CTL | THOMPSON
INCORPORATED

PRELIMINARY GEOTECHNICAL INVESTIGATION
3624 EAST MULBERRY
FORT COLLINS, COLORADO

Prepared For:

SISU INVESTMENTS LP
P.O. Box 2165
Fort Collins, Colorado 80522

Attention: David Lund

Project No. FC07317-115

April 8, 2016

400 North Link Lane | Fort Collins, Colorado 80524
Telephone: 970-206-9455 Fax: 970-206-9441

TABLE OF CONTENTS

SCOPE

This report presents the results of our Preliminary Geotechnical Investigation for 3624 East Mulberry in Fort Collins, Colorado. The purpose of our investigation was to identify geologic hazards that may exist at the site and to evaluate the subsurface conditions to assist in planning and budgeting for the proposed development. The report includes descriptions of the subsoils, bedrock, and groundwater conditions found in our exploratory borings and discussions of site development as influenced by geotechnical considerations.

This report was prepared based upon our understanding of the development plans. The recommendations are considered preliminary and can be used as guidelines for further planning of development and design of grading. We should review final development and grading plans to determine if additional investigation is merited, or if we need to revise our recommendations. Additional investigations will be required to design building foundations and pavements. A summary of our findings and recommendations is presented below. More detailed discussions of the data, analysis and recommendations are presented in the report.

SUMMARY OF CONCLUSIONS

1. No geologic or geotechnical conditions were identified which would preclude development of this site. Shallow groundwater was encountered in some areas of the site. We believe proper engineering design and construction practices can help mitigate the effects of geotechnical concerns at the site.

2. Soils encountered across the site generally consisted of sandy clay and clayey sand overlying clean to clayey, sand and gravel. No bedrock was encountered in our borings.

3. Groundwater was encountered during drilling in all four borings at depths of approximately 7 to 9½ feet. Groundwater was measured several days after drilling in three borings at depths ranging of about 7 to 8 feet.

Caving soils prevented delayed groundwater measurements in one of the borings. Groundwater levels fluctuate seasonally. Our measurements represent only current groundwater conditions and may not be indicative of other times, or at other locations.

4. Overlot grading can be considered to raise grades at this site to create a separation from groundwater, where necessary. We recommend a 3-foot, preferably 5-foot separation from foundation elements and floor slabs to the groundwater. The soils encountered can be used as site grading fill. In general, import fill should meet or exceed the engineering properties as the native soils. The properties of the fill will affect performance of improvements. Fill should be properly moisture-conditioned and compacted.

5. Spread footing foundations are likely appropriate for development at the site. A design-level geotechnical investigation is required for specific foundation recommendations.

6. Slab-on-grade basement floors are likely appropriate for development at the site. Based on swell testing of soil samples from the site, the risk of poor slab performance is likely low. A design-level geotechnical investigation is required for specific floor system recommendations.

7. Preliminary data indicates sandy clay and clayey sand will likely be present as subgrade soils for pavements. New fill is assumed to possess equal or better qualities as the native soil. Estimated pavement sections are provided in the report. Subgrade stabilization may be necessary to reduce expansive potential of the subgrade soils. Mitigation may include moisture and/or chemical treatment of the subgrade soils.

8. Overall surface drainage should be designed to provide rapid run-off of surface water away from the proposed residences. Water should not be allowed to pond near the crest of slopes, on or adjacent to pavements, or adjacent to structures. All permanent slopes should be re-vegetated to reduce erosion.

9. Further investigations are required to make design recommendations for foundations, floors, and pavements.

SITE DESCRIPTION

The property at 3624 East Mulberry consists of a large, one-story, 2,500 square foot house and a few outbuildings located on approximately 5.25 acres on the northeast side of Fort Collins, Colorado. There are large piles of rubble and debris near the outbuildings. The site is relatively flat. Groundcover consists of grass, weeds and trees. Hotels and restaurants exist to the east of the property and there is undeveloped and agricultural land to the north and west.

PROPOSED DEVELOPMENT

We understand the parcel could be used for commercial or residential development with possible below grade areas. Floor systems are expected to be slab-on-grade or structural. Utilities and roadways will likely be constructed during the development of the site. Development and grading plans were not available at the time of this report preparation. Grading operations may include raising grades in areas with shallow groundwater.

GEOLOGIC HAZARDS

Colorado is a challenging location to practice geotechnical engineering. The climate is relatively dry and the near-surface soils are typically dry and relatively stiff. These soils and related sedimentary bedrock formations tend to react to changes in moisture conditions. Some of the soils swell as they increase in moisture and are called expansive soils. Other soils can settle significantly upon wetting and are referred to as collapsing soils. Most of the land available for development east of the Front Range is underlain by expansive clay or claystone bedrock near the surface. Laboratory tests on soil and bedrock samples from this site show low to moderate swell potential. The soils that exhibit collapse are more likely west of the Continental Divide; however, both types of soils occur all over the state.

FIELD AND LABORATORY INVESTIGATIONS

Subsurface conditions were investigated by drilling four exploratory borings at the approximate locations shown on Figure 1. The test holes were drilled using a truck-mounted drill rig with 4-inch diameter, continuous-flight augers. Our field representative observed drilling, logged the soils and bedrock found in the borings and obtained samples. Summary logs of the soils found in the borings and field penetration resistance values are presented on Figure 2.

Samples of soil were obtained by driving a modified California-type sampler (2.5 inch O.D.) and a 2.0-inch O.D. split spoon sampler into the subsoils using a 140-pound hammer falling 30 inches. Samples recovered from the test holes were returned to our laboratory and visually classified by the geotechnical engineer for this project. Laboratory testing included moisture content, dry unit weight, swell-consolidation, Atterberg Limits, particle size analysis, and water-soluble sulfate measurements. Swell test samples from the site were wetted at a pressure approximating the weight of the overburden soils. Laboratory test results are presented in Appendix A and summarized in Table A-I.

SUBSURFACE CONDITIONS

Soils encountered across the site generally consisted of sandy clay and clayey sand overlying clean to clayey, sand and gravel. Bedrock was not encountered in our borings. Swell testing of four soil samples from across the site indicated 0.1 percent compression to 2.4 percent swell potential when wetted at approximate overburden pressures. The sandy clay classified as medium stiff to stiff according to field penetration test results. The granular material classified as loose to medium dense. Particle size analyses indicated fines contents (percent passing the No. 200 sieve) of 5 to 28 percent.

Groundwater was encountered during drilling in four borings at depths of approximately 7 to 9½ feet. Groundwater was measured several days after drilling in three borings at depths of about 7 to 8 feet. Caving soils prevented delayed groundwater measurements in one boring (TH-1). Groundwater levels can be expected to fluctuate seasonally. Our measurements represent only current groundwater conditions, and may not be indicative of other times, or at other locations.

DEVELOPMENT RECOMMENDATIONS

The primary geotechnical concern that we believe will influence development of this site and performance of improvements is shallow groundwater. We believe by raising grades and limiting foundation depths, the impacts of shallow groundwater can be mitigated, but not eliminated. Additional evaluation of the groundwater conditions is recommended to estimate maximum seasonal groundwater levels.

Site Grading

The properties of fill will affect the performance of foundations, slabs-on-grade, utilities, and pavements. The ground surface in areas to be filled should be stripped of vegetation, scarified, moisture-conditioned, and densely compacted. The on-site soils can be used as site grading fill provided they are substantially free of organics and other deleterious materials. Permanent cut and fill slopes should be no steeper than 3:1 (horizontal to vertical) and be seeded or mulched to reduce erosion. Use of flatter (4:1) slopes is preferable.

Our experience has shown clay fill, moisture treated to optimum moisture content or above, will exhibit lower swell than drier material. Clay fill should be moisture-conditioned to between optimum and 3 percent above optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698). Sand fill should be moisture-conditioned to within 2 percent of optimum moisture content. The placement and compaction of site grading fill should be observed and density tested by our representative during construction. Guideline grading specifications are presented in Appendix B. Permanent slopes should be terraced and re-vegetated to reduce erosion.

Utility Construction

We believe excavations for utility installation can be performed with heavy-duty excavation equipment. Groundwater will likely be encountered in deep trenches. Bracing and/or temporary dewatering may be required during utility construction. Dewatering may be accomplished by sloping excavations to occasional sumps where water can be removed by pumping. The sumps should be several feet below the bottom of the excavations so that water is pumped down through the soils rather than up through the bottom of the excavations to reduce potential that the support capacity of the subsoils will be compromised.

Utility trenches should be sloped or shored to meet local, state, and federal safety regulations. Excavation slopes specified by OSHA are dependent upon soil types and groundwater conditions encountered. Seepage and groundwater conditions in trenches may downgrade the soil type. Initial trench excavations may be unstable and require flatter slopes than required by OSHA. Contractors should identify the soils encountered in the excavations and refer to OSHA standards to determine appropriate slopes. Excavations deeper than 20 feet should be designed by a professional engineer.

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. Our experience indicates compacted trench backfill may settle 1 to 2 percent. More settlement may occur if wetting of the fill occurs. Trench backfill should be placed in thin loose lifts, moisture-conditioned and compacted as recommended in the Site Grading section of this report. The placement and compaction of backfill should be observed and tested by our firm during construction.

Preliminary Pavement Thicknesses

The subgrade will likely consist of the native sandy clay and clayey sand. We have assumed any fill placed at the site will have properties equal to or better than the native materials. We judge there is a low to moderate risk of expansive soil related distress to pavements. Soft, yielding soils may be encountered that may require stabilization. Subgrade stability may be accomplished using moisture treatment and/or chemical treatment with lime or fly ash in the upper 1-foot of the subgrade. Preliminary pavement thickness alternatives are presented in Table 1 below. These thicknesses should be used for planning purposes only. We recommend a subgrade investigation and final pavement design after site grading is complete.

TABLE 1

PRELIMINARY PAVEMENT THICKNESS ALTERNATIVES

Classification	HMA* + ABC*	PCC*
Parking / Local Standard Residential (EDLA = 10)	4"-5.5" HMA + 6"-8" ABC	6"- 7" PCC
Residential Collector (EDLA = 50)	5.5"- 6.5" HMA + 6"-10" ABC	6"- 7" PCC

*HMA = Hot Mix Asphalt; ABC = Aggregate Base Course;
PCC = Portland Cement Concrete

CONSIDERATIONS FOR STRUCTURES

Our field and laboratory data indicate the soil and bedrock conditions are relatively consistent across the site. The following discussions are preliminary and are not intended for design or construction. After grading is completed, a design level geotechnical investigation should be conducted which provides recommendations and design criteria for the planned construction.

Foundations

Spread footing are likely appropriate for development at the site. A design-level geotechnical report will likely include a minimum dead load specification to mitigate potential foundation heave related to swelling soils. Foundation depths will be limited by shallow groundwater in some areas of the site.

Floor System and Slabs-on-Grade Construction

Low swelling soils are present at this site. Recommended basement floor systems are likely to be slabs-on-grade. Structural floors should be considered where floor movement cannot be tolerated.

Basements

Where below grade areas are planned, excavations may be limited in depth due to the presence of shallow groundwater. We recommend at least 3 feet between floor slabs and groundwater. Irrigation practices in the area contribute to current groundwater conditions and are likely to influence future groundwater conditions. Foundation drains will be necessary around basements and potentially crawl spaces.

We advocate discharge of foundation drains to an area underdrain where a gravity outfall is possible. Basement walls should be designed to resist lateral earth pressures.

Surface Drainage

The performance of foundations will be influenced by surface drainage. The ground surface around proposed buildings should be shaped to provide runoff of surface water away from the structure and off of pavements. We generally recommend slopes of at least 12 inches in the first 10 feet where practical in the landscaping areas surrounding buildings. There are practical limitations on achieving these slopes. Irrigation should be minimized to control wetting. Roof downspouts should discharge beyond the limits of backfill. Water should not be allowed to pond on or adjacent to pavements. Proper control of surface runoff is also important to limit the erosion of surface soils. Sheet flow should not be directed over unprotected slopes. Water should not be allowed to pond at the crest of slopes. Permanent slopes should be re-vegetated to reduce erosion.

Water can follow poorly compacted fill behind curbs and gutters and in utility trenches. This water can soften fill and undermine the performance of the roadways, flatwork, and foundations. We recommend compactive effort be used in placement of all fill.

General Design Considerations

Exterior sidewalks and pavements supported above the on-site clays are subject to post construction movement. Flat grades should be avoided to prevent possible ponding, particularly next to the building due to soil movement. Positive grades away from the buildings should be used for sidewalks and flatwork around the perimeter of the buildings in order to reduce the possibility of lifting of this flatwork, resulting in ponding next to the structures.

Joints next to buildings should be thoroughly sealed to prevent the infiltration of surface water. Where concrete pavement is used, joints should also be sealed to reduce the infiltration of water. Since some post construction movement of pavement and flatwork may occur, joints around the buildings should be periodically observed and resealed where necessary.

Roof drains should be discharged well away from the structures, preferably by closed pipe systems. Where roof drains are allowed to discharge on concrete flatwork or pavement areas next to the structures, care should be taken to insure the area is as water tight as practical to eliminate the infiltration of this water next to the buildings.

CONCRETE

For sites with Class 2 sulfate exposure, ACI recommends using a cement meeting the requirements for Type V (sulfate resistant) cement or the equivalent, with a maximum water-to-cementitious material ratio of 0.45 and air entrainment of 5 to 7 percent. As an alternative, ACI allows the use of cement that conforms to ASTM C 150 Type II requirements, if it meets the Type V performance requirements (ASTM C 1012) of ACI 201, or ACI allows a blend of any type of Portland cement and fly ash that meets the performance requirements (ASTM C 1012) of ACI 201. In Colorado, Type II cement with 20 percent Class F fly ash usually meets these performance requirements. The fly ash content can be reduced to 15 percent for placement in cold weather months, provided a water-to-cementitious material ratio of 0.45 or less is maintained. ACI also indicates concrete with Class 2 sulfate exposure should have a minimum compressive strength of 4500 psi.

Sulfate attack problems are comparatively rare in this area when quality concrete is used. Considering the range of test results, we believe risk of sulfate attack is lower than indicated by the few laboratory tests performed. The risk is also lowered to some extent by damp-proofing the surfaces of concrete walls in contact with the soil. ACI indicates sulfate resistance for Class 1 exposure can be achieved by using Type II cement, a maximum water-to-cementitious material ratio of 0.50, and a minimum compressive strength of 4000 psi. We believe this approach should be used as a minimum at this project. The more stringent measures outlined in the previous paragraph will better control risk of sulfate attack and are more in alignment with written industry standards.

RECOMMENDED FUTURE INVESTIGATIONS AND TESTING

Based on the results of this investigation and the proposed development, we recommend the following investigations be performed by our firm:

1. Review of site grading plans once the plans are available;
2. Subgrade Investigation and Pavement Design after grading;
3. Design-level Soils and Foundation Investigation for each lot after grading;
4. Construction testing and observation during site development, and building construction, including compaction testing of grading fill, utility trench backfill and pavements, and foundation installation observations.

LIMITATIONS

Our exploratory borings were located to obtain preliminary subsoil data indicative of conditions on this site. Although our borings were spaced to obtain a reasonably accurate picture of subsurface conditions, variations in the subsoils not indicated in our borings are always possible. We believe this investigation was conducted in a manner consistent with that level of skill and care ordinarily used by members of the profession currently practicing under similar conditions in the locality of this project. No warranty, express or implied, is made.

This report was prepared from data developed during our field exploration, laboratory testing, engineering analysis, and experience with similar conditions. The recommendations contained in this report were based upon our understanding of the planned construction. If plans change or differ from the assumptions presented herein, we should be contacted to review our recommendations. If we can be of further service in discussing the contents of this report or in the analysis of the building and pavement from the geotechnical point of view, please call.

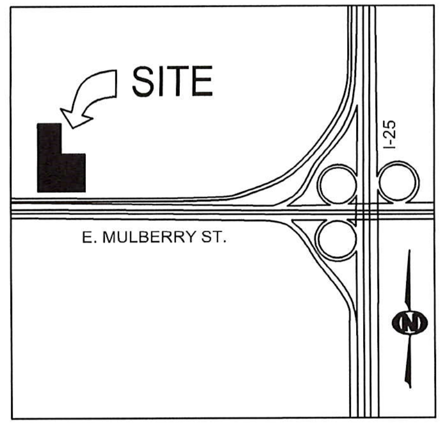
Very truly yours,
CTL | THOMPSON, INC.

Trace S. Krausse, EI
Staff Geotechnical Engineer

Spencer Schram, PE
Geotechnical Department Manager

COLORADO LICENSED
SPENCER A. SCHRAM
46576
APR 11 2016
PROFESSIONAL ENGINEER

TSK:SAS
(2 copies)

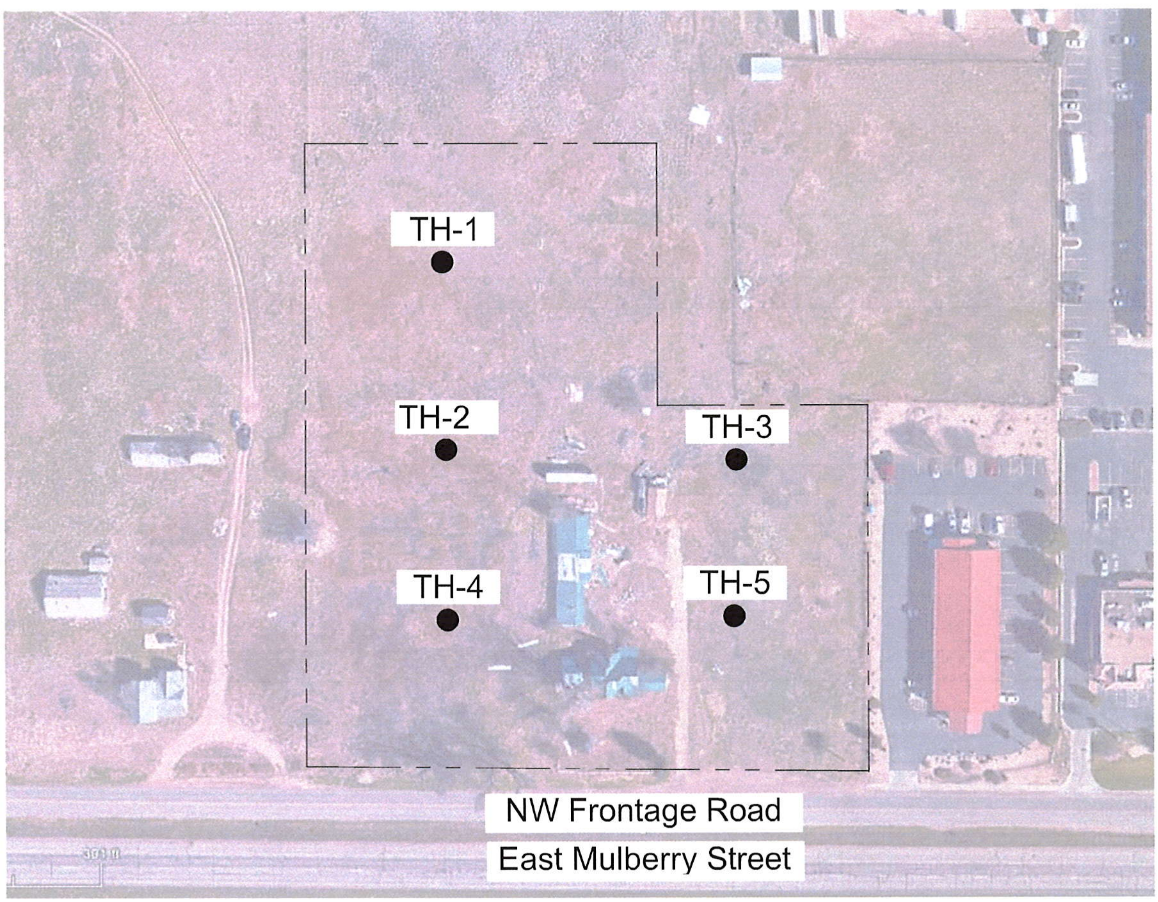


VICINITY MAP
FORT COLLINS, COLORADO
NOT TO SCALE

LEGEND:

TH-1 ● INDICATES APPROXIMATE LOCATION OF EXPLORATORY BORING

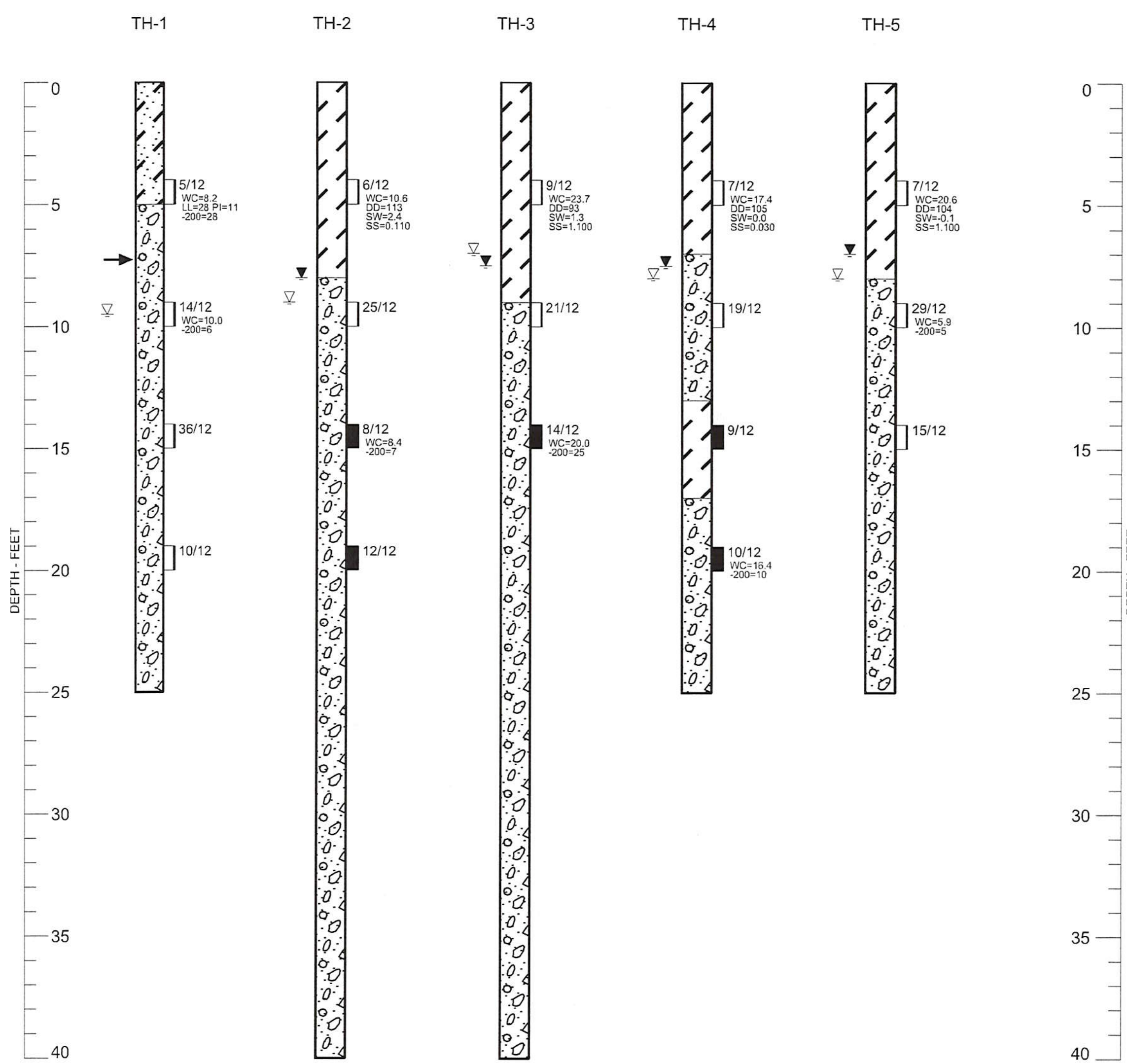
— - - — - - APPROXIMATE PROPERTY BOUNDARY



Locations of Exploratory Borings

FIGURE 1

SISU INVESTMENTS LP
3624 EAST MULBERRY
CTL I T PROJECT NO. FC07317-115



LEGEND:

CLAY, SANDY, SLIGHTLY MOIST TO MOIST, MEDIUM STIFF TO STIFF, BROWN (CL)

SAND, CLAYEY, MOIST, LOOSE, BROWN (SC)

SAND AND GRAVEL, CLEAN TO SLIGHTLY CLAYEY, MOIST TO WET, LOOSE TO MEDIUM DENSE BROWN (SW-SC, SP, SC)

DRIVE SAMPLE. THE SYMBOL 5/12 INDICATES 5 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

DRIVE SAMPLE. THE SYMBOL INDICATES BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.0-INCH O.D. SAMPLER INCHES.

WATER LEVEL MEASURED AT TIME OF DRILLING.

WATER LEVEL MEASURED SEVERAL DAYS AFTER DRILLING.

INDICATES DEPTH WHERE HOLE CAVED PRIOR TO SECONDARY GROUNDWATER MEASUREMENTS.

NOTES:

1. THE BORINGS WERE DRILLED ON MARCH 11 AND 15, 2016, USING 4-INCH DIAMETER CONTINUOUS-FLIGHT AUGERS AND A TRUCK-MOUNTED DRILL RIG.
2. THESE LOGS ARE SUBJECT TO THE LIMITATIONS, CONCLUSIONS AND EXPLANATIONS IN THIS REPORT.
3. WC - INDICATES MOISTURE CONTENT (%).
   DD - INDICATES DRY DENSITY (PCF).
   SW - INDICATES SWELL WHEN WETTED UNDER OVERBURDEN PRESSURE (%).
   -200 - INDICATES PASSING NO. 200 SIEVE (%).
   LL - INDICATES LIQUID LIMIT.
   PI - INDICATES PLASTICITY INDEX.
   SS - INDICATES SOLUBLE SULFATE CONTENT (%).

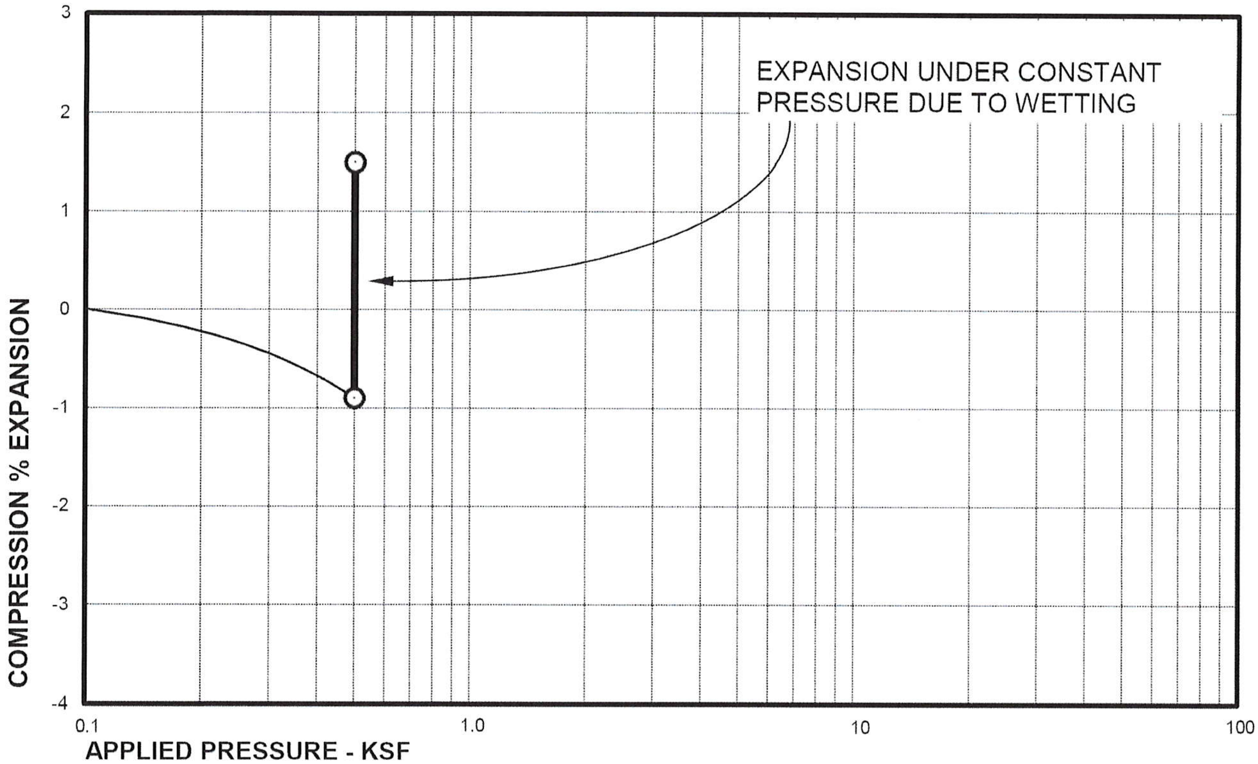
SISU INVESTMENTS LP
3624 EAST MULBERRY
CTL | T PROJECT NO. FC07317-115

Summary Logs of Exploratory Borings

FIGURE 2

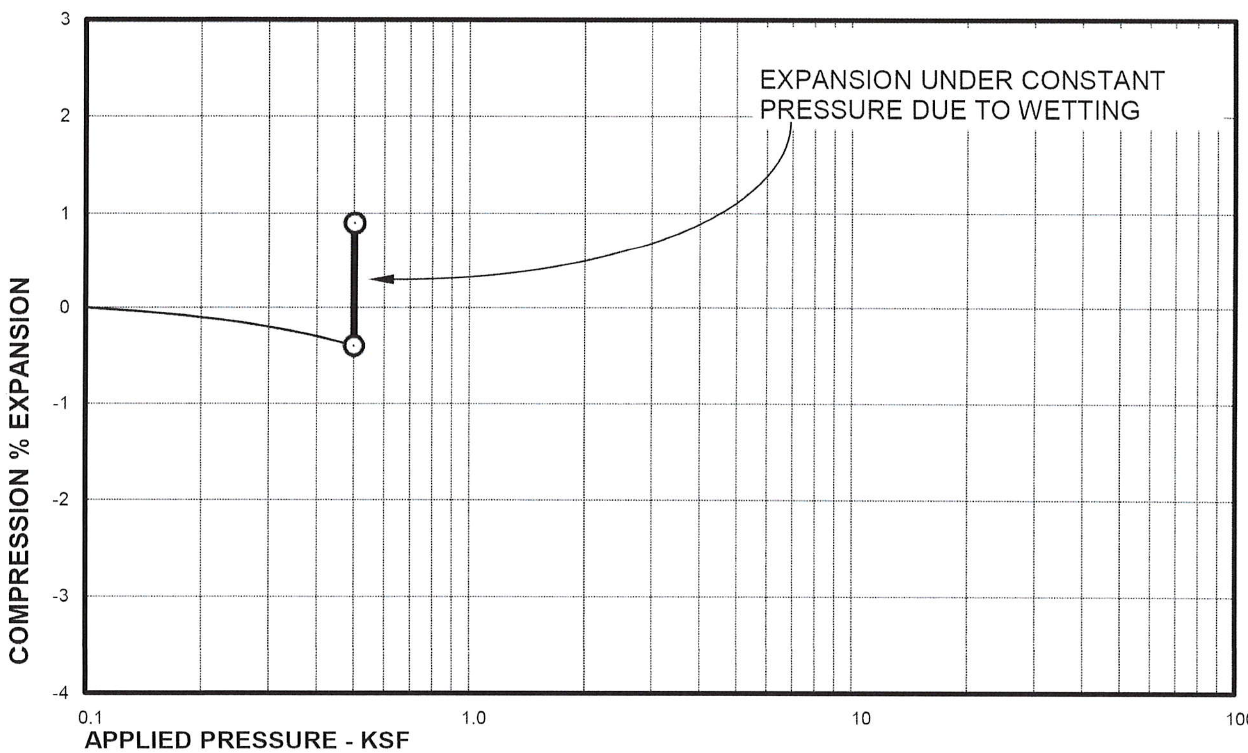
APPENDIX A

LABORATORY TEST RESULTS



Sample of CLAY, SANDY (CL)
From TH - 2 AT 4 FEET

DRY UNIT WEIGHT= 113 PCF
MOISTURE CONTENT= 10.6 %

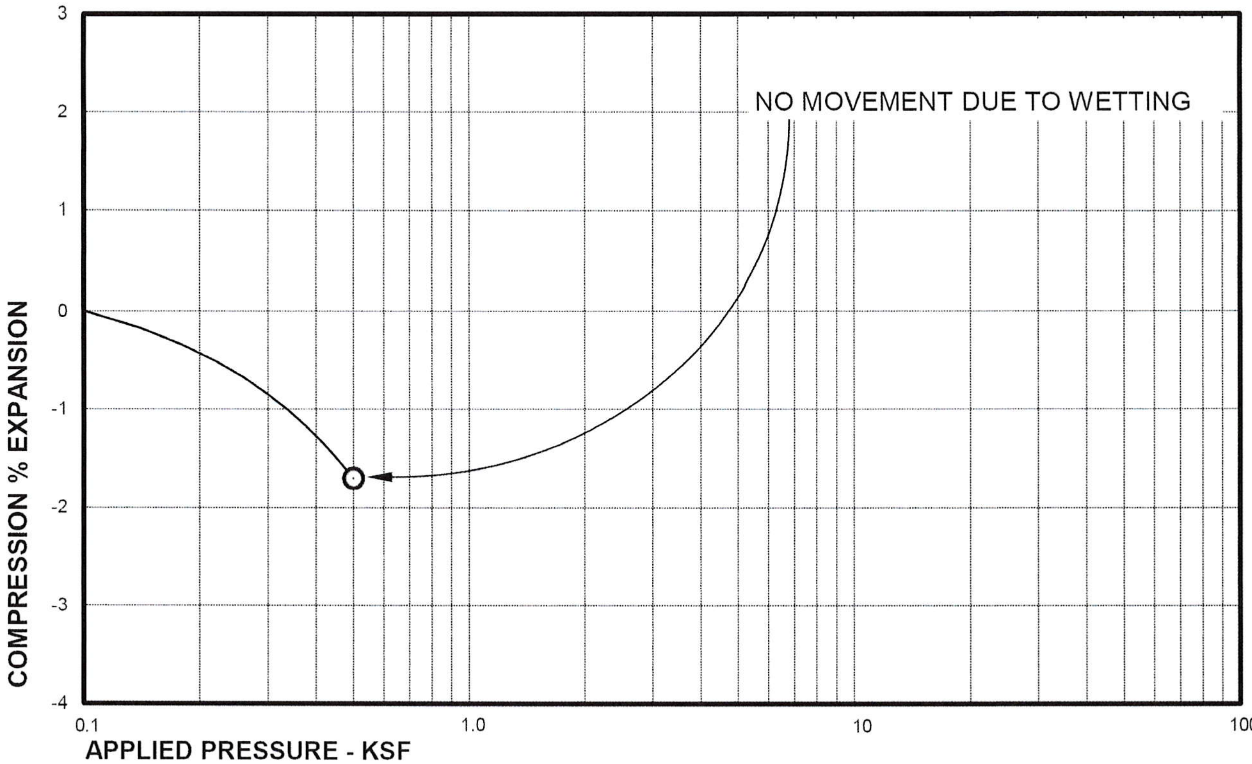


Sample of CLAY, SANDY (CL)
From TH - 3 AT 4 FEET

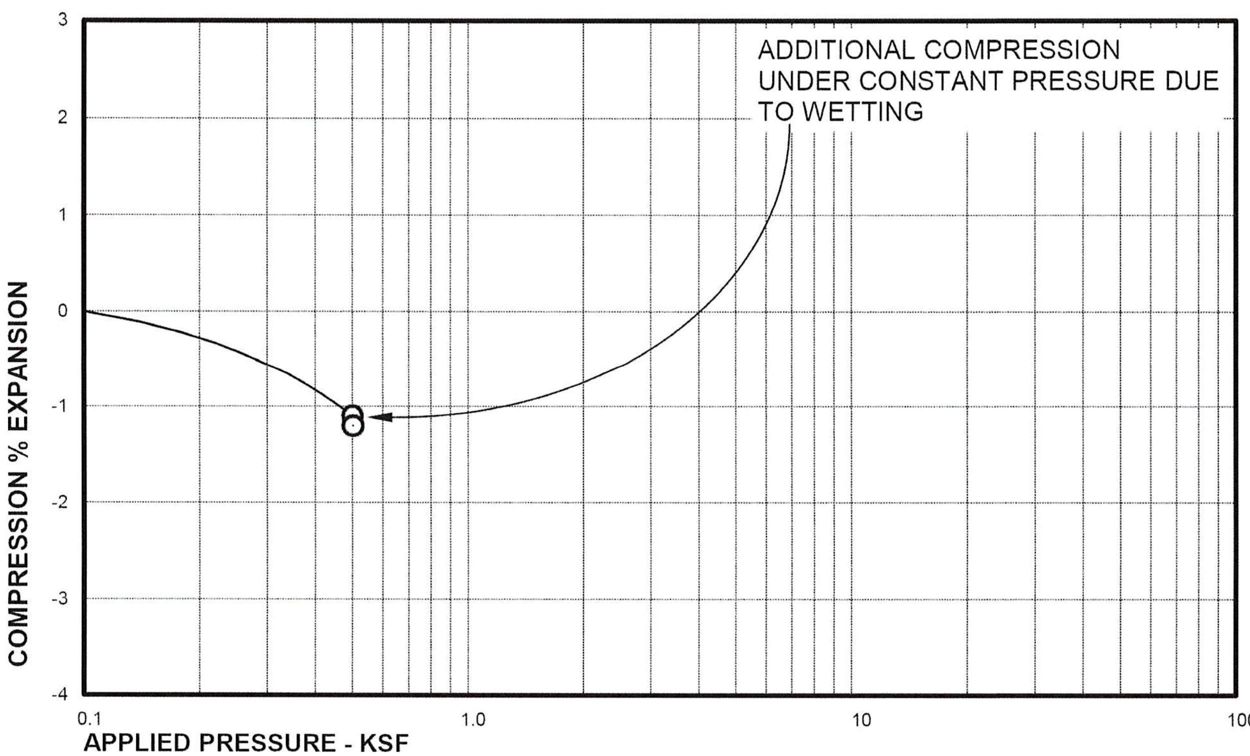
DRY UNIT WEIGHT= 93 PCF
MOISTURE CONTENT= 23.7 %

Swell Consolidation

FIGURE A-1



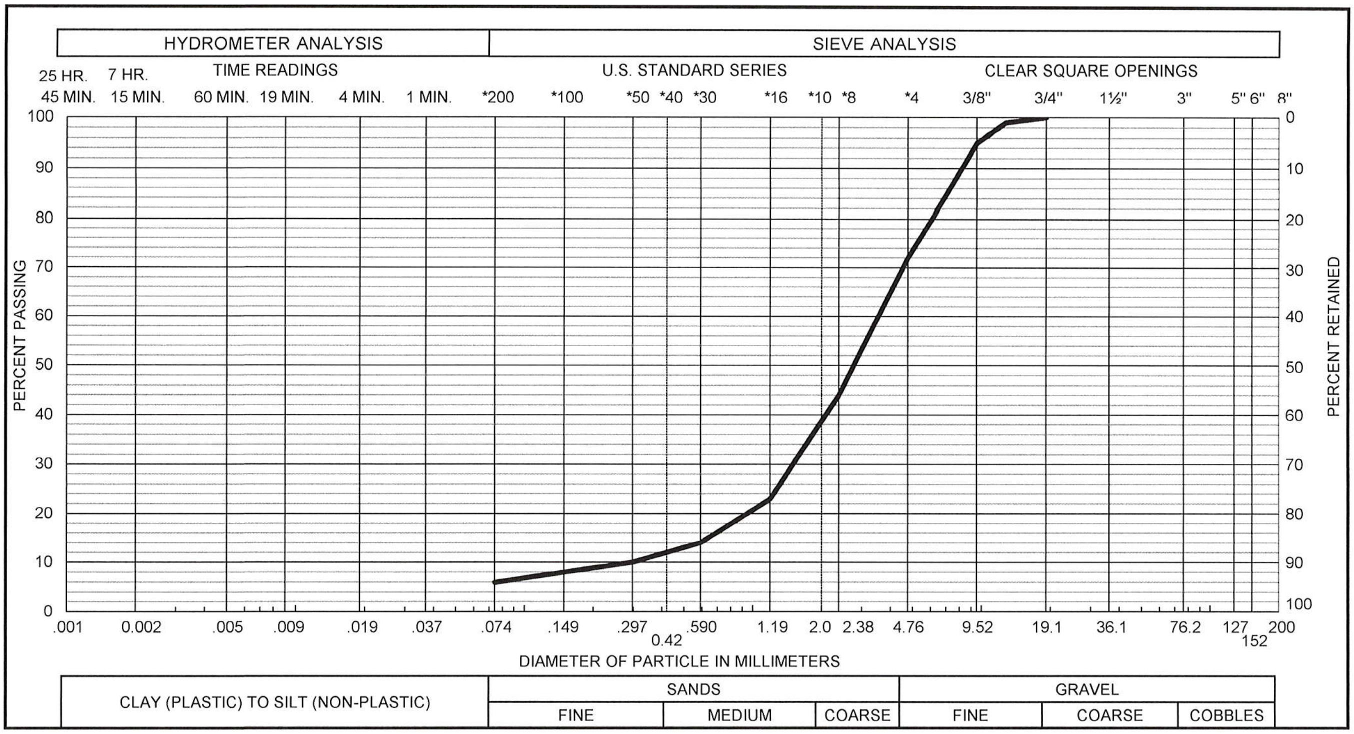
Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	105	PCF
From	TH - 4 AT 4 FEET	MOISTURE CONTENT=	17.4	%



Sample of	CLAY, SANDY (CL)	DRY UNIT WEIGHT=	104	PCF
From	TH - 5 AT 4 FEET	MOISTURE CONTENT=	20.6	%

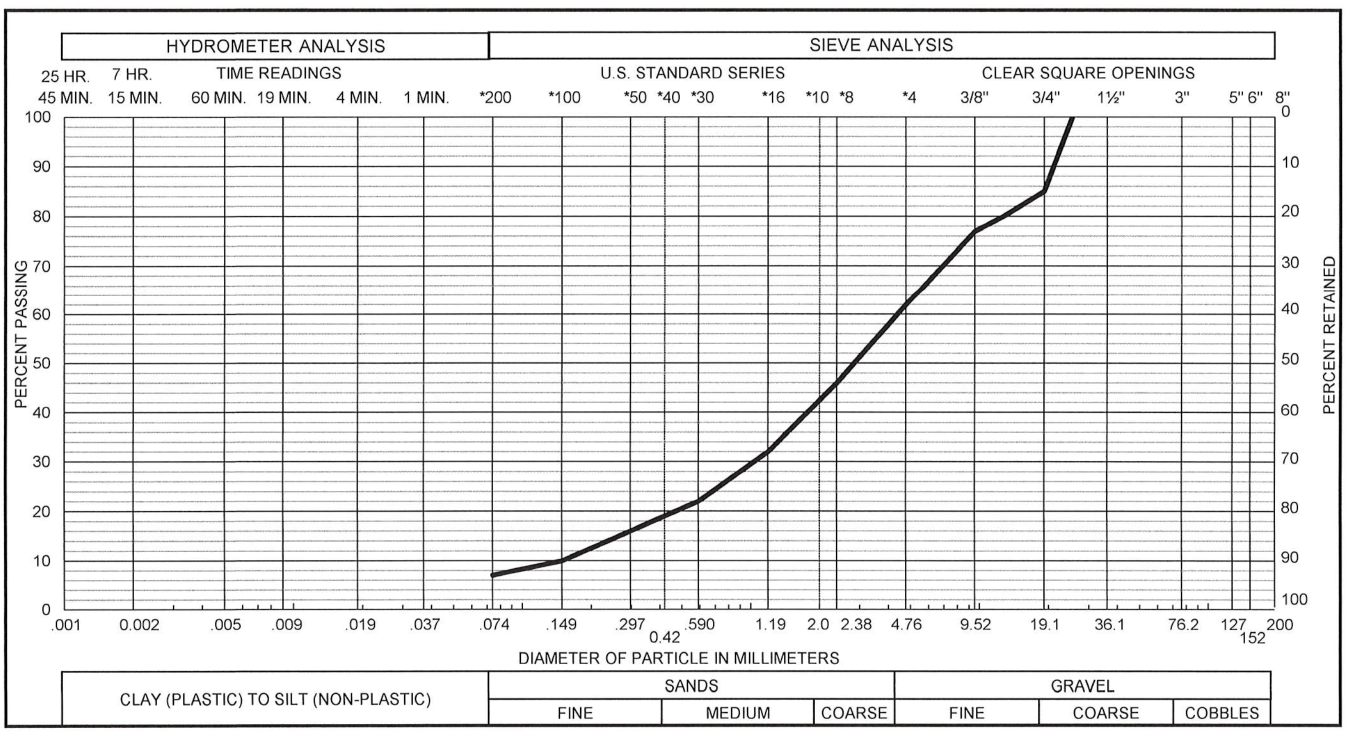
Swell Consolidation

FIGURE A-2



Sample of SAND, GRAVELLY, SLIGHTLY CLAYEY (SW-SC)
From TH - 1 AT 9 FEET

GRAVEL 28 % SAND 66 %
SILT & CLAY 6 % LIQUID LIMIT %
PLASTICITY INDEX %



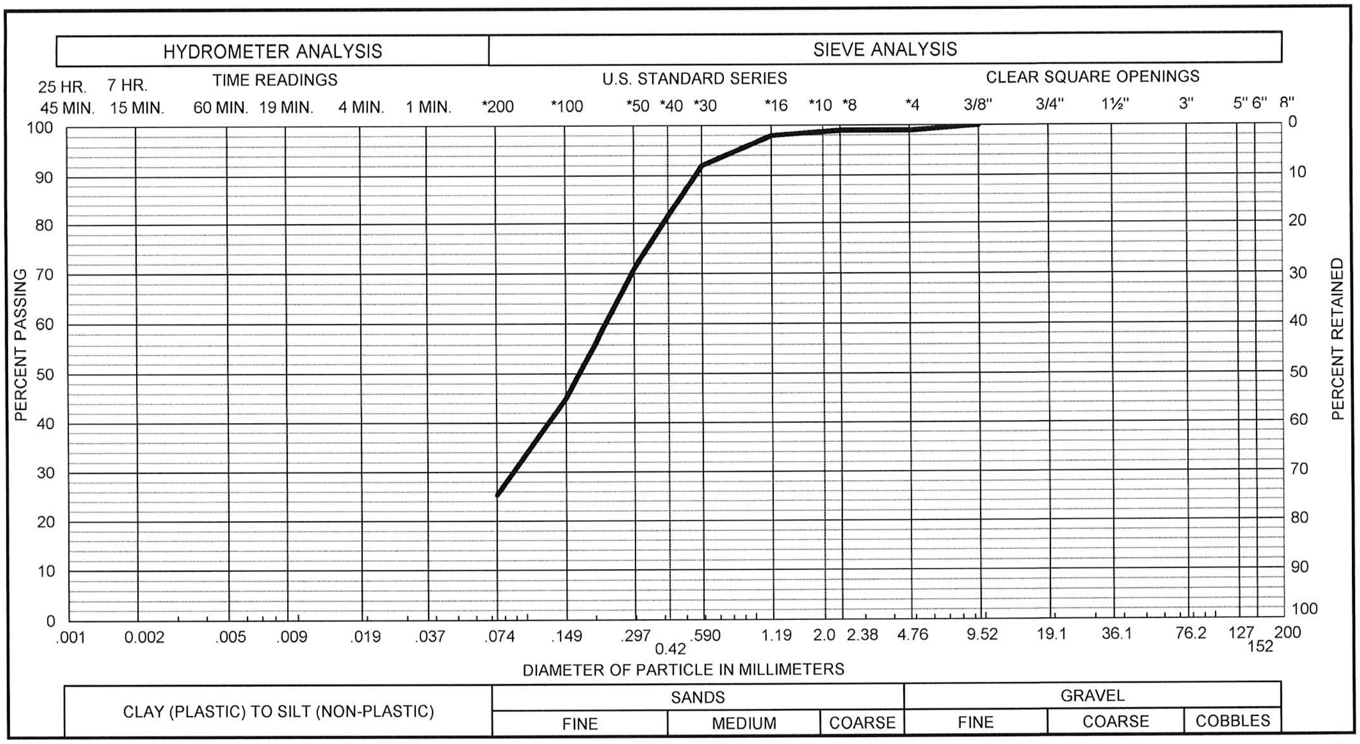
Sample of SAND, GRAVELLY, SLIGHTLY CLAYEY (SW-SC)
From TH - 2 AT 14 FEET

GRAVEL 38 % SAND 55 %
SILT & CLAY 7 % LIQUID LIMIT %
PLASTICITY INDEX %

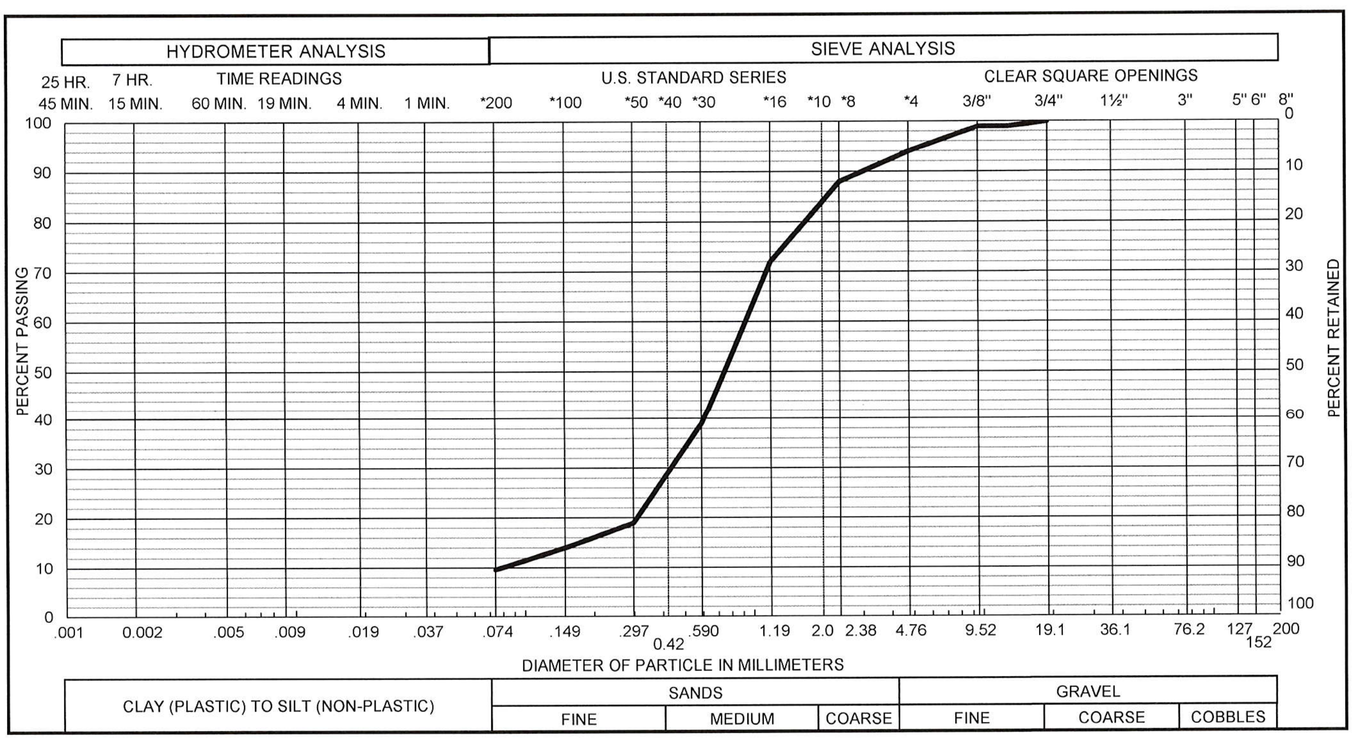
SISU INVESTMENTS LP
3624 EAST MULBERRY
CTL | T PROJECT NO. FC07317-115

Gradation Test Results

FIGURE A-3



Sample of	SAND, CLAYEY (SC)	GRAVEL 1 %	SAND 74 %
From	TH - 3 AT 14 FEET	SILT & CLAY 25 %	LIQUID LIMIT %
		PLASTICITY INDEX %	

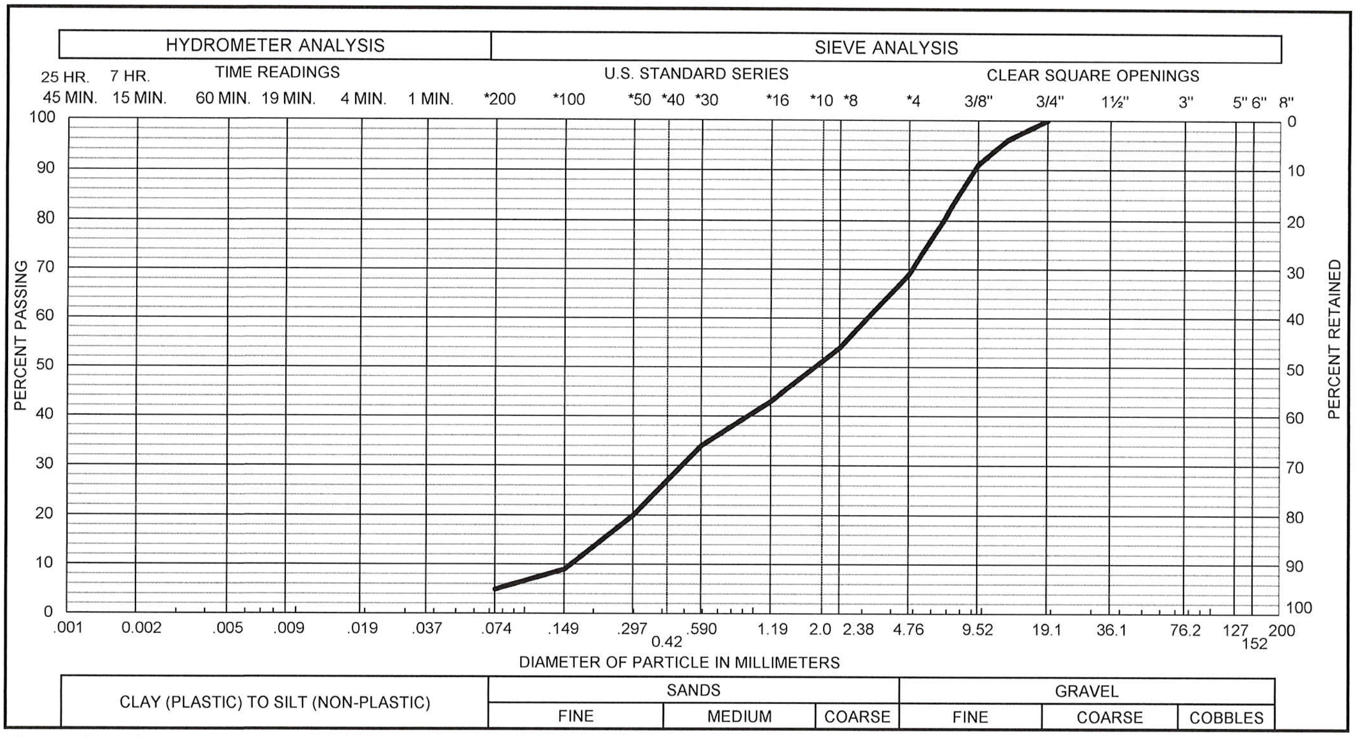


Sample of	SAND, GRAVELLY, SLIGHTLY CLAYEY (SW-SC)	GRAVEL 6 %	SAND 84 %
From	TH - 4 AT 19 FEET	SILT & CLAY 10 %	LIQUID LIMIT %
		PLASTICITY INDEX %	

SISU INVESTMENTS LP
3624 EAST MULBERRY
CTL | T PROJECT NO. FC07317-115

Gradation
Test Results

FIGURE A-4



Sample of SAND, GRAVELLY (SP)
From TH - 5 AT 9 FEET

GRAVEL 31 % SAND 64 %
SILT & CLAY 5 % LIQUID LIMIT %
PLASTICITY INDEX %

SISU INVESTMENTS LP
3624 EAST MULBERRY
CTL | T PROJECT NO. FC07317-115

Gradation
Test Results

FIGURE A-5

TABLE A-I

SUMMARY OF LABORATORY TESTING

BORING	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS		SWELL TEST RESULTS*		PASSING NO. 200 SIEVE (%)	WATER-SOLUBLE SULFATES (%)	DESCRIPTION
				LIQUID LIMIT	PLASTICITY INDEX	SWELL* (%)	APPLIED PRESSURE (PSF)			
TH-1	4	8.2		28	11			28		SAND, CLAYEY (SC)
TH-1	9	10.0						6		SAND, GRAVELLY, SLIGHTLY CLAYEY (SW-SC)
TH-2	4	10.6	113			2.4	500		0.11	CLAY, SANDY (CL)
TH-2	14	8.4						7		SAND, GRAVELLY, SLIGHTLY CLAYEY (SW-SC)
TH-3	4	23.7	93			1.3	500		1.10	CLAY, SANDY (CL)
TH-3	14	20.0						25		SAND, CLAYEY (SC)
TH-4	4	17.4	105			0.0	500		0.03	CLAY, SANDY (CL)
TH-4	19	16.4						10		SAND, SLIGHTLY CLAYEY (SW-SC)
TH-5	4	20.6	104			-0.1	500		1.10	CLAY, SANDY (CL)
TH-5	9	5.9						5		SAND, GRAVELLY (SP)

* NEGATIVE VALUE INDICATES COMPRESSION.

APPENDIX B

GUIDELINE SITE GRADING SPECIFICATIONS

GUIDELINE SITE GRADING SPECIFICATIONS

1. <u>DESCRIPTION</u>

   This item shall consist of the excavation, transportation, placement, and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of excess cut materials that may be placed outside of the development boundaries.

2. <u>GENERAL</u>

   The Soils Engineer shall be the Owner's representative. The Soils Engineer shall approve fill materials, method of placement, moisture contents and percent compaction, and shall give written approval of the completed fill.

3. <u>CLEARING JOB SITE</u>

   The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. <u>SCARIFYING AREA TO BE FILLED</u>

   All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction.

5. <u>COMPACTING AREA TO BE FILLED</u>

   After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content (0 to 3 percent above optimum moisture content for clays and within 2 percent of optimum moisture content for sands) and compacted to not less than 95 percent of maximum dry density as determined in accordance with ASTM D 698.

6. <u>FILL MATERIALS</u>

   Fill soils shall be free from organics, debris or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than six (6) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SW, SP, GP, GC, and GM are acceptable. Concrete, asphalt, organic matter and other deleterious materials or debris shall not be used as fill.

7. MOISTURE CONTENT AND DENSITY

Fill material shall be moisture conditioned and compacted to the criteria in the table, below. Maximum density and optimum moisture content shall be determined from the appropriate Proctor compaction tests. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

FILL COMPACTION AND MOISTURE REQUIREMENTS

Soil Type	Depth from Final Grade (feet)	Moisture Requirement (% from optimum)	Density Requirement
Clay	0 to 15 feet	0 to +3	95% of ASTM D 698
Sand		-2 to +2	95% of ASTM D 698
Clay	Greater than 15 feet	-2 to +1	98% of ASTM D 698
Sand		-2 to +1	95% of ASTM D 1557

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disk the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill shall be compacted to the criteria above. At the option of the Soils Engineer, soils classifying as SW, GP, GC, or GM may be compacted to 95 percent of maximum density as determined in accordance with ASTM D 1557 or 70 percent relative density for cohesionless sand soils. Fill materials shall be placed such that the thickness of loose materials does not exceed 12 inches and the compacted lift thickness does not exceed 6 inches.
Compaction as specified above shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Engineer for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Soils Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

9. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is not appreciable amount of loose soils on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to 5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

10. PLACEMENT OF FILL ON NATURAL SLOPES

Where natural slopes are steeper than 20 percent in grade and the placement of fill is required, benches shall be cut at the rate of one bench for each 5 feet in height (minimum of two benches). Benches shall be at least 10 feet in width. Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

11. DENSITY TESTS

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is not within specification, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates that the moisture content and density of previously placed materials are as specified.

13. NOTICE REGARDING START OF GRADING

The Contractor shall submit notification to the Soils Engineer and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

14. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, and percentage compaction shall be reported for each test taken.

15. DECLARATION REGARDING COMPLETED FILL

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, and was placed in general accordance with the specifications.