AGEC
Applied GeoTech

GEOTECHNICAL INVESTIGATION

PROPOSED WEST WEBER SUBDIVISION

APPROXIMATELY 3800 WEST 1800 SOUTH

WEBER COUNTY, UTAH

PREPARED FOR:

JAR DEVELOPMENT
4968 HOLLADAY PINES COURT
SALT LAKE CITY, UTAH 84117

ATTENTION: JAY RICE

PROJECT NO. 1160708 **SEPTEMBER 29, 2016**

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

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EXECUTIVE SUMMARY

1. Up to approximately 1½ feet of topsoil was encountered in the upper portion of test pits excavated at the site. The natural soil encountered below the topsoil consists of lean clay with silt and silty sand layers. The interlayered soil extends the maximum depth investigated, approximately 13 feet.

2. Subsurface water was encountered in the test pits at depths ranging from approximately 4½ to 7 feet below the existing ground surface when measured 9 to 10 days after excavation. Fluctuations in the subsurface water level will occur over time. An evaluation of such fluctuations in the subsurface water level is beyond the scope of this report.

3. The upper natural soil at the site consists predominantly of lean clay. Construction equipment access difficulties can be expected in areas where the subgrade consists of very moist to wet clay. Placement of 1½ to 2½ feet of gravel in these areas will generally improve site conditions for rubber-tired construction equipment access.

4. The proposed residences may be supported on spread footings bearing on the undisturbed natural or on compacted structural fill extending down to the undisturbed natural soil. Footings bearing on the undisturbed natural soil may be designed using an allowable net bearing pressure of 1,200 pounds per square foot (psf). Footings bearing on at least 2 feet of properly compacted structural fill extending down to the undisturbed natural soil may be designed using an allowable net bearing pressure of 2,000 psf.

5. The site is located within an area mapped as having a "high" liquefaction potential (Anderson and others, 1994). A site specific liquefaction analysis was not requested as part of this study. Clay and soil above the free water level are not susceptible to liquefaction. Loose sand below the free water level is susceptible to liquefaction. Liquefaction should be considered a hazard at this site. A site specific liquefaction analysis could be performed and would better define the liquefaction potential for the site.

6. Geotechnical information related to foundations, subgrade preparation, pavement design, materials and compaction are included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed West Weber subdivision to be located at approximately 3800 West 1800 South in Weber County, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundation support and pavement. The study was conducted in general accordance with our proposal dated August 25, 2016.

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 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 two parcels each approximately 40 acres in size.

North Parcel

The north parcel is located along the north side of 1800 South Street. There are no permanent structures or pavement on the site. The ground surface at the site is relatively flat with a gently slope down to the northwest.

The areas to the north and east of the north parcel consists of undeveloped farm land. The area west of the north parcel consists of a residential development with one to two-story, wood-frame structures.

South Parcel

The south parcel is located along the south side of 1800 South Street. There are no permanent or pavements on the site. The ground surface at the site is relatively flat with a gentle slope down to the northwest. The ground surface along a portion of the southeast area of the south parcel is approximately 10 feet higher in elevation than the surrounding areas.

The areas to the east, west and south of the south parcel consist of undeveloped land and farm fields.

There are shallow irrigation ditches along both sides of 1800 South Street. There was water in the ditches at the time of the field study.

FIELD STUDY

The field study was conducted on September 12 and 13, 2016. The test pits were excavated at the approximate locations indicate 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 Figures 2 and 3 with legend and notes on Figure 4.

The test pits were backfilled with excavated material without significant compaction. The backfill in the test pits should be removed and properly compacted where it will remain below proposed structures, floor slabs, pavements or other site improvements.

SUBSURFACE CONDITIONS

Up to approximately 1½ feet of topsoil was encountered in the upper portion of test pits excavated at the site. The natural soil encountered below the topsoil consists of lean clay with silt and silty sand layers. The interlayered soil extends the maximum depth investigated, approximately 13 feet.

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

Topsoil - The topsoil consists of lean clay and silty sand. It is slightly moist to moist, brown to gray and contains roots and organics.

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

Laboratory tests conducted on samples of the clay indicate that it has natural moisture contents ranging from 24 to 26 percent and natural dry densities ranging from 89 to 100 pounds per cubic foot (pcf).

An unconfined compressive strength of 2,690 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 clay will compress a small to moderate amount with the addition of light to moderate loads. Results of the consolidation tests are presented on Figure 5.

Silt - The silt contains small amounts of sand and contains a slightly porous structure. It is stiff, slightly moist and brown to light gray.

Silty Sand - The silty sand contains small to moderate amounts of silt, occasional poorly-graded sand with silt and occasional thin clay layers. It is medium dense, moist to wet and brown.

Laboratory tests conducted on samples of the silty sand indicate that it has natural moisture contents ranging from 26 to 28 percent and natural dry densities ranging from 93 to 97 pcf.

Interlayered Lean Clay and Silty Sand - The interlayered soil is medium stiff/medium dense, wet and brown.

Poorly-graded Sand with Silt - The sand is medium dense, moist to wet and brown.

Laboratory tests conducted on a sample of the sand indicates that it has a natural moisture content of 26 percent and a natural dry density of 97 pcf.

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

SUBSURFACE WATER

Subsurface water was encountered in the test pits at depths ranging from approximately 4½ to 7 feet below the existing ground surface when measured 9 to 10 days after excavation. Fluctuations in the subsurface water level will occur over time. An evaluation of such fluctuations in the subsurface water level is beyond the scope of this report.

PROPOSED CONSTRUCTION

The site is approximately 80 acres in size with approximately 40 acres on each of the north and south sides of 1800 South Street (see Figure 1). We assume houses will consist of one to three-story, wood-frame residences with the potential for basements. We have assumed building loads will consist of wall loads up to 3 kips per lineal foot and column loads up to 30 kips based on typical residential construction in the area.

Paved roads are planned to extend through the proposed development. We have assumed traffic conditions for pavement areas consisting primarily of relatively light passenger vehicles, five delivery trucks per day and five buses and two garbage trucks per week.

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

RECOMMENDATIONS

Based on the subsurface conditions encountered, our understanding of the proposed construction and our experience in the area, the following recommendations are given:

A. Site Grading

Site grading plans were not provided to AGEC at the time of our investigation. We anticipate that relatively small amounts of grade change (less than 3 feet) will be needed to facilitate construction at the site. Fill placed to raise grade for the project should be place as soon as possible prior to building construction.

1. <u>Pavement Subgrade Preparation</u>

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

Subgrade areas should be proof-rolled prior to fill placement to identify soft areas. Soft areas should be removed and replaced with gravel containing less than 15 percent passing the No. 200 sieve. If the clay subgrade is very moist to wet, the subgrade should not be proof-rolled but cut to the undisturbed natural soil below unsuitable fill, topsoil and other deleterious materials and a sufficient thickness of gravel placed to provide construction equipment access.

Construction access difficulties can be expected when the subgrade consists of very moist to wet, fine-grained soil. Under these conditions, placement of 1½ to 2½ feet of gravel will provide limited support for moderately loaded rubber-tired construction equipment and facilitate pavement construction. Consideration may be given to placing a support fabric between the natural soil and granular fill to facilitate construction.

2. <u>Excavation</u>

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

Excavations that extend below the free water level should be dewatered. The water level should be maintained below the base of the excavation during initial fill and concrete placements.

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

Free-draining gravel with less than 5 percent passing the No. 200 sieve should be used as fill or backfill below the original water level. Consideration should be given to using a support fabric above the subgrade prior to placement of free-draining gravel.

Material placed as fill to support structures should be non-expansive granular soil. The natural clay and silt are not recommended for use as fill below structures but may be used in pavement areas or as foundation backfill or as utility-trench backfill, if the topsoil, organics, debris and other deleterious materials are removed or they may be used in landscaping areas. The sand meeting the criteria above may be considered for use as fill or backfill.

The on-site soil will likely require moisture conditioning (wetting or drying) prior to use as fill. 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 fill should be adjusted to within 2 percent of the optimum moisture content 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 structures should be sloped away from the buildings in all directions. Roof downspouts and drains should discharge 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 structures may be supported on spread footings bearing on the undisturbed natural soil or on compacted structural fill extending down to the undisturbed natural soil. Structural fill should extend out away from the edge of the footings at least a distance equal to the depth of fill beneath the footings.

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

2. Bearing Pressure

Foundations bearing on the undisturbed natural soil may be designed using an allowable net bearing pressure of 1,200 psf. Footings bearing on at least 2 feet of properly compacted structural fill extending down to the undisturbed natural soil may be designed using an allowable net bearing pressure of 2,000 psf.

Footings should have a minimum width of 1½ feet and a minimum depth of embedment of 1 foot.

3. Settlement

We estimate that settlement will be less than 1 inch for footings designed as indicated above. Differential settlement is estimated to be on the order of ¾ of an inch or less.

Disturbance of the soil below foundations can result in greater settlement. Care should be taken to minimize disturbance of the soil to remain below foundations so that settlement can be maintained within tolerable limits.

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. 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 structural fill or concrete placement.

7. Construction Observation

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

C. Concrete Slabs 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, organics, debris and other deleterious materials should be removed from below proposed floor slabs.

2. Underslab Sand and/or Gravel

A 4-inch layer of free-draining sand and/or gravel (less than 5 percent passing the No. 200 sieve) should be placed below the concrete slabs for ease of construction and to promote even curing of the slab concrete.

D. Lateral Earth Pressures

1. Lateral Resistance for Footings

Lateral resistance for spread footings placed on compacted structural fill or the natural soil is controlled by sliding resistance developed between the footing and the structural fill or natural soil. Friction values of 0.35 and 0.45 may be used in design for ultimate lateral resistance for footings bearing on the fine-grained soil or granular fill, respectively.

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 32 pcf for the active condition and 17 pcf for at-rest condition. The equivalent fluid weight should be decreased by 32 pcf for the passive condition. This assumes a horizontal ground acceleration of 0.51g which represents a 2 percent probability of exceedance in a 50-year period (IBC, 2015).

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. Seismic, Faulting and Liquefaction

1. Seismicity

Listed below is a summary of the site parameters for the International Building Code 2015:

a.	Site Class	D*
b.	Short Period Spectral Response Acceleration, S_S	1.25g
c.	One Second Period Spectral Response Acceleration, S_1	0.42g

**The International Building Code, 2015 indicates that Site Class F should be used for soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils.*

2. Faulting

There are no mapped active faults extending near or through the project site. The closest mapped fault, considered to be active, is a portion of the Wasatch fault located approximately 6.7 miles northeast of the site (Black and others, 2003).

3. Liquefaction

The site is located within an area mapped as having a "high" liquefaction potential (Anderson and others, 1994). Research indicates that the soil type most susceptible to liquefaction during a large magnitude earthquake is loose, clean sand. The liquefaction potential for soil tends to decrease with an increase in fines content and density. Clay and soil above the free water level are not considered susceptible to liquefaction. Potentially liquefiable soil (loose sand) was encountered at the site. Liquefaction should be considered a hazard at the site. A site specific liquefaction analysis that includes an investigation to a depth of approximately 30 feet could be performed to better define the liquefaction potential at the site. The site specific liquefaction analysis was not requested as part of this study.

F. Subsurface Drains

Due to the relatively shallow depth to subsurface water, we recommend that floor levels that extend below the existing ground surface be protected with a subsurface drain system. The drain system 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 residence. The gravel should extend approximately 1 foot above the top of the footing and higher than any penetrations through the foundation wall (water lines, etc.)

2. The flow line of the pipe should be placed at least 18 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 building.

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 clean-outs to allow access into the perimeter drain should cleaning of the pipe be required in the future.

G. Water Soluble Sulfates

The results of water soluble sulfate testing were not available at the time of this report preparation. The test results and recommendations relating to the use of sulfate resistant cement will be submitted separately.

H. Pavement

Based on the subsoil conditions encountered, laboratory test results and the assumed traffic as indicated in the Proposed Construction section of the report, the following pavement support recommendations are given:

1. Subgrade Support

The near surface soil consists predominantly of lean clay. A CBR of 2½ percent was used in the analysis which assumes a clay subgrade.

2. Pavement Thickness

Based on the subsoil conditions encountered, assumed traffic conditions presented in the Proposed Construction section of this report, a design life of 20 years for flexible pavement 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 high quality base course is calculated. In areas with no truck or bus traffic and in areas where at least 6 inches of granular borrow is provided to facilitate construction of the pavement section, the base course thickness may be reduced to 6 inches. Alternatively, a rigid pavement section consisting of 5 inches of Portland cement concrete may be constructed above a properly prepared subgrade.

The near surface soil consists predominantly of clay. Approximately 1½ to 2½ feet of granular borrow may be needed to provide equipment access and to facilitate construction of the pavement when the upper soil is very moist to wet.

3. Pavement Materials and Construction

a. Flexible Pavement (Asphaltic Concrete)

The pavement materials should meet the 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 specifications for the applicable jurisdiction. The pavement thickness indicated above assumes that the concrete will have a 28-day compressive strength of 4,000 pounds per square inch.

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.

I. Preconstruction Meeting

A preconstruction meeting should be held with representatives of the owner, project architect, geotechnical engineer, general contractor, earthwork contractor and other members of the design team to review construction plans, specifications, methods and schedule.

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, the data obtained from laboratory testing and our experience in the area. 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.

LICENSED PROFESSIONAL ENGINEER
9-29-16
No. 264456
CHRISTOPHER J.
BECKMAN
STATE OF UTAH

Christopher J. Beckman, P.E.

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

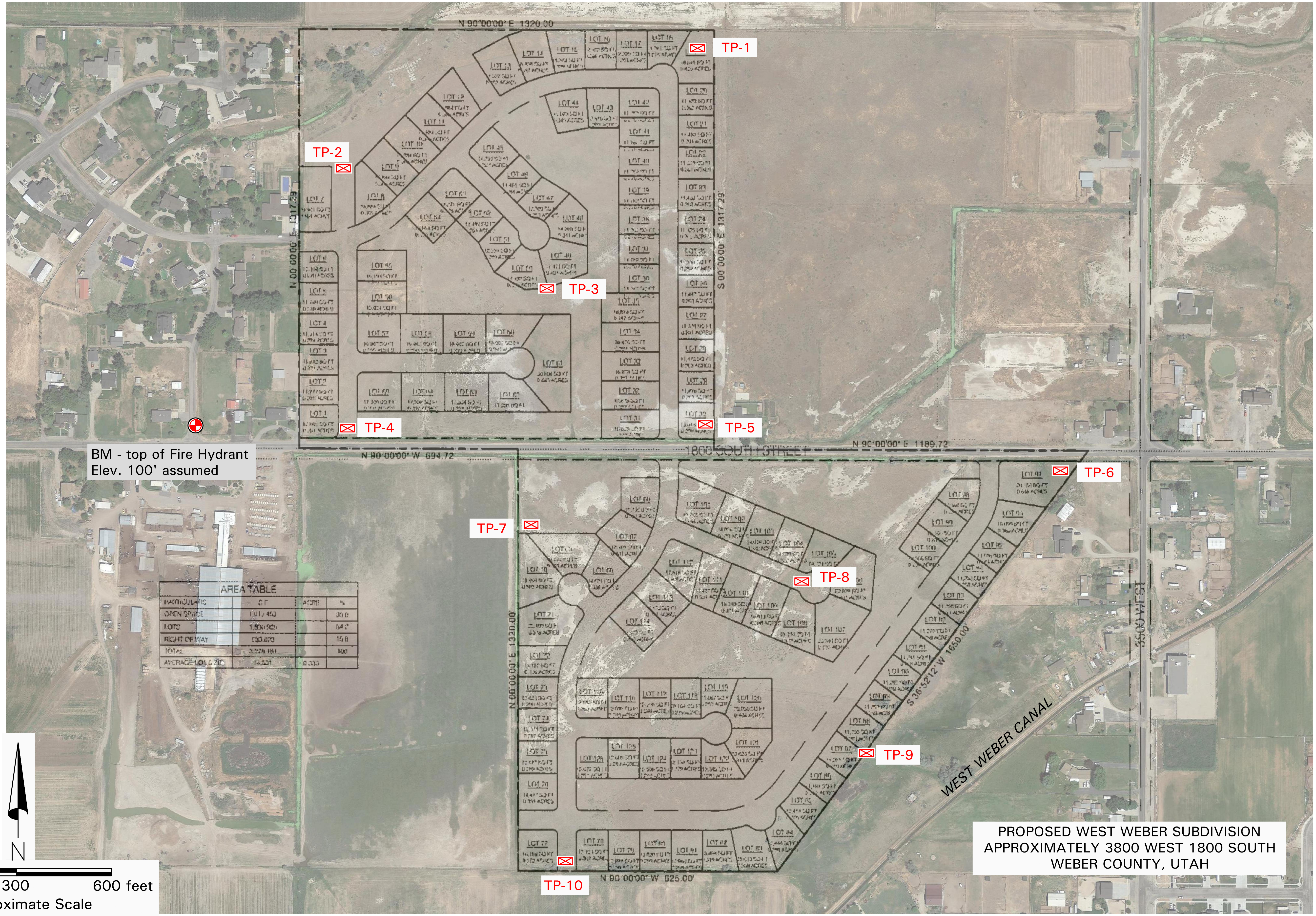
CJB/rs

REFERENCES

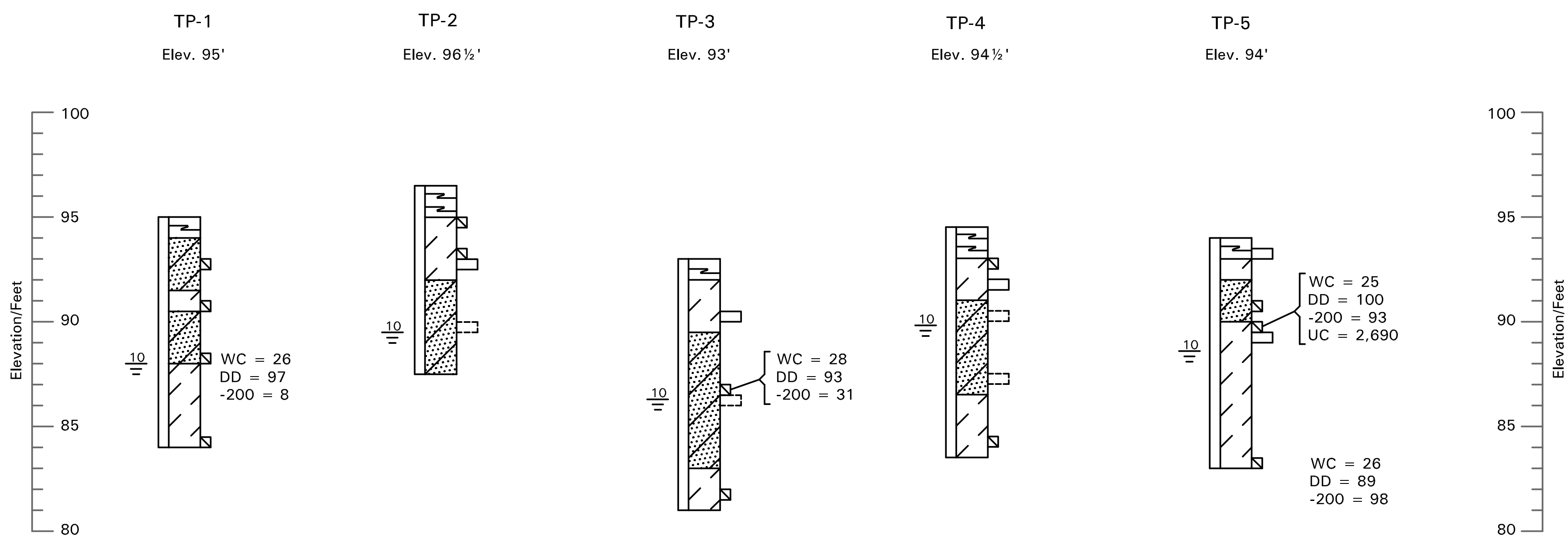
Anderson, L.R., Keaton, J.R., and Bay, J., 1994; Liquefaction Potential Map for Weber County, Utah; Utah Geological Survey Contract Report 94-1.

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, 2015; International Code Council, Inc., Falls Church, Virginia.

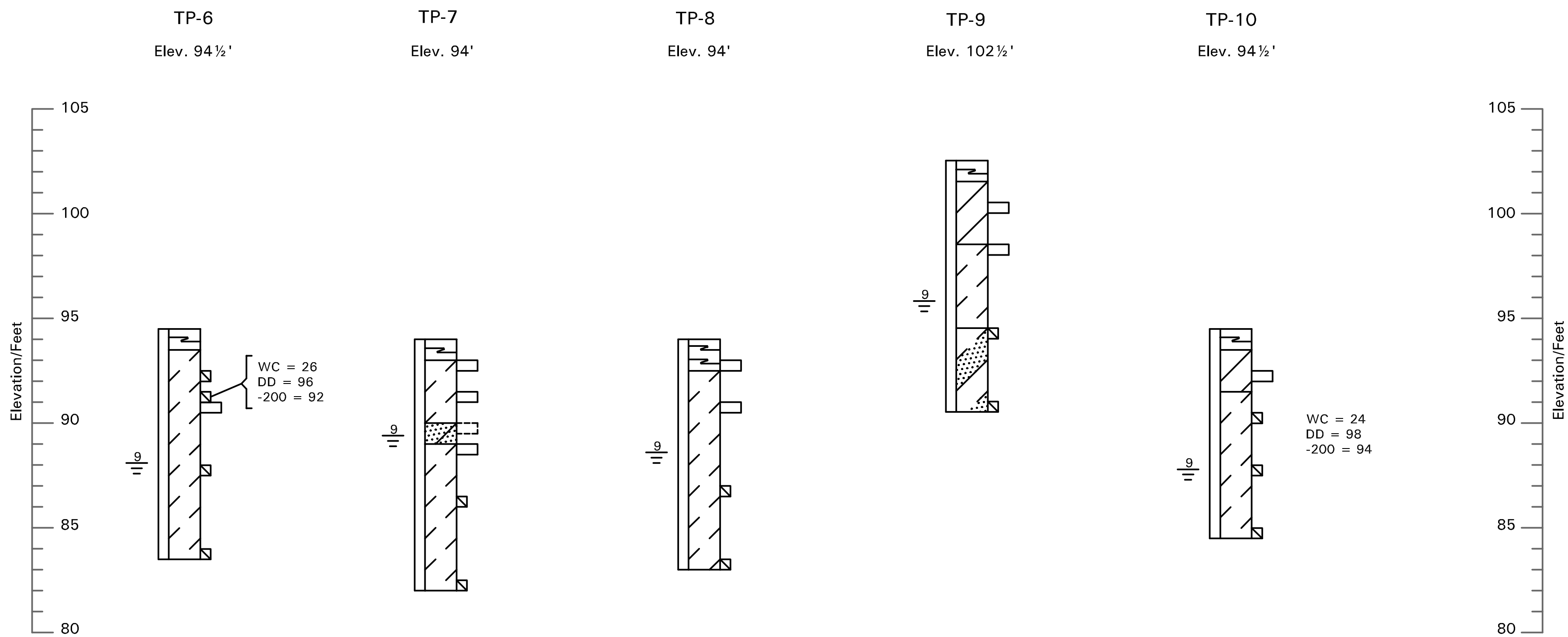


1160708	AGEC	Test Pit Locations	Figure 1



Approximate Vertical Scale 1" = 8'

See Figure 4 for Legend and Notes



Approximate Vertical Scale 1" = 8'

See Figure 4 for Legend and Notes

1160708	AGEC	Test Pit Logs - South Parcel	Figure 3

LEGEND:

Topsoil; lean clay to silty sand, slightly moist to moist, brown to gray, roots and organics.

Lean Clay (CL); small to moderate amounts of sand, soft to stiff, moist to wet, brown to gray.

Silt (ML); small amounts of sand, slightly porous, stiff, slightly moist, light brown to light gray.

Silty Sand (SM); small to moderate amounts of silt, occasional poorly-graded sand with silt, occasional thin lean clay layers, medium dense, moist to wet, brown.

Interlayered Lean Clay and Silty Sand (CL/SM); medium stiff/medium dense, wet, brown.

Poorly-graded Sand with Silt (SP-SM); medium dense, moist to wet, brown.

Indicates relatively undisturbed hand drive sample taken.

Indicates disturbed sample taken.

Indicates relatively undisturbed block sample taken.

Indicates slotted 1½ inch PVC pipe installed in the test pit to the depth shown.

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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 September 12 and 13, 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 automatic 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).

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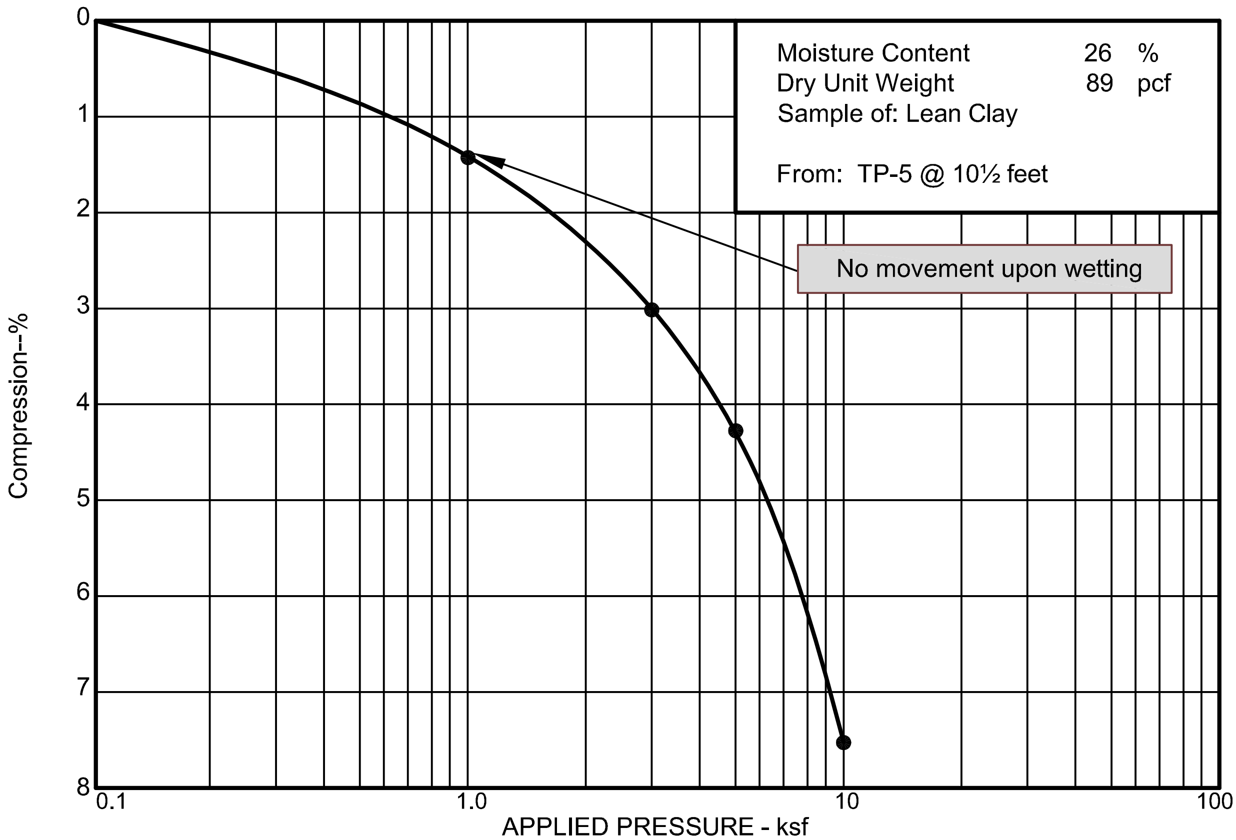

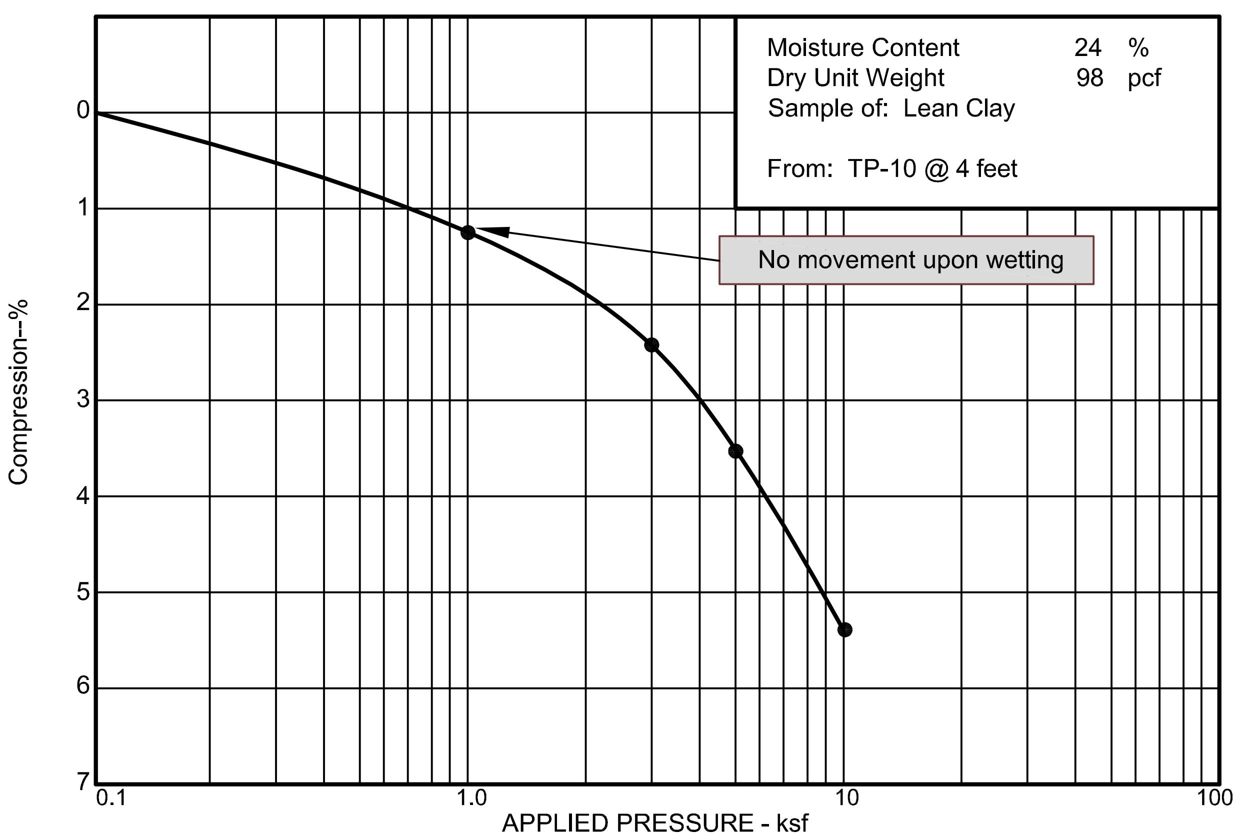

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1160708

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	6½	26	97			8					Poorly-graded Sand with Silt
TP-3	6	28	93			31					Silty Sand
TP-5	4	25	100			93			2,690		Lean Clay
	10½	26	89			98					Lean Clay
TP-6	3	26	96			92					Lean clay
TP-10	4	24	98			94					Lean Clay