AGEC
Applied GeoTech

Autumnwood Estates

GEOTECHNICAL INVESTIGATION

PROPOSED RESIDENTIAL DEVELOPMENT

12100 SOUTH 3600 WEST

RIVERTON, UTAH

PREPARED FOR:

IVORY HOMES
978 EAST WOODOAK LANE
SALT LAKE CITY, UTAH 84117

ATTENTION: KYLE HONEYCUTT

PROJECT NO. 1131058

JANUARY 9, 2014

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EXECUTIVE SUMMARY

1. The subsurface soils encountered at the site consist of approximately 1 to 1 ½ feet of topsoil overlying lean clay that extends to depths ranging from approximately 7 to 10 feet below the ground surface. Gravel was encountered below the clay and extends to the maximum depth investigated, approximately 13 feet.

2. No subsurface water was encountered in the test pits at the time of excavation.

3. The natural clay, extending to depths of approximately 7 to 10 feet below the ground surface, is sightly to moderately porous. Some of the clay tested in the laboratory is moisture-sensitive where it collapses and becomes more compressible when wetted. The natural clay should be removed from below the proposed buildings.

4. The proposed residences may be supported on spread footings bearing on the undisturbed natural gravel or on compacted structural fill extending down to the undisturbed natural gravel. Spread footings bearing on the undisturbed natural gravel or on compacted structural fill extending down to the gravel, may be designed using an allowable net bearing pressure of 3,500 pounds per square foot.

5. There is a risk of differential settlement for pavement and exterior concrete flatwork where they are constructed above moisture-sensitive soil. Where the moisture-sensitive soil is left in-place below pavement and other improvements, the soil may collapse and become more compressible when wetted. We estimate potential settlement up to approximately 1 ½ inches if the moisture-sensitive soil remains below pavement and flatwork concrete and becomes wet. Removal of the moisture-sensitive soil below these areas and replacing it with properly compacted fill would eliminate the risk of movement due to moisture-sensitive soil. A portion of the moisture-sensitive soil could be removed and replaced with low permeable compacted fill to reduce the amount of potential differential settlement. The on-site clay could be used as low permeable fill if properly compacted at a moisture content within 2 percent of the optimum moisture content.

6. The upper natural soil consists of lean clay. Where the subgrade consists of clay, construction access difficulties may be encountered for rubber-tired construction equipment during periods when the upper soil is very moist to wet. Placement of granular fill may be needed to provide equipment access and to facilitate construction of the pavement when the upper soil is very moist to wet.

7. Geotechnical information related to foundations, subgrade preparation, pavement design and materials is included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed residential development to be located at 12100 South 3600 West in Riverton, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundations and pavement. The study was conducted in general accordance with our proposal dated November 21, 2013.

Field exploration was conducted to obtain information on the subsurface conditions. Samples obtained from the field investigation were tested in the laboratory to determine physical and engineering characteristics of the on-site soil. Information obtained from the field and laboratory was used to define conditions at the site for our engineering analysis and to develop recommendations for the proposed foundations and pavement.

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.

SITE CONDITIONS

The site consisted of a cultivated field at the time of our field. There are no permanent structures or pavement on the site

There are several unlined irrigation ditches extending through the property.

The site has a gentle slope down to the east with approximately 30 feet of elevation difference across the property. There is a moderate slope along the west edge of the site sloping up to 3600 West Street. The road is approximately 4 to 8 feet higher than the property.

Vegetation at the site consists of sparse grass and weeds. Several inches of snow covered the site at the time of our field study.

The site is bordered on the east by the Utah Lake Distribution canal. The canal appears to be unlined and did not have water flowing in it at the time of our field study.

There is generally residential development in all directions from the site. The site is bordered on the west by 3600 West Street, which is a 2-lane asphalt-paved road.

FIELD STUDY

The field study was conducted on December 7, 2013 and January 3, 2014. Five test pits were excavated at the site at the approximate locations indicated on Figure 1 using a rubber-tired backhoe. The test pits were logged and soil samples obtained by an engineer from AGEC. Logs of the subsurface conditions encountered in the test pits are graphically shown on Figure 2 with legend and notes on Figure 3.

The test pits were backfilled without significant compaction. The backfill in the test pits should be properly compacted where it will support buildings, floor slabs, pavement or other improvements.

SUBSURFACE CONDITIONS

The subsurface soils encountered at the site consist of approximately 1 to 1½ feet of topsoil overlying lean clay that extends to depths ranging from approximately 7 to 10 feet below the ground surface. Gravel was encountered below the clay and extends to the maximum depth investigated, approximately 13 feet.

A description of the various soils encountered in the test pits follows:

Topsoil - The topsoil consists of sandy lean clay. It is moist, dark brown and contains roots and organics.

Lean Clay - The clay contains occasional silty sand layers. It is medium stiff to very stiff, slightly moist to very moist, brown and slightly to moderately porous.

Laboratory tests conducted on samples of the clay indicate natural moisture contents range from 13 to 36 percent and natural dry densities range from 74 to 95 pounds per cubic foot (pcf).

Consolidation tests conducted on samples of the clay indicate that some of the material is moisture sensitive where it becomes more compressible when wetted. The results of consolidation tests are presented on Figures 4 through 14.

Clayey Gravel with Sand - The gravel contains cobbles up to approximately 5 inches in size. It is medium dense, slightly moist to moist and brown.

Results of the laboratory tests are summarized on Table I and are included on the logs of the test pits.

SUBSURFACE WATER

No subsurface water was encountered in the test pits at the time of excavation to the maximum depth investigated, approximately 13 feet. Slotted PVC pipe was installed in Test Pits TP-3 and TP-5, which were excavated adjacent to the canal. No water was present in the pipes when checked on December 16, 2013.

PROPOSED CONSTRUCTION

We understand that the site encompasses 19.34 acres, which will be subdivided for residential construction. We anticipate that the residences will consist of one to two-story, wood-frame structures with basements. We have assumed building loads consisting of wall loads up to 3 kips per lineal foot and column loads up to 30 kips.

We understand that paved roads will be constructed through the development. We have assumed traffic for the roads consisting predominantly of passenger vehicles with one delivery truck and two busses per day and two garbage trucks per week.

If the proposed construction, building loads or traffic is significantly different from what is described above, we should be notified so that we can reevaluate the recommendations given.

RECOMMENDATIONS

A. Site Grading

Site grading plans were not provided for our review. We anticipate that there will be up to approximately 3 feet of cut and fill for the proposed development.

1. <u>Subgrade Preparation</u>

   Prior to placing grading fill or base course, the topsoil, organic material, unsuitable fill and other deleterious materials should be removed.

   The upper soil at the site consists of lean clay. Access difficulties may be encountered when the clay is very moist to wet such as during the winter and spring or after periods of precipitation or snowmelt. Placement of granular borrow will improve site access and may be needed to facilitate pavement construction. Generally, 1 ½ to 2 feet of granular borrow will provide limited support for moderately loaded rubber-tired construction equipment above a very moist to wet clay subgrade.

Moisture-sensitive soil was generally encountered at the site to depths of approximately 7 to 10 feet below the ground surface. There is a risk of differential settlement for pavement and exterior concrete flatwork where they are constructed above moisture-sensitive soils. Where the moisture-sensitive soil is left in-place below pavement and other improvements, the soil may collapse and become more compressible when wetted. We estimate potential settlement up to approximately 1½ inches if the moisture-sensitive soil remains below pavement and flatwork concrete and becomes wet. Removing the moisture-sensitive soil below these areas and replacing it with properly compacted fill would eliminate the risk of movement due to moisture-sensitive soil. A portion of the moisture-sensitive soil could be removed and replaced with low permeable compacted fill to reduce the amount of differential settlement. The on-site clay could be used as low permeable fill if properly compacted at a moisture content within 2 percent of the optimum moisture content.

2. Excavation

We anticipate that excavation at the site can be accomplished with typical excavation equipment. Care should be taken not to disturb the natural soil to remain in the proposed building and pavement areas.

3. Materials

Listed below are materials recommended for imported structural fill:

Fill to Support	Recommendations
Footings	Non-expansive granular soil Passing No. 200 Sieve < 35% Liquid Limit < 30% Maximum size 4 inches
Floor Slab (Upper 4 inches)	Sand and/or Gravel Passing No. 200 Sieve < 5% Maximum size 2 inches
Slab Support	Non-expansive granular soil Passing No. 200 Sieve < 50% Liquid Limit < 30% Maximum size 6 inches

Fill placed below areas of proposed buildings should consist of granular soils as indicated above. The natural clay and fill consisting of clay are not recommended for use as structural fill below the proposed buildings.

Consideration may be given to using fine-grained soils, such as reuse of the existing porous soil, as fill below areas of proposed pavement or other site improvement or for use as backfill. If fine-grained material such as the natural clay is used as fill, the moisture content of the material should be adjusted to within 2 percent of the optimum moisture content to facilitate compaction. This will likely require significant moisture conditioning (wetting or drying) depending on whether the moisture of the soil is above or below the optimum moisture content at the time of construction. Drying of the soil may not be practical during cold or wet times of the year.

4. Compaction

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

Fill To Support	Compaction
Foundations	≥ 95%
Concrete Slabs and Pavement	≥ 90%
Landscaping	≥ 85%
Retaining Wall Backfill	85 - 90%

Base course should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D 1557.

The moisture of the soil should be adjusted to within 2 percent of optimum to facilitate compaction.

Fill and pavement materials placed for the project should be frequently tested for compaction. Fill should be placed in thin enough lifts to allow for proper compaction.

5. Drainage

The ground surface surrounding the proposed buildings should be sloped away from the residences in all directions. Roof down spouts and drains should discharge beyond the limits of backfill. In addition, we recommend that landscape irrigation be kept to a minimum around buildings.

The collection and diversion of drainage away from the pavement surface is important to the satisfactory performance of the pavement section. Proper drainage should be provided.

B. Foundations

1. Bearing Material

Moisture-sensitive soil was generally encountered to depths ranging from approximately 7 to 10 feet below the ground surface. The moisture-sensitive soil is not suitable to support the proposed residences. The proposed residences may be supported on spread footings bearing on the undisturbed natural gravel below the moisture-sensitive soil or on compacted structural fill that extends down to the undisturbed natural gravel. Structural fill placed below footings should extend out away from the edge of footings at least a distance equal to the depth of fill below footings.

2. Bearing Pressure

Spread footings bearing on the undisturbed natural gravel or on compacted structural fill extending down to the undisturbed natural gravel may be designed using an allowable net bearing pressure of 3,500 pounds per square foot (psf).

3. Settlement

We estimate that total and differential settlement will be less than ½ inch for footings designed as indicated above.

4. Temporary Loading Conditions

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

5. Minimum Footing Width and Embedment

Spread footings should have a minimum width of 1½ feet and a minimum depth of embedment of 10 inches.

6. Frost Depth

Exterior footings and footings beneath unheated areas should be placed at least 30 inches below grade for frost protection.

7. Foundation Base

The base of foundation excavations should be cleared of loose or deleterious material prior to structural fill or concrete placement. The subgrade should not be scarified prior to structural fill placement.

8. Construction Observation

A representative of the geotechnical engineer should observe footing excavations prior to structural fill or concrete placement.

C. Concrete Slab-on-Grade

1. Slab Support

Concrete slabs may be supported on the undisturbed natural soil below the moisture-sensitive soil or on compacted structural fill that extends down to the undisturbed natural soil below the moisture-sensitive soil.

Topsoil, unsuitable fill, organics, debris, moisture-sensitive soil and other deleterious materials should be removed from below proposed slabs.

As an alternative to removing the moisture-sensitive soil from below concrete slabs, consideration may be given to providing a structural floor supported by the building foundations.

2. Underslab Sand and/or Gravel

Consideration may be given to placing a 4-inch layer of free-draining sand and/or gravel (less than 5 percent passing the No. 200 sieve) below slabs to promote even curing of the slab concrete.

D. Lateral Earth Pressures

1. Lateral Resistance for Footings

Lateral resistance for footings placed on natural soil or on compacted structural fill is controlled by sliding resistance between the footing and foundation soils. A friction value of 0.35 may be used in design for ultimate lateral resistance.

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

Soil Type	Active	At-Rest	Passive
Clay & Silt	50 pcf	65 pcf	250 pcf
Sand & Gravel	40 pcf	55 pcf	300 pcf

3. Seismic Conditions

Under seismic conditions, the equivalent fluid weight should be increased by 31 pcf and 16 pcf for active and at-rest conditions, respectively, and decreased by 31 pcf for the passive condition. This assumes a peak horizontal ground acceleration of 0.49g for a seismic event having a 2 percent probability of exceedance in a 50-year period (IBC, 2012).

4. Safety Factors

The values recommended above for active and passive conditions assume mobilization of the soil to achieve the soil strength. Conventional safety factors used for structural analysis for such items as overturning and sliding resistance should be used in design.

E. Seismicity, Faulting and Liquefaction

1. Seismicity

Listed below is a summary of the site parameters for the 2012 International Building Code.

a.	Site Class	D
b.	Short Period Spectral Response Acceleration, S_S	1.20g
c.	One Second Period Spectral Response Acceleration, S_1	0.40g

2. Faulting

There are no mapped active faults extending near or through the site. The closest mapped fault, considered to be active, is the Wasatch fault located approximately 7 miles east of the site (Salt Lake County, 2002).

3. Liquefaction

The area of the proposed subdivision is mapped as having a "very low" potential for liquefaction (Salt Lake County, 2002). Based on the subsurface conditions encountered at the site, the Salt Lake County liquefaction hazard map and our understanding of the geologic conditions in the area, liquefaction is not a hazard for the proposed development.

F. Water Soluble Sulfates

One sample of the natural soil was tested in the laboratory for water soluble sulfate content. Results of the test indicate there is less than 0.1 percent water soluble sulfate in the samples tested. Based on the results of the test and published literature, the natural soil possesses negligible sulfate attack potential on concrete.

No special cement type is required for concrete placed in contact with the natural soil. Other conditions may dictate the type of cement to be used in concrete for the project.

G. Pavement

Based on the subsurface soil conditions encountered, laboratory test results and the assumed traffic, the following pavement support recommendations are given:

1. Subgrade Support

   The near surface soil consists of lean clay. A California Bearing Ratio (CBR) of 3 percent was used in the analysis.

2. Pavement Thickness

   Based on the subsoil conditions, assumed traffic, a design life of 20 years for flexible and 30 years for rigid pavement and methods presented by the Utah Department of Transportation, a flexible pavement section consisting of 3 inches of asphaltic concrete overlying 9 inches of base course is calculated. The base course thickness could be reduced to 6 inches in areas where no significant truck traffic is anticipated such as cul-de-sacs or parking areas. A rigid pavement section consisting of 5 inches of Portland cement concrete placed on a prepared subgrade may be used as an alternative to the asphaltic concrete pavement section.

   Granular borrow will likely be needed if the subgrade consists of very moist to wet clay as discussed in the subgrade preparation section of the report. Where at least 6 inches of granular borrow is provided, the base course thickness may be reduced to 6 inches.

3. Pavement Materials and Construction

a. Flexible Pavement (Asphaltic Concrete)

The pavement materials should meet the material specifications for the applicable jurisdiction. Other materials may be considered for use in the pavement section. The use of other materials may result in the need for different pavement material thicknesses.

b. Rigid Pavement (Portland Cement Concrete)

The pavement thickness indicated assumes that the pavement will have aggregate interlock joints and that a concrete shoulder or curb will be provided.

The pavement materials should meet the material specifications for the applicable jurisdiction. The pavement thickness indicated above assumes that the concrete will have a 28-day compressive strength of 4,000 psi. Concrete should be air-entrained with approximately 6 percent air. Maximum allowable slump will depend on the method of placement but should not exceed 4 inches.

4. Jointing

Joints for concrete pavement should be laid out in a square or rectangular pattern. Joint spacings should not exceed 30 times the thickness of the slab. The joint spacings indicated should accommodate the contraction of the concrete and under these conditions steel reinforcing will not be required. The depth of joints should be approximately one-fourth of the slab thickness.

H. Subsurface Drains

The natural soil extending to depths of approximately 7 to 10 feet below the ground surface consists of lean clay. The clay classifies as Group II soil based on Table

R405.1 of the International Residential Code. Foundation drains would not be required where the excavation for the below grade portion of the residence extends down to the natural gravel or where granular fill is placed below the residence and the granular fill extends down to the natural gravel. If fine-grained material were used as structural fill, such as the natural clay, foundation drains would be recommended below the below-grade floor portion of the residence. Foundation drains should include at least the following items:

1. The underdrain system should consist of a perforated pipe installed in a gravel filled trench around the perimeter of the subgrade floor portion of the building.

2. The flow line of the pipe should be placed at least 14 inches below the finished floor level and should slope to a sump or outlet where water can be removed by pumping or by gravity flow.

3. If placing the gravel and drain pipe requires excavation below the bearing level of the footing, the excavation for the drain pipe and gravel should have a slope no steeper than 1 horizontal to 1 vertical so as not to disturb the soil below the footing.

4. A filter fabric should be placed between the natural soil and the drain gravel. This will help reduce the potential for fine-grained material filling in the void spaces of the gravel.

5. The subgrade floor slab should have at least 6 inches of free-draining gravel placed below it and the underslab gravel should connect to the perimeter drain.

6. Consideration should be given to installing cleanouts to allow access into the perimeter drain should cleaning of the pipe be required in the future.

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 test pits excavated at the approximate locations indicated on the site plan and the data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the proposed construction, subsurface conditions or groundwater level is found to be significantly different from what is described above, we should be notified to reevaluate the recommendations given.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

PROFESSIONAL ENGINEER
1/10/14
JAY R.
MCQUIVEY
No. 177892-2202
STATE OF UTAH

Jay R. McQuivey, P.E.

Reviewed by Douglas R. Hawkes, P.E., P.G.

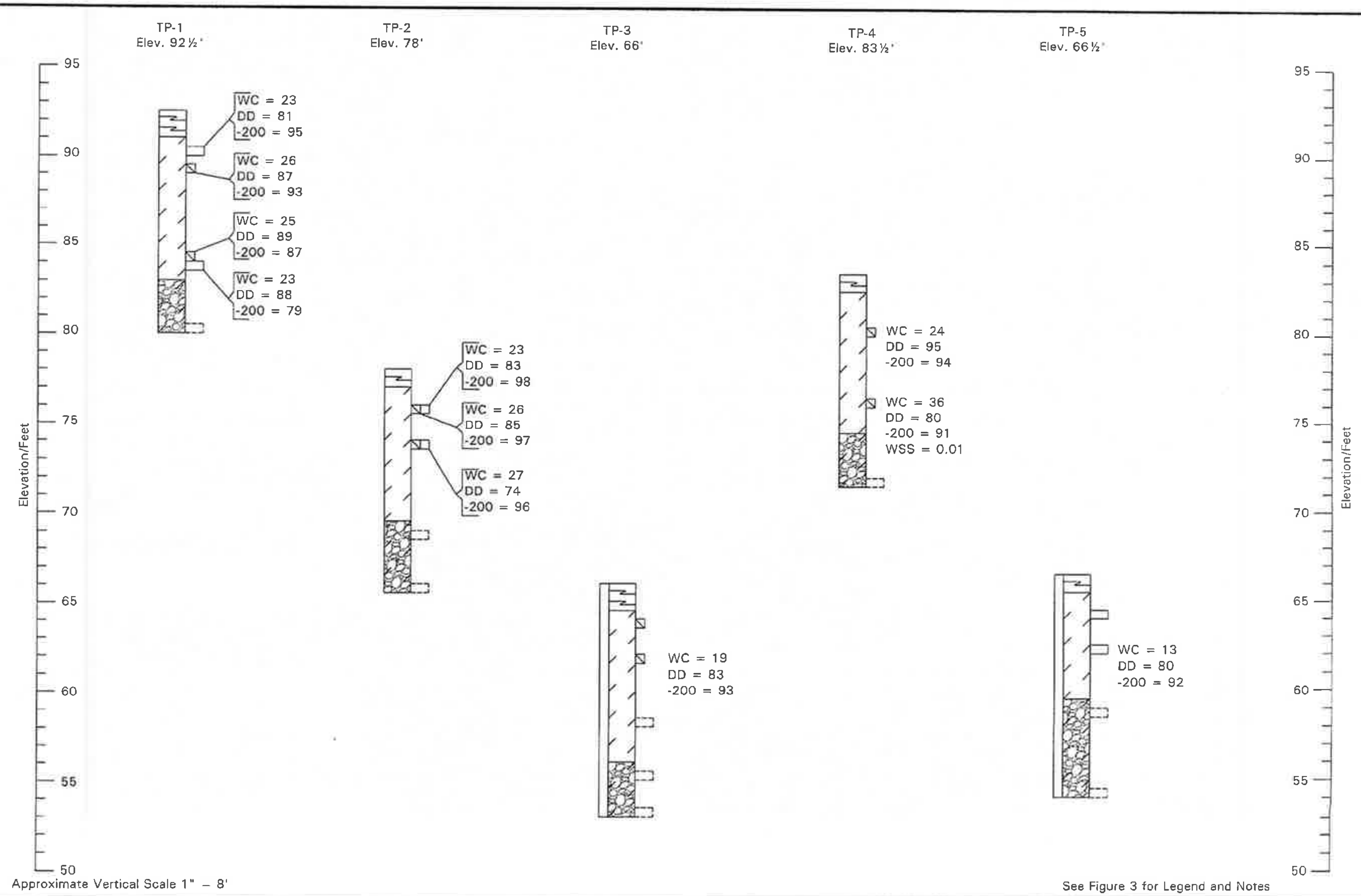
JRM/bw

REFERENCES

International Building Codes, 2012; International Code Council, Inc., Falls Church, Virginia.

Salt Lake County, 2002; Surface Rupture and Liquefaction Potential Special Study Areas Map, Salt Lake County, Utah, adopted March 31, 1989, updated March 2002, Salt Lake County Public Works - Planning Division, 2001 South State Street, Salt Lake City, Utah.

1131058	AGEC	Locations of Test Pits	Figure 1



1131058	AGEC Applied GeoTech	Logs of Test Pits	Figure 2

LEGEND:

	Topsoil; sandy lean clay, moist, dark brown, roots and organics.
	Lean Clay (CL); occasional silty sand layers, medium stiff to very stiff, slightly moist to very moist, brown, slightly to moderately porous.
	Clayey Gravel with Sand (GC); cobbles up to 5 inches in size, medium dense, slightly moist to moist, brown.
	Indicates relatively undisturbed hand drive sample taken.
	Indicates disturbed sample taken.
	Indicates relatively undisturbed block sample taken.
	Indicates slotted 1 ½ inch PVC pipe installed in the test pit to the depth shown.

NOTES:

1. Test pits were excavated on December 7, 2013 and January 3, 2014 with a rubber-tired backhoe.
2. Locations of test pits were measured approximately by pacing from features shown on the site plan provided.
3. Elevations of test pits were measured by automatic level and refer to the benchmark shown on Figure 1.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between the materials shown on the test pit logs represent the approximate boundaries between material types and the transitions may be gradual.
6. No free water was encountered in the test pits at the time of excavation.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   -200 = Percent Passing No. 200 Sieve;
   WSS = Water Soluble Sulfates (%).

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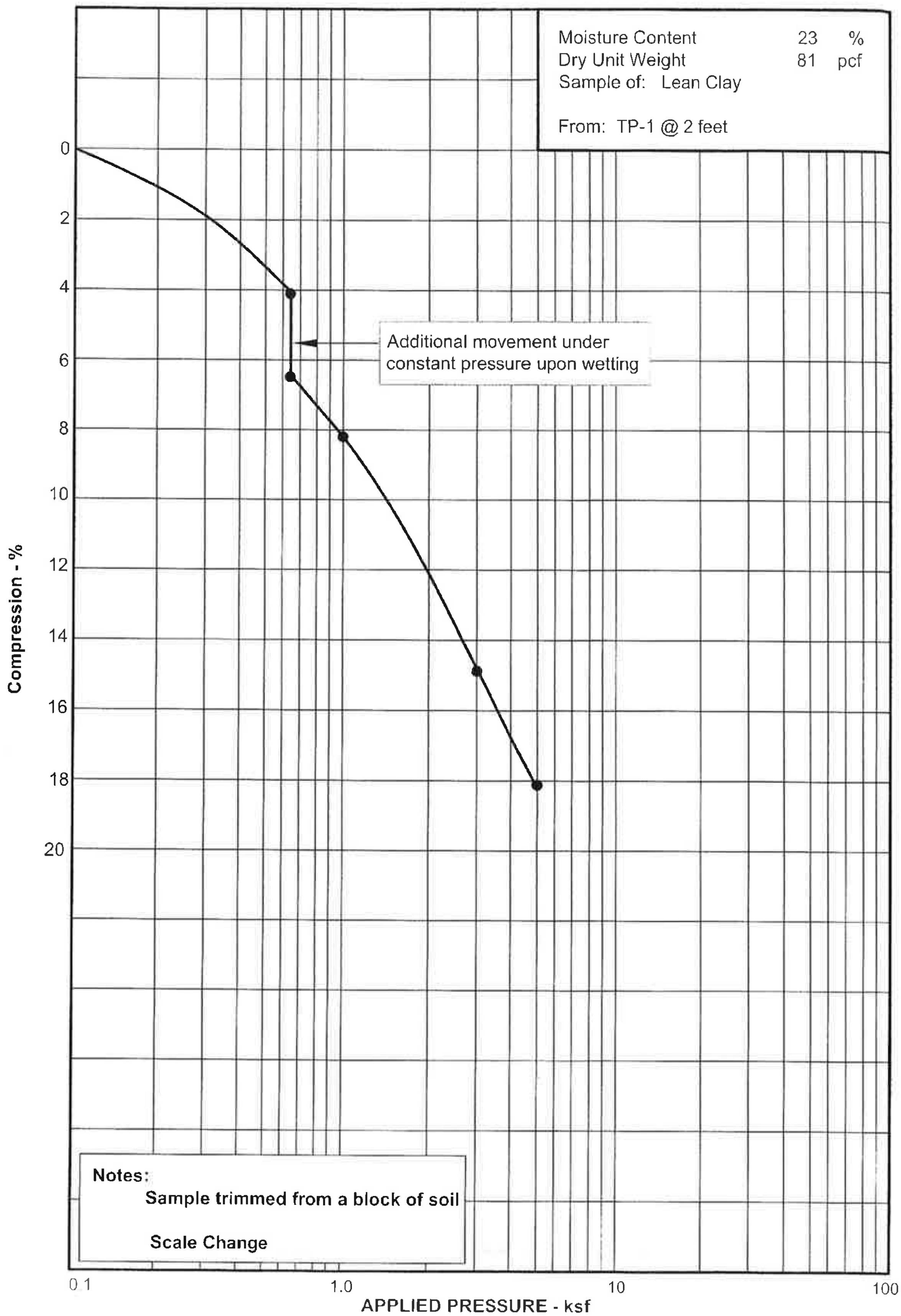

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CONSOLIDATION TEST RESULTS

Figure 4

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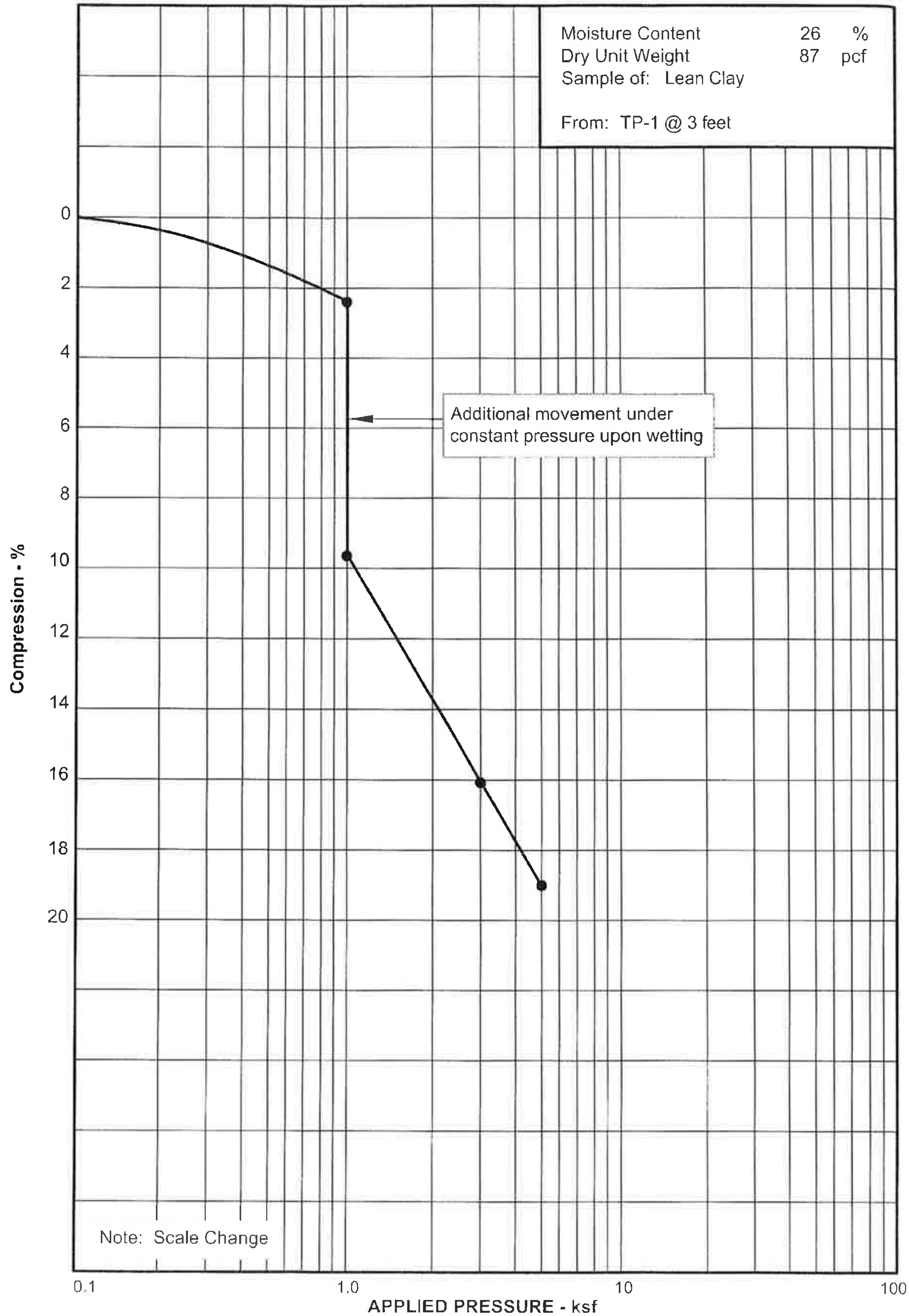
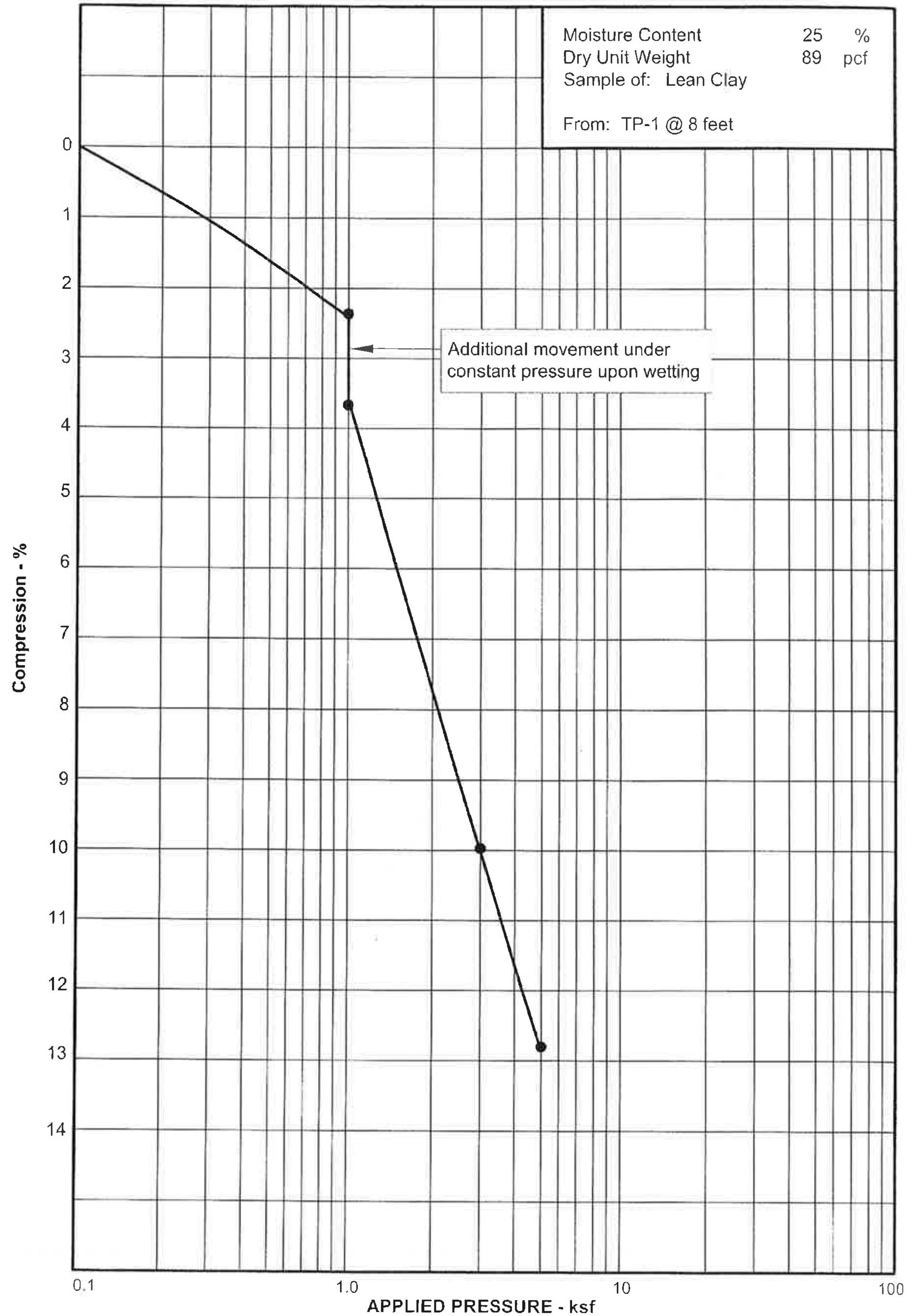


Project No. 1131058 **CONSOLIDATION TEST RESULTS** **Figure 5**

Applied Geotechnical Engineering Consultants, Inc.



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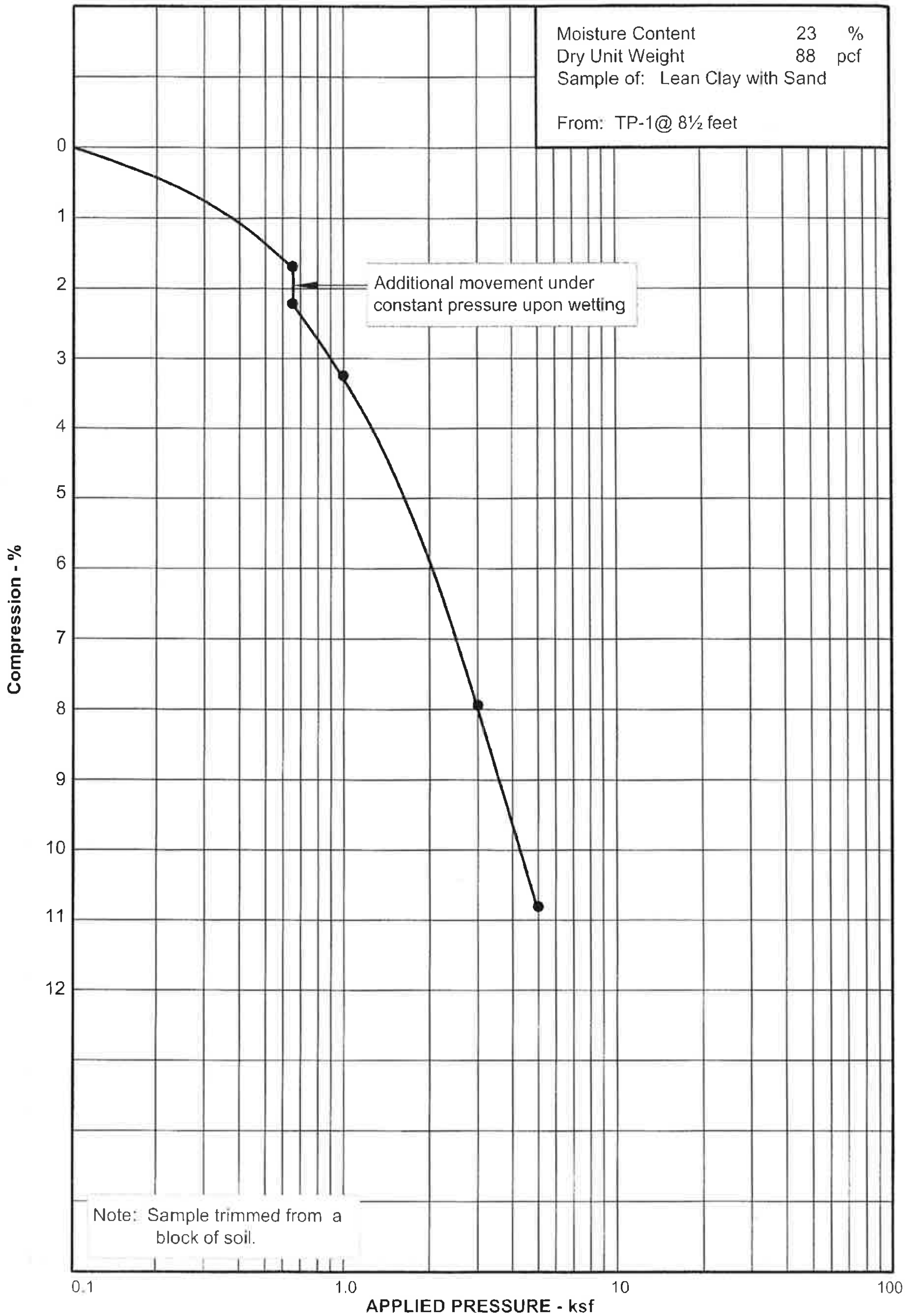
CONSOLIDATION TEST RESULTS

Figure 6

Applied Geotechnical Engineering Consultants, Inc.



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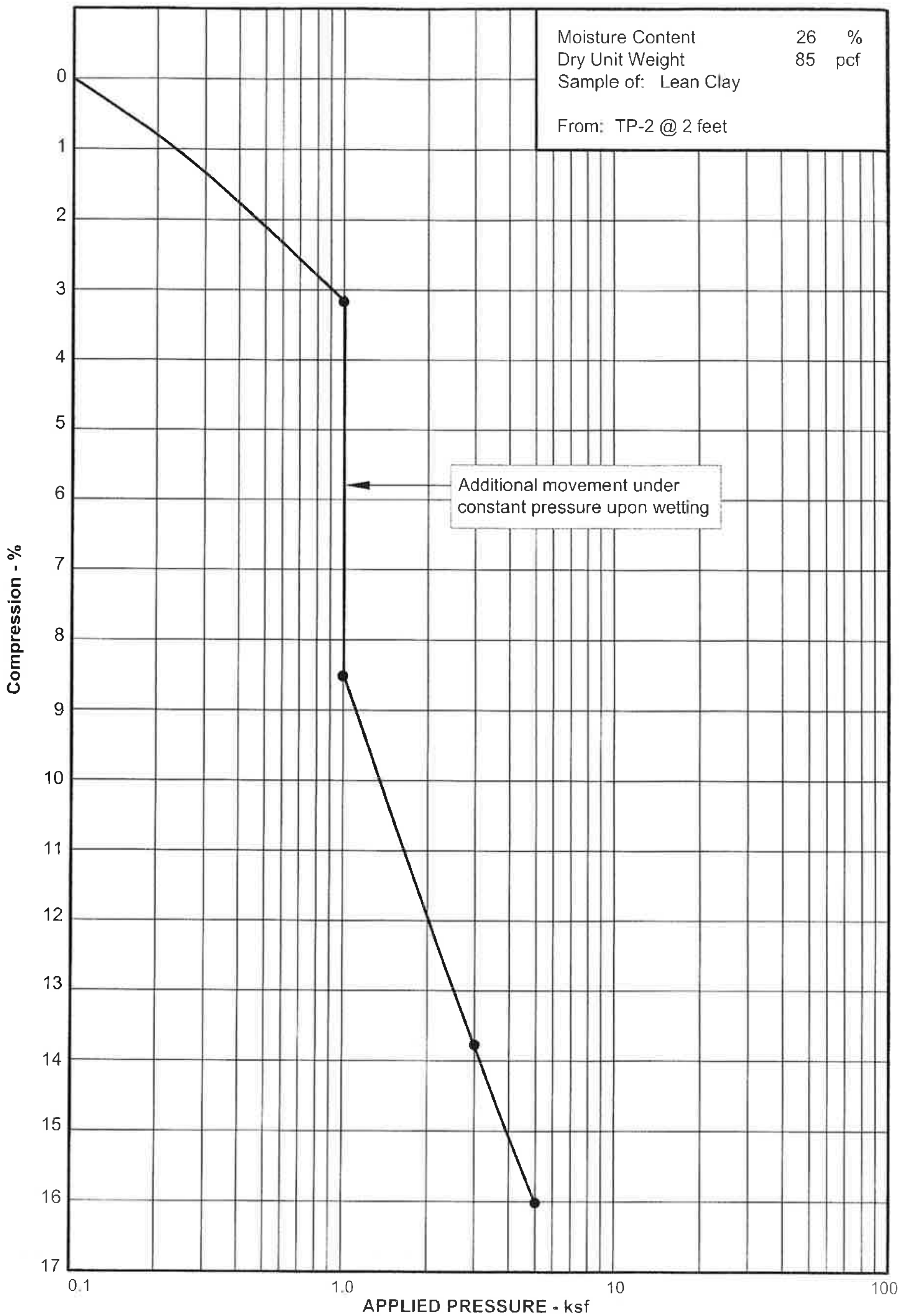
CONSOLIDATION TEST RESULTS

Figure 7

Applied Geotechnical Engineering Consultants, Inc.



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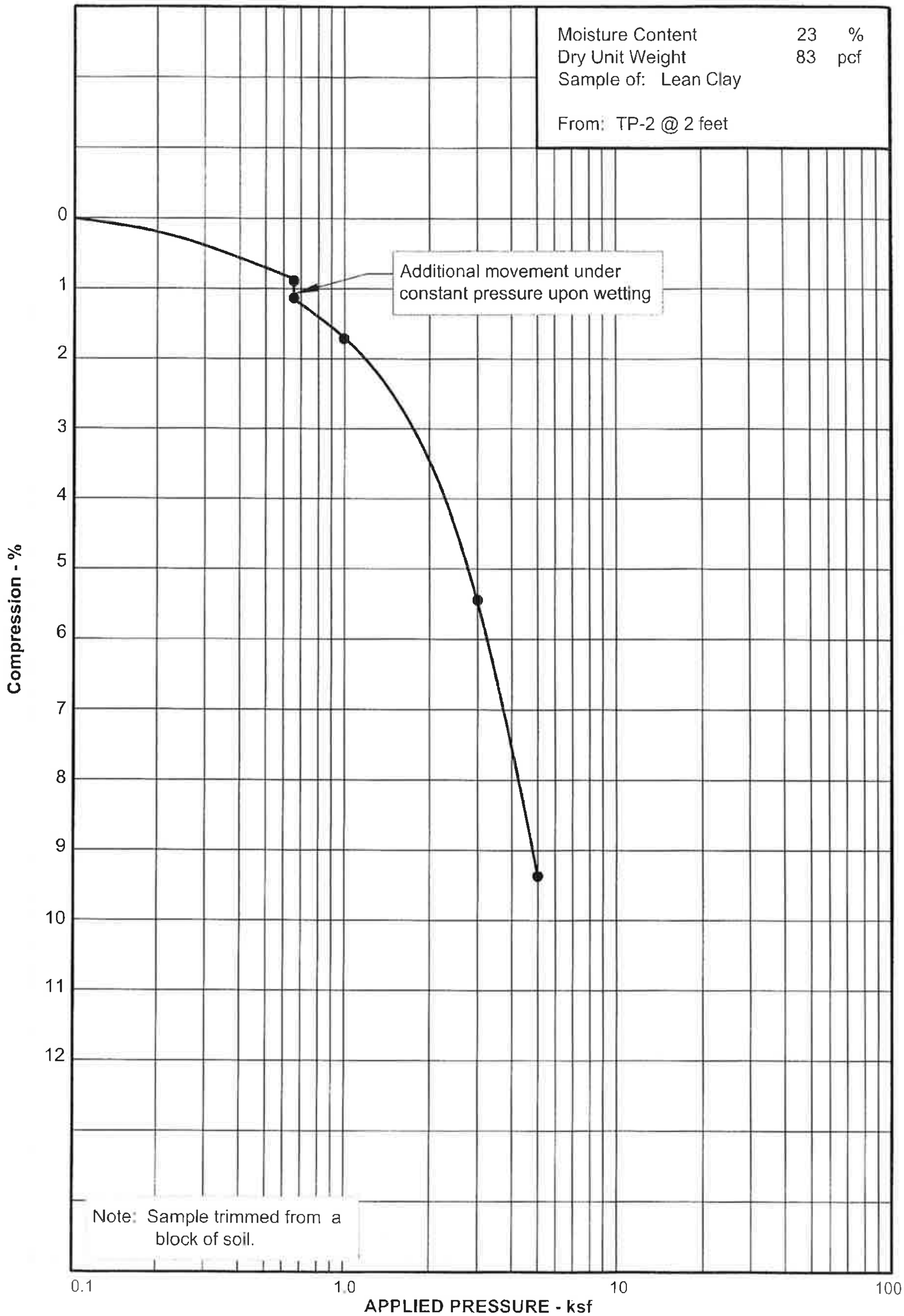
CONSOLIDATION TEST RESULTS

Figure 8

Applied Geotechnical Engineering Consultants, Inc.



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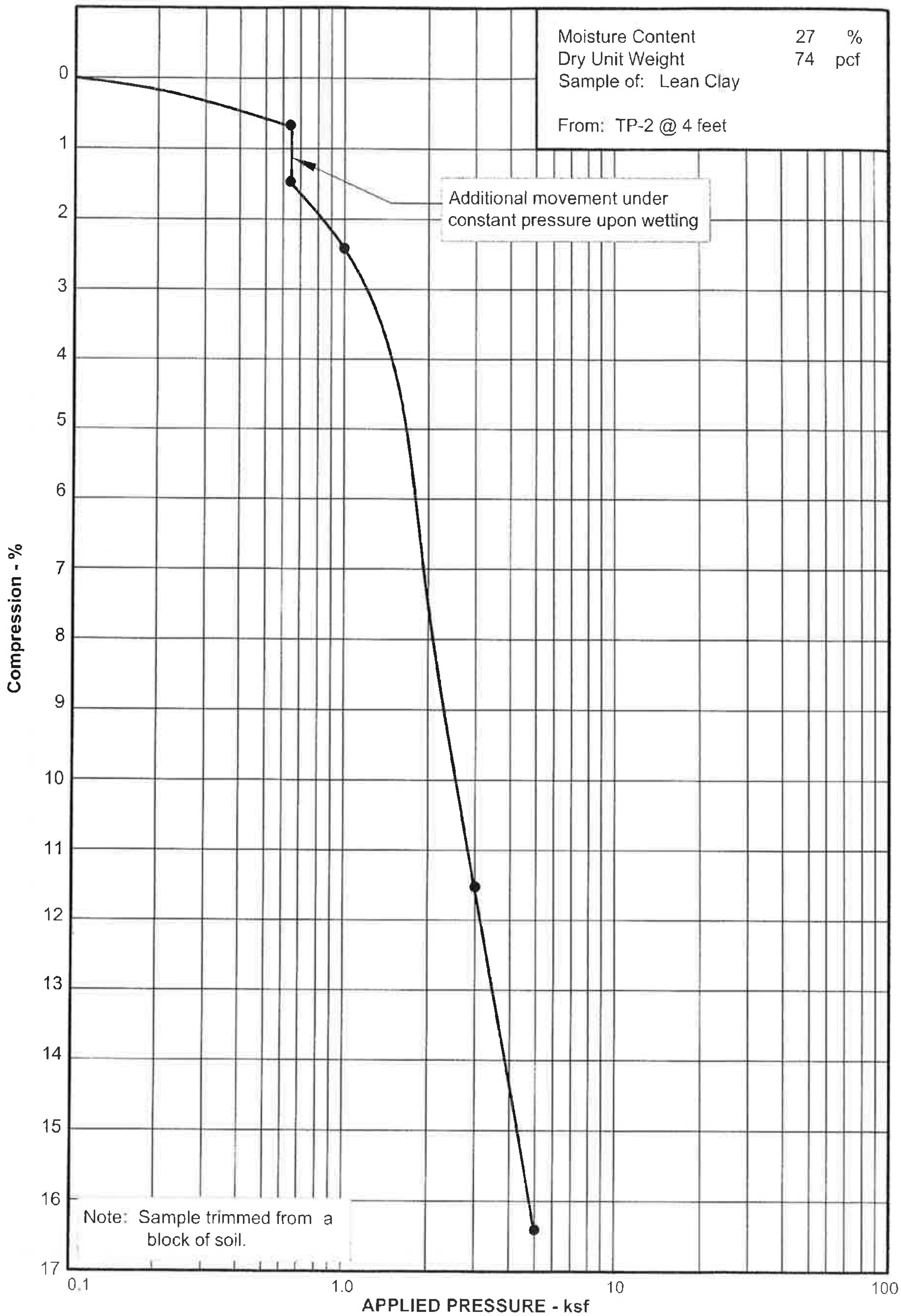
CONSOLIDATION TEST RESULTS

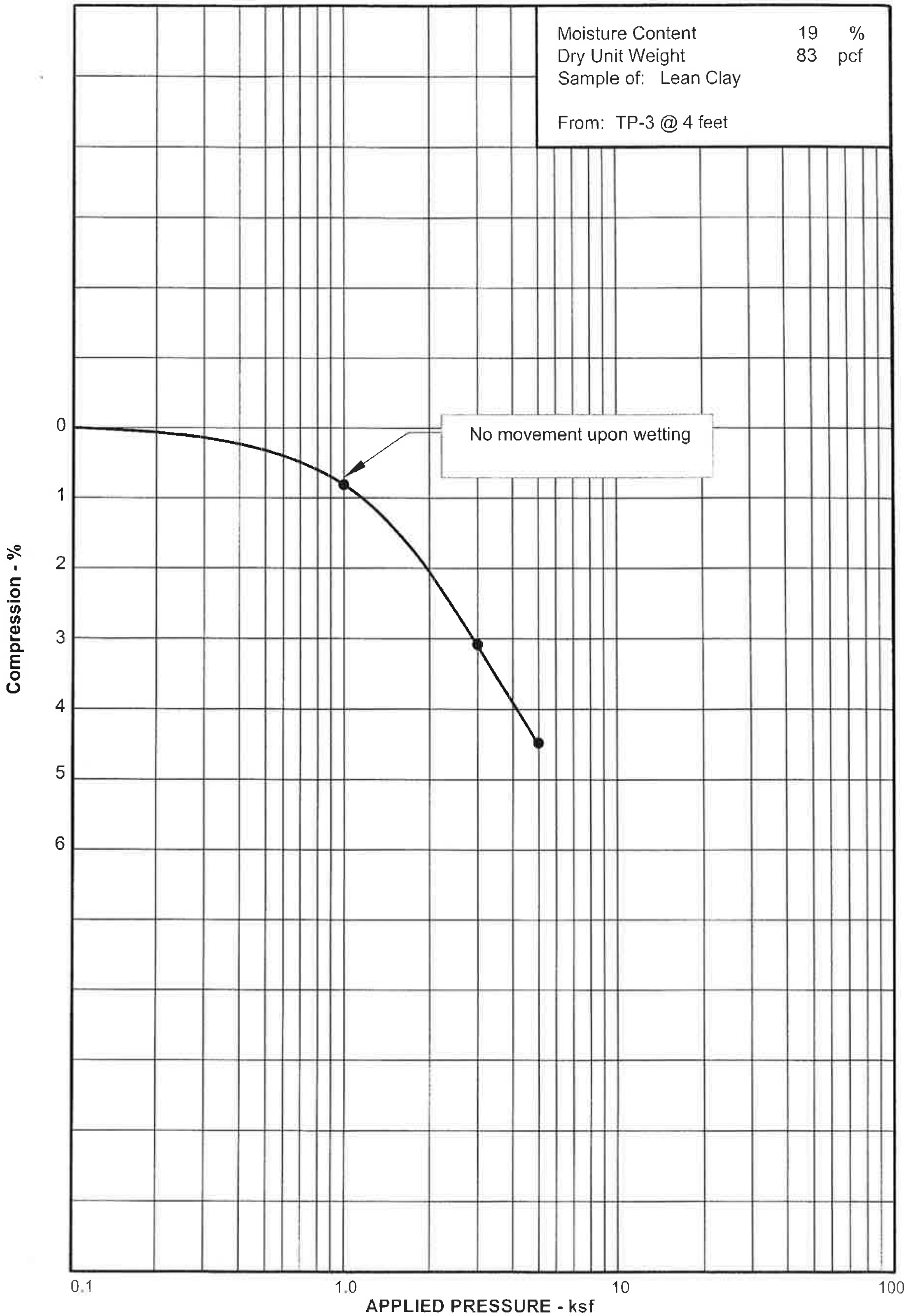
Figure 9

Applied Geotechnical Engineering Consultants, Inc.



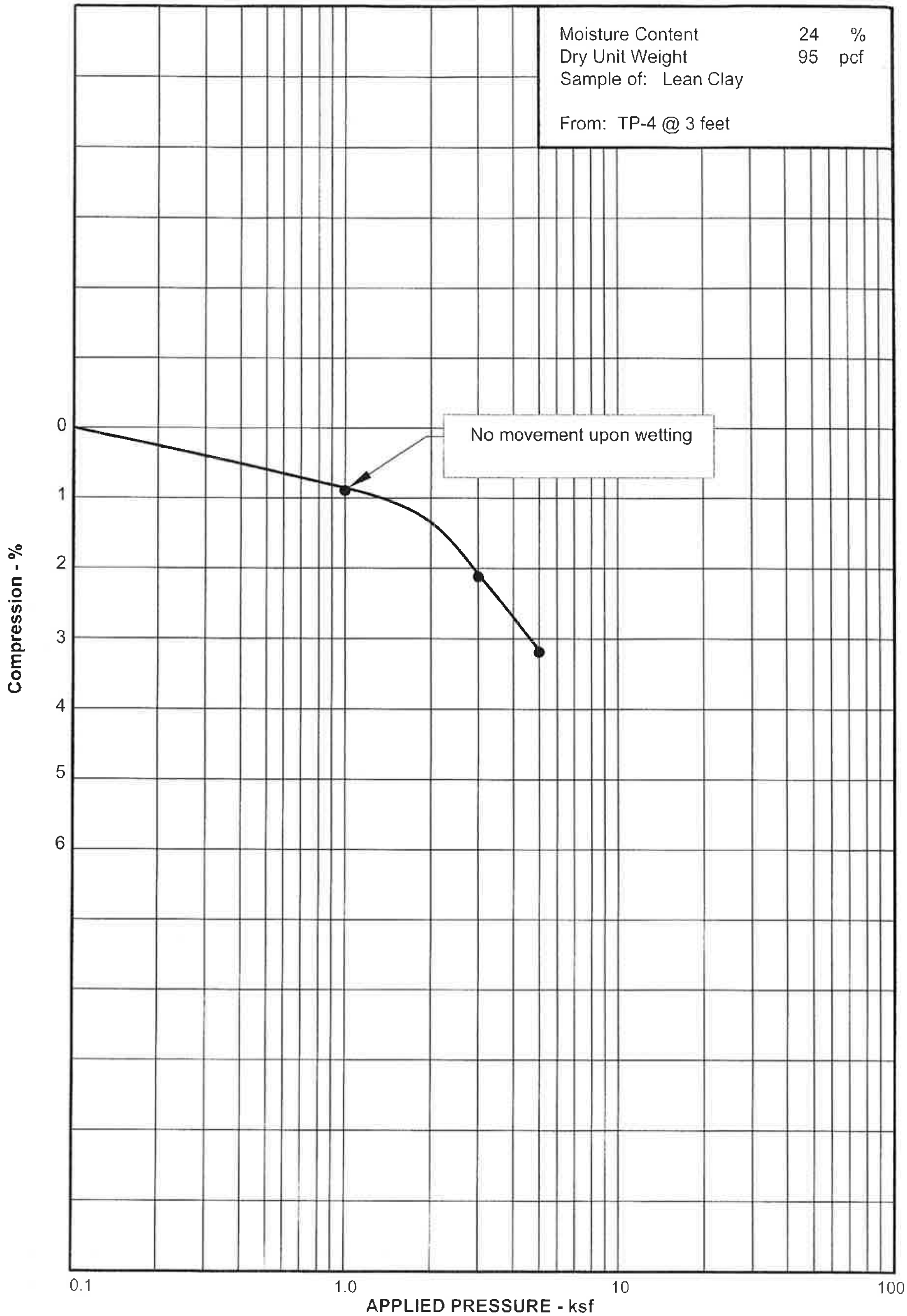
Project No. 1131058 **CONSOLIDATION TEST RESULTS** **Figure 10**

Applied Geotechnical Engineering Consultants, Inc.



Project No. 1131058 **CONSOLIDATION TEST RESULTS** **Figure 11**

Applied Geotechnical Engineering Consultants, Inc.



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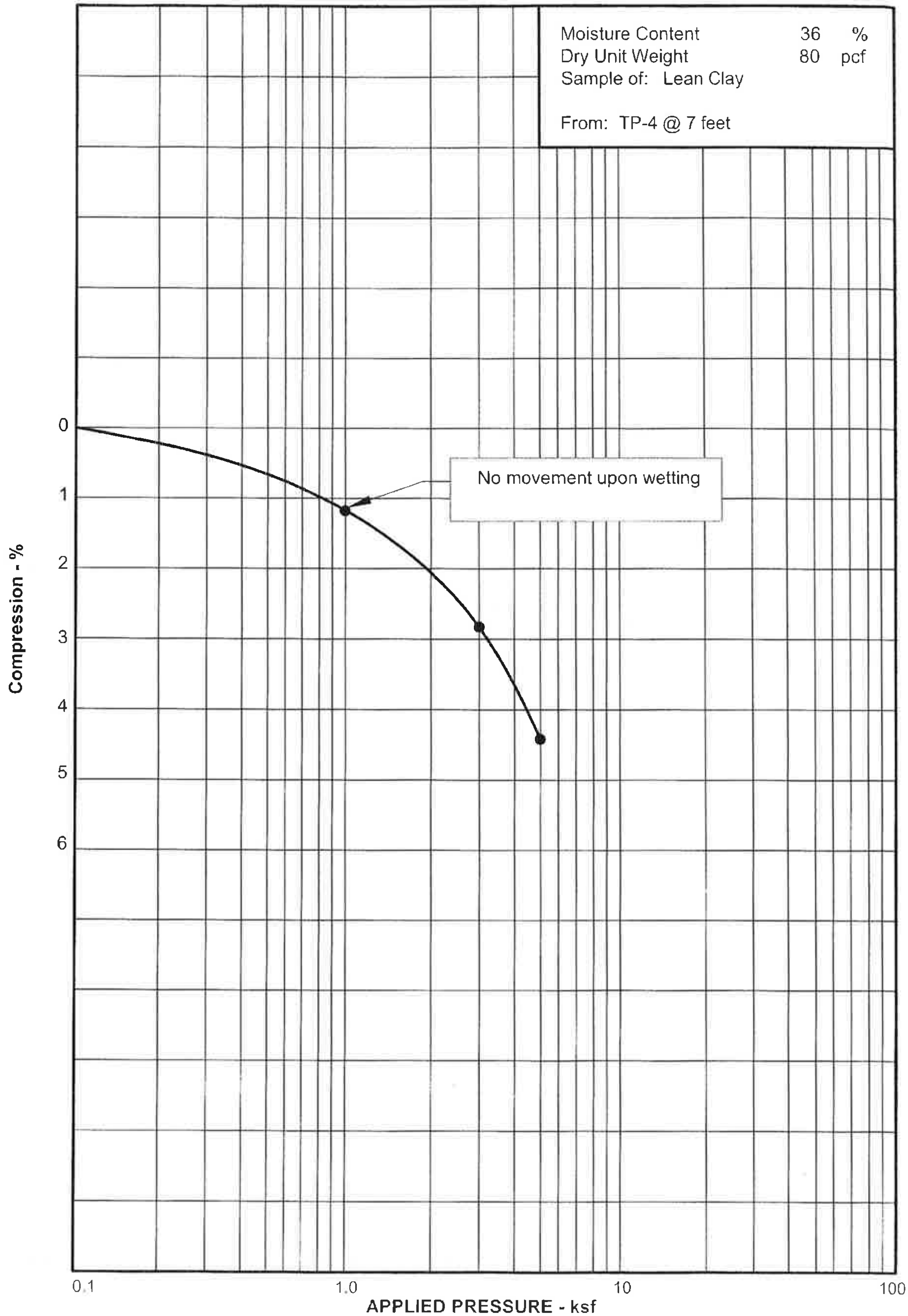
CONSOLIDATION TEST RESULTS

Figure 12

Applied Geotechnical Engineering Consultants, Inc.



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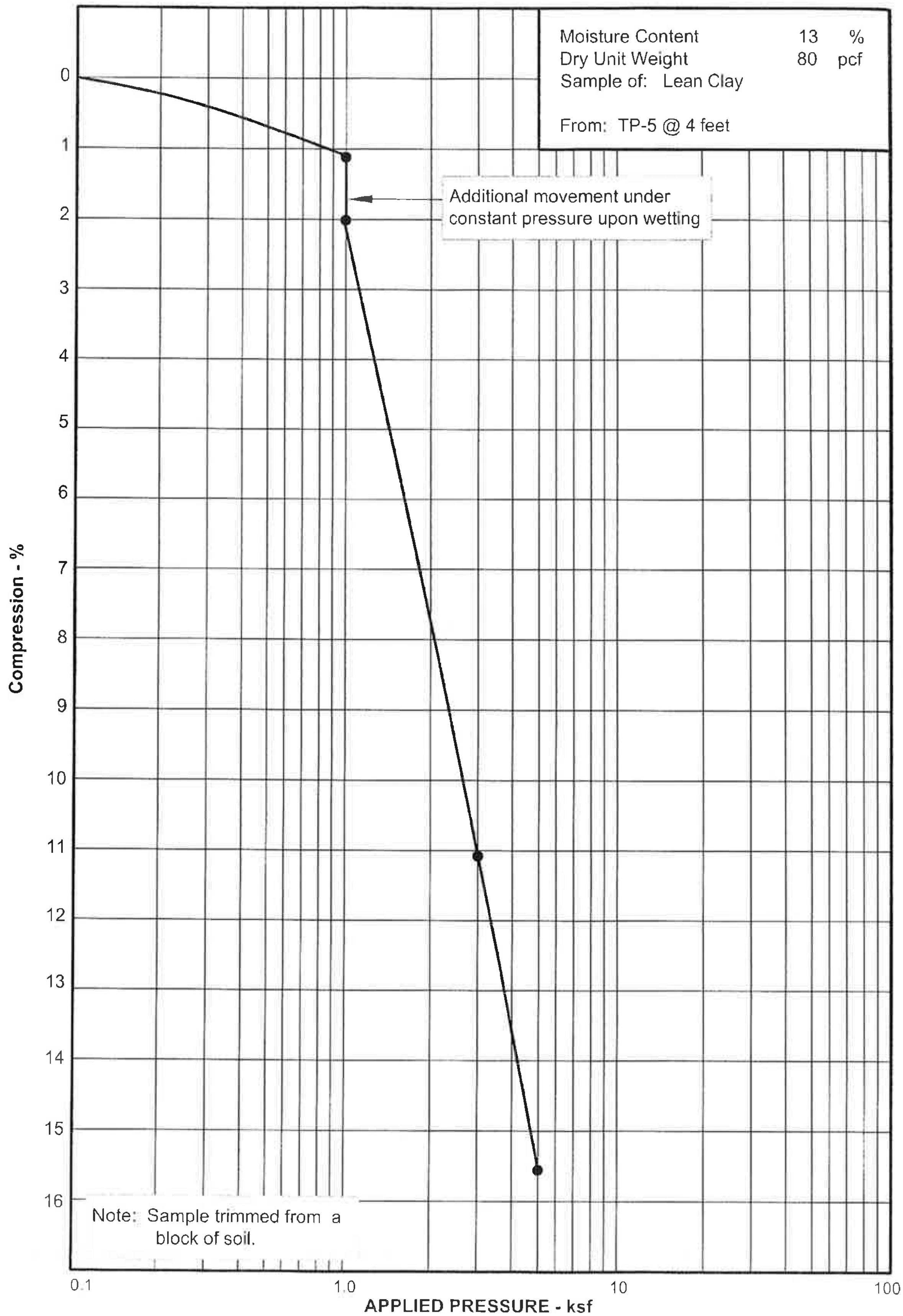
CONSOLIDATION TEST RESULTS

Figure 13

Applied Geotechnical Engineering Consultants, Inc.



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CONSOLIDATION TEST RESULTS

Figure 14

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1131058

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
TP-1	2	23	81			95					Lean Clay
	3	26	87			93					Lean Clay
	8	25	89			87					Lean Clay
	8½	23	88			79					Lean Clay with Sand
TP-2	2	26	85			97					Lean Clay
	2	23	83			98					Lean Clay
	4	27	74			96					Lean Clay
TP-3	4	19	83			93					Lean Clay
TP-4	3	24	95			94					Lean Clay
	7	36	80			91				0.01	Lean Clay
TP-5	4	13	80			92					Lean Clay