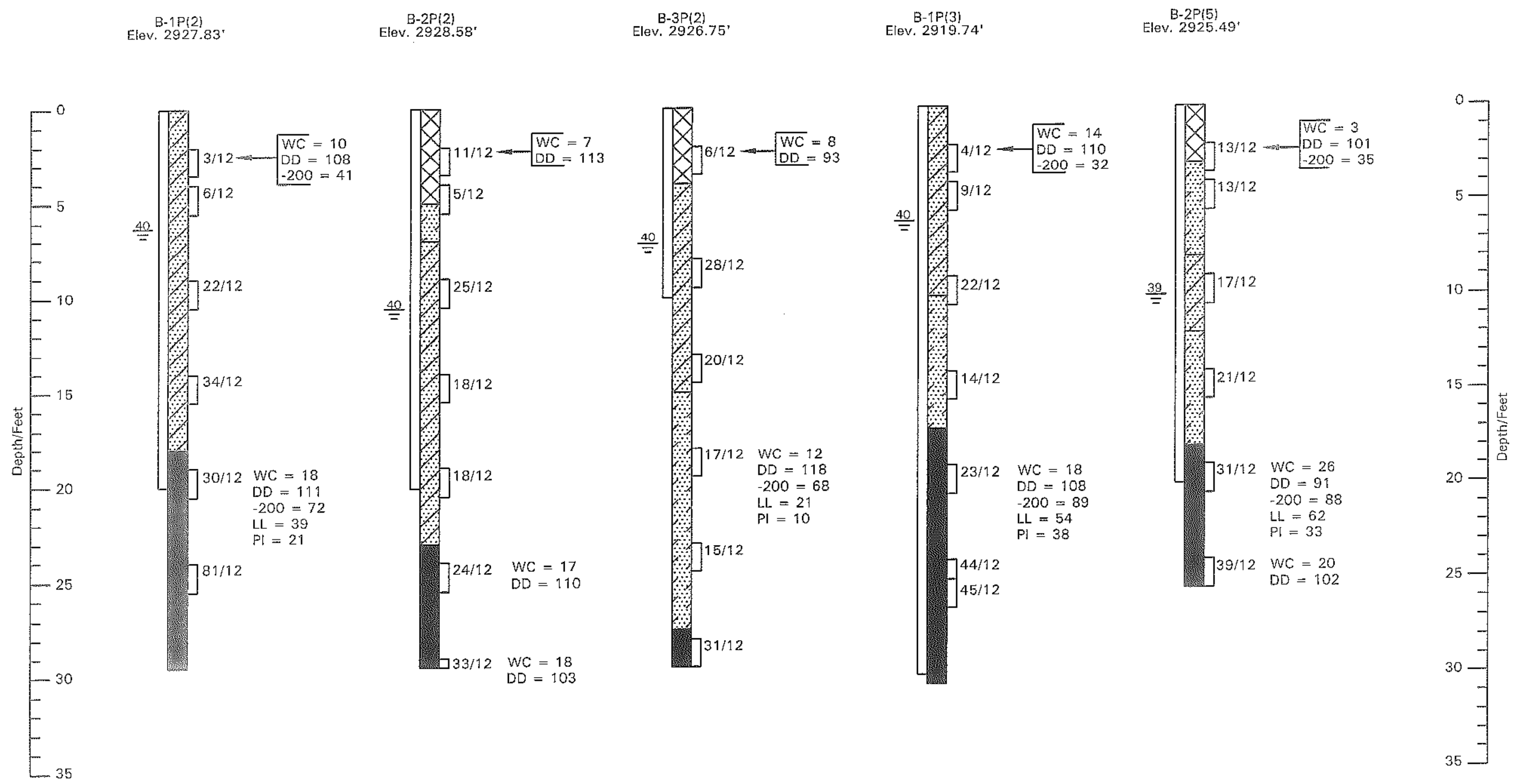
Approximate Scale

Depth to groundwater and mudstone - Previous study

Boring No.	Elevation (feet)	Approx. depth to groundwater (feet)	Approx. depth to mudstone (feet)
B-1	2950	12	>30
B-2	2943.5	8	20
B-3	2945	12	27
B-4	2940	8	20
B-5	2941	12	27
B-6	2943	12	27
B-7	2942	13	>30
B-8	2934	7	21
B-9	2926	15	24
B-1	2942	13	26
B-2	2940	NA	16
B-3	2929	11	19
B-4	2936	13	>32
B-5	2928	10	32
B-9	2913	6	19
B-15	2934	10	23
B-16	2935	NA	14
B-17	2934	16	>30
B-18	2920	9	27
B-1	2935.5	14	>35
B-2	2931.0	11	>31
B-3	2920.0	3	21
B-4	2928.5	11	>30
B-5	2917.0	5	21

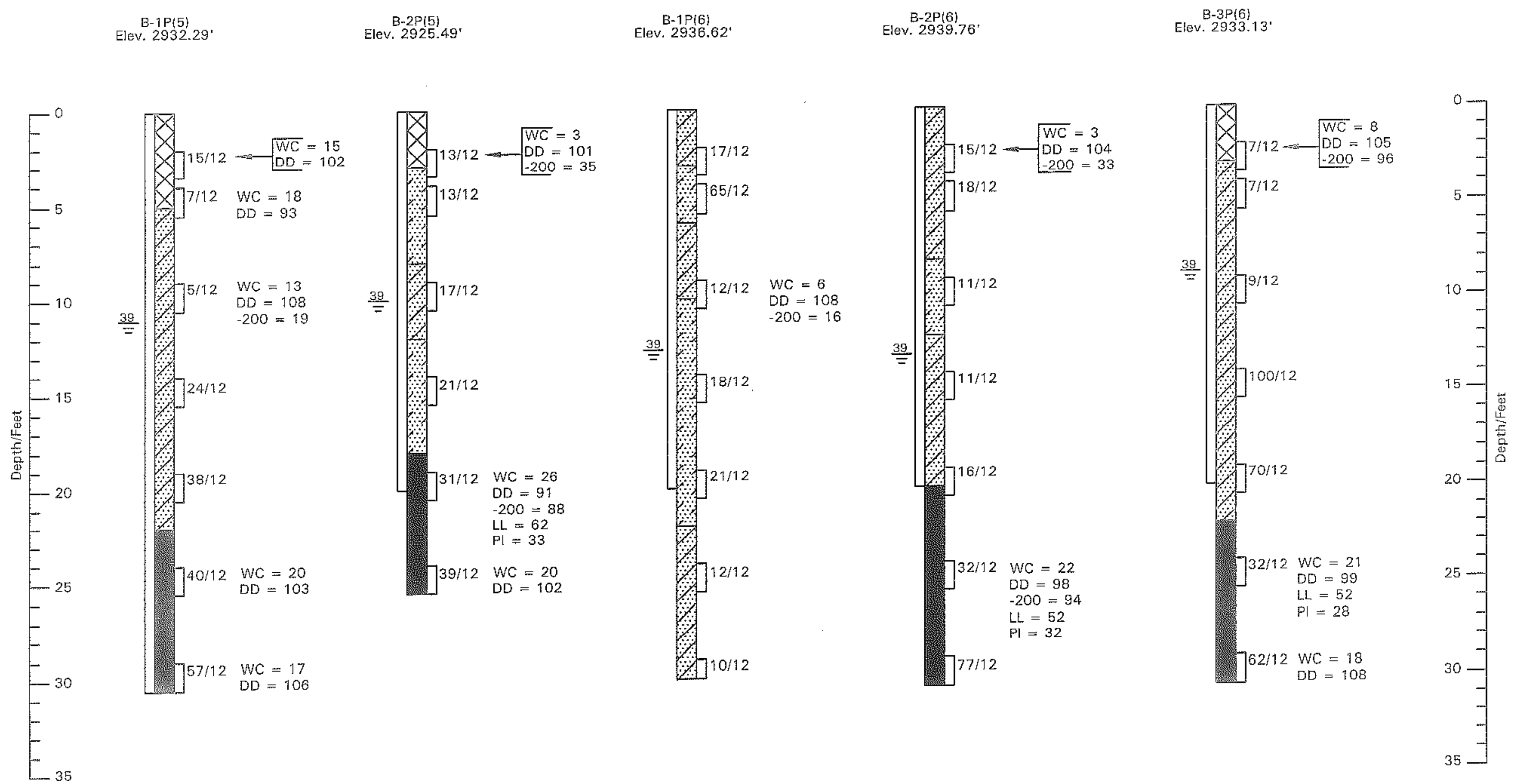


2130401 | AGEC | Site Plan | Figure 2



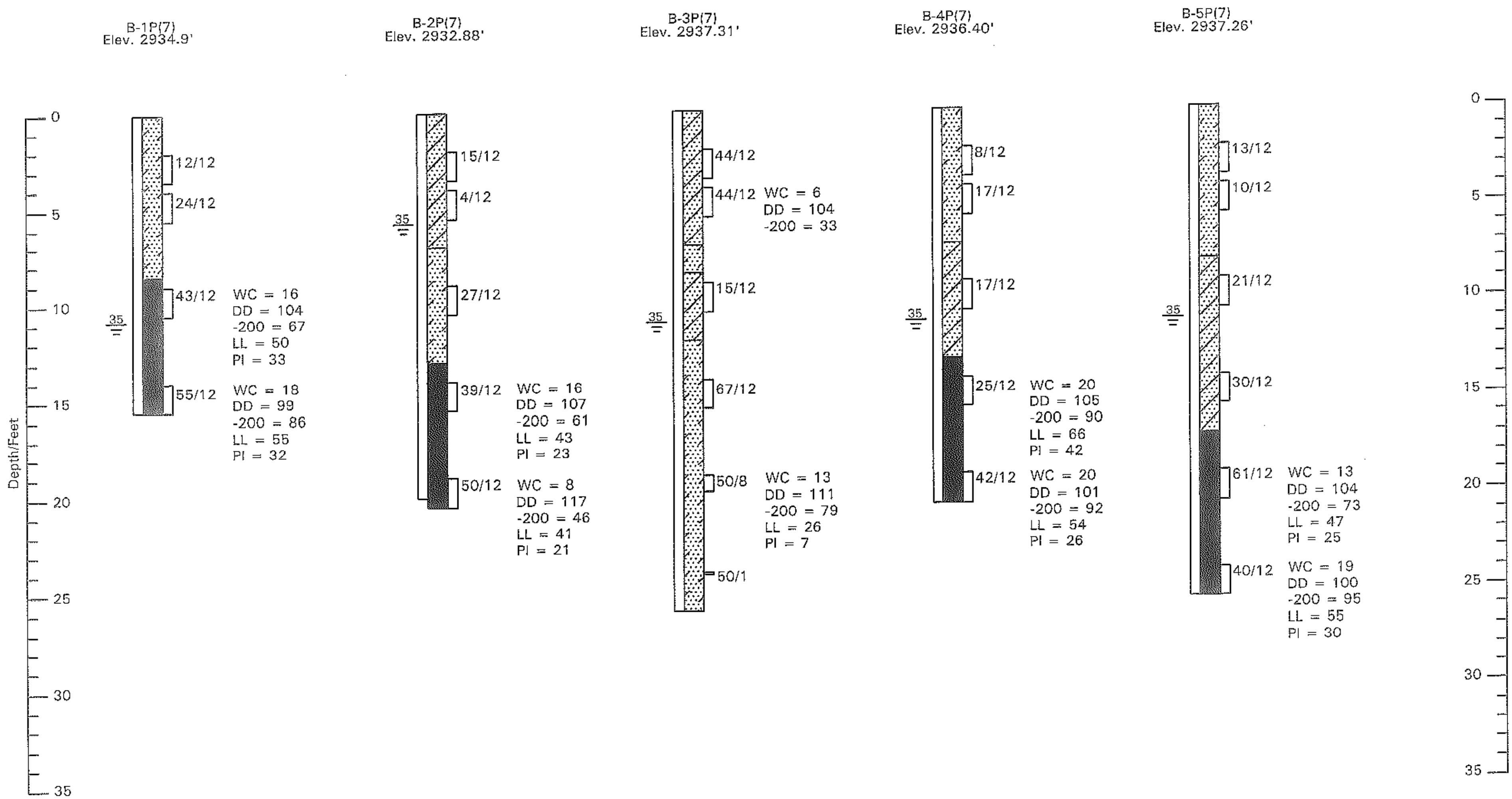
See Figure 7 for Legend and Notes

2130401 | AGEC | Logs of Exploratory Borings | Figure 3



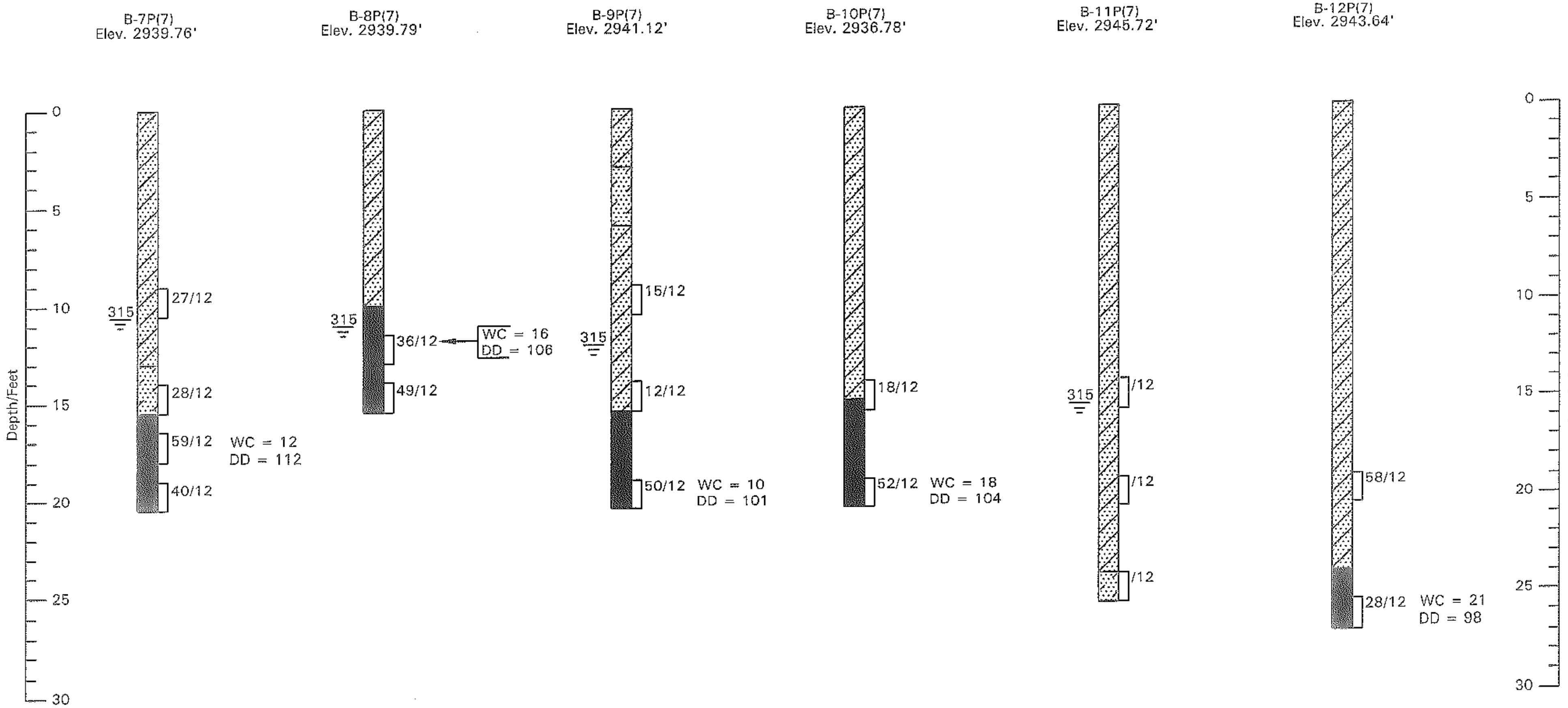
See Figure 7 for Legend and Notes

2130401 | AGEC | Logs of Exploratory Borings | Figure 4



See Figure 7 for Legend and Notes

2130401	AGEC	Logs of Exploratory Borings	Figure 5



See Figure 7 for Legend and Notes

2130401	AGEC	Logs of Exploratory Borings	Figure 6

LEGEND:

Fill; consists of silty sand interbedded with clayey sand, poorly compacted, moist, fine-grained, red.

Clayey sand (SC); loose to dense, moist to wet, fine to medium grained, low plastic, dark red to brown.

Silty sand (SM); loose to dense, moist (near surface) to wet, fine-grained, low plastic, red.

Mudstone bedrock; soft, moist, high plastic, purple.

10/12 California drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches.

Indicates slotted 1 inch PVC pipe installed in the boring to the depth shown.

Indicates relatively undisturbed hand drive sample taken.

Indicates relatively undisturbed block sample taken.

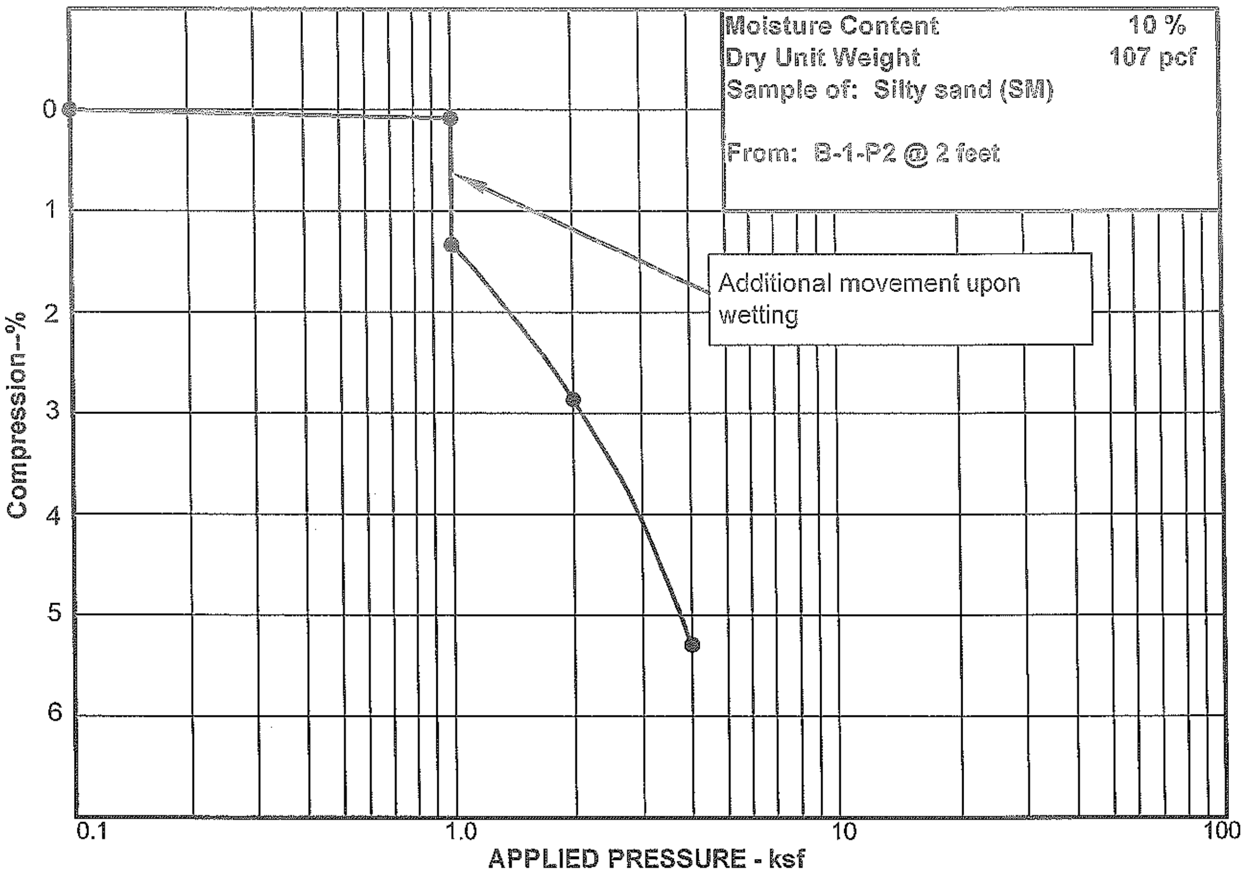
Indicates disturbed sample taken.

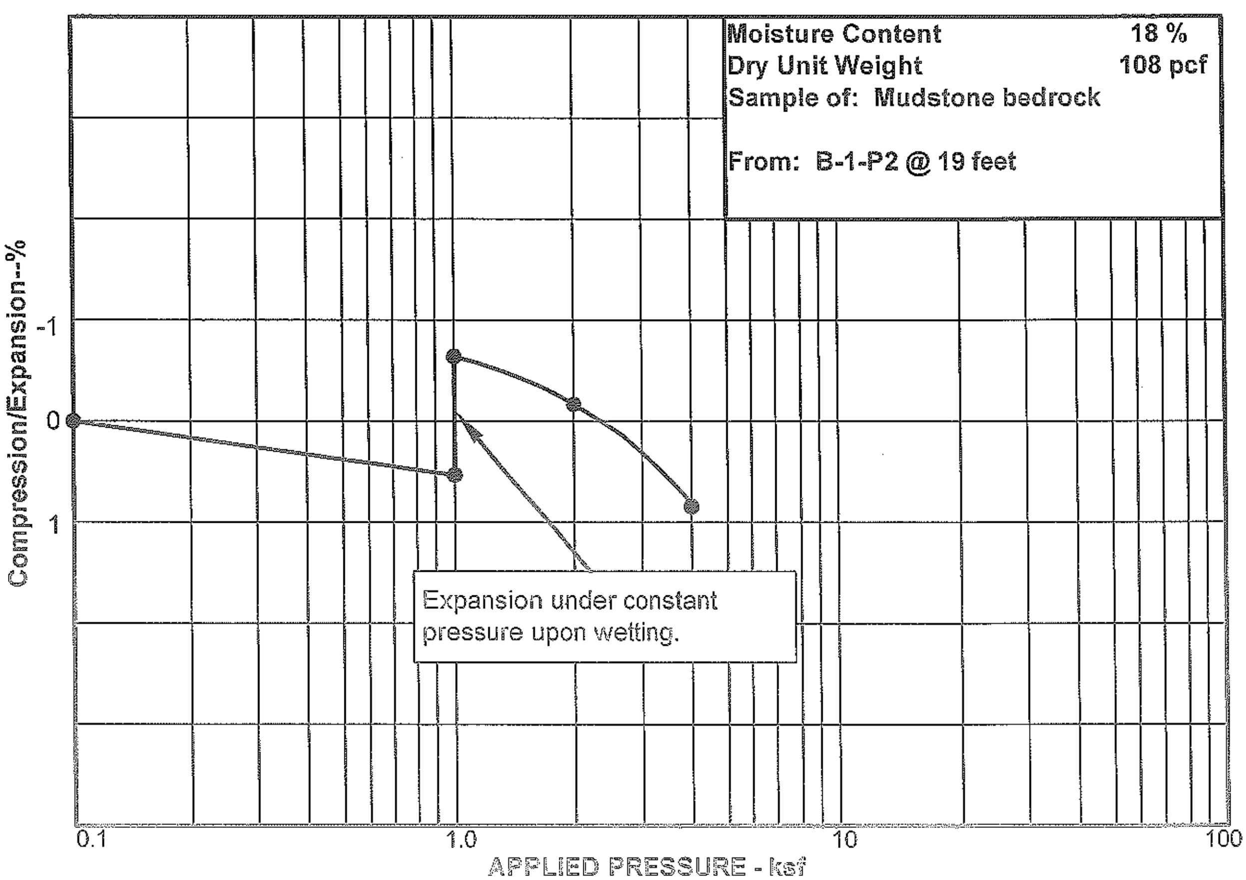
0 Indicates the depth to free water and the number days after excavation the measurement was taken.

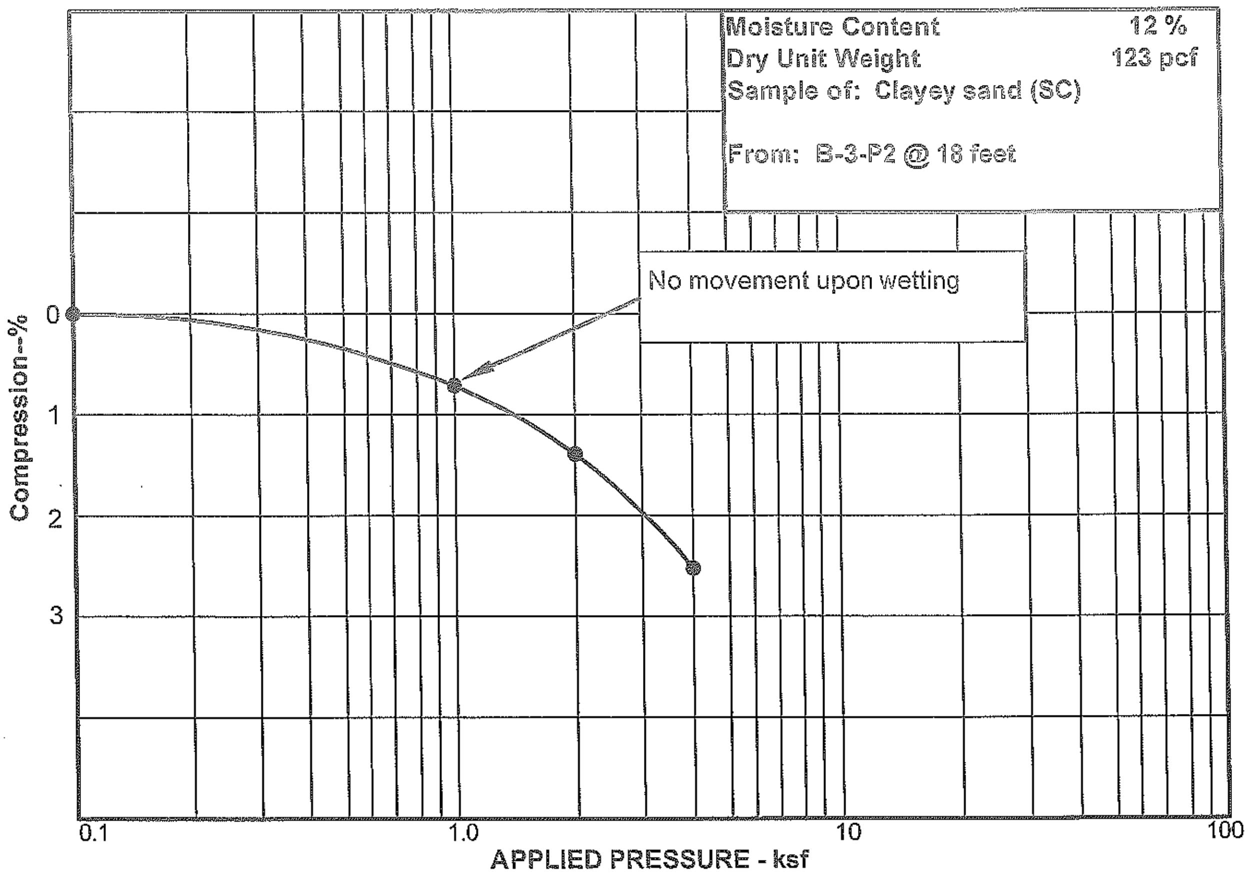
Indicates practical backhoe refusal on boulders, sandstone bedrock, or limestone bedrock.

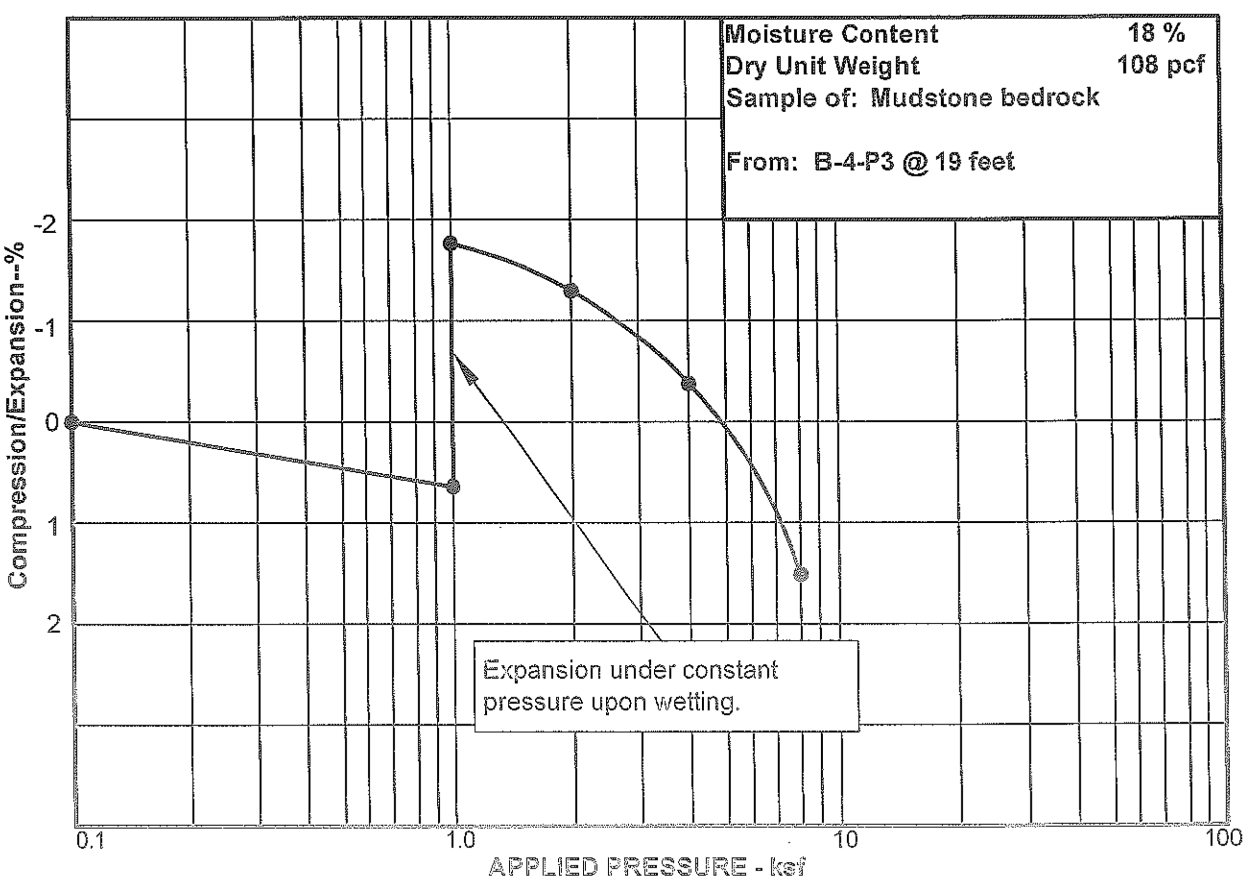
NOTES:

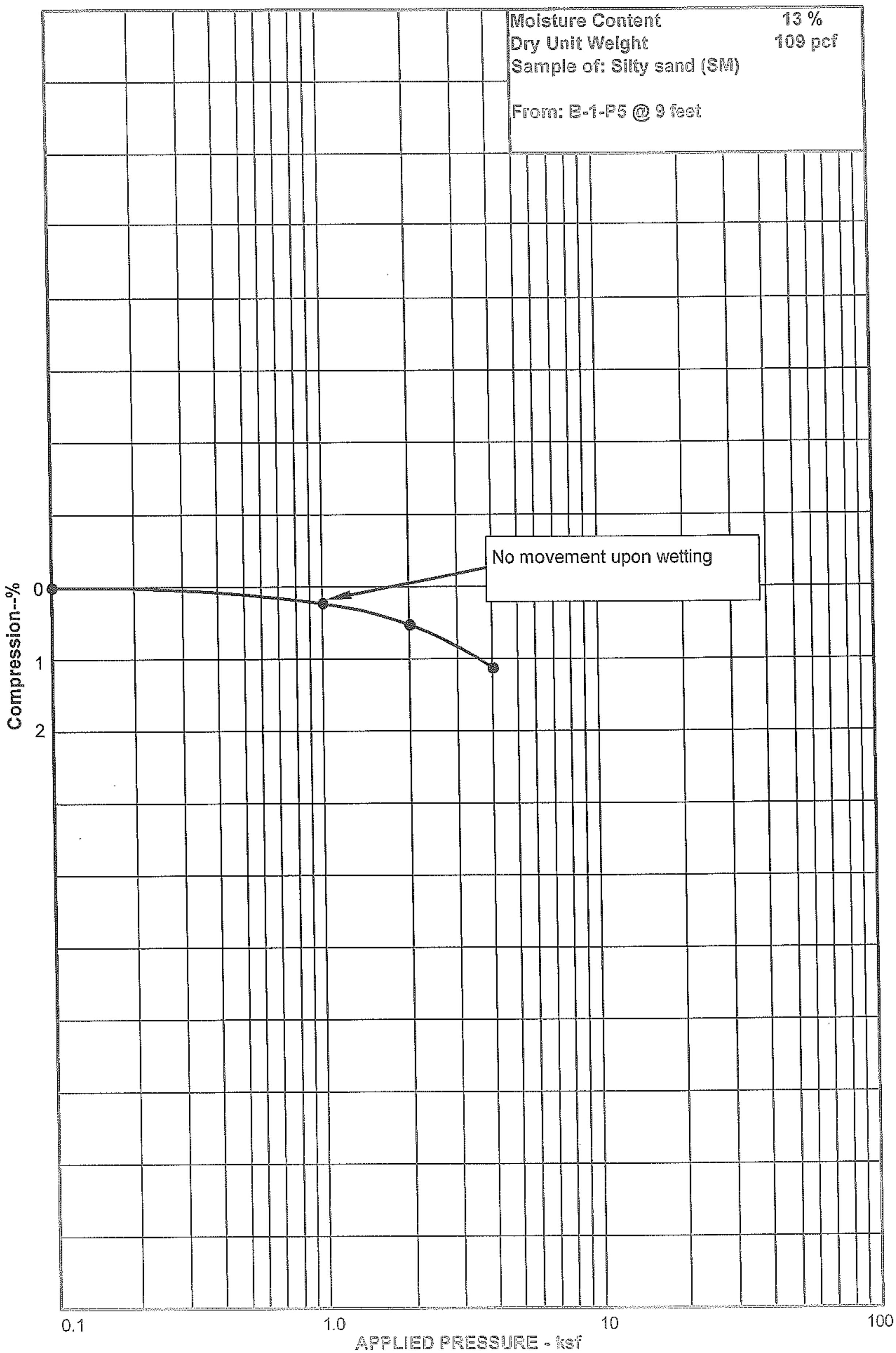
1. The borings were drilled on May 22, 23, 28 and on August 20, 2013 with a truck mounted drill rig equipped with 7-inch hollow-stem augers.
2. The locations and elevations of the borings were surveyed by Rosenberg Associates.
3. The lines between the materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
4. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.
5. WC = water content (%);
   DD = dry density (pcf);
   +4 = percent retained on the No. 4 sieve;
   -200 = percent passing No. 200 sieve;
   LL = liquid limit (%);
   PI = plasticity index (%);
   NP = non-plastic.

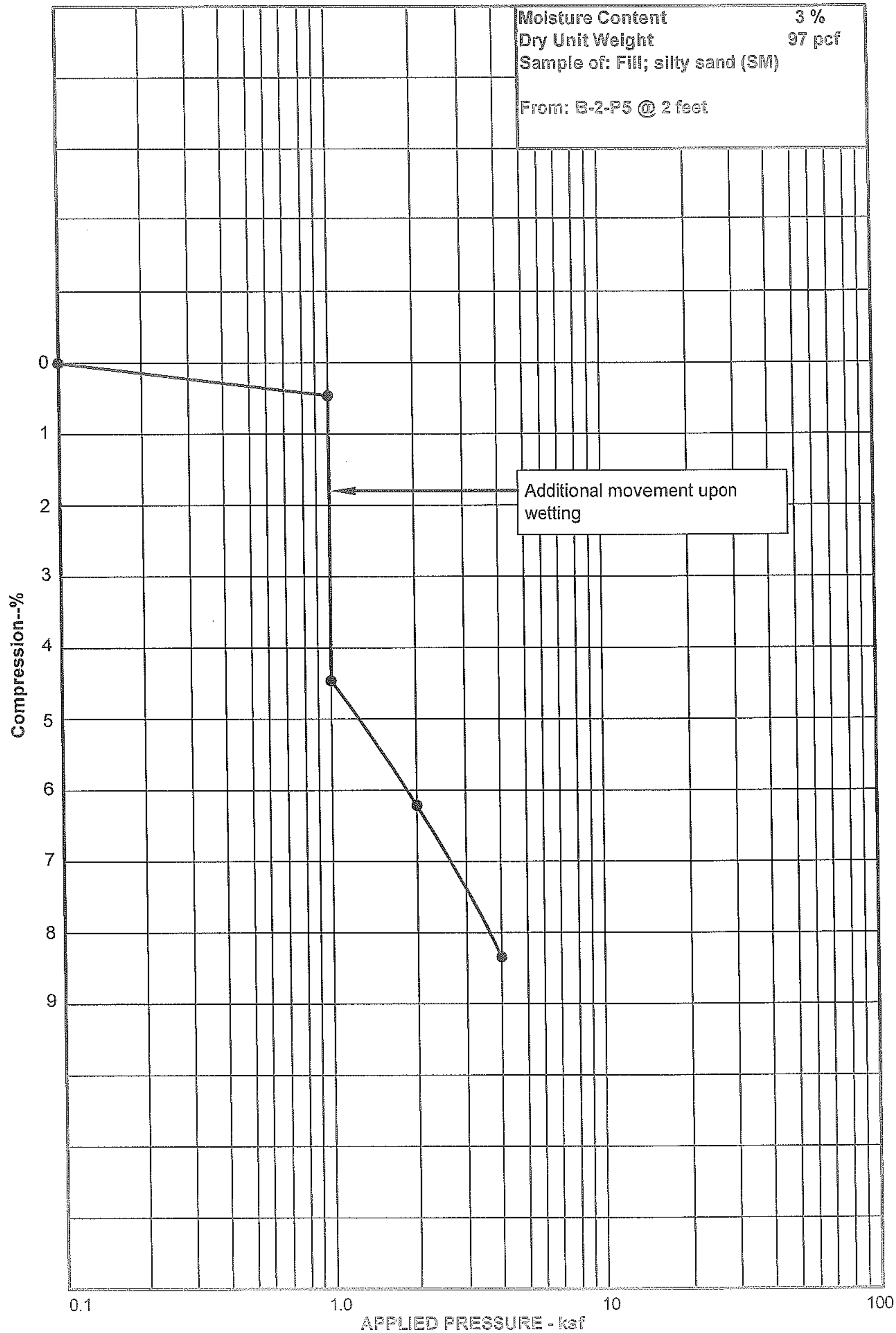

Moisture Content 10 %
Dry Unit Weight 107 pcf
Sample of: Silty sand (SM)
From: B-1-P2 @ 2 feet
Additional movement upon wetting
Compression--%
0
1
2
3
4
5
6
0.1
1.0
10
100
APPLIED PRESSURE - ksf

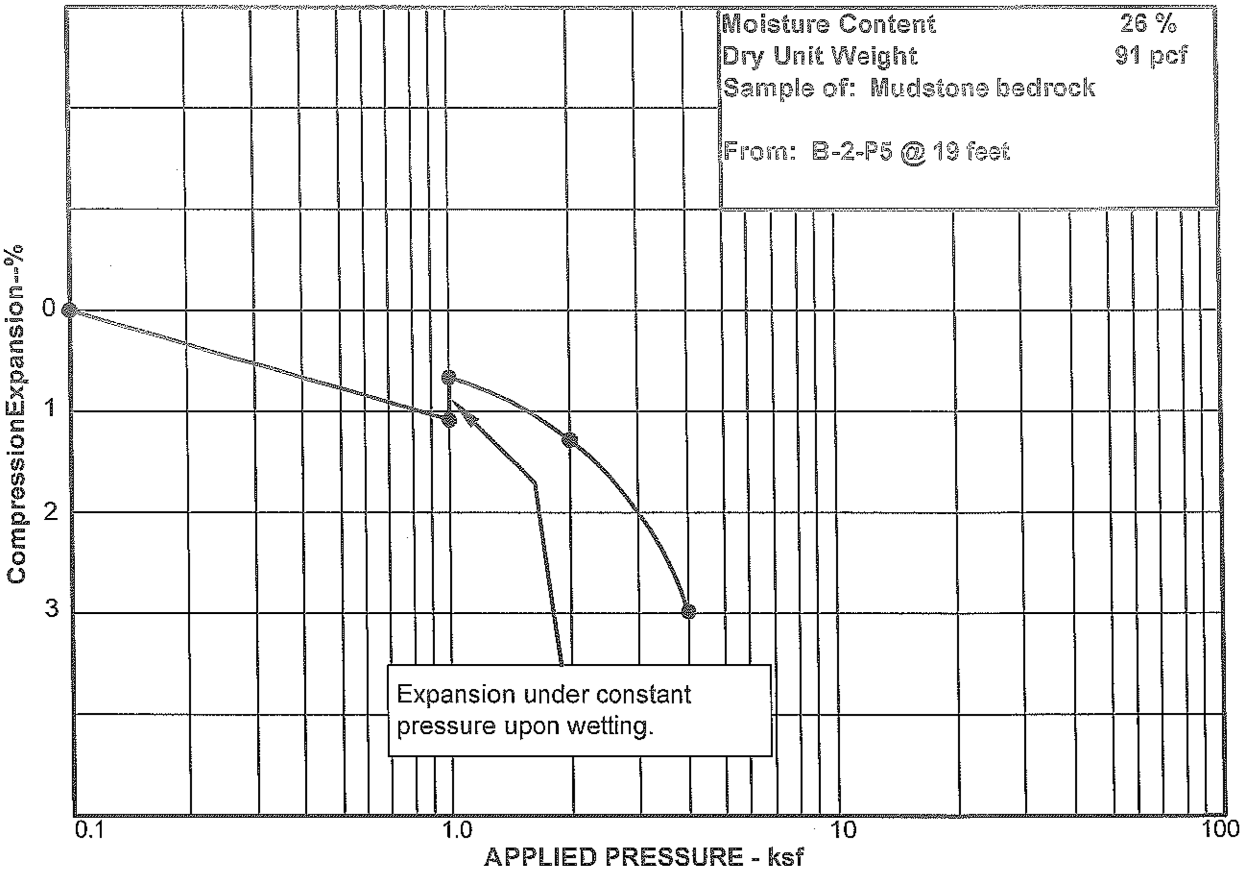

Moisture Content 18 %
Dry Unit Weight 108 pcf
Sample of: Mudstone bedrock
From: B-1-P2 @ 19 feet
Expansion under constant pressure upon wetting.
Compression/Expansion--%
-1
0
1
0.1
1.0
10
100
APPLIED PRESSURE - ksf

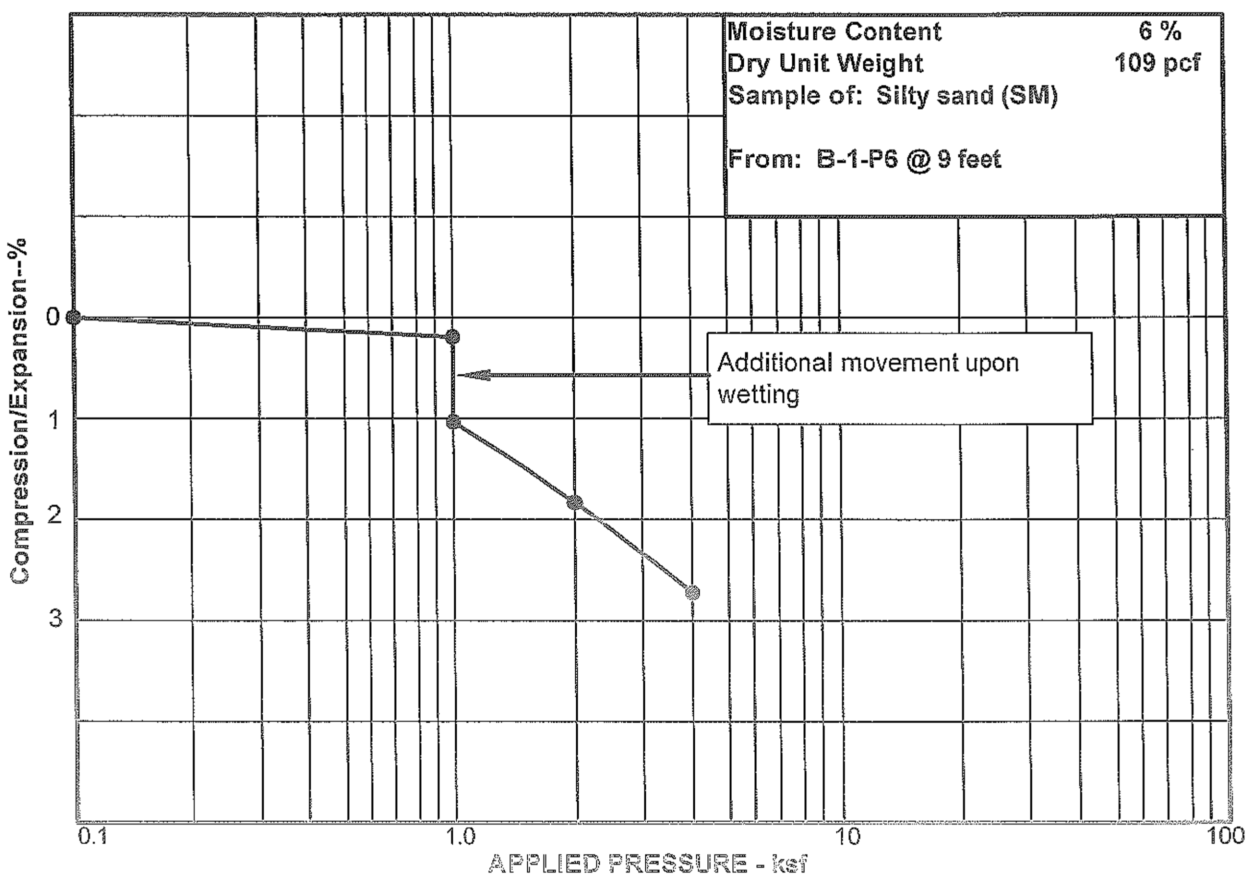

Moisture Content 12 %
Dry Unit Weight 123 pcf
Sample of: Clayey sand (SC)
From: B-3-P2 @ 18 feet
No movement upon wetting
Compression--%
0
1
2
3
0.1
1.0
10
100
APPLIED PRESSURE - ksf


Moisture Content 18 %
Dry Unit Weight 108 pcf
Sample of: Mudstone bedrock
From: B-4-P3 @ 19 feet
Expansion under constant pressure upon wetting.
Compression/Expansion--%
-2
-1
0
1
2
0.1
1.0
10
100
APPLIED PRESSURE - ksf


Moisture Content 13 %
Dry Unit Weight 109 pcf
Sample of: Silty sand (SM)
From: B-1-P5 @ 9 feet
No movement upon wetting
Compression--%
0
1
2
0.1
1.0
10
100
APPLIED PRESSURE - ksf


Moisture Content 3 %
Dry Unit Weight 97 pcf
Sample of: Fill; silty sand (SM)
From: B-2-P5 @ 2 feet
Additional movement upon wetting
Compression--%
0
1
2
3
4
5
6
7
8
9
0.1
1.0
10
100
APPLIED PRESSURE - ksf


Moisture Content 26 %
Dry Unit Weight 91 pcf
Sample of: Mudstone bedrock
From: B-2-P5 @ 19 feet
Compression/Expansion--%
0
1
2
3
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf


Moisture Content 6 %
Dry Unit Weight 109 pcf
Sample of: Silty sand (SM)
From: B-1-P6 @ 9 feet
Compression/Expansion--%
0
1
2
3
Additional movement upon wetting
0.1
1.0
10
100
APPLIED PRESSURE - ksf

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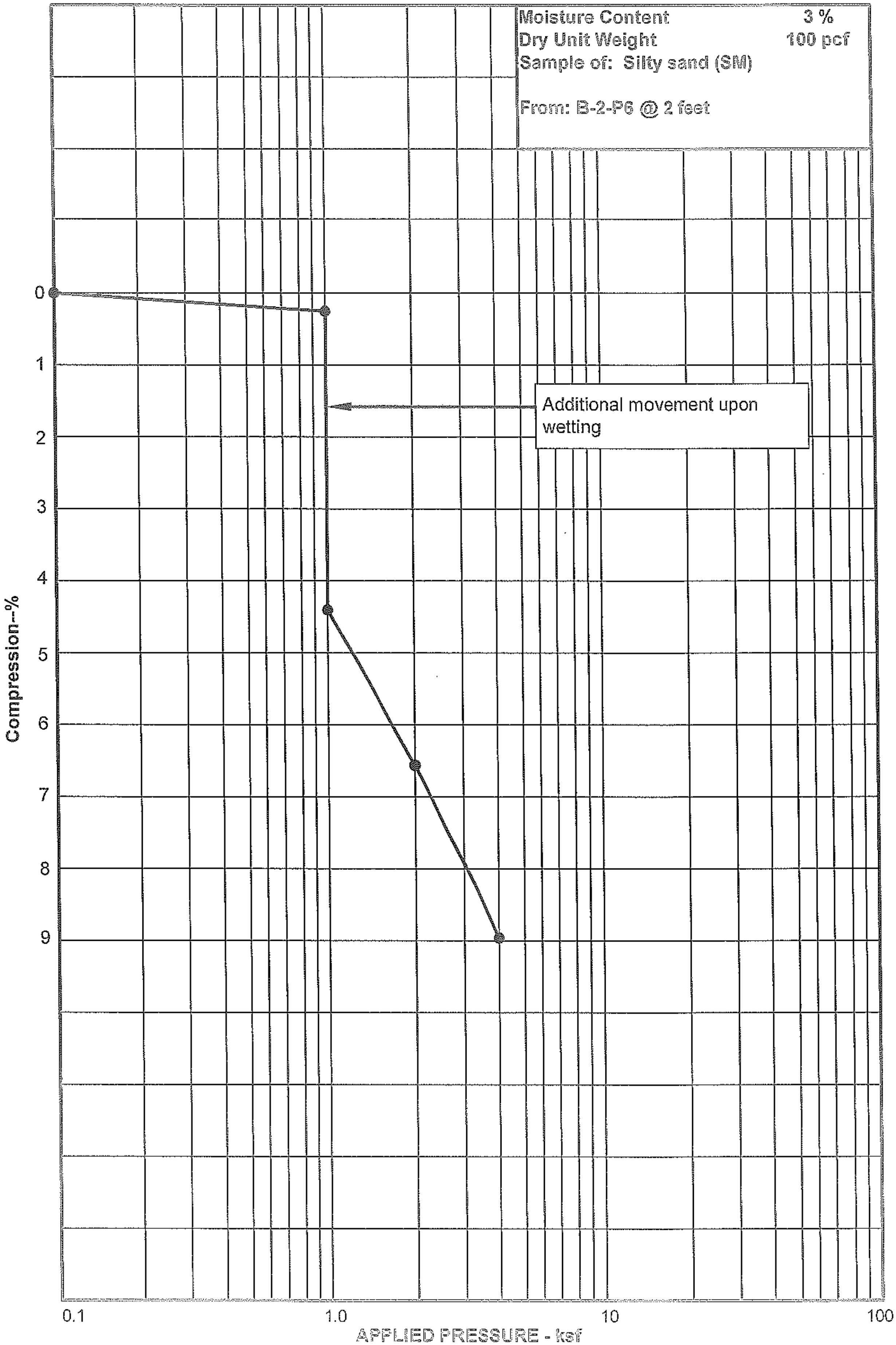
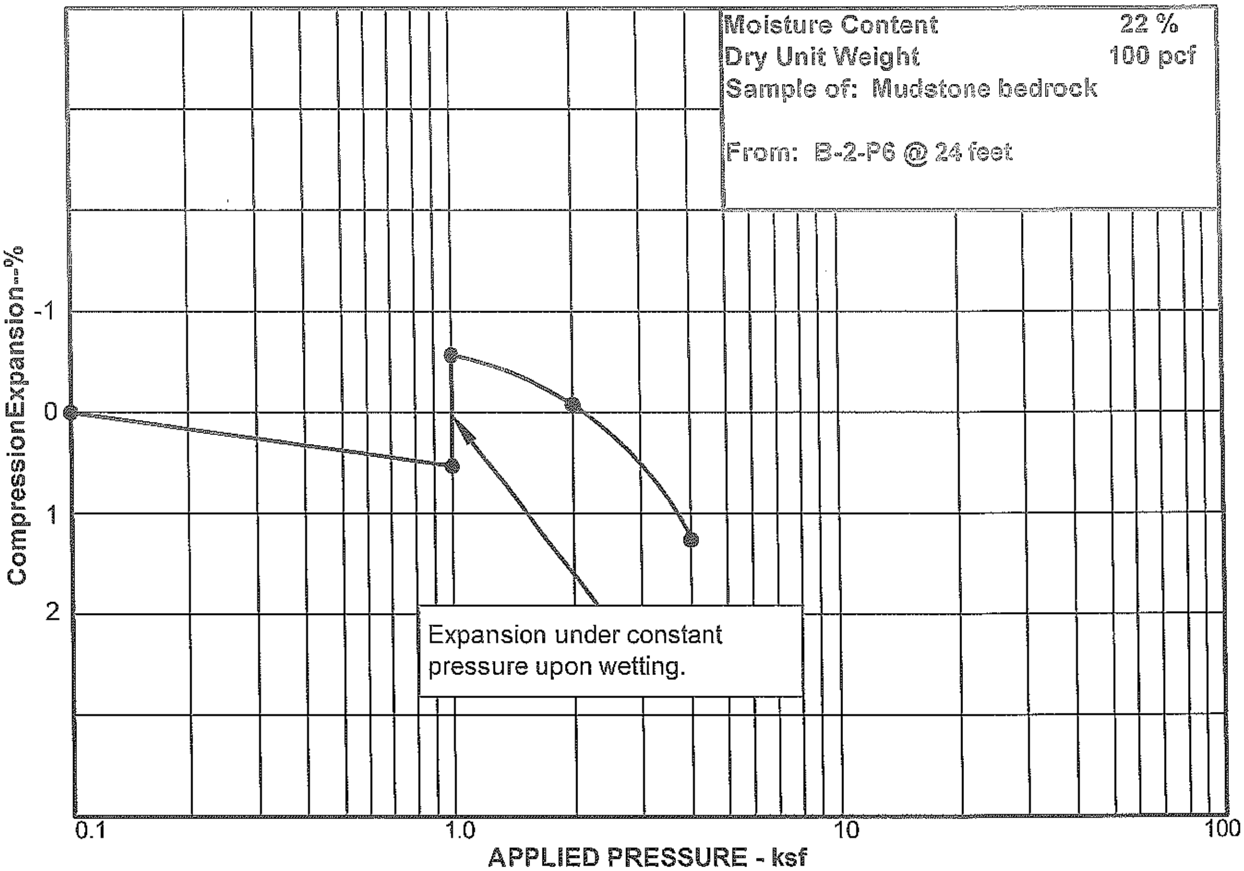
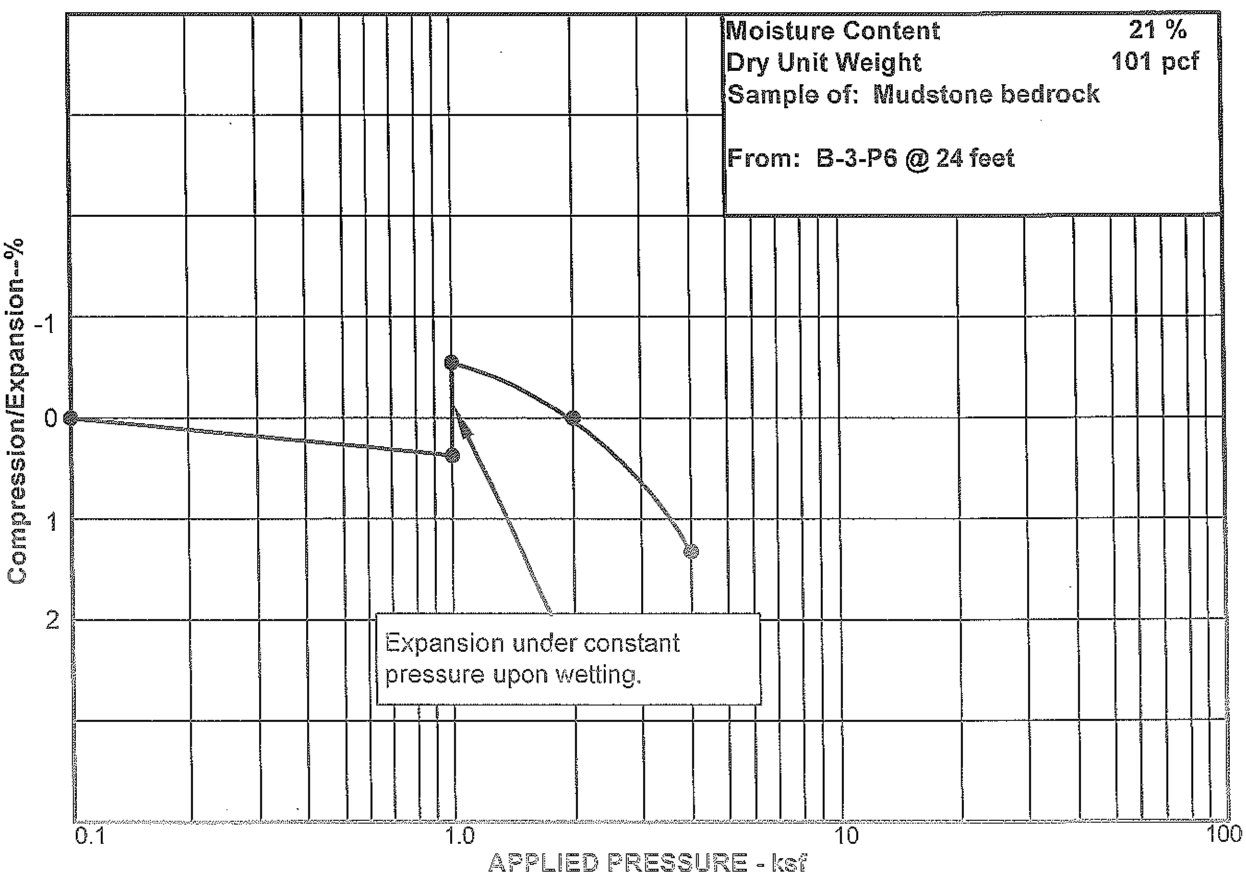
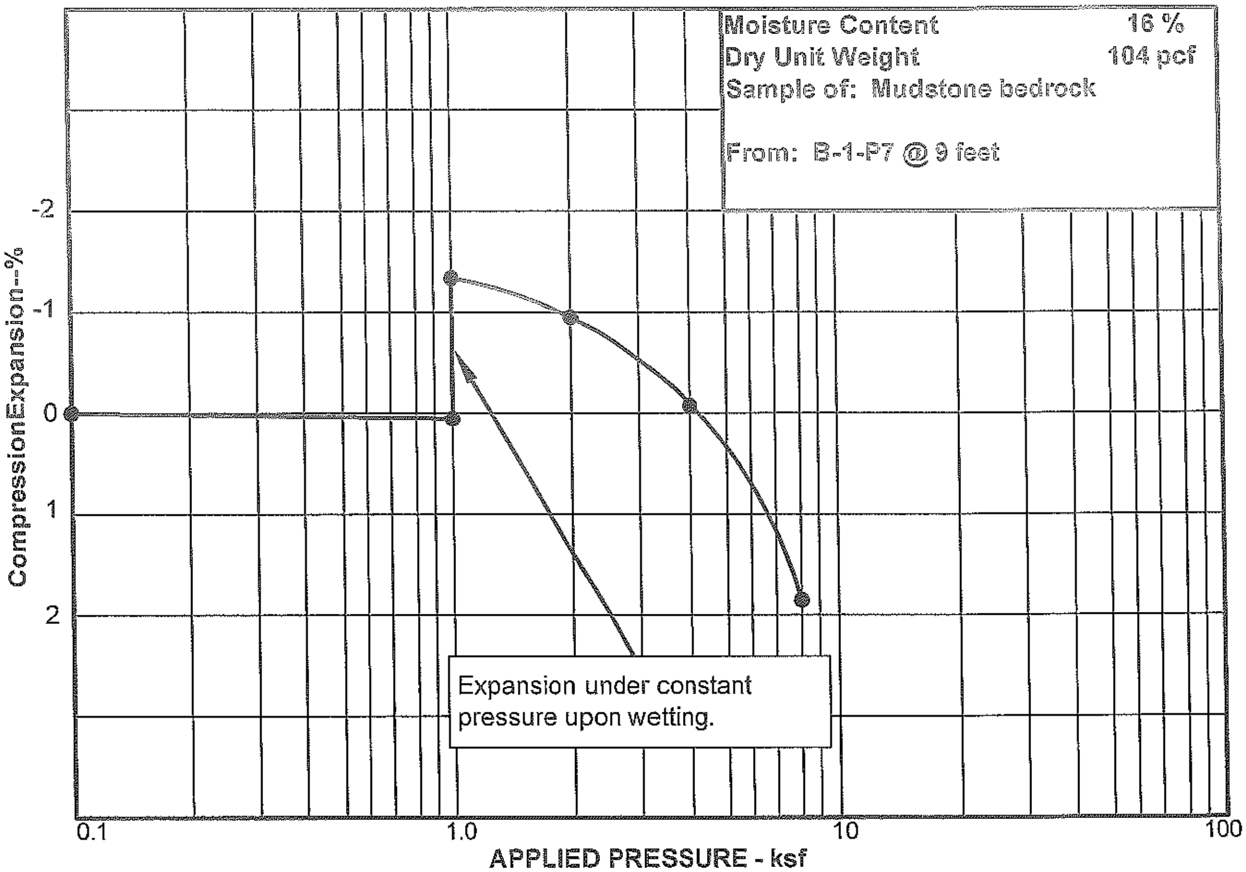


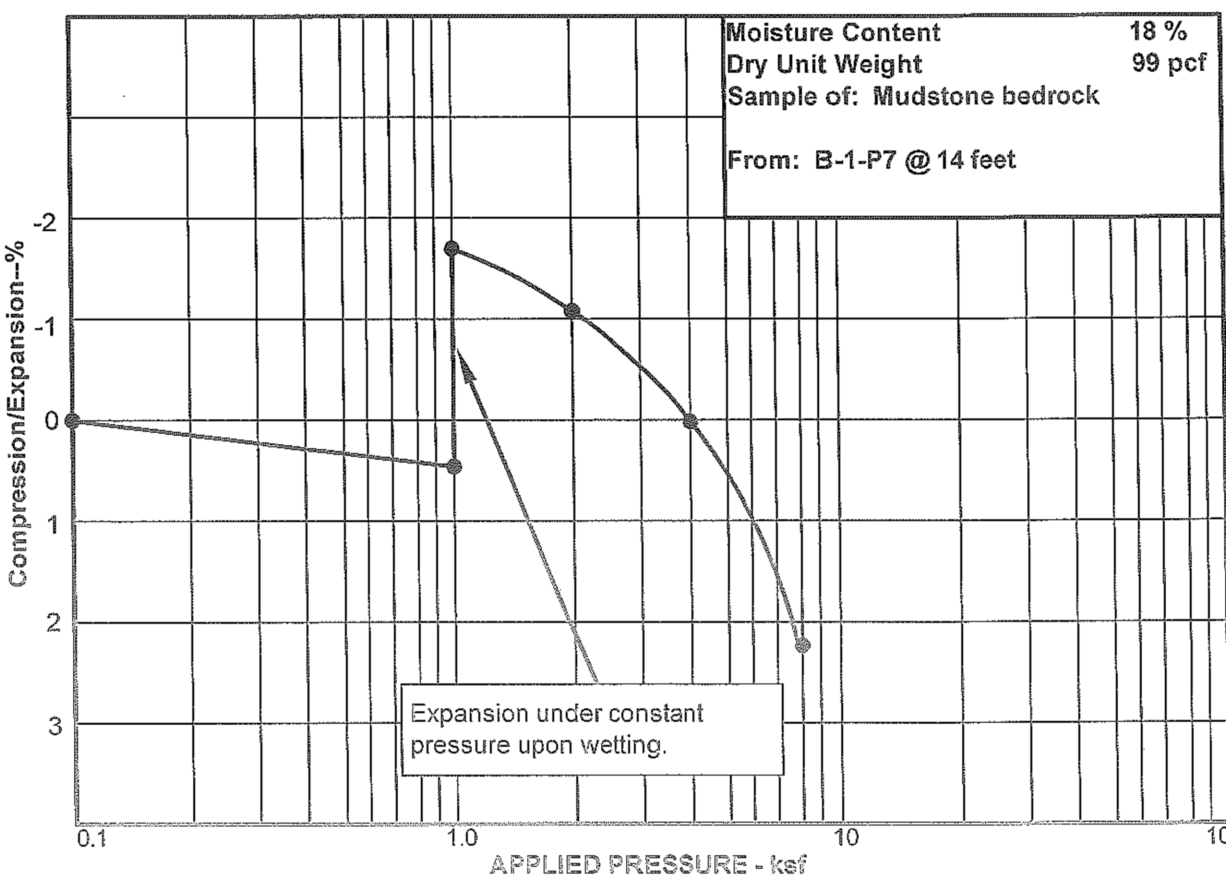
Project No. 2130401 CONSOLIDATION TEST RESULTS Figure 13

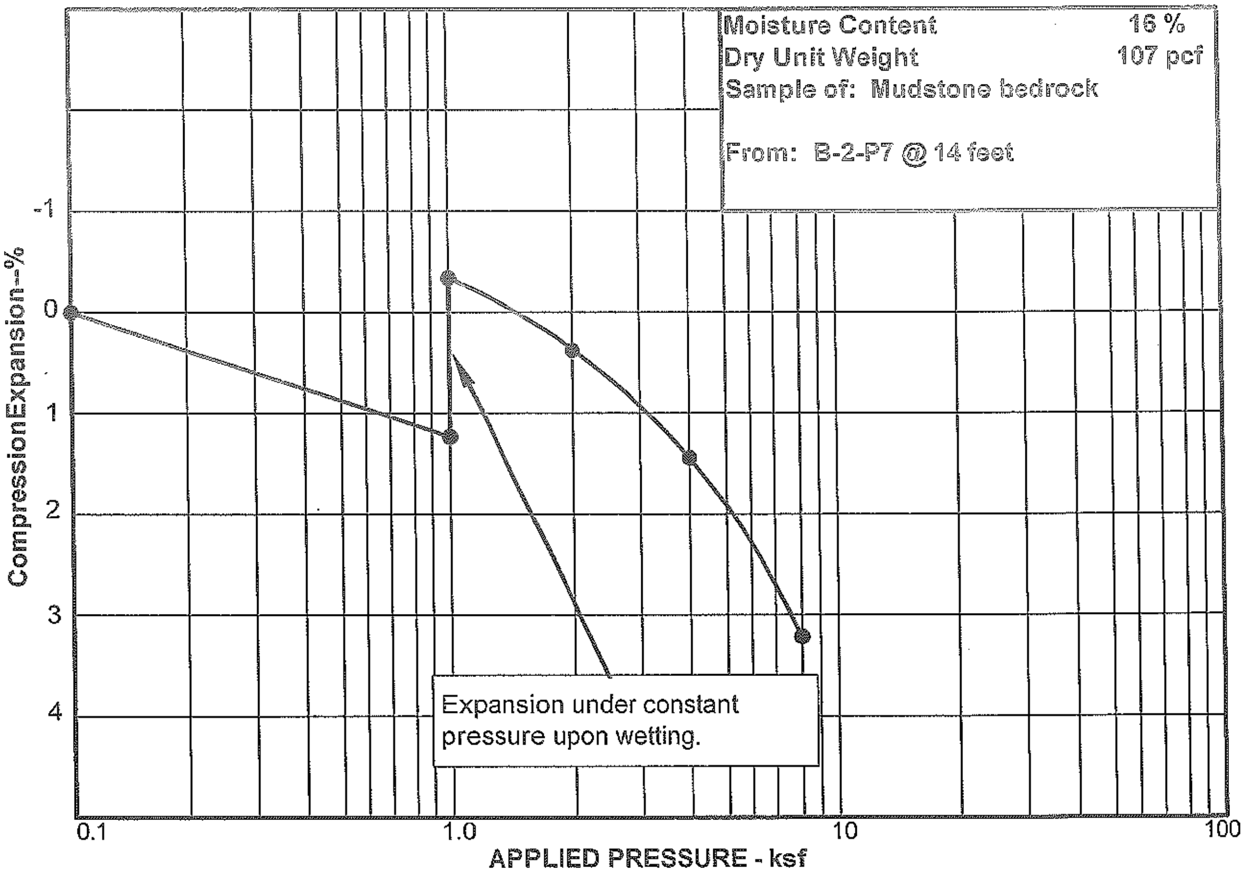

Moisture Content 22 %
Dry Unit Weight 100 pcf
Sample of: Mudstone bedrock
From: B-2-P6 @ 24 feet
Compression Expansion--%
-1
0
1
2
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

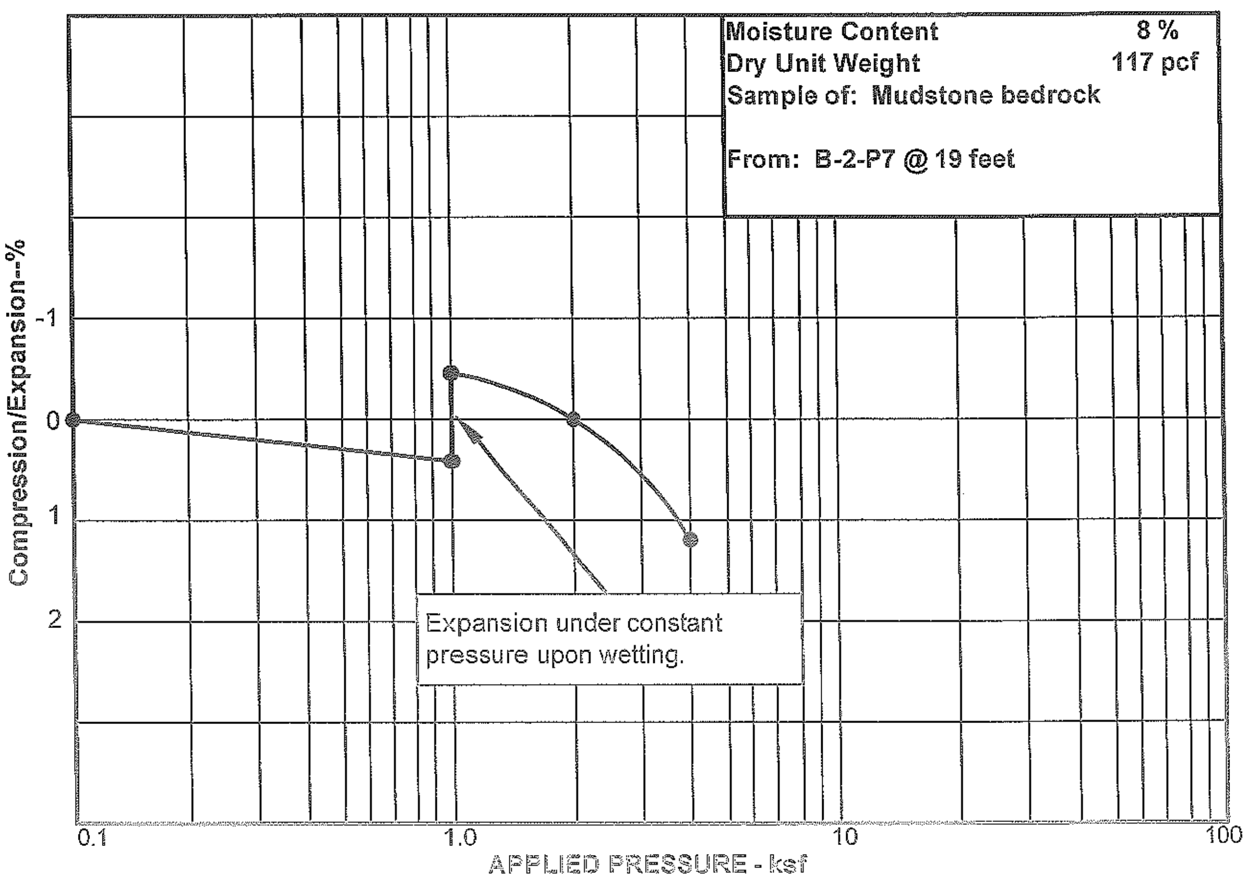

Moisture Content 21 %
Dry Unit Weight 101 pcf
Sample of: Mudstone bedrock
From: B-3-P6 @ 24 feet
Compression/Expansion--%
-1
0
1
2
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

Applied Geotechnical Engineering Consultants, Inc.

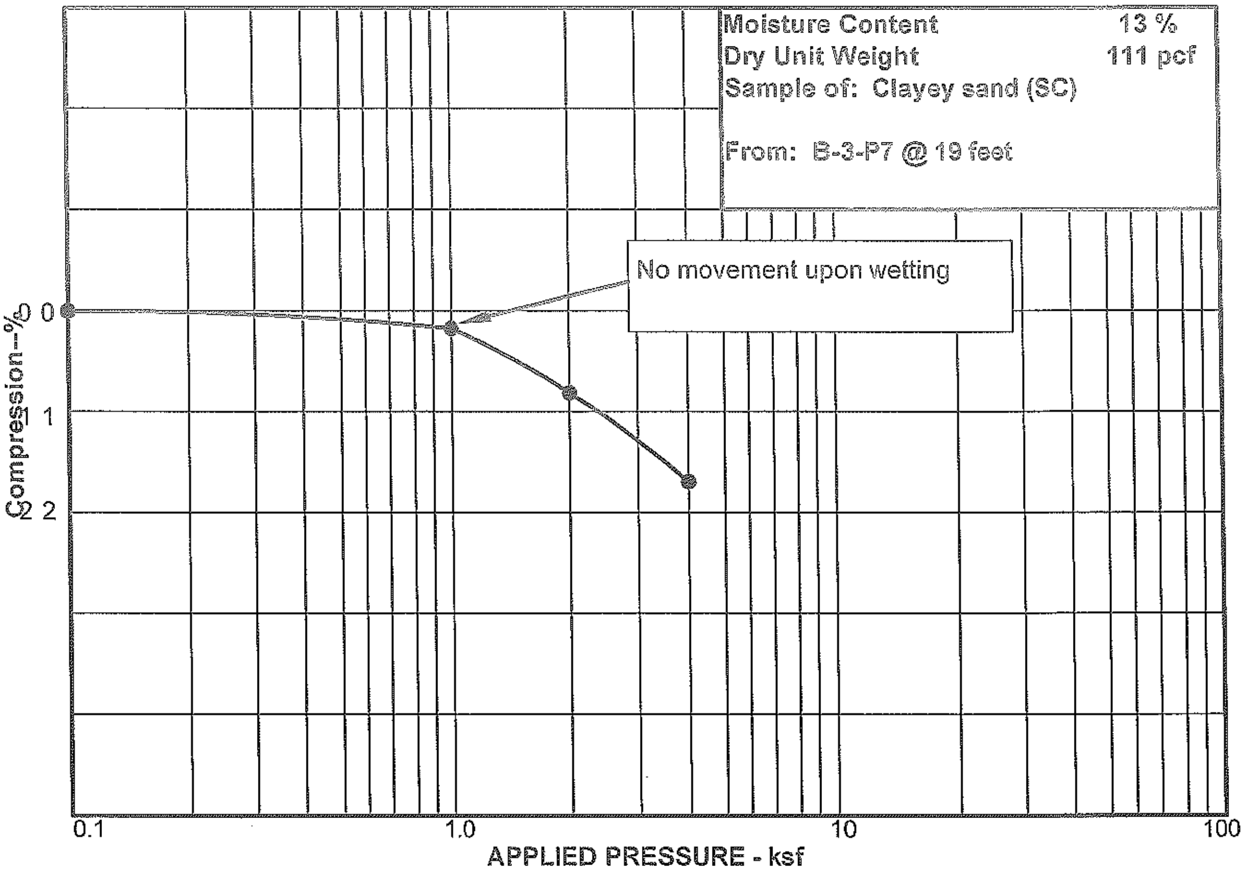


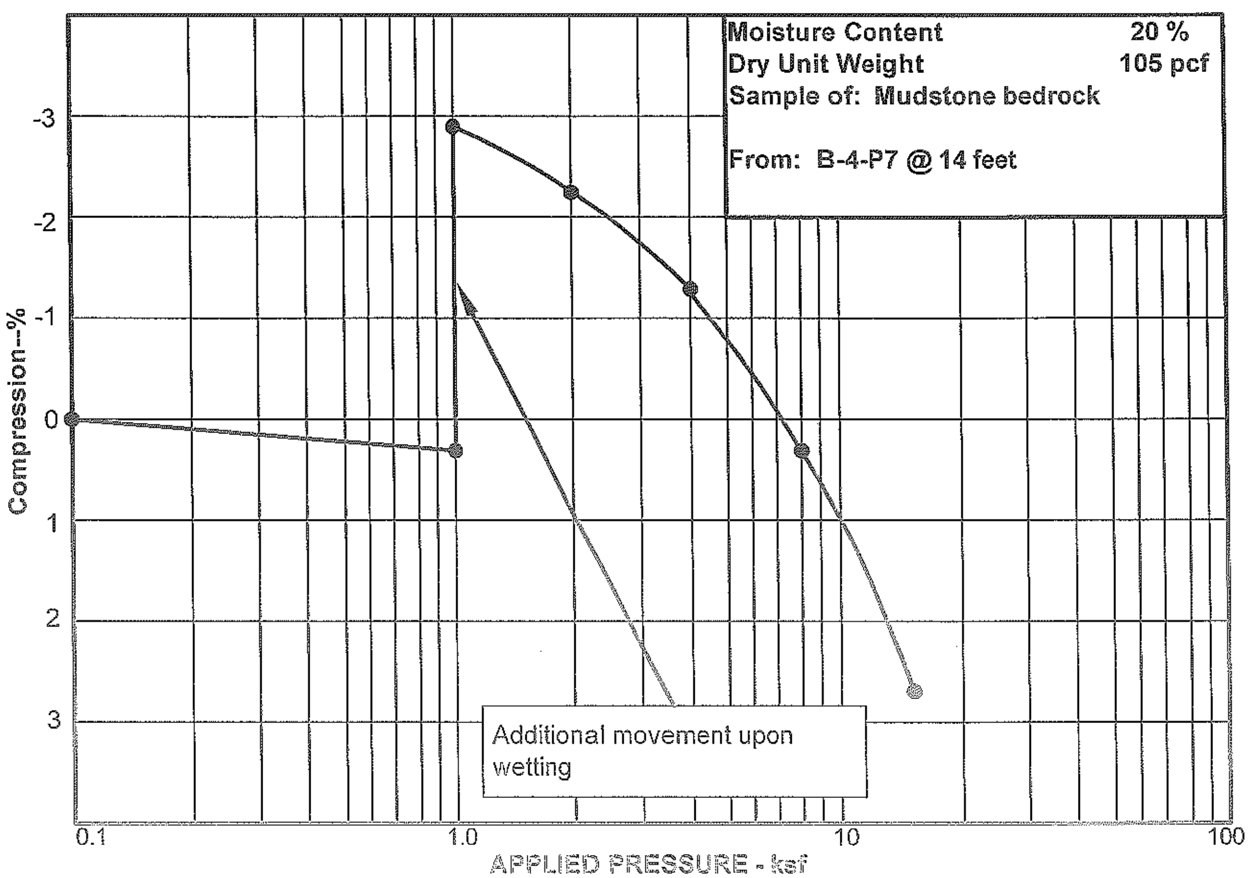



Moisture Content 16 %
Dry Unit Weight 107 pcf
Sample of: Mudstone bedrock
From: B-2-P7 @ 14 feet
Compression Expansion--%
-1
0
1
2
3
4
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

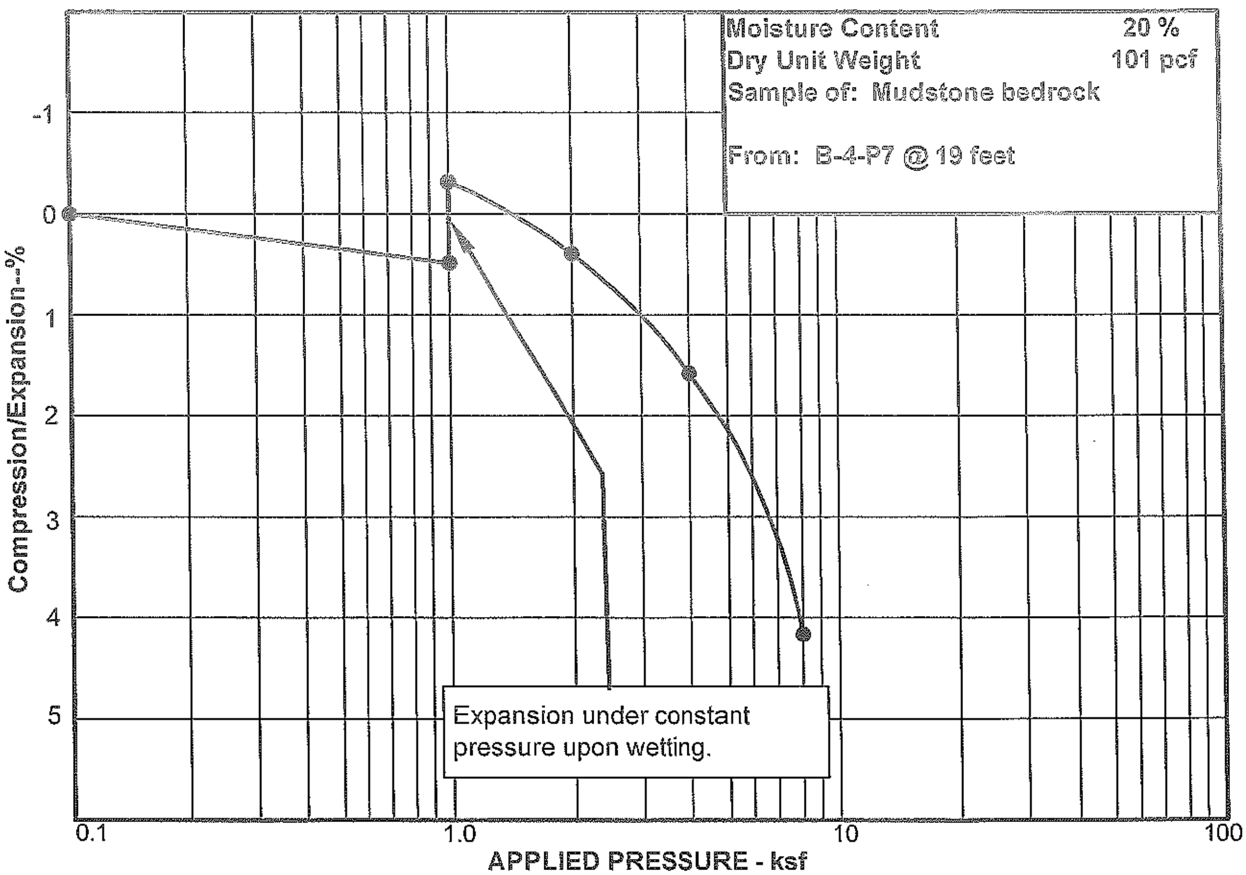

Moisture Content 8 %
Dry Unit Weight 117 pcf
Sample of: Mudstone bedrock
From: B-2-P7 @ 19 feet
Compression/Expansion--%
-1
0
1
2
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

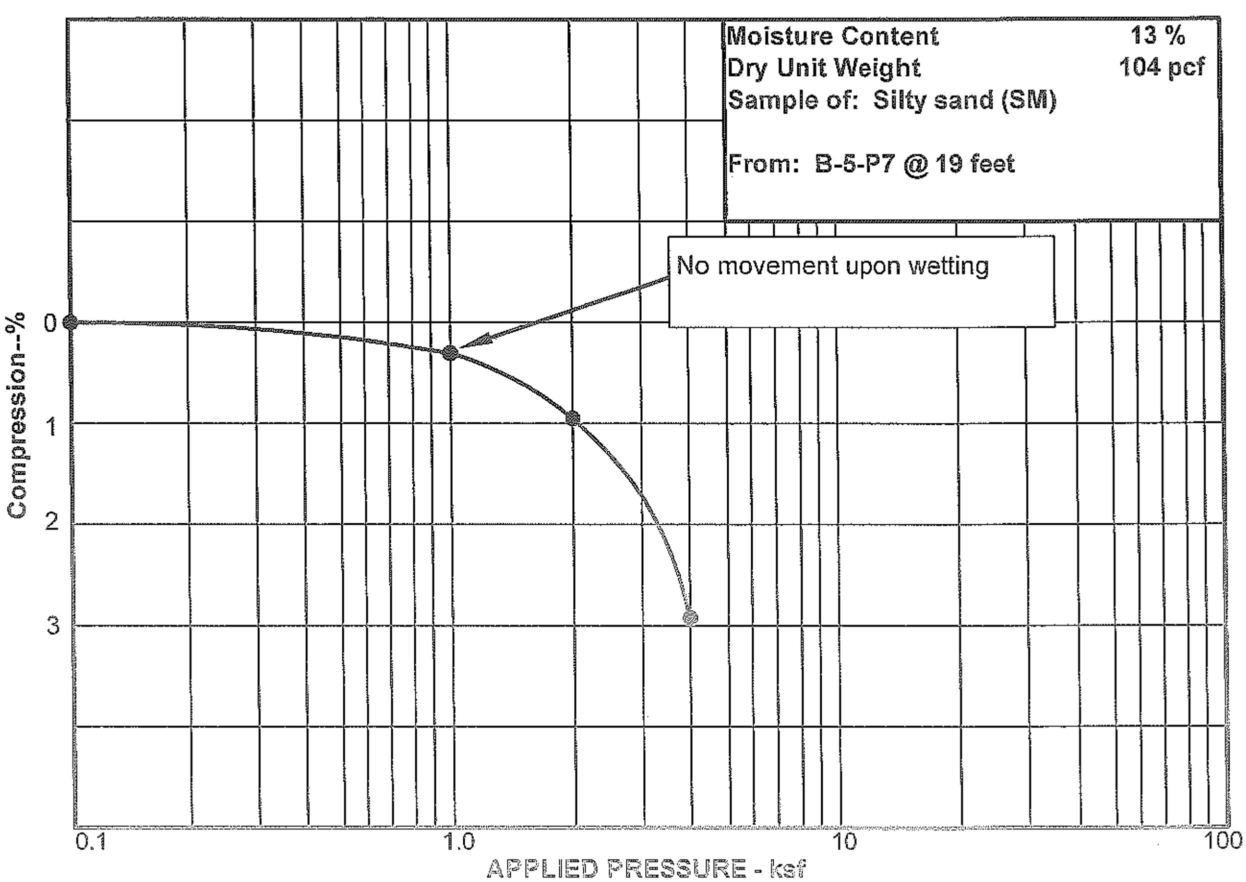
Applied Geotechnical Engineering Consultants, Inc.



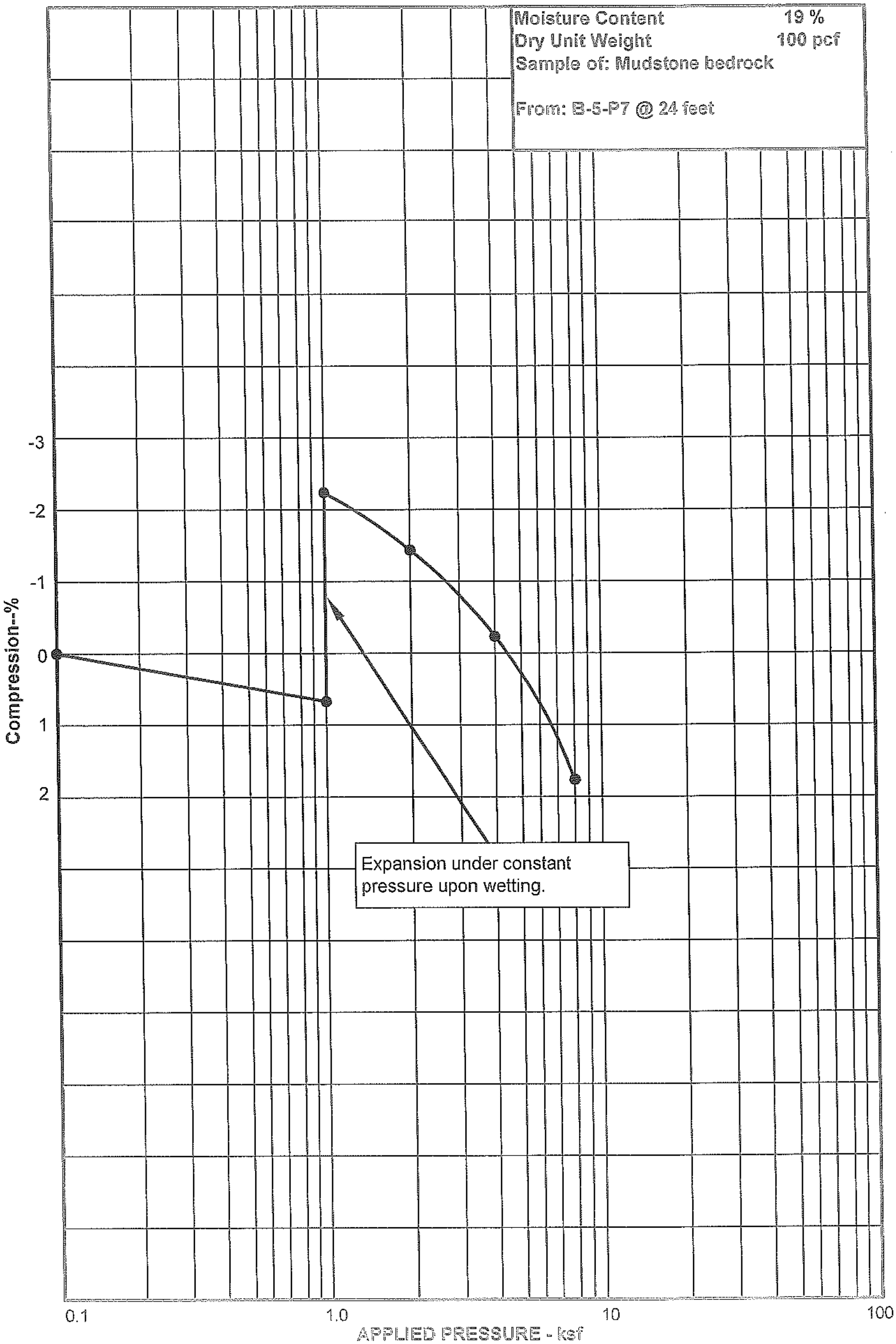


Applied Geotechnical Engineering Consultants, Inc.

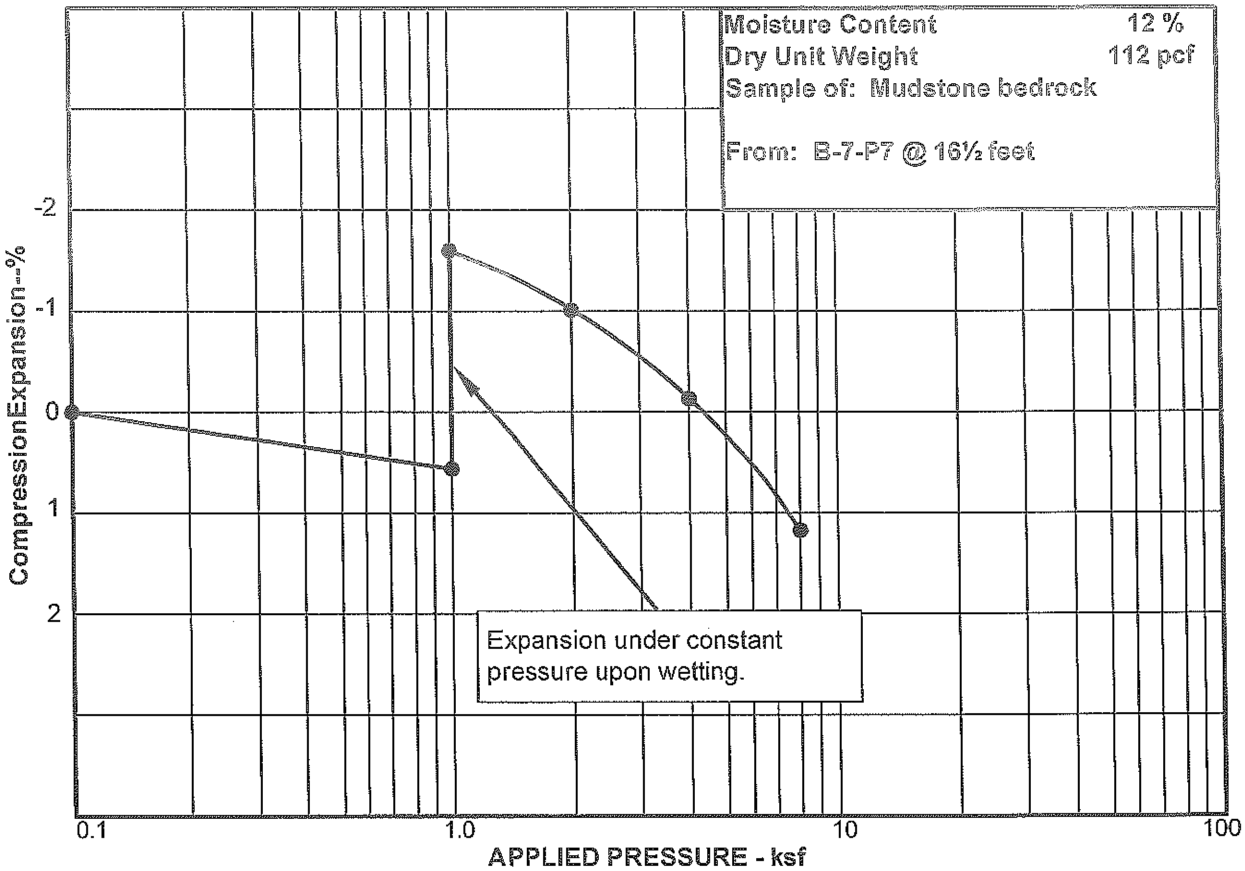


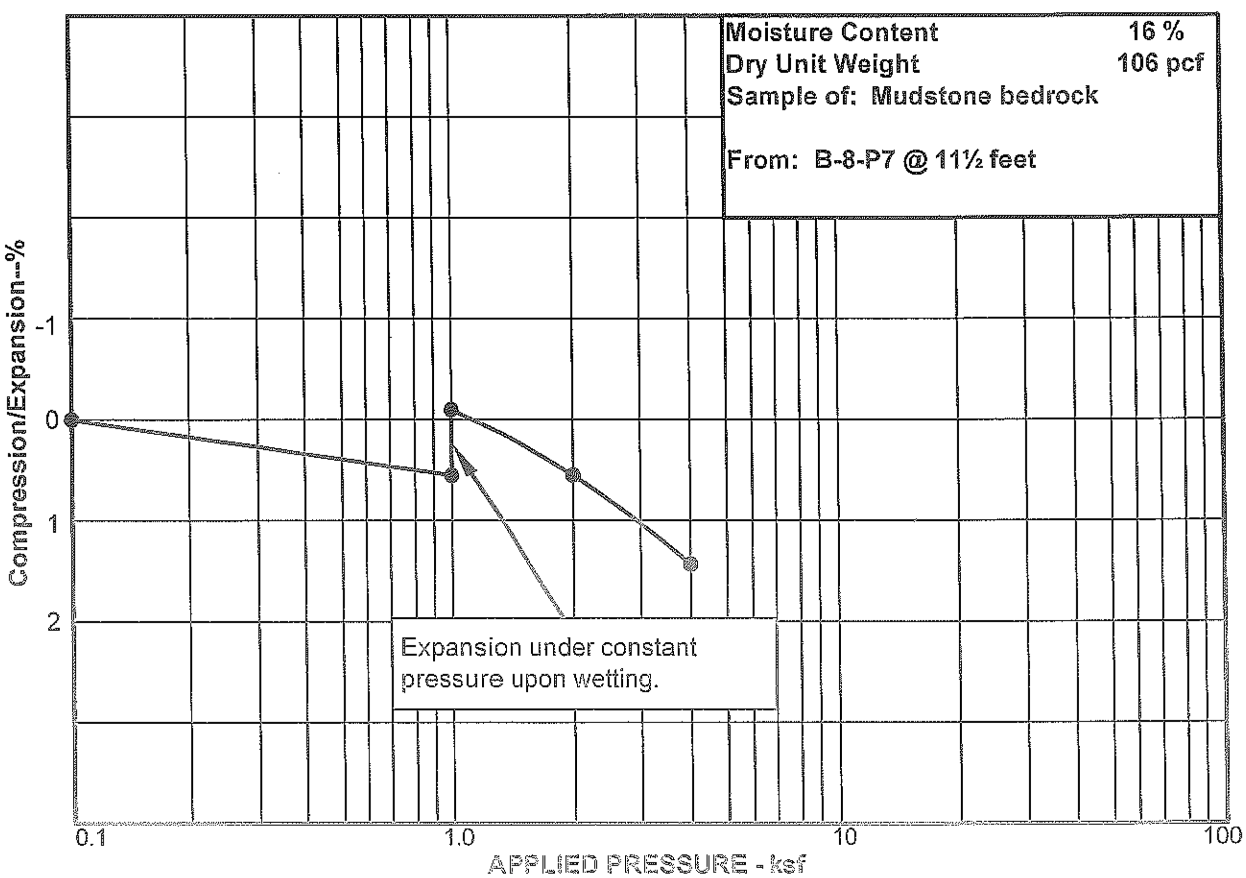


Applied Geotechnical Engineering Consultants, Inc.

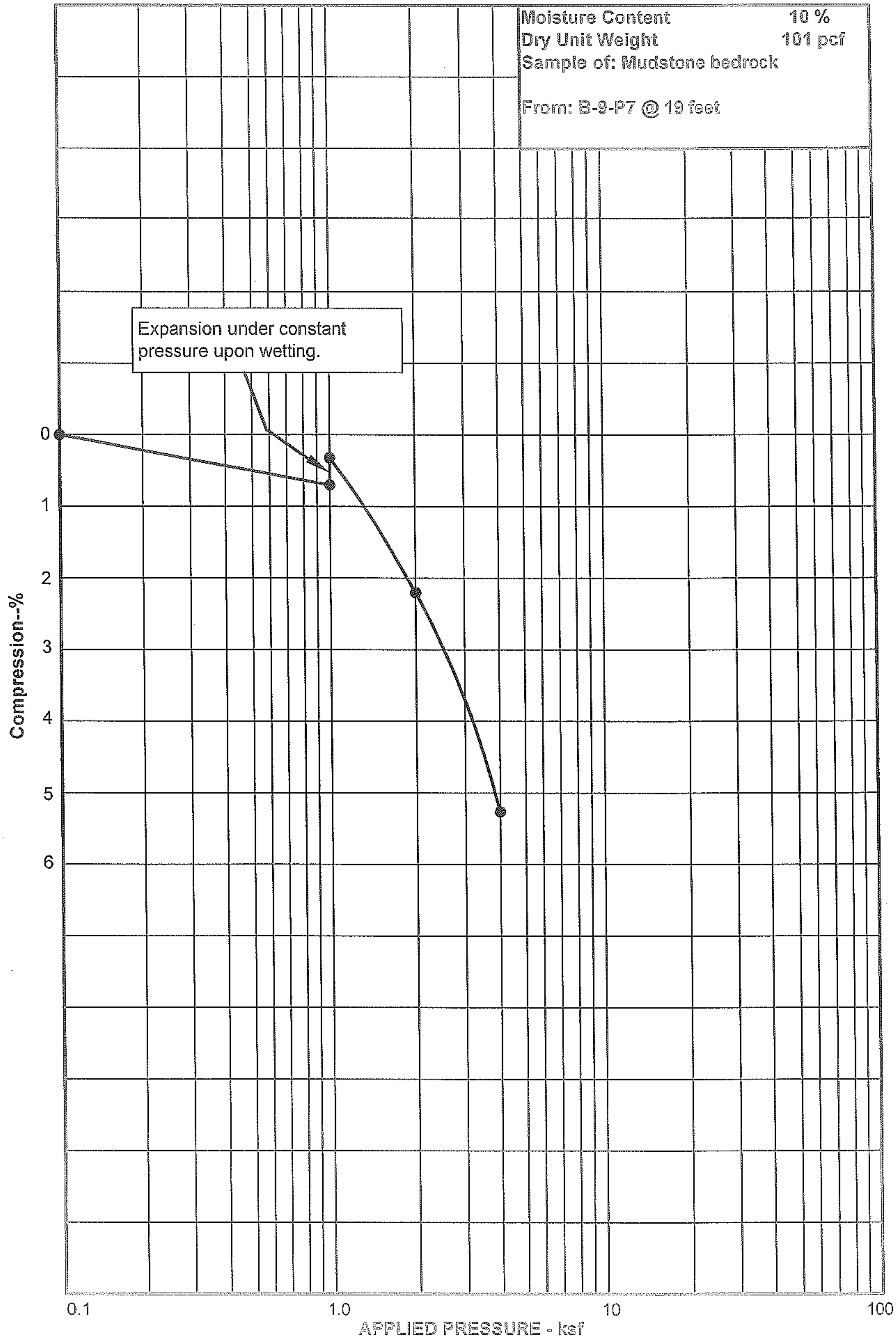


Project No. 2130401 CONSOLIDATION TEST RESULTS Figure 19

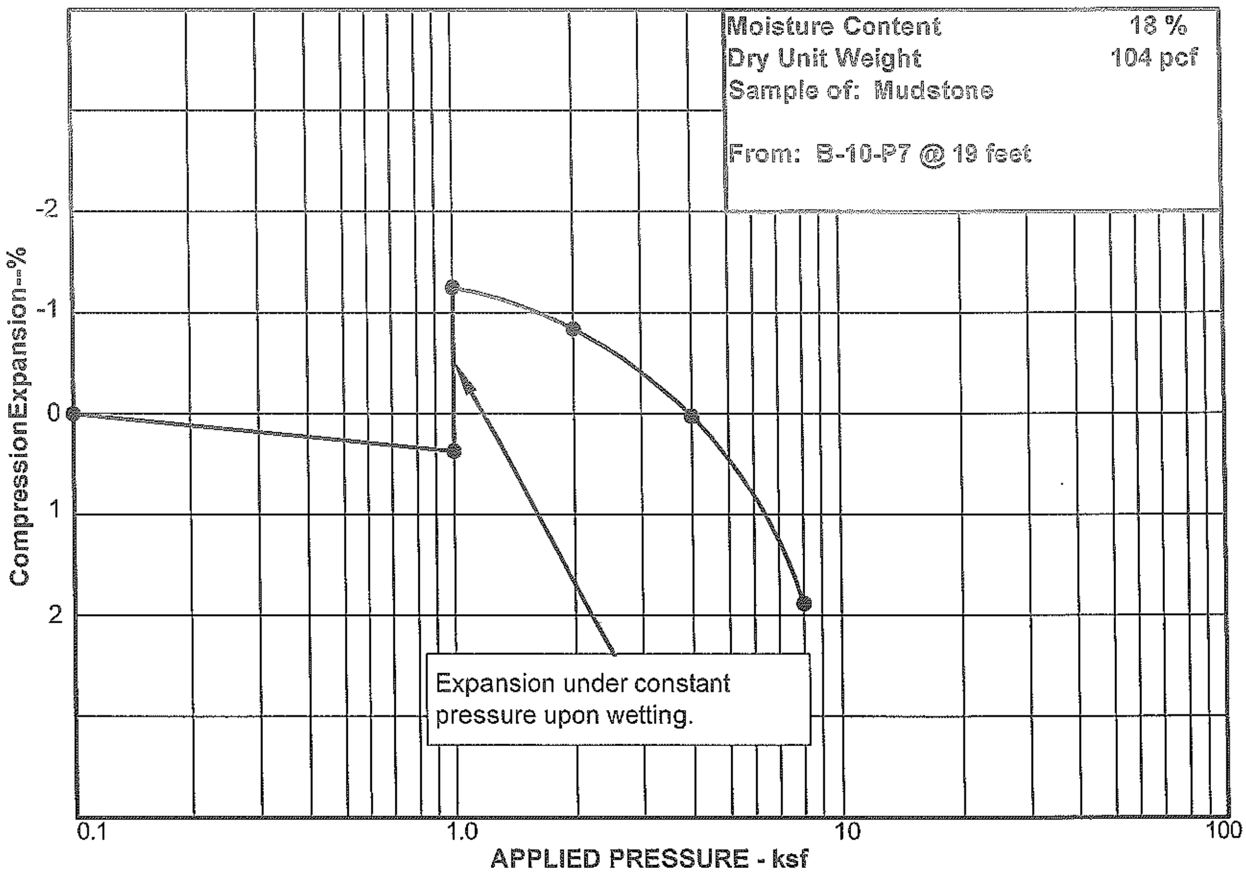

Moisture Content 12 %
Dry Unit Weight 112 pcf
Sample of: Mudstone bedrock
From: B-7-P7 @ 16½ feet
Compression Expansion--%
-2
-1
0
1
2
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

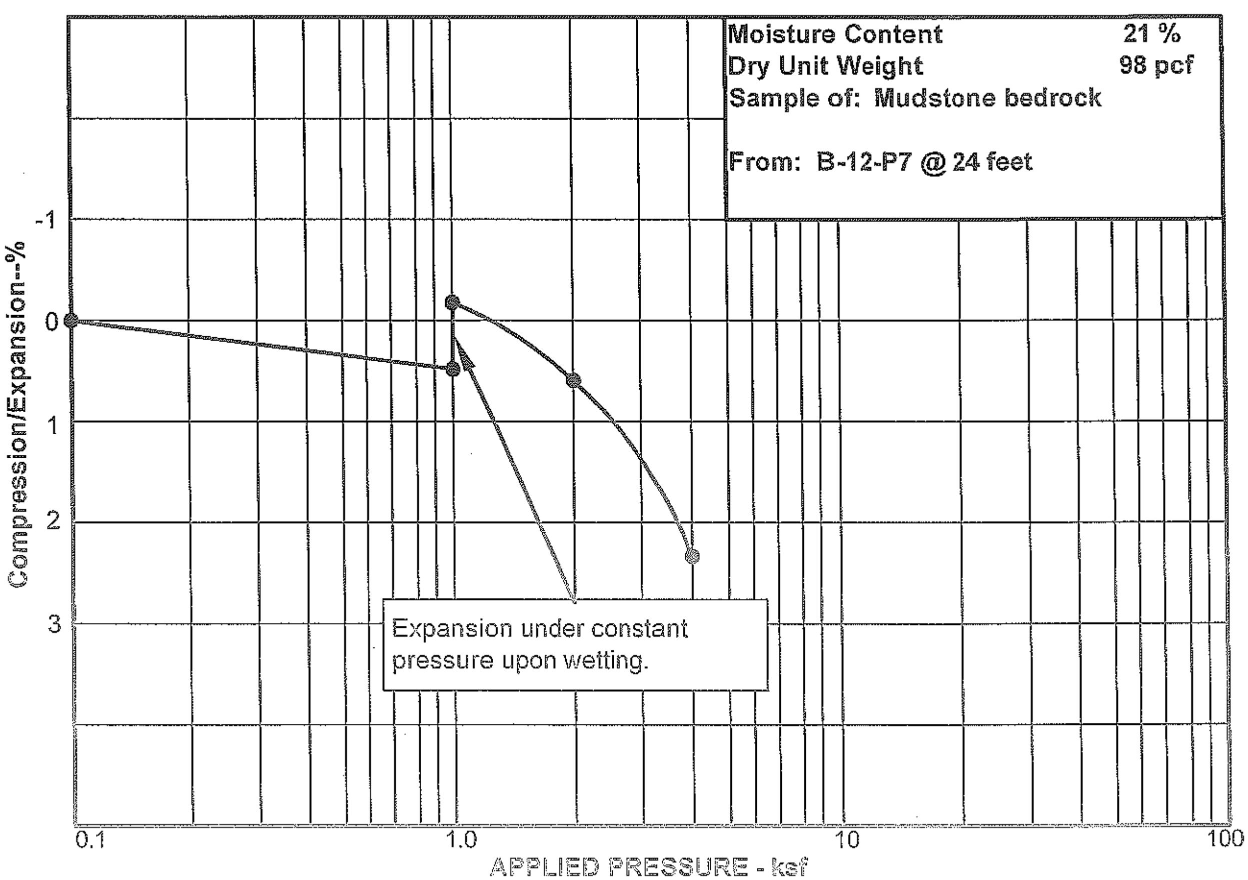

Moisture Content 16 %
Dry Unit Weight 106 pcf
Sample of: Mudstone bedrock
From: B-8-P7 @ 11½ feet
Compression/Expansion--%
-1
0
1
2
Expansion under constant pressure upon wetting.
0.1
1.0
10
100
APPLIED PRESSURE - ksf

Applied Geotechnical Engineering Consultants, Inc.



Applied Geotechnical Engineering Consultants, Inc.





APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

Bella Sol Subdivision, Phases 2-7

Project Number 2130401

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		SAMPLE CLASSIFICATION
BORING NO.	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
B-1-P2	2	10	108			41			Silty sand (SM)
B-1-P2	19	18	111			72	39	21	Mudstone bedrock
B-2-P2	2	7	113						Fill
B-2-P2	24	17	110						Mudstone bedrock
B-2-P2	29	18	103						Mudstone bedrock
B-3-P2	2	8	93						Fill
B-3-P2	18	12	118			68	21	10	Clayey sand (SC)
B-1-P3	4	14	110			32			Silty sand (SM)
B-1-P3	19	18	108			89	54	38	Mudstone bedrock
B-1-P5	2	15	102						Fill
B-1-P5	4	18	93						Fill
B-1-P5	9	13	108			19			Silty sand (SM)
B-1-P5	24	20	103						Mudstone bedrock
B-1-P5	29	17	106						Mudstone bedrock
B-2-P5	2	3	101			35			Fill

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

Bella Sol Subdivision, Phases 2-7

Project Number 2130401

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		SAMPLE CLASSIFICATION
BORING NO.	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
B-2-P5	19	26	91			88	62	33	Mudstone bedrock
B-2-P5	24	20	102						Mudstone bedrock
B-1-P6	9	6	108			16			Silty sand (SM)
B-2-P6	2	3	104			33			Silty sand (SM)
B-2-P6	24	22	98			94	52	32	Mudstone bedrock
B-3-P6	2	8	106			96			Fill
B-3-P6	24	21	99				52	28	Mudstone bedrock
B-3-P6	29	18	108						Mudstone bedrock
B-1-P7	9	16	104			67	50	33	Mudstone bedrock
B-1-P7	14	18	99			86	55	32	Mudstone bedrock
B-2-P7	14	16	107			61	43	23	Mudstone bedrock
B-2-P7	19	8	117			46	41	21	Mudstone bedrock
B-3-P7	4	6	104			33			Silty sand (SM)
B-3-P7	19	13	111			79	26	7	Clayey sand (SC)
B-4-P7	14	20	105			90	66	42	Mudstone bedrock
B-4-P7	19	20	101			92	54	26	Mudstone bedrock

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

Bella Sol Subdivision, Phases 2-7

Project Number 2130401

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		SAMPLE CLASSIFICATION
BORING NO.	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
B-5-P7	19	13	104			73	47	25	Mudstone bedrock
B-5-P7	24	19	100			95	55	30	Mudstone bedrock
B-7-P7	16½	12	112						Mudstone bedrock
B-8-P7	11½	16	106						Mudstone bedrock
B-9-P7	19	10	101						Mudstone bedrock
B-10-P7	19	18	104						Mudstone bedrock
B-12-P7	24	21	98						Mudstone bedrock