AGEC

Applied GeoTech

GEOLOGIC AND GEOTECHNICAL STUDY

PROPOSED COOK RESIDENCE

5900 NORTH 3100 EAST

LIBERTY, UTAH

PREPARED FOR:

CLAYTON COOK
6275 NORTH FORK ROAD
LIBERTY, UT 84310

PROJECT NO. 1170956

DECEMBER 19, 2017

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EXECUTIVE SUMMARY

1. Seismic ground shaking is considered the only significant geologic hazard at the site. This hazard will be mitigated through structural design. It is our professional opinion that landslide, debris flow, rockfall, surface fault rupture, tectonic subsidence and liquefaction are not significant hazards at the site.

2. The subsurface soil encountered consists of approximately ½ foot of topsoil overlying clay, which extends to a depth of approximately 2 to 2½ feet. Gravel was encountered below the clay and extends the full depth of the test pits, approximately 10 feet.

   Test Pits TP-4 and TP-5 were excavated in an area of fill planned to be used as fill below the proposed residence. The fill consists predominantly of clayey gravel with sand and cobbles up to approximately ½ foot in size. Assuming that the fill in this area is consistent in composition to that encountered in the two test pits, it would be suitable for use as fill below the proposed residence if the organics, debris, particles over approximately 3 inches in size and other deleterious materials are removed from the fill.

3. Subsurface water was encountered at depths of approximately 1½, 2½ and 1 foot in Test Pits TP-1, TP-2 and TP-3, respectively. No water was encountered in Test Pits TP-4 and TP-5. Fluctuations in the depth to water should be expected over time.

4. The proposed residence may be supported on spread footings bearing on the undisturbed natural gravel or on structural fill extending down to the natural gravel and may be designed for a net allowable bearing pressure of 3,500 pounds per square foot.

5. Construction equipment access difficulties can be expect in areas of clay subgrade when the clay is very moist to wet. Placement of 1 to 2 feet of granular fill will improve construction equipment access in areas of very moist to wet clay subgrade.

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

SCOPE

This report presents the results of geologic-hazard and geotechnical studies for a proposed residence to be constructed at approximately 5900 North 3100 East in Liberty, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundations. The study was conducted in general accordance with our proposal dated November 16, 2017.

The geotechnical study was conducted to evaluate geotechnical aspects of the project. The geologic-hazard study was conducted to evaluate geologic hazards that may affect the proposed development of the lot. The hazards evaluated are surface fault rupture, landslide, tectonic subsidence, rockfall, debris flow and liquefaction. The study included a review of geologic literature, aerial photographs and Lidar data, site reconnaissance, subsurface exploration and geologic analysis.

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.

SITE CONDITIONS

At the time of our field study, there were no permanent structures or pavement on the site. The site consists of an undeveloped field.

The ground surface at the site slopes gently down toward the east.

Vegetation at the site consists of grass and weeds.

The surrounding area consists of undeveloped ground similar to the site.

FIELD STUDY

The field study was conducted on November 28, 2017. Five 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 presented 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 removed and replaced with properly compacted fill where it will support proposed buildings, floor slabs or other settlement-sensitive improvements.

SUBSURFACE CONDITIONS

The subsurface soil encountered consists of approximately ½ foot of topsoil overlying clay, which extends to a depth of approximately 2 to 2½ feet. Gravel was encountered below the clay and extends the full depth of the test pits, approximately 10 feet.

Test Pits TP-4 and TP-5 were excavated in an area of fill planned to be used as fill below the proposed residence. The fill consists predominantly of clayey gravel with sand and cobbles up to approximately ½ foot in size. Assuming that the fill in this area is consistent in composition to that encountered in the two test pits, it would be suitable for use as fill below the proposed residence if the organics, debris, particles over approximately 3 inches in size and other deleterious materials are removed from the fill.

A description of the soil encountered in the test pits follows:

> Fill - The fill consists of clayey gravel with sand and cobbles up to approximately ½ foot in size. It is slightly moist and brown.

Results of gradation and moisture-density tests performed on the fill are presented on Figure 6.

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

Lean Clay - The clay contains a moderate amount of sand and gravel. It is soft to medium stiff, very moist to wet and brown to dark brown.

Laboratory tests performed on a sample of the clay indicate it has a natural moisture content of 26 percent and a natural dry density of 94 pounds per cubic foot (pcf). Results a consolidation test performed on a sample of the clay indicate it will compress a small to moderate amount with the addition of light to moderate loads. Results of the consolidation test are presented on Figure 4.

Clayey Gravel with Sand - The gravel contains cobbles and boulders up to approximately 1½ feet in size. It is medium dense, wet and brown to dark gray.

Results of a gradation test of the gravel are presented on Figure 5.

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

SUBSURFACE WATER

Subsurface water was encountered at depths of approximately 1½, 2½ and 1 foot in Test Pits TP-1, TP-2 and TP-3, respectively. No water was encountered in Test Pits TP-4 and TP-5. Fluctuations in the depth to water should be expected over time.

PROPOSED CONSTRUCTION

A single-family residence is planned for the site. We assume the building will be a one to two-story structure with a slab-on-grade floor or crawl space. We have assumed building loads to consist of wall loads up to 2½ kips per lineal foot and column loads up to 30 kips.

We would expect that grading for the lot will result in less than 5 feet of grade change.

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

GEOLOGIC-HAZARD STUDY

A. Office Methods of Investigation

Geologic conditions at the site were evaluated by a review of geologic literature, aerial photographs and Lidar data. Aerial photographs used during the investigation were downloaded from the Utah Geological Survey website. They have photograph numbers of ELK-2-44 and 45 and a photograph date of June 25, 1963. The Lidar data has a date of 2011 and was obtained from the Open Topography website.

1. Geologic Literature Review

   The site is located in Ogden Valley, which is a northwest trending valley within the Wasatch Mountains of north/central Utah. The valley is filled with an accumulation of lacustrine, alluvial and colluvial sediments from deposition during the past 15 million years (Crittenden and Sorensen, 1985). The surface deposits across the site consist of Quaternary-age alluvium consisting of clay overlying clayey gravel with cobbles and boulders.

Ogden Valley is a down-dropped structure with the Ogden Valley Northeast margin fault along the northeast side of the valley and the Ogden Valley Southwest margin fault and the Ogden Valley North Fork fault along the southwest side of the valley. These faults are oriented in a general northwest/southeast direction with the two western faults estimated to have moved in the last 750,000 years and the east fault having evidence of movement in the last 2.6 million years. The faults are considered normal faults with dip direction down to the northeast on the two west fault systems and down to the southwest for the Ogden Valley Northeast margin fault. The faults are considered relatively old structures and do not represent a surface-fault-rupture hazard for development within the Ogden Valley area. Tectonic subsidence associated with fault movement would similarly not be a significant hazard at this site.

The Utah Fault and Fold database shows the Ogden Valley North Fork fault to extend near or below the site. No active faults are mapped through or near the site. The closest active fault to the site based on the Utah Geological Survey database is the Wasatch fault located approximately 3 miles to the southwest.

The geologic map by Crittenden and Sorensen (1985) shows the site to be underlain by alluvial-fan deposits of Holocene age. Mapping by Coogan and King (2001) shows the area underlain by similar deposits. The Elliott and Harty (2010) landslide map shows no landslides in the area of the site.

2. Aerial Photograph and Lidar Review

The geologic literature indicates that there are no landslide deposits in the area of the site. Review of aerial photographs and Lidar data finds no evidence of landslide deposits on the property. The slope of the site and surrounding area is sufficiently flat such that landslide is not considered a potential hazard at this site.

Based on the topography of the site and surrounding area, rockfall and debris flow are not potential geologic hazards at the site.

3. Seismicity

The property is located in the Intermountain Seismic Zone, which consists of an area of relatively high historical seismic activity. The most intense seismic ground shaking at the site is expected to originate from the Wasatch fault zone. The Wasatch fault zone is considered capable of producing earthquakes on the order of 7 to 7.5 magnitude and can result in significant seismic ground shaking at the site. The US Geological Survey data indicate that a peak ground acceleration of 0.47g can be expected to have a 2 percent probability of being exceeded in a 50-year time period at this site (IBC, 2015).

B. Field Methods of Investigation

Three test pits were used to determine subsurface conditions at the site. A site reconnaissance was performed to determine if there is evidence of landslide features in the area and none were found.

Liquefaction is unlikely to be a hazard at this site because of the type of sediments encountered but investigation to a depth of at least 30 feet would be needed determine the liquefaction potential at the site. Such a study is beyond the scope of work for this project.

C. Geologic Conclusions

Seismic ground shaking is considered the only significant geologic hazard at the site. This hazard will be mitigated through structural design. It is our professional opinion that landslide, debris flow, rockfall, surface fault rupture, tectonic subsidence and liquefaction are not significant hazards at the site.

GEOTECHNICAL RECOMMENDATIONS

A. Site Grading

1. Subgrade Preparation

Prior to placing grading fill or base course, the topsoil, clay, organic material, unsuitable fill and other deleterious materials should be removed from below the proposed building area. The clay may remain outside the proposed building area.

Construction equipment access difficulties can be expect in areas of clay subgrade when the clay is very moist to wet. Placement of 1 to 2 feet of granular fill will improve construction equipment access in areas of very moist to wet clay subgrade.

2. Cut and Fill Slopes

Temporary unretained excavation slopes in the clay may be constructed at 1 horizontal to 1 vertical or flatter. Temporary unretained excavation slopes in the gravel may be constructed at 1½ horizontal to 1 vertical or flatter if the excavation is dewatered. Permanent, unretained cut and fill slopes up to 15 feet in height may be constructed at slopes of 2 horizontal to 1 vertical or flatter. Slopes greater than 15 feet in height will require a stability analysis.

Good surface drainage should be provided upslope of cut and fill slopes to direct surface runoff away from the face of the slopes. The slopes should be protected from erosion by revegetation or other methods.

3. Excavation

We anticipate that excavation at the site can be accomplished with heavy-duty excavation equipment. Some difficulty can be expected for confined excavations where boulders are encountered. Care should be taken not to disturb the natural soil to remain in the proposed building area.

Excavations that extend to very moist to wet soil near or below the groundwater level will require the use of excavation equipment supported from outside and above excavations. If excavations extend below the water level, care should be taken to dewater the excavations. The water level should be maintained below the base of the excavation during placement of fill and concrete. Free-draining gravel with less than 5 percent passing the No. 200 sieve should be used for fill or backfill below the original water level.

4. 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 the proposed building should consist of granular soil as indicated above. The on-site sand and gravel and fill investigated at the proposed fill source area at Test Pits TP-4 and TP-5 are generally expected to meet these criteria if the organics, debris and oversized particles are removed. The clay is not recommended for use as fill below the building.

Free-draining gravel should be used as fill below the original water level.

5. 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	≥ 90%
Landscaping	≥ 85%
Retaining Wall Backfill	85 - 90%

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

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

6. Drainage

The ground surface surrounding the proposed building should be sloped away from the residence in all directions. Roof down spouts and drains should discharge beyond the limits of backfill.

B. Foundations

1. Bearing Material

The proposed residence may be supported on spread footings bearing on the undisturbed natural gravel or on structural fill extending down to the 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.

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

2. Bearing Pressure

Spread footings may be designed for a net allowable bearing pressure of 3,500 pounds per square foot.

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 36 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 or on compacted structural fill that extends down to the undisturbed natural soil.

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

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 0.45 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 28 pcf and 13 pcf for active and at-rest conditions, respectively, and decreased by 28 pcf for the passive condition. This assumes a peak horizontal ground acceleration of 0.47g for a seismic event having 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. Seismicity, Faulting and Liquefaction

1. Seismicity

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

a.	Site Class	D
b.	Short Period Spectral Response Acceleration, S_S	1.10g
c.	One Second Period Spectral Response Acceleration, S_1	0.39g

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 3 miles southwest of the site (Utah Geological Survey, 2017).

3. Liquefaction

Based on the subsurface conditions encountered at the site, published literature and our understanding of the geologic conditions in the area, liquefaction is not considered a hazard at this site.

F. Water Soluble Sulfates

Based on past experience in the area, the natural soil in the area 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. Preconstruction Meeting

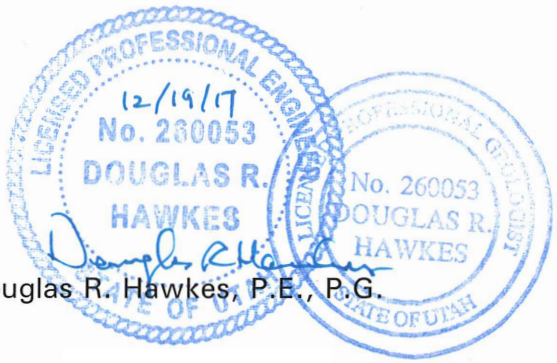
A preconstruction meeting should be held with representatives of the owner, project architect, geotechnical engineer, general contractor, earthwork contractor and other members of the design team to review construction plans, specifications, methods and schedule.

LIMITATIONS

The geologic portion of the analysis and report findings are based on published geologic maps and reports, aerial photographs and Lidar data of the site, the test pits excavated at the approximate locations indicated on Figure 1 and our interpretation of geologic conditions at the site. Our conclusions are based on currently accepted geologic interpretation of this information.

The geotechnical 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 in the report are based on information obtained from 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 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.



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

Reviewed by Jay R. McQuivey, P.E.

DRH/rs

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Coogan, J.C. and King, J.K.,2000; Progress report geologic map of the Ogden 30' X 60' quadrangle, Utah and Wyoming, Utah Geological Survey Open-file Map 380.

Crittenden, M.D.,Jr. and Sorensen, M.L., 1985; Geologic map of the North Ogden quadrangle and part of the Ogden and Plain City quadrangles, Box Elder and Weber Counties, Utah, US Geological Survey Map I-1606.

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

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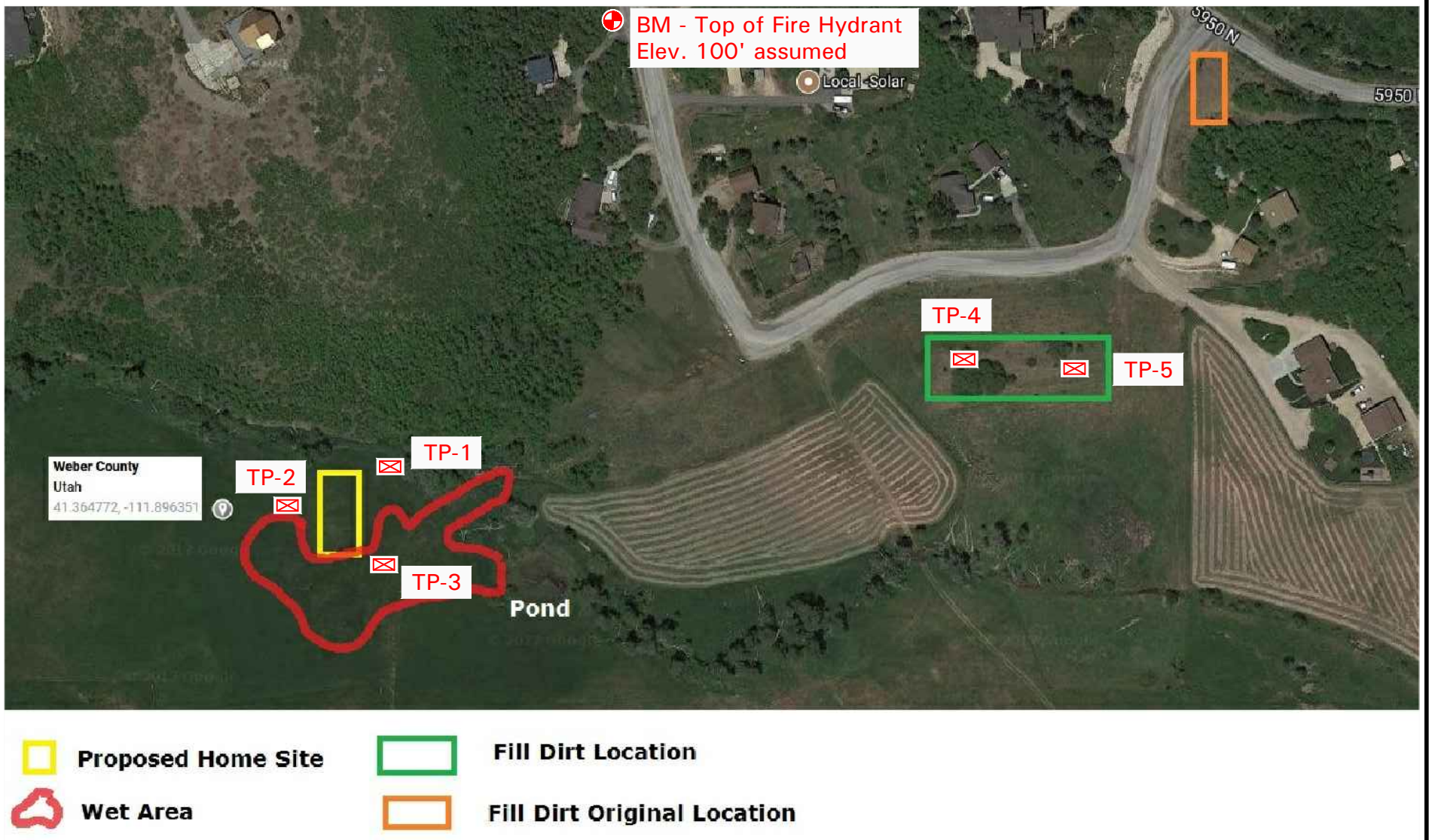
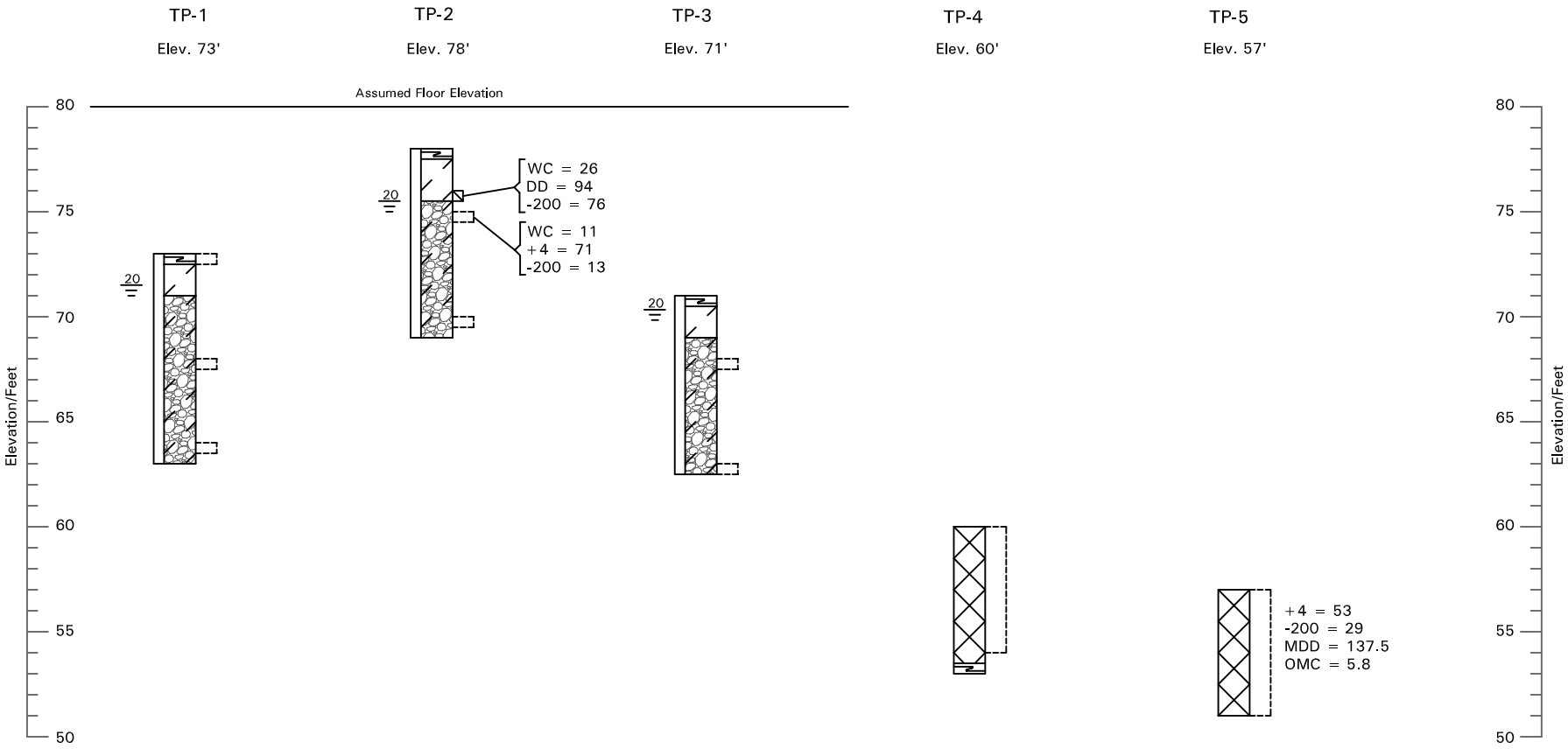


1170956	AGEC	Test Pit Boring Locations	Figure 1



Approximate Vertical Scale 1" = 8'

See Figure 3 for Legend and Notes

1170956	AGEC	Test Pit Logs	Figure 2

LEGEND:

Fill; clayey gravel with sand, cobbles up to approximately ½ foot in size, moist, brown to grayish brown.

Topsoil; sandy lean clay with gravel, very moist to wet, dark brown, roots, organics.

Lean Clay (CL); moderate amount of sand and gravel, soft to medium stiff, very moist to wet, brown to dark brown.

Clayey Gravel with Sand (GC); cobbles, boulders up to approximately 1½ feet in size, medium dense, wet, brown to dark gray.

Indicates disturbed sample taken.

Indicates relatively undisturbed hand drive sample taken.

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

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 November 28, 2017 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);
   +4 = Percent Retained on the No. 4 Sieve;
   -200 = Percent Passing the No. 200 Sieve;
   MDD = Maximum Dry Density per ASTM D1557 (pcf);
   OMC = Optimum Moisture Content per ASTM D1557 (%).

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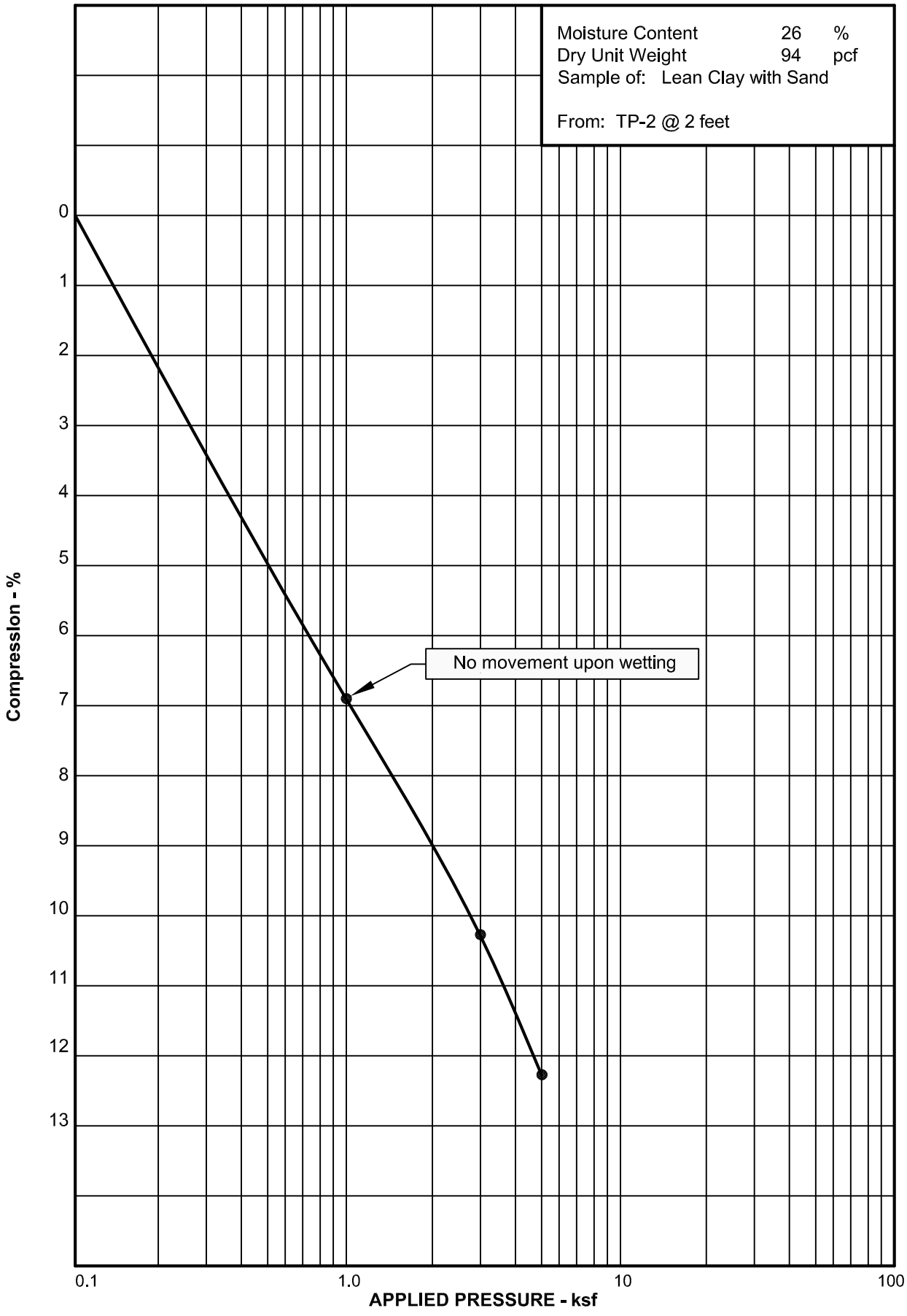
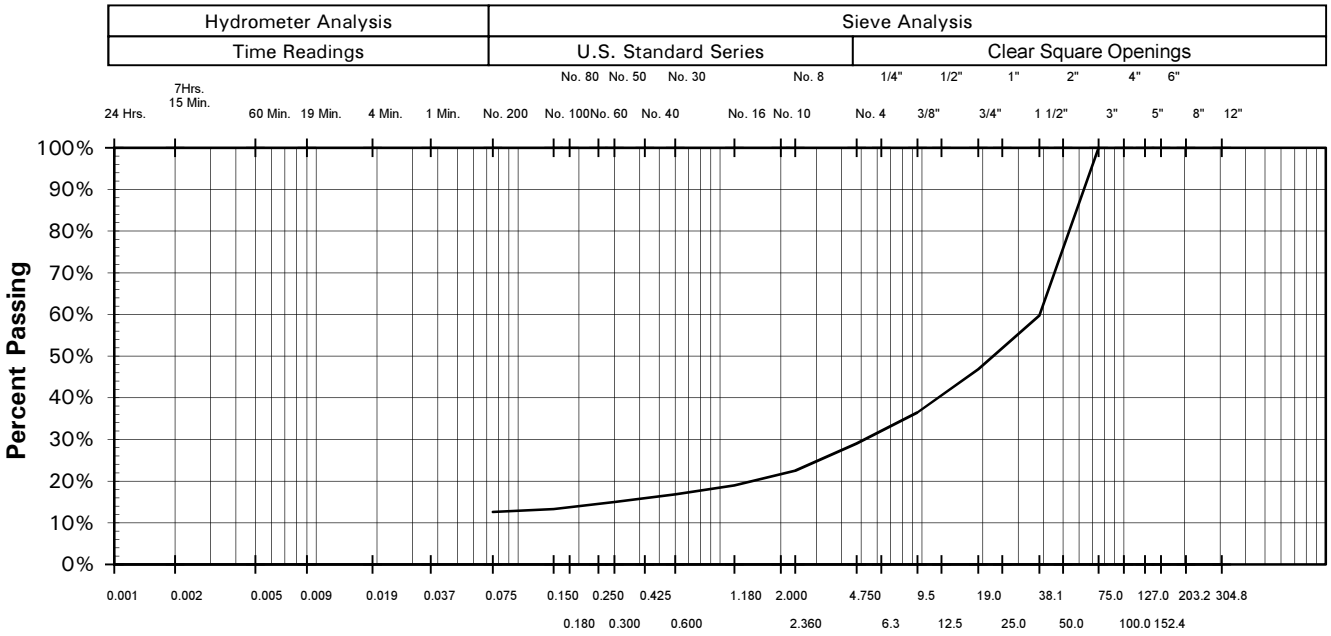


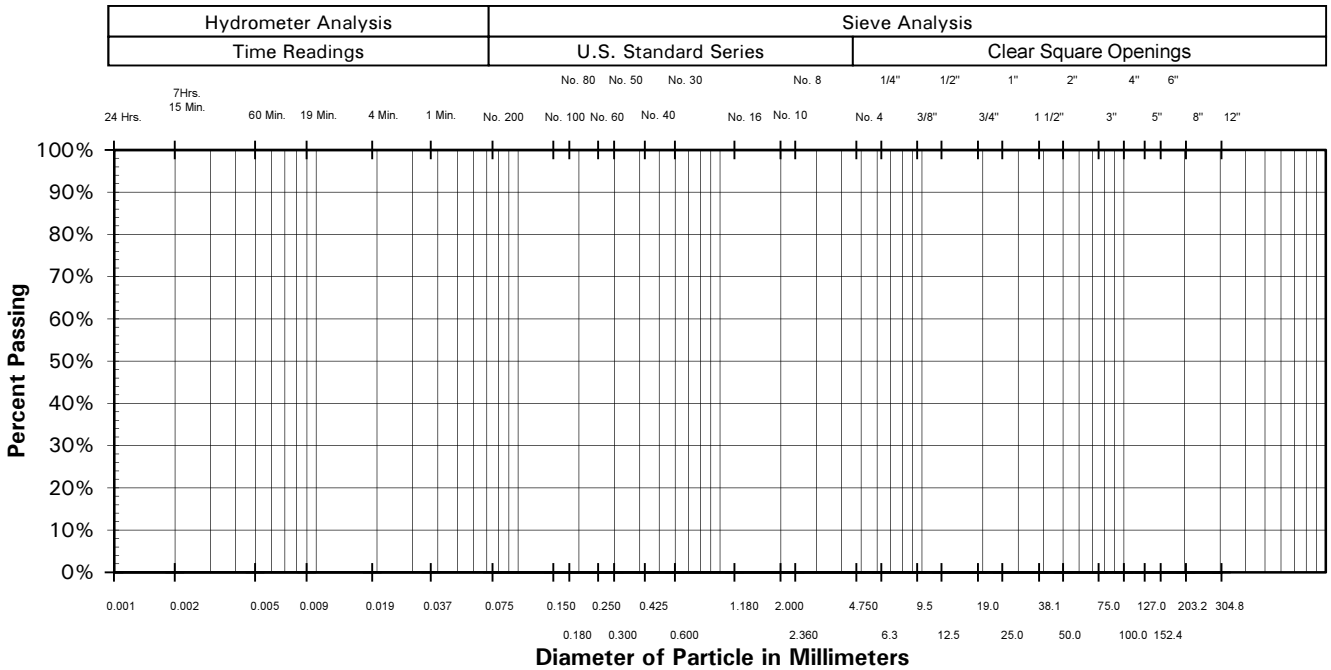
Project No. 1170956 **CONSOLIDATION TEST RESULTS** **Figure 4**

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	71%	Liquid Limit	-
Sand	16%	Plasticity Index	-
Silt and Clay	13%	Sample Location	TP-2 @ 3 feet
Sample Description	Clayey Gravel with Sand		



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel	-	Liquid Limit	-
Sand	-	Plasticity Index	-
Silt and Clay	-	Sample Location	
Sample Description			

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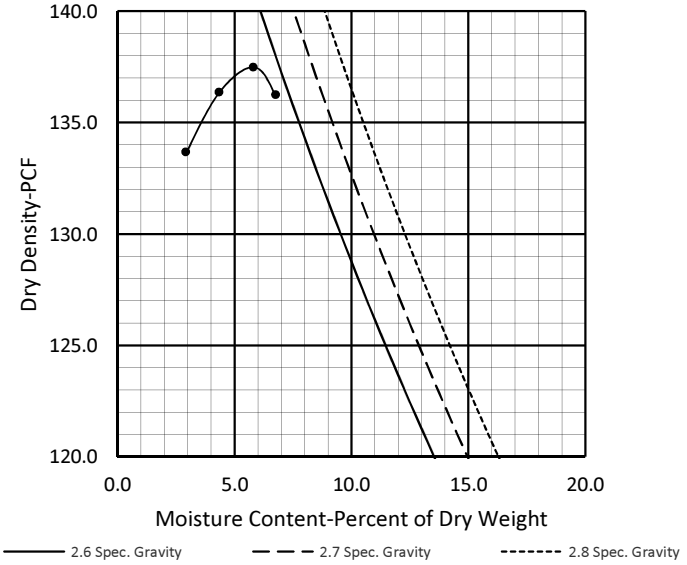
Moisture - Density Relationship, Gradation, & Classification Results



SAMPLE IDENTIFICATION

Project Name:	Cook
Project No.	1170956
Sample No.	15321
Sample Location:	TP-5 at 0' to 5'
Date Sampled:	-
Sampled By:	-

TESTING INFORMATION

Date Tested:	12/02/17
Tested By:	RN
Reviewed By:	KBB
Test Procedure:	ASTM D1557 C
Specific Gravity:	Assumed 2.6
Moisture Curing:	Not Used

ATTERBERG DATA

Plasticity Determined by ASTM D 2488

PROCTOR RESULTS

Maximum Dry Density (Corrected)	137.5 pcf
Optimum Moisture	5.8 %
Rock Correction	*10.2 pcf*

Final Based on Microwave Oven Moisture Contents

VISUAL-MANUAL DESCRIPTION (ASTM D2488)

Clayey Gravel with Sand (GC)

Contains 4-Inch Minus Cobble

GRADATION RESULTS

Sieve Designation	Sieve Opening Size (mm)	Percent Passing, Based on Total Sample
8"	200	100%
5"	127	100%
4"	100	100%
3"	76.2	97%
1 1/2"	38.1	77%
3/4"	19.1	66%
3/8"	9.52	57%
#4	4.76	47%
#8	2.38	42%
#16	1.19	38%
#30	0.59	35%
#50	0.297	32%
#100	0.149	30%
#200	0.074	29%

GRAVEL	SAND	SILT & CLAY

GRAVEL&COBBLE	SAND	SILT & CLAY
53%	18%	29%

Figure 6

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER 1170956

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION			MODIFIED PROCTOR		UNCONFINED COMPRESSIVE STRENGTH (PSF)	WATER SOLUBLE SULFATE (%)	SAMPLE CLASSIFICATION
TEST PIT	DEPTH (FEET)			GRAVEL (%)	SAND (%)	SILT/ CLAY (%)	MAXIMUM DRY DENSITY (PCF)	OPTIMUM MOISTURE (%)			
TP-2	2	26	94			76					Lean Clay with Sand
	3	11		71	14	13					Clayey Gravel with Sand
TP-5	0-6			53	18	29	137.5	5.8			Fill; Clayey Gravel with Sand