AGEC
Applied GeoTech

GEOTECHNICAL INVESTIGATION

RESIDENTIAL DEVELOPMENT

4000 WEST 2200 SOUTH

TAYLOR, UTAH

PREPARED FOR:

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

ATTENTION: CHASE FREEBAIRN

PROJECT NO. 1160392

JUNE 16, 2016

600 West Sandy Parkway • Sandy, Utah 84070 • (801) 566-6399 • FAX (801) 566-6493

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. The subsurface soil encountered in the test pits consists of approximately 1 to 1½ feet of topsoil generally overlying lean clay that extends to the maximum depth investigated, approximately 12½ feet. Silty sand was encountered below the topsoil in Test Pits TP-1 and TP-6 and extends to depths of approximately 2½ and 4 feet, respectively.

2. Subsurface water was measured at depths of approximately 3, 8½, 3, 6, 3½ and 4½ feet below the ground surface in Test Pits TP-1 through TP-6, respectively, based on measurement taken on June 13, 2016.

3. The proposed residences may be supported on spread footings bearing on at least 2 feet of compacted structural fill that extends down to the undisturbed natural soil. Spread footings bearing on compacted structural fill may be designed using an allowable net bearing pressure of 1,500 pounds per square foot. Free-draining gravel may be needed for use as the initial lifts of structural fill for excavations that extend down near or below the original free water level.

4. The upper natural soil generally consists of lean clay with areas of silty sand and subsurface water is at a relatively shallow depth. When the upper soil is very moist to wet, construction access difficulties may be encountered for rubber-tired construction equipment. Placement of approximately 1½ to 2½ feet of granular fill will likely be needed in areas where the upper soil is very moist to wet to provide limited access to moderate-sized, rubber-tired equipment and to facilitate pavement construction.

5. Water was encountered at a relatively shallow depth at the site. Floor levels extending below the original ground surface should be protected with a perimeter drain system. Recommendations for subsurface drains are included in this report.

6. If relatively large areas of the site will be raised more than approximately 3 feet above the existing ground surface, the site grading fill should be placed well in advance of the construction of structures or other improvements sensitive to differential settlement.

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

SCOPE

This report presents the results of a geotechnical investigation for the proposed residential development to be constructed at 4000 West 2200 South in Taylor, 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 May 11, 2016.

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 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 consists of a triangular shaped piece of property that was used as a cultivated field at the time of our study. There are no permanent structures or pavement on the site.

The site is relatively flat with a gentle slope down to the northwest.

Vegetation consists of alfalfa. There are a few trees along the edges of the site.

There is an unlined ditch along the west side of the site. There are unlined and concrete-lined ditches along the southeast side of the site.

There are houses with basements to the southeast of the site. There are cultivated fields to the north and west.

FIELD STUDY

The field study was conducted on May 26, 2016. Six test pits were excavated 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 or other improvements.

SUBSURFACE CONDITIONS

The subsurface soil encountered in the test pits consists of approximately 1 to 1½ feet of topsoil generally overlying lean clay that extends to the maximum depth investigated, approximately 12½ feet. Silty sand was encountered below the topsoil in Test Pits TP-1 and TP-6 and extends to depths of approximately 2½ and 4 feet, respectively.

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

Topsoil - The topsoil consists of lean clay with sand. It is moist to very moist, dark brown and contains roots and organics.

Lean Clay - The lean clay contains small to moderate amounts of sand and occasional sand layers. It is soft to medium stiff, very moist to wet and brown to gray.

Laboratory tests conducted on samples of the lean clay indicate natural moisture contents of 26 to 30 percent and natural dry densities of 93 to 100 pounds per cubic foot (pcf).

An unconfined compressive strength of 680 pounds per square foot (psf) was measured for a sample of the clay tested in the laboratory.

Consolidation tests conducted on samples of the clay indicate that the soil will compress a small to moderate amount with the addition of light to moderate loads. Results of the consolidation tests are presented on Figures 4, 5 and 6.

Silty Sand - The sand is medium dense, very moist to wet and brown to gray.

Laboratory tests conducted on a sample of the silty sand indicate a natural moisture content of 22 percent and a natural dry density of 109 pcf.

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

SUBSURFACE WATER

Subsurface water was measured at depths of approximately 3, 8½, 3, 6, 3½ and 4½ feet below the ground surface in Test Pits TP-1 through TP-6, respectively, based on measurement taken on June 13, 2016. Slotted PVC pipe was installed in the test pits to facilitate future measurement of the free water level. Fluctuations in the water level will occur over time. An evaluation of such fluctuations is beyond the scope of this report.

PROPOSED CONSTRUCTION

We understand that the site encompasses approximately 27 acres and will be developed for approximately 23 residential lots. We anticipate that the homes will be one to two-story, wood-frame structures with slab-on-grade floors or basements. We have assumed building loads consisting of wall loads up to 3 kips per lineal foot and column loads up to 30 kips.

Roads are planned to extend through the development. We have assumed traffic for roads consisting predominantly of passenger vehicles with one delivery truck and two buses 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

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

A. Site Grading

Site grading plans were not provided for our review. With the relatively shallow depth to subsurface water encountered at the site, we anticipate that the site grade may be raised several feet to improve conditions for construction and facilitate basement construction. Where relatively large areas of the site are raised more than approximately 3 feet above the existing ground surface, the site grading fill should be placed well in advance to construction of buildings or other improvements sensitive to differential settlement so that most of the settlement induced by the load of the site grading fill occurs prior to building construction.

1. Excavation

   We anticipate that excavation at the site can be accomplished with typical excavation equipment.

   If excavation extends below the water level, the excavation should be dewatered. The water level should be maintained below the base of the excavation during initial fill and concrete placement.

2. Subgrade Preparation

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

   The upper natural soil consists of clay and silty sand and subsurface water is at a relatively shallow depth. Construction equipment access difficulties should be anticipated for rubber-tired construction equipment when the upper soil is very moist to wet. Approximately 1½ to 2½ feet of granular fill will likely be needed to provide construction equipment access over the very moist to wet clay or silty sand subgrade. To stabilize soft areas, provide equipment access and facilitate pavement construction, granular fill should ideally consist of angular gravel containing less than 15 percent passing the No. 200 sieve. Consideration may be given to placing a support fabric below the gravel.

Care should be taken to not disturb the natural soil to remain below areas of proposed buildings and pavement.

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

The natural soil is not recommended for use as structural fill, but may be considered for use as site grading fill or wall backfill if the topsoil, organics, debris and other deleterious materials are removed or it may be used in landscape areas.

The use of the on-site soil as fill will likely require moisture conditioning to facilitate proper compaction. Drying of the soil may not be practical during cold or wet times of the year.

Free-draining gravel should be used as fill below the original water level. A goetextile may be placed between the natural soil and gravel to facilitate construction and reduce particle migration into the gravel.

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.

To facilitate the compaction process, the fill should be compacted at a moisture content within 2 percent of the optimum moisture content.

Fill and pavement materials placed for the project should be frequently tested for compaction.

5. Drainage

The ground surface surrounding the proposed buildings should be sloped away from the buildings in all directions. Roof downspouts and drains should discharge well beyond the limits of backfill.

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

With the proposed construction and the subsurface conditions encountered, the proposed residences may be supported on spread footings bearing on at least 2 feet of compacted structural fill. Structural fill should extend down to undisturbed natural soil and out away from the footings at least a distance equal to the depth of the structural fill below the footing. Free-draining gravel may be needed for initial lifts of structural fill where excavations extend down near or below the original free water level. Consideration should be given to providing a support fabric between the natural soil and the free-draining gravel.

Topsoil, organics, unsuitable fill, debris and other deleterious materials should be removed from below proposed foundation areas.

2. Bearing Pressures

Spread footings bearing on at least 2 feet of compacted structural fill may be designed using an allowable net bearing pressure of 1,500 psf. Footings should have a width of at least 1½ feet and a depth of embedment of at least 10 inches.

3. Temporary Loading Conditions

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

4. Settlement

We estimate that total and differential settlement will be less than 1 inch and ¾ inch, respectively, for footings bearing on compacted structural fill.

5. Frost Depth

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

6. Foundation Base

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

7. Excavation Observation

A representative of AGEC 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 or on compacted structural fill extending down to the undisturbed natural soil.

Topsoil, unsuitable fill and other deleterious materials should be removed from below proposed floor slab areas.

2. Underslab Sand and/or Gravel

Consideration should be given to placing a 4-inch layer of free draining sand and/or gravel with less than 5 percent passing the No. 200 sieve below the concrete slabs.

D. Lateral Earth Pressures

1. Lateral Resistance for Footings

Lateral resistance for footings placed on compacted structural fill is controlled by sliding resistance between the footing and the structural fill or between the structural fill and the natural soil. 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 the 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 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 30 and 15 pcf for active and at-rest conditions, respectively, and decreased by 30 pcf for the passive condition. This assumes a peak horizontal ground acceleration of 0.50g for a 2 percent probability of exceedance in a 50-year period (IBC, 2012).

4. Safety Factors

The values recommended above assume mobilization of the soil to achieve the soil strength under active and passive conditions. 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 International Building Code 2012:

a.	Site Class	D
b.	Short Period Spectral Response Acceleration, S_S	1.24g
c.	One Second Period Spectral Response Acceleration, S_1	0.41g

2. Faulting

There are no mapped active faults extending through the site. The closest mapped fault considered to be active is the Wasatch fault located approximately 7 miles east of the site (Black and others, 2003).

3. Liquefaction

The site is located in an area mapped as having a "high" potential for liquefaction (Anderson and others, 1994). The subsurface soils encountered to the depth of the test pits consist predominantly of lean clay. The clay is not considered to be susceptible to liquefaction. However, there may be soil layers at greater depth that would be susceptible to liquefaction during a major seismic event. A site-specific evaluation of the liquefaction potential is beyond the scope of this study. The potential for settlement to occur due to liquefaction during a seismic event should be considered as a potential hazard at the site.

F. Subsurface Drains

Subsurface drains should be provided for floors that extend below the existing ground surface.

Subsurface drains should consist of 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.

G. Water Soluble Sulfates

One sample of the natural soil was tested in the laboratory for water soluble sulfate content. Test results indicate there is less than 0.1 percent water soluble sulfate in the sample 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.

H. 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 clay and silt. A California Bearing Ratio (CBR) of 3 percent was used in the analysis which assumes a lean clay subgrade.

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. 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 or silt 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. 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.

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 Figure 1 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 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
6/16/16
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

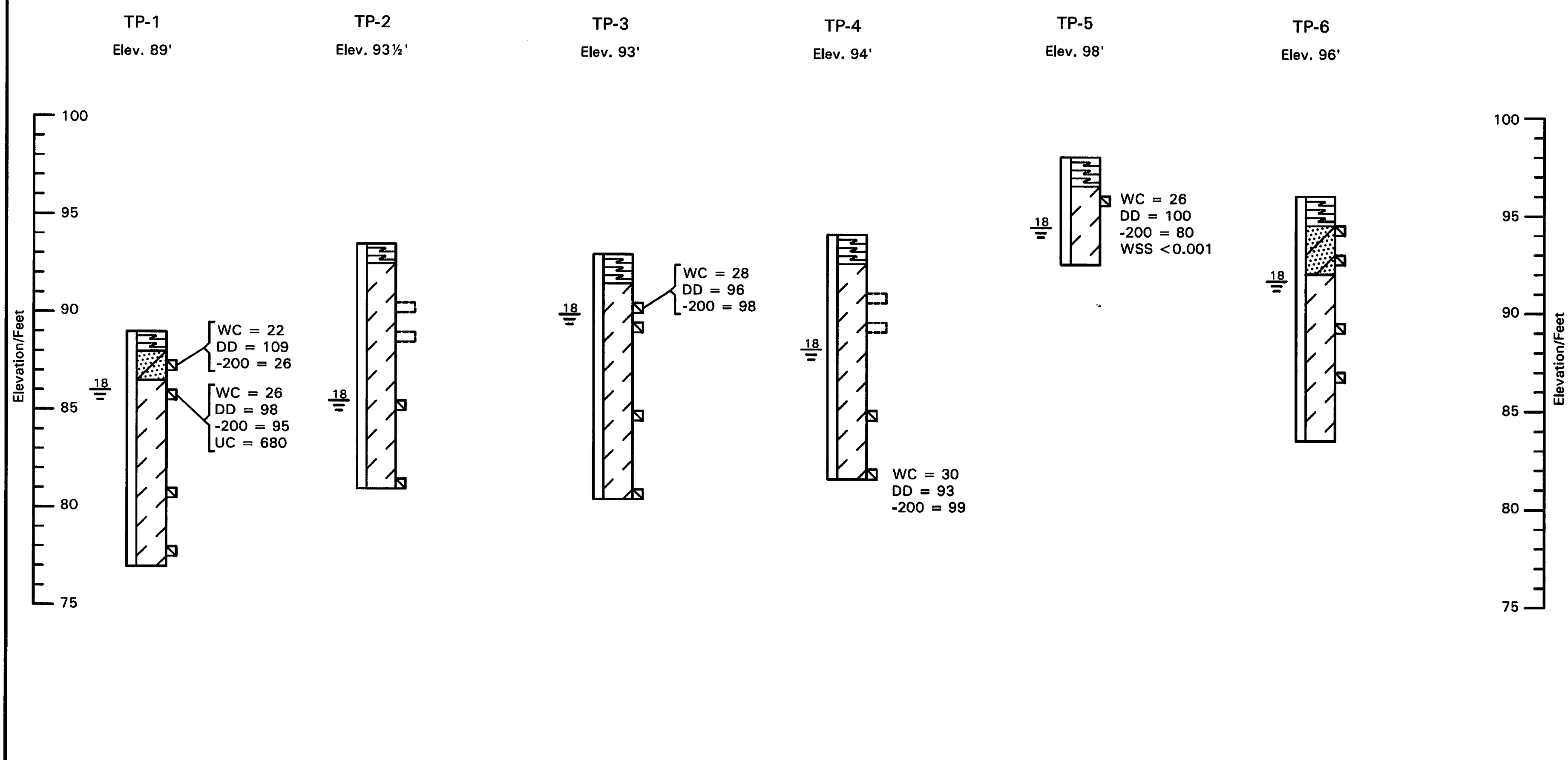
REFERENCES

Anderson, L.R., Keaton, J.R., and Bay, J., 1994; Liquefaction Potential Map for Weber County, Utah; Utah Geological Survey Contract Report 94-1.

Black, B.D., Hecker, S., Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003; Quaternary fault and fold database and map of Utah; Utah Geological Survey Map 193DM.

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

1160392	AGEC	Test Pit Locations	Figure 1



Approximate Vertical Scale 1" = 8'

See Figure 3 for Legend and Notes

1160392	AGEC	Test Pit Logs	Figure 2

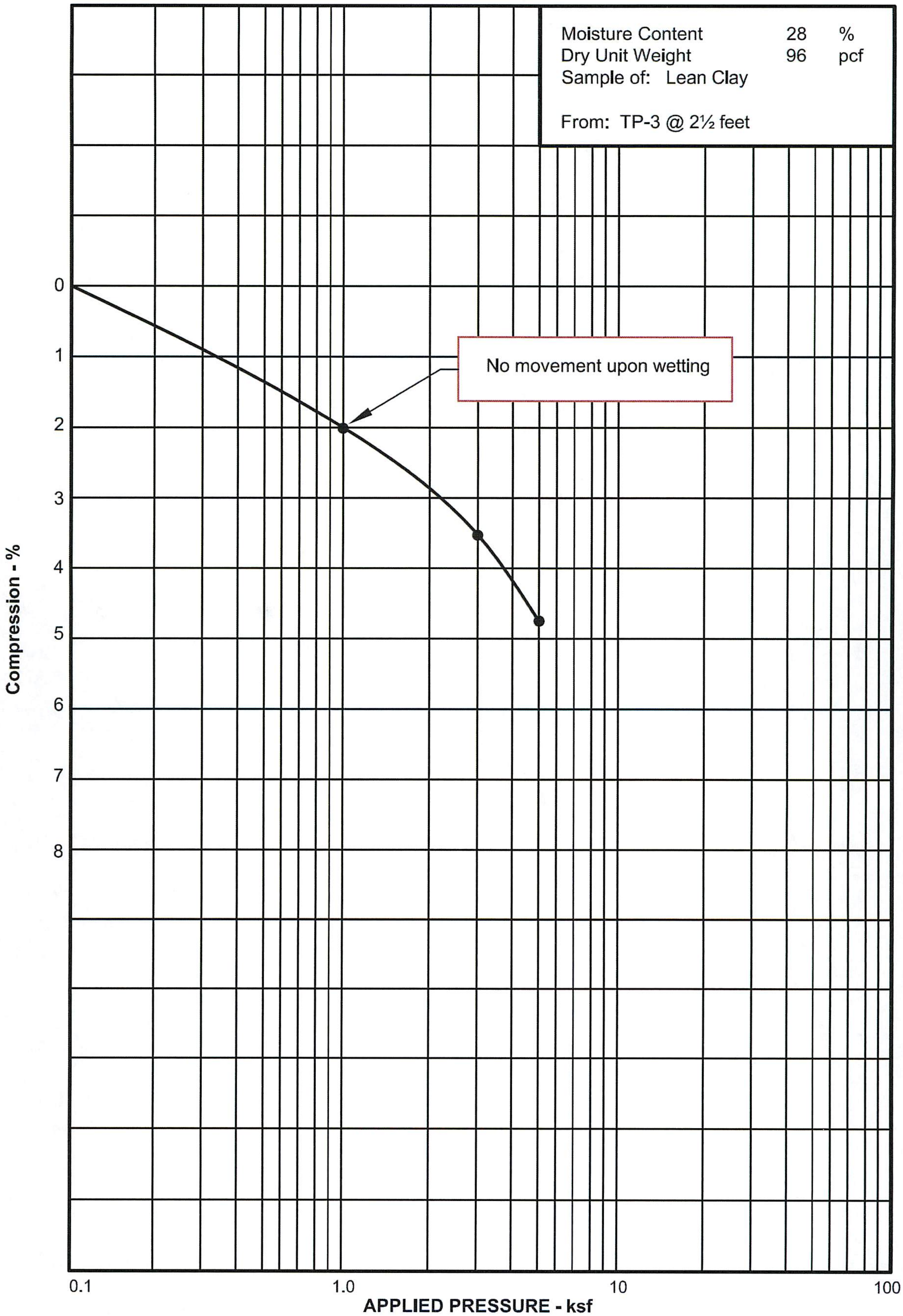
LEGEND:

- Topsoil; lean clay with sand, moist to very moist, dark brown, roots and organics.
- Lean Clay (CL); small to moderate amount of sand, occasional sand layers, soft to medium stiff, very moist to wet, brown to gray.
- Silty Sand (SM); medium dense, very moist to wet, brown to gray.
- Indicates relatively undisturbed hand drive sample taken.
- Indicates disturbed sample taken.
- Indicates slotted 1 ½ inch PVC pipe installed in the test pit to the depth shown.
- 18 — Indicates the depth to free water and the number of days after excavation the measurement was taken.

NOTES:

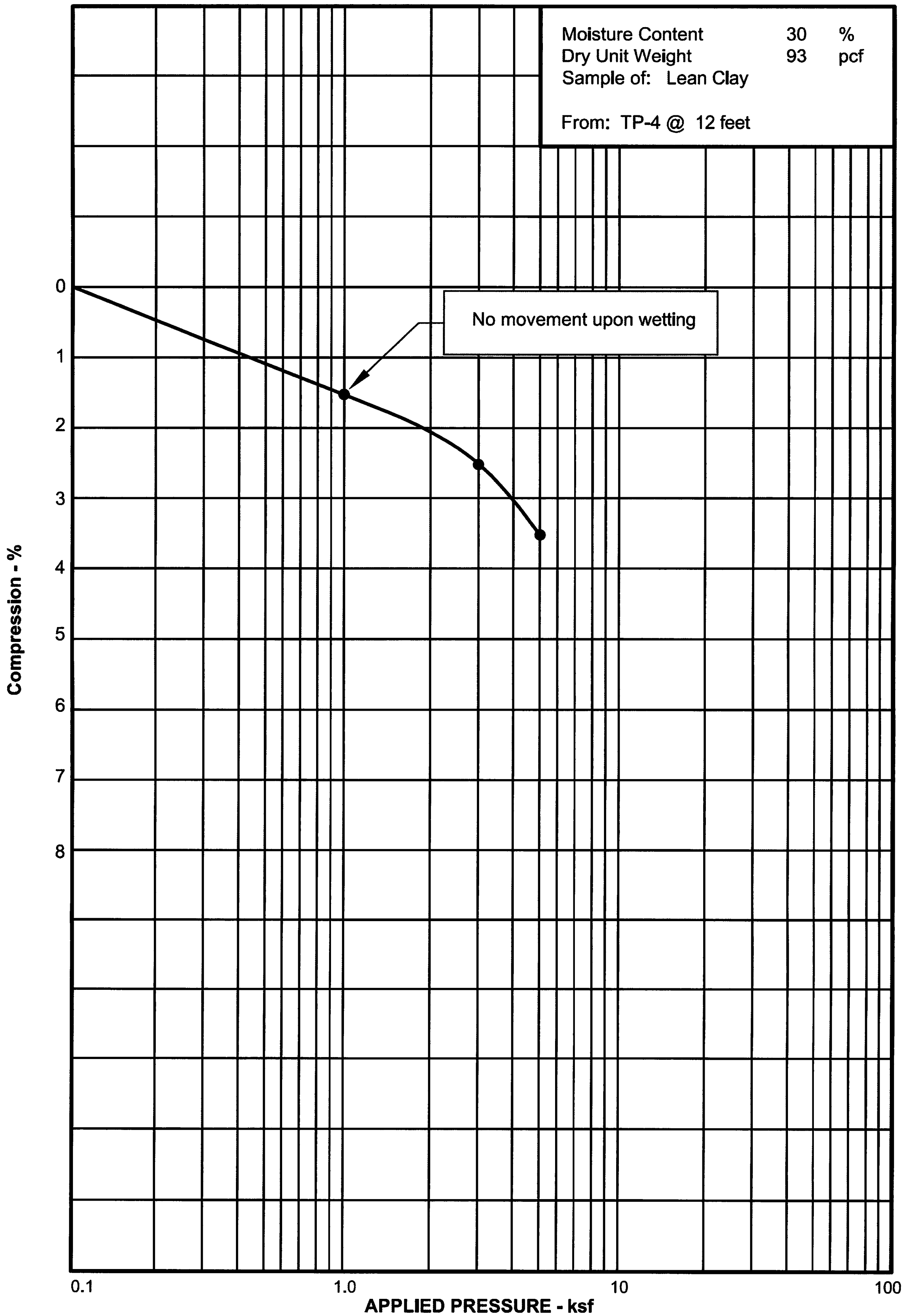
1. The test pits were excavated on May 26, 2016 with a rubber-tired backhoe.
2. Locations of the test pits were measured approximately by pacing from features shown on the site plan provided.
3. Elevations of the test pits were measured by hand level and refer to the bench mark shown on Figure 1.
4. The test pit locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level will occur with time.
7. WC = Water Content (%);
   DD = Dry Density (pcf);
   -200 = Percent Passing the No. 200 Sieve;
   UC = Unconfined Compressive Strength (psf);
   WSS = Water Soluble Sulfates (%).

Applied Geotechnical Engineering Consultants, Inc.



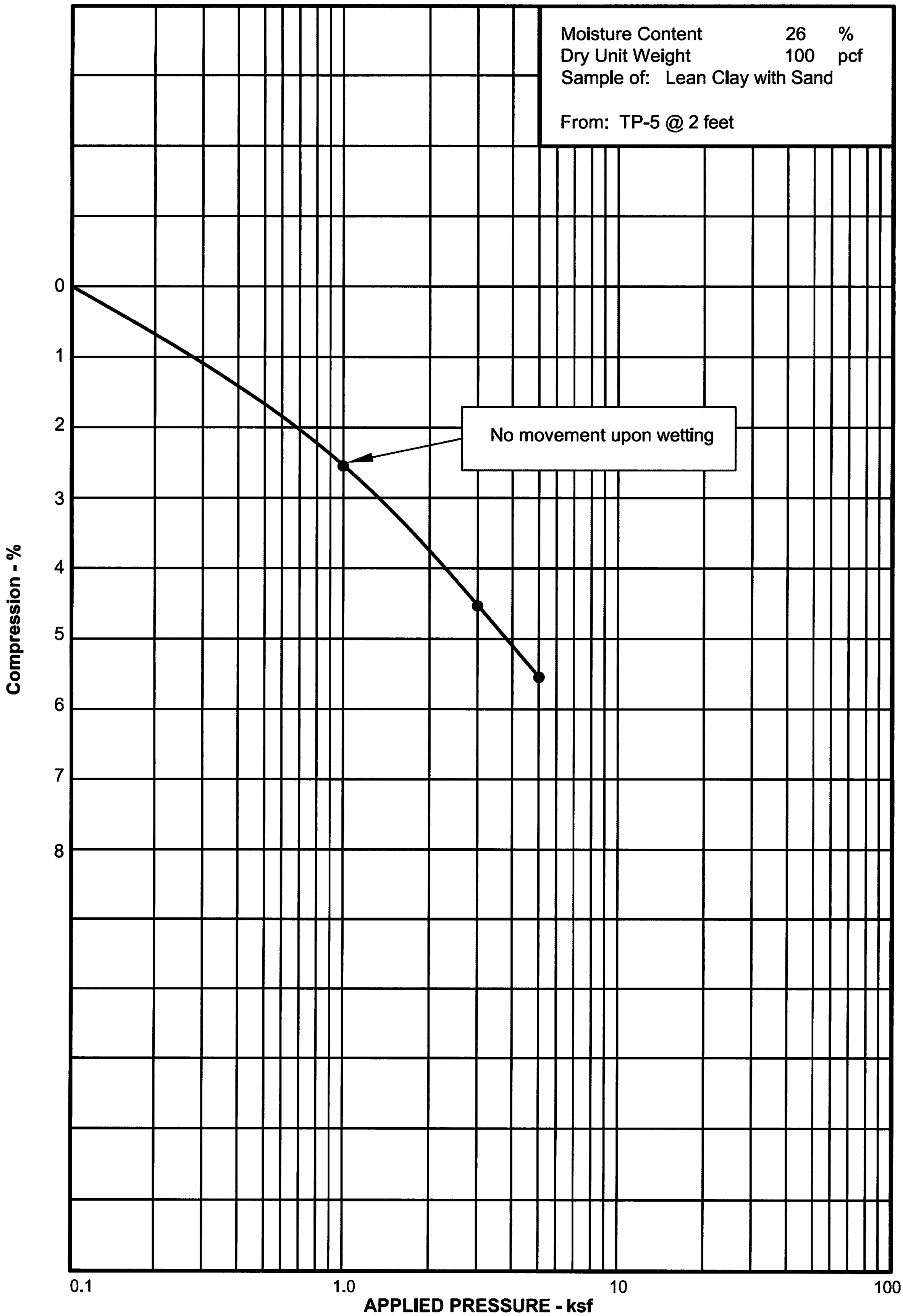
Project No. 1160392 **CONSOLIDATION TEST RESULTS** **Figure 4**

Applied Geotechnical Engineering Consultants, Inc.



Project No. 1160392 **CONSOLIDATION TEST RESULTS** **Figure 5**

Applied Geotechnical Engineering Consultants, Inc.



Project No. 1160392 **CONSOLIDATION TEST RESULTS** **Figure 6**

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1160392

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	1½	22	109			26					Silty Sand
	3	26	98			95			680		Lean Clay
TP-3	2½	28	96			98					Lean Clay
TP-4	12	30	93			99					Lean Clay
TP-5	2	26	100			80				<0.001	Lean Clay with Sand