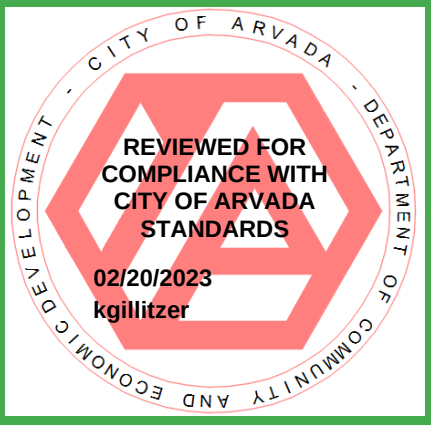

Geotechnical Site Development Study
GEOS Neighborhood, Blocks 1 through 9
Arvada, Colorado

GEOS Ventures, LLC
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Denver, Colorado 80204

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Project Number 207623
January 11, 2021

TABLE OF CONTENTS

ATTACHMENTS

1.0 EXECUTIVE SUMMARY

A. G. Wassenaar, Inc. (AGW) completed the geotechnical site development study for the proposed residential development. The data collected during our field exploration and laboratory work and our analysis, opinions, and conclusions are presented. The purpose of our study is to provide design recommendations for planning and site development and preliminary design concepts for foundation systems, interior floor support, and streets.

The subsurface materials encountered in our test borings consist of fill, topsoil, clay, and sand overlying sedimentary bedrock. Claystone and/or sandstone bedrock was encountered at depths ranging from 18 to 26 feet. Ground water was encountered at depths ranging from 6 to 16 feet.

Site development considerations should include provisions for the presence of existing fill and shallow ground water.

Depending on site grading, it is likely that most of the structures could be founded on spread or pad-type footings bearing on the natural, undisturbed soils or on moisture treated fill below frost depth. The existing fill should be excavated. Preliminary foundation design concepts are presented.

Floors and flatwork being considered for construction on-grade will require a specific risk analysis by the Client because of the potential for movement of the soils encountered. Slabs supported by soil will be subject to movement. Options for floor support are discussed in the report. Foundation subsurface drainage systems will be necessary for all below grade areas. Extensive drain systems will be required when foundations are within 4 feet of ground water.

Water soluble sulfate test results indicate that site and foundation concrete may be designed for negligible sulfate exposure. Preliminary pavement and other geotechnical-related recommendations are presented in the following report. We encourage the Client to read this report in its entirety and not to solely rely on the cursory information contained in this summary.

2.0 PURPOSE

This report presents the results of a geotechnical site development study for the proposed residential development to be located southwest of West 69th Place and Juniper Court in Arvada, Colorado. The study was conducted to determine geotechnical design criteria for planning, site evaluation, and development considerations. Preliminary geotechnical design concepts are also presented for foundations, interior floor support, foundation drainage, and street construction. Factual data gathered during the field and laboratory work are summarized on Figures 1 through 4 and in Appendix A. Our opinions and recommendations presented in this report are based on the data generated during the field exploration, laboratory testing, and our experience with similar type projects. The information contained in the following reports were considered during the preparation of this report:

- *Fill Depth Evaluation and Preliminary Pavement Study, GEOS Neighborhood, West of West 69th Avenue and Joyce Street, Arvada, Colorado*, by AGW, Project Number 080157, dated April 24, 2008

- *Preliminary Soil and Foundation Investigation, Cottonwood West, West of West 69th Avenue and Joyce Street, Arvada, Colorado*, by CTC-Geotek, Inc., Project 262005, dated March 3, 2006

This study was performed in general conformance with our Proposal Number 207623, dated November 20, 2020. This report is not intended to provide design criteria for individual foundations or street construction. Additional geotechnical studies will be required to develop these types of final design criteria and construction recommendations.

3.0 PROPOSED CONSTRUCTION

We understand the proposed 25-acre residential development will consist of single-family residences, townhomes, detached garages, and the associated utility and roadway infrastructure. Products with basements or crawl spaces are planned. The Client prefers to develop the site to avoid, if possible, the use of drilled piers and interior structural floors. Preliminary grading plans were not available at the time of this study.

4.0 SITE CONDITIONS

The site is vacant with vegetation consisting of grasses and weeds. The site slopes gently downward to the east. The site has been graded previously. West 70th Avenue and a residential subdivision are located to the north, Juniper Court and Block 10 of the GEOS Neighborhood is located to the east, a vacant parcel is located to the south, and Ralston Creek is located to the west. No bedrock outcrops were observed on the site.

5.0 FIELD EXPLORATION

Subsurface conditions were explored by drilling 11 test borings at the approximate locations indicated on Figure 1. The borings were advanced using a 4-inch diameter, continuous flight auger powered by a truck-mounted drill rig. At frequent intervals, samples of the subsurface materials were obtained using a Modified California sampler and a split spoon sampler which were driven into the soil by dropping a 140-pound hammer through a free fall of 30 inches. The Modified California sampler is a 2.5-inch outside diameter by 2-inch inside diameter device. The split spoon sampler is a 2.0-inch outside diameter by 1.375-inch inside diameter device. The number of blows required for the sampler to penetrate 12 inches and/or the number of inches that the sampler is driven by 50 blows gives an indication of the consistency or relative density of the soils and bedrock materials encountered. Results of the penetration tests and locations of sampling are presented on the "Test Boring Logs", Figures 2 through 4. Ground water measurements were made at the time of drilling and after drilling.

6.0 LABORATORY TESTING

The samples obtained during drilling were returned to the laboratory where they were visually classified by a geotechnical engineer. Laboratory testing was then assigned to specific samples to evaluate their engineering properties. The laboratory tests included swell-consolidation tests to evaluate the effect of wetting and loading on the selected samples. Gradation analysis and Atterberg limits tests were conducted to evaluate grain size distribution and plasticity. In addition, representative samples were tested for water soluble sulfates. The test results are summarized on Figures 2 through 4 and in Appendix A.

7.0 SUBSURFACE CONDITIONS

The subsurface materials encountered in our test borings consist of fill, topsoil, clay, and sand overlying sedimentary bedrock. Claystone and/or sandstone bedrock was encountered at depths ranging from 18 to 26 feet. Ground water was encountered at depths ranging from 6 to 16 feet. A more complete description of the subsurface conditions is shown on Figures 2 through 4.

7.1 Fill

Fill was encountered in six of the 11 test borings and was between 6½ and 16 feet thick. The fill consisted of sand which was silty, clayey to very clayey, slightly gravelly to gravelly, with clay lenses, and mottled brown. The existing fill is discussed more fully under Geotechnical Concerns.

7.2 Natural Soil

Topsoil was encountered in four of the 11 test borings. The topsoil consisted of sandy clay up to ½-foot thick. It was organic, moist, and dark brown.

Sand was encountered in 10 of the 11 test borings. The sand was loose to dense, silty, clayey to very clayey, with trace gravel to slightly gravelly, with clay lenses, moist to wet, and brown to light brown. The sand has low expansion potential and low to moderate settlement potential.

Sand and gravel was encountered in all 11 test borings. The sand and gravel was medium dense to dense, slightly silty, clayey to very clayey, moist to wet, and brown to light brown. The sand and gravel has low expansion and settlement potential.

Clay was encountered in four of the 11 test borings. The clay was stiff, silty, sandy, slightly moist to moist, and brown. The clay has low expansion and consolidation potential.

7.3 Bedrock

Claystone bedrock was encountered in three of the 11 test borings at depths ranging from 24 to 26 feet. The claystone was hard to very hard, silty, with trace sand to very sandy, iron stained, with sandstone lenses, moist to very moist, and blue gray to dark gray. The claystone has high expansion potential.

Sandstone bedrock was encountered in five of the 11 test borings at depths ranging from 18 to 25 feet. The sandstone was medium hard to very hard, poorly cemented, with well cemented lenses, silty, iron stained, wet, and blue gray to dark gray to olive to rust. The sandstone has low expansion potential.

Interbedded claystone and sandstone bedrock was encountered in two of the 11 test borings at depths of 19½ and 26 feet. This bedrock was medium hard to very hard, silty, iron stained, very moist to wet, and blue gray to dark gray. This bedrock has moderate expansion potential.

7.4 Ground Water

Ground water was encountered in all 11 test borings at depths ranging from 6 to 16 feet at the time of drilling. When we returned three to nine days later, ground water was encountered in all 11 test borings at depths ranging from 7½ to 16 feet. Ground water levels fluctuate with changing seasons and irrigation patterns and are expected to rise after construction is complete and landscape irrigation commences.

8.0 GEOTECHNICAL CONCERNS

8.1 Existing Fill

Fill was encountered in six of the 11 test borings and was between 6½ and 16 feet thick. It is not known whether the fill encountered was placed as fill capable of supporting a structure or other structural elements. No records of this fill placement have been provided for our review. Unless documentation is provided that is deemed acceptable, with maps indicating original and as built topography, all the existing fill should be excavated prior to placement of new fill, structures, or other structural appurtenances. The fill stockpiles should be completed excavated prior to the placement of new fill. The excavated fill should be evaluated to determine its suitability for placement as new fill across the site.

8.2 Shallow Ground Water

Ground water was encountered at depths less than 15 feet in over 80% of the site. Ground water less than 15 feet below the site grading elevation will likely affect utility construction and some site grading operations. Ground water less than 10 feet below the site grading elevation will likely affect foundation excavations. In addition, ground water less than 5 feet below the existing or final ground surface will pose stabilization problems during site grading, foundation construction, and may cause problems during pavement construction. We recommend that foundations be constructed at least 4 feet above ground water level to reduce the potential for future water problems.

Site development should be planned to avoid or manage the ground water. Avoidance may entail raising the site grades to provide sufficient distance between the bottom of foundations and the ground water, allowing only at-grade construction (no basements) or other methods. Removing the ground water may entail the construction of drain systems and/or barriers that draw the ground water down sufficiently to allow below grade construction.

9.0 SITE DEVELOPMENT

9.1 Site Grading

We understand the fill materials to be used at the site will be from on-site cut areas. In general, suitable inorganic on-site or off-site soils may be used for structural fill. Topsoil, soil containing significant vegetation, organic debris, or other deleterious material should be excavated and removed from structural areas. The existing fill should be excavated. Off-site material considered for new fill should be evaluated by AGW prior to importing to the site. The following are general site grading recommendations:

1. **The site grading plans should be reviewed by AGW prior to commencement of work at the site.**

2. It is recommended that AGW be retained on an essentially full-time basis to observe and test the fill placement. AGW should also be retained to provide observations and/or testing of the other items discussed below. The purpose of this observation and testing is to provide the Client with a greater degree of confidence that the work is being performed within the recommendations of this geotechnical study and the project specifications.
3. Existing fill was found in six of the 11 test borings. The fill was placed under unknown conditions. Therefore, we recommend that the fill be entirely excavated. The fill should be observed during excavation to determine whether the excavated material may be re-used in the structural areas as new fill. Excavation of isolated test pits (with or without density-compaction testing) will not provide enough information, in our opinion, to allow the fill to remain in place.
4. All topsoil and vegetation should be stripped and removed prior to fill placement. The vegetation, organic soils, or topsoil should be wasted from the site, placed in non-structural areas (parks, landscaping, tracts, etc.) and/or stockpiled for future use in revegetating the surface of exposed slopes. In no case should these materials be used in the structural areas or where the stability of slopes will be affected.
5. The stripped foundation areas should be observed by AGW prior to fill placement. Any soft soils found in these areas must be removed or stabilized as necessary prior to fill placement.
6. After the fill areas have been cleared, the exposed soils should be scarified to a minimum depth of 6 inches, brought to the proper moisture content, and then compacted according to Appendix B.
7. The compaction and moisture content of the soils will be dependent upon material types and the depth and location of placement. The specifications outlined in Appendix B are based upon providing a fill with sufficient shear strength to support structures and sufficient moisture to reduce the potential of swell of the expansive soil used in the fill.
8. Placement and compaction of fill should continue to final overlot grade. We recommend that the lots not be left low or "dished-out" and that placement of fill not stop at foundation elevation.
9. Other specifications outlined in Appendix B should be followed.

9.2 Construction Excavations

In our opinion, the majority of the site grading, utility, and foundation excavations may be constructed using conventional earth-moving equipment for the Front Range area. Excavations deeper than 3 feet should be properly sloped or braced to prevent collapse of potentially caving soils. For planning purposes, the existing fill, sand, gravel, and any soil influenced by ground water are "Type C", the clay is a "Type B", and the underlying bedrock is a "Type A" according to OSHA regulations. A final determination of the soil type must be made by the Contractor's "Competent Person" (as defined by OSHA Regulation). Local, city, county, state, and federal (OSHA) regulations should be followed.

9.3 Utility Construction

In our experience, utility excavations may be constructed using conventional earth-moving equipment for the Front Range area. All excavations should be sloped or shored in the interest of safety, following local and federal (OSHA) regulations. For planning purposes, OSHA soil type designations are discussed under "Construction Excavations". Final determination of the soil types must be made by the contractor's "Competent Person" (as defined by OSHA) at the time of construction.

The presence of ground water may be a constraint upon utility construction. It will be necessary to dewater all trenches constructed below the ground water level. A possible method for dewatering would be to begin construction of the deeper (sewer) utilities at their outfall and to work upstream. Other methods include pumping from the trench in the work area or construction of well points along the trenches. The utility contractor must be made aware of the ground water conditions.

Trench backfill within all structural areas should, as a minimum, be compacted using the same methods and to the same specifications as required for overlot grading. This is especially important where utility lines and laterals are constructed beneath foundation, alley, and driveway areas. Trenches in streets should be compacted to City of Arvada specifications. Observation and testing of fill placement must be performed during trench backfilling.

The choice of compaction equipment can have a significant effect on the performance of trench fills. It is our experience that utility trench backfills compacted with a compaction wheel attached to an excavator experience more settlement (both in area and magnitude) than those compacted with self-propelled equipment. While the contractor has control of the means and methods of construction, the Client should be aware of this issue.

9.4 Subsurface Drainage

The ground water encountered is anticipated to cause significant problems in areas of the site during development, especially if the overexcavation option is selected. As discussed under "Geotechnical Concerns", ground water should be avoided wherever possible. Additionally, clay soils and bedrock were encountered in the test borings drilled for this study. These types of material have a relatively low permeability and can develop a perched water condition. Perched water conditions generally occur after development and construction have taken place, when landscape irrigation and surface drainage conditions are changed.

For these reasons, an overall area drain (underdrain) should be considered for the site. In addition, the overall area drain could also provide for a discharge and collection point for individual foundation drains. If an area drain discharge is not available, the individual foundation drains will discharge collected water to the ground surface near each residence. Surface discharge can result in water recycling to the foundation drain and ponding of water where surface grading is not sufficient for water flow. Foundation drain discharge can also result in algae growth where water continually crosses sidewalks which become ice hazards on walkways and gutters in the winter months.

Typically, overall area drains can be designed and constructed with installation of the sanitary sewer system. However, the City of Arvada should be consulted to determine where an overall system is

allowed. The civil engineering company contracted to design the infrastructure should be able to provide this design. We are available to assist in drain design. For the system to work, the area drain must be graded to a positive discharge point. If a permanent outfall for an area drain cannot be determined, the area drain should not be constructed.

If it is decided not to install an overall area drain, an alternative would be to establish points of positive gravity discharge for the gravel bedding beneath the sewer. We also recommend any basement or below grade area be provided with a perimeter subsurface drainage system sloped to drain to a positive gravity discharge such as a sump or connected directly to the overall area drain system.

9.5 Surface Drainage

We recommend that provisions be made to divert surface runoff away from development areas. This may reduce potential problems associated with excess water in structure bearing soils. The site should be designed such that a 10% slope can be established near the structures after foundation construction. Slopes of at least 2% should be planned in landscaped areas once the water is away from the foundations.

10.0 WATER SOLUBLE SULFATES

Laboratory tests conducted on selected soil samples yielded water soluble sulfates ranging from less than 100 parts per million (ppm) to 500 ppm. Based upon these results and our experience in the area, the site soils and bedrock are assigned to possess negligible (S0 or RS0) sulfate exposure per ACI 318 or ACI 332. We recommend the "ACI Manual of Concrete Practice", of the most recent edition be used for proper concrete mix design properties as they relate to these conditions.

11.0 PRELIMINARY FOUNDATION DESIGN CONCEPTS

The foundation recommendations for each structure are dependent upon the subsurface profile and engineering properties of the materials encountered at and near the depth of the proposed foundation. The information in the following sections presents preliminary foundation concepts which must be finalized for each building site upon completion of the overlot grading operations. AGW should be retained to perform design level soil and foundation studies after completion of site grading.

11.1 Footings

If portions of the site are overexcavated and the excavated materials are placed as moisture treated fill, it is likely most if not all the structures could be founded on spread or pad-type footings bearing on the natural, undisturbed soils or on moisture treated fill. The footings must be founded below frost depth. The footings will likely be designed for maximum soil bearing pressures ranging from 1,500 to 3,000 psf. Minimum dead load pressures of 700 to 1,000 psf will likely be required.

11.2 Lateral Earth Pressures

Foundation walls with fill on only one side will need to be designed for lateral earth pressures. For this site, lateral earth pressures calculated based upon equivalent fluid densities on the order of 50 to 80 pcf should be anticipated. The preliminary estimates are for properly placed and compacted fill at foundation walls. They should not be used for site retaining walls.

11.3 Interior Floors (Basement Products)

For the basement products, if the existing fill is excavated, it is likely that most of the structures will be assessed with low slab risk performance evaluation. If the risk tolerance for slab movement is zero, structural floors should be constructed.

11.4 First Floor Construction (Crawl Space Products)

For crawl space products, structural floors will be constructed in the living areas of the residences. For the garage areas, it is likely that there will be a low risk of garage slab movement after existing fill is excavated.

11.5 Drain Systems

Drain systems will be required around the lowest excavation level for below grade spaces for each structure. Either interior or exterior drains may be used for most of the site. Where ground water is within 4 feet of the foundation, a more extensive drain system will be required. This may include gravel across the entire foundation, drain laterals, or combination interior and exterior drains. The drains must lead to a positive gravity outfall or sump. If an overall subdivision area drain is constructed, individual drains should be connected into this system if allowed by the jurisdiction.

11.6 Backfill and Surface Drainage

Foundation backfill should be moistened and compacted to reduce future settlement. The site grading should consider a slope of 10% away from the foundation at the completion of construction. All other drainage swales in landscaped areas should slope at a minimum of 2%.

12.0 PRELIMINARY STREET PAVEMENT DESIGN

Pavement design is based on the engineering properties of the subgrade and pavement materials, the assumed design traffic conditions, and City of Arvada pavement regulations. Effective pavement structures are composed of various pavement materials bearing upon properly prepared subgrade soils. The following preliminary pavement recommendations are based upon the subsurface conditions encountered and our experience in the area.

It appears the proposed subgrade materials will likely be sand, gravel, clay, or fill constructed from these materials with AASHTO Soil Classifications of A-2-4, A-6, and A-7-6. Based upon the subgrade soil classifications, we have estimated the relative strengths of the subgrade soils presented above to determine the preliminary pavement thicknesses. Based on this information and utilizing the design methodology determined from the pavement design regulations for the City of Arvada, the alternatives presented below were calculated. These preliminary thickness recommendations are based on a design life of 20 years. It should be emphasized that the design alternatives provided are preliminary for the materials anticipated. The final design thicknesses could be more or less than indicated depending upon the materials sampled during the final pavement design.

Pavement Thickness Alternatives for Interior Streets

Street Type	HBP (in)	HBP / ABC (in)	Concrete (in)
Local Street	6.5 to 7.5	4.5 to 5.5 / 6.0 to 8.0	-
Alley	-	-	6.0 or 8.0 *

HBP = Hot Bituminous Pavement, ABC = Aggregate Base Course
* 8.0 inches if inverted

Proper surface and subsurface drainage are essential for adequate performance of pavements. It has been our experience that water from landscaped areas can infiltrate pavement subgrade soils and result in softening of the subgrade followed by pavement damage. Therefore, provisions should be made to maintain adequate drainage and/or contain runoff from such areas. In addition, water and irrigation lines should be thoroughly pressure tested for leaks prior to placement of pavement materials.

It must be reiterated that the information contained in this section is preliminary in nature. More detailed information will be required by the City of Arvada prior to issuance of a paving permit. Therefore, when overlot grading is complete at the site, a final pavement evaluation must be performed.

13.0 FINAL DESIGN CONSULTATION AND CONSTRUCTION OBSERVATION

This report has been prepared for the exclusive use of GEOS Ventures, LLC to provide geotechnical criteria for the proposed project. The data gathered and the conclusions and recommendations presented herein are based upon the consideration of many factors including, but not limited to, the type of structures proposed, the configuration of the structures, the proposed usage of the site, the configuration of surrounding structures, the geologic setting, the materials encountered, and our understanding of the level of risk acceptable to the Client. Therefore, the conclusions and recommendations contained in this report should not be considered valid for use by others unless accompanied by written authorization from AGW.

AGW should be contacted if the Client desires an explanation of the contents of this report. AGW should be retained to provide future geotechnical services for the site including, but not limited to, design level geotechnical studies, consultation during design, observation and testing during construction, and other geotechnically related services. Failure to contract with AGW for these services or selection of a firm other than AGW to provide these services will eliminate liability for AGW. We are available to discuss this with you.

14.0 GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be tempered by engineering judgment and experience. Therefore, the solutions or recommendations presented in any geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structures will perform

as desired or intended. What the engineering recommendations presented in the preceding sections do constitute is our judgement of those measures that increase the chances for the structures and improvements performing satisfactorily. The Developer, Builder, and Owner must understand this concept of risk, as it is they who must ultimately decide what is an acceptable level of risk for the proposed development of the site.

15.0 LIMITATIONS

We believe the professional judgments expressed in this report are consistent with that degree of skill and care ordinarily exercised by practicing design professionals performing similar design services in the same locality, at the same time, at the same site and under the same or similar circumstances and conditions. No other warranty, express or implied, is made. In the event that any changes in the nature, design or location of the facility are made, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing. Because of the constantly changing state of the practice in geotechnical engineering, and the potential for site changes after our field exploration, this report must not be relied upon after a period of three years without our firm being given the opportunity to review and, if necessary, revise our findings.

The test borings drilled for this study were spaced to obtain an understanding of subsurface conditions for design purposes. Variations frequently occur from these conditions which are not indicated by the test borings. These variations are sometimes sufficient to necessitate modifications in the designs. If unexpected subsurface conditions are observed by any party during site development, we must be notified to review our recommendations.

Our scope of services for this project did not include, either specifically or by implication, any research, identification, testing, or assessment relative to past or present contamination of the site by any source, including biological (i.e., mold, fungi, bacteria, etc.). If such contamination were present, it is likely that the exploration and testing conducted for this report would not reveal its existence. If the Client is concerned about the potential for such contamination or pollution, additional studies should be undertaken. We are available to discuss the scope of such studies with you.

Our scope of services for this project did not include a local or global geological risk assessment. Therefore, issues such as mine subsidence, slope stability, faults, etc. were not researched or addressed as part of this study. If the Client is concerned about these issues, we are available to discuss the scope of such studies upon your request.

Sincerely,

A. G. Wassenaar, Inc.

COLORADO LICENSED
KATHLEEN ANN NOONAN
32156
PROFESSIONAL ENGINEER

Kathleen A. Noonan, M.S., P.E.
Senior Geotechnical Engineer
Digitally signed by: Kathleen A. Noonan, PE
Date: 2021.01.11 14:15:01 -07'00'

Reviewed by:

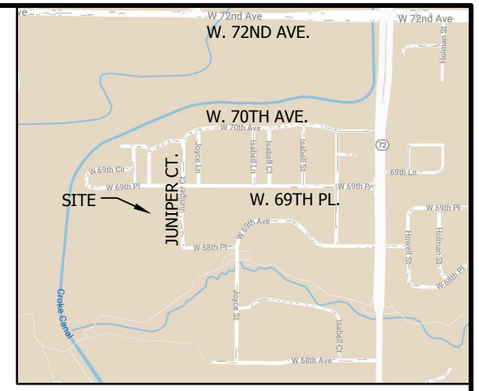
Ashley A. McDaniels, P.E.
Project Engineer

GEOS NEIGHBORHOOD, BLOCKS 1 THROUGH 9
ARVADA, COLORADO

N

0 150 300

Scale in Feet



VICINITY MAP
NOT TO SCALE

NOTES:
1. TEST BORINGS ARE OVERLAID ON "GEOS BLOCKS 1-4 SITE PLAN WITH BUILDINGS", PREPARED BY LAUDICK & LAUDICK, DATED NOVEMBER 20, 2020.
2. ALL LOCATIONS ARE APPROXIMATE.

AGW
A.G. WASSENAAR, INC.

SITE PLAN AND VICINITY MAP	PROJECT NO. 207623 FIGURE 1

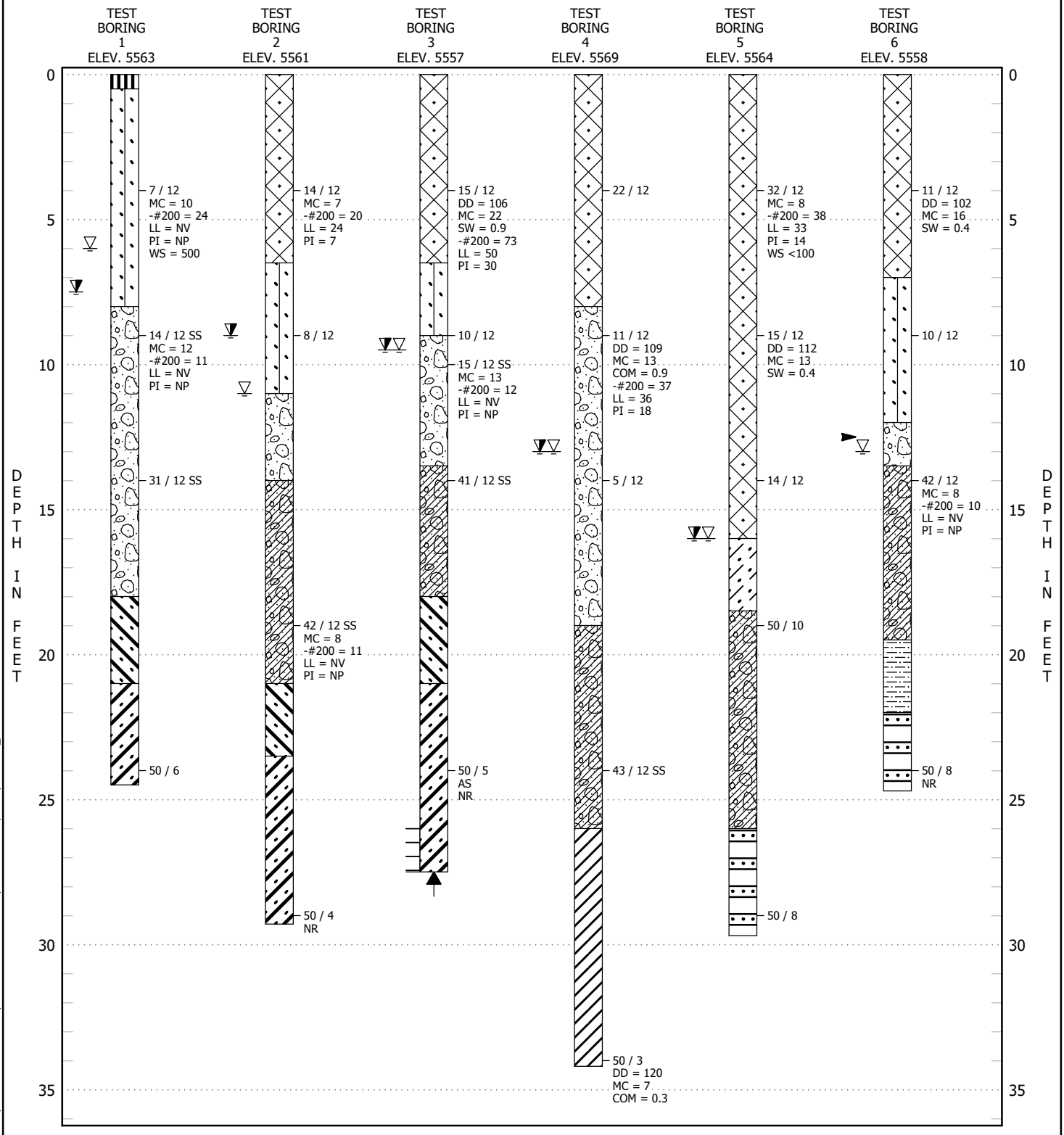
A.G. WASSENAAR, INC.

CLIENT GEOS Ventures, LLC

PROJECT NAME GEOS Neighborhood, Blocks 1 through 9

PROJECT NUMBER 207623

PROJECT LOCATION Arvada, Colorado



SEE FIGURE 4 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

FIGURE 2

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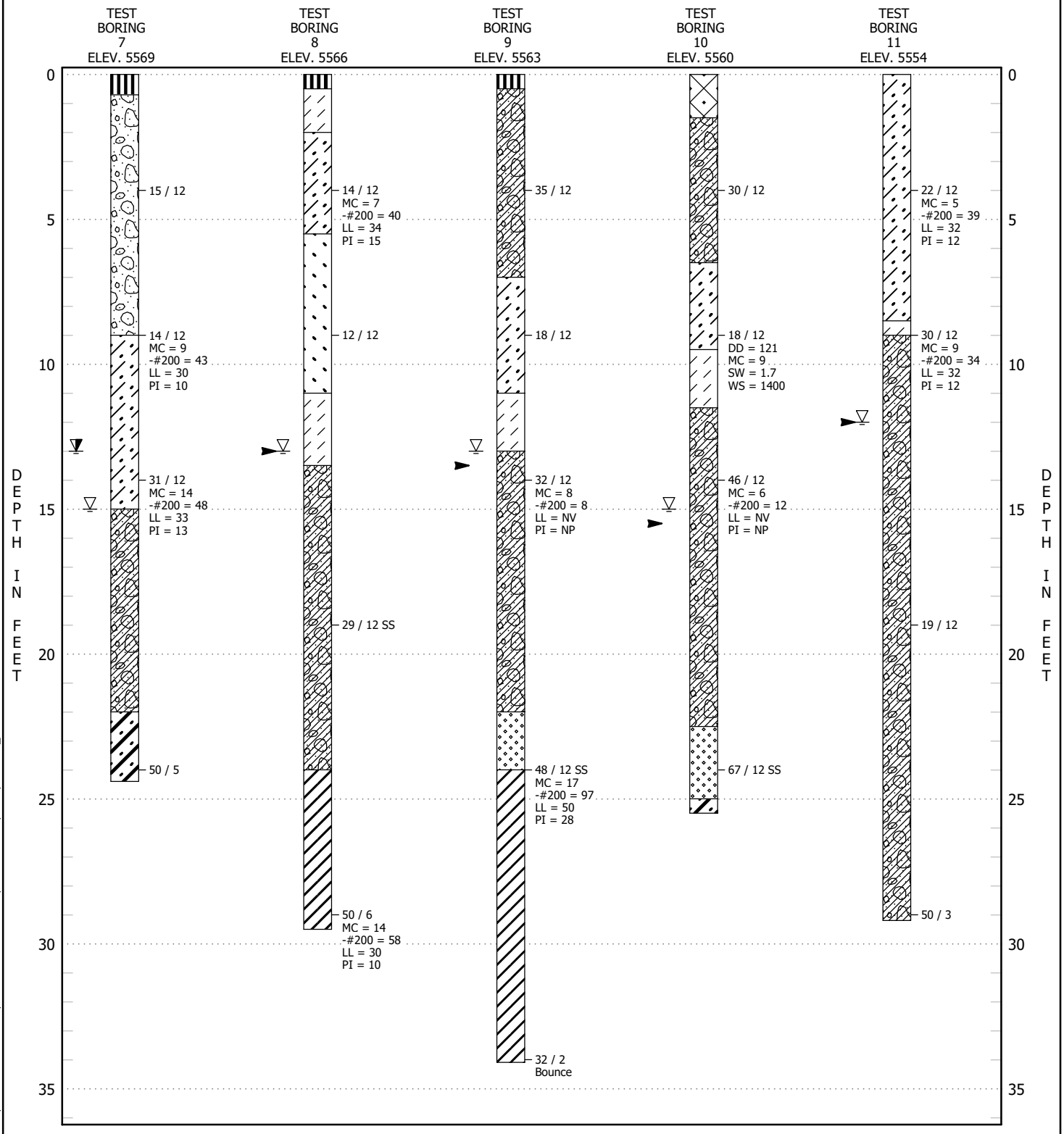
AGW
A.G. WASSENAAR, INC.

CLIENT GEOS Ventures, LLC **PROJECT NAME** GEOS Neighborhood, Blocks 1 through 9

PROJECT NUMBER 207623 **PROJECT LOCATION** Arvada, Colorado



SEE FIGURE 4 FOR LEGEND AND NOTES TO TEST BORINGS

TEST BORING LOGS

FIGURE 3

U:\PROJECT FILES\2 - GEOTECHNICAL\207623 GEOS SD KAN\TO BE SAVED\GINT\207623S_GT2020-12-17 GEOS NEIGHBORHOOD BLOCKS 1-9 SD.GPJ

A.G. WASSENAAR, INC.

CLIENT GEOS Ventures, LLC

PROJECT NAME GEOS Neighborhood, Blocks 1 through 9

PROJECT NUMBER 207623

PROJECT LOCATION Arvada, Colorado

SOIL DESCRIPTIONS


Fill, sand, medium dense, silty, clayey


Topsoil, clay, sandy, organic


Clay, stiff to very stiff


Sand, loose


Sand, medium dense, silty


Sand, medium dense, silty, clayey


Sand, dense to very dense, silty


Sand and gravel, medium dense to dense, silty


Sand and gravel, dense to very dense, clayey


Claystone (Bedrock), hard to very hard


Sandstone (Bedrock), firm to medium hard


Sandstone (Bedrock), hard to very hard


Claystone/Sandstone (Bedrock), interbedded, weathered to medium hard


Claystone/Sandstone (Bedrock), interbedded, hard to very hard

ABBREVIATIONS

DD	Dry density of sample in pounds per cubic foot (pcf)
MC	Moisture content as a percentage of dry weight of soil (%)
SW	Percent swell under a surcharge of 1000 pounds per square foot (psf) upon wetting (%)
COM	Percent compression under a surcharge of 1000 pounds per square foot (psf) upon wetting (%)
UC	Unconfined compressive strength in pounds per square foot (psf)
-#200	Percent passing the Number 200 sieve (%)
LL	Liquid Limit
PI	Plasticity Index
NP	Non-Plastic
NV	No Value
pH	Acidity or alkalinity of sample in pH units
R	Resistivity in ohms.cm
WS	Water soluble sufates in parts per million (ppm)
CL	Chlorides in percent (%)
x/y	X blows of a 140-pound hammer falling 30 inches were required to drive a 2.5-inch outside diameter sampler Y inches
x/y SS	X blows of a 140-pound hammer falling 30 inches were required to drive a 2.0-inch outside diameter sampler Y inches
C-x	Depth of cut to grade (rounded to the nearest foot)
F-x	Depth of fill to grade (rounded to the nearest foot)
FG	Finished grade (rounded to the nearest foot)
NR	No sample recovered
Bounce	Sampler bounced during driving
B	Bulk sample
AS	Auger sample
	Moderately to well cemented layer
—	Approximate depth of cut
	Depth at which practical drilling refusal was encountered
	Water level at time of drilling
	Caved depth at time of drilling
	Water level 3 to 9 day(s) after drilling
	Caved depth 3 to 9 day(s) after drilling

Notes:

1. Test borings were drilled December 4, 2020 and December 7, 2020.
2. Location of the test borings were staked by others at locations chosen by this firm.
3. The horizontal lines shown on the logs are to differentiate materials and represent the approximate boundaries between materials. The transitions between materials may be gradual.
4. Elevations were obtained from staking provided by others and have been rounded to the nearest foot.
5. Boring logs shown in this report are subject to the limitations, explanations, and conclusions of this report.

LEGEND AND NOTES

FIGURE 4

U:\PROJECT FILES\2 - GEOTECHNICAL\207623 GEOS SD KAN\TO BE SAVED\GINT\207623S_GT2020-12-17 GEOS NEIGHBORHOOD BLOCKS 1-9 SD.GPJ

APPENDIX A
LABORATORY TEST RESULTS

AGW
A.G. WASSENAAR, INC.

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
January 11, 2021

Test Boring Number	Depth (feet)	Soil Type	Natural Dry Density (pcf)	Natural Moisture (%)	Swell / Consolidation (-) (%) [1]	Swell Pressure (psf)	% Passing #200 Sieve	Atterberg		Water Soluble Sulfates (ppm)
								Liquid Limit LL	Plasticity Index PI	
1	4	Sand, silty, slightly gravelly		10			24	NV	NP	500
1	9	Sand, very gravelly, slightly silty		12			11	NV	NP	
2	4	Fill, sand, silty, clayey, slightly gravelly		7			20	24	7	
2	19	Gravel, very sandy, slightly silty		8			11	NV	NP	
3	4	Fill, clay, sandy	106	22	0.9	2,800	73	50	30	
3	10	Sand, gravelly, slightly silty		13			12	NV	NP	
4	9	Sand, very clayey, gravelly	109	13	-0.9	NA	37	36	18	
4	34	Claystone, very sandy	120	7	-0.3	NA				
5	4	Fill, sand, very clayey, gravelly		8			38	33	14	<100
5	9	Fill, sand, very clayey, gravelly	112	13	0.4	2,100				
6	4	Fill, sand, very clayey, gravelly	102	16	0.4	1,700				
6	14	Sand, very gravelly, slightly silty		8			10	NV	NP	
7	9	Sand, very clayey, trace gravel		9			43	30	10	
7	14	Clay, very sandy, slightly gravelly (lens)		14			48	33	13	
8	4	Sand, very clayey, trace gravel		7			40	34	15	
8	29	Claystone, very sandy		14			58	30	10	
9	14	Gravel, very sandy, slightly silty		8			8	NV	NP	
9	24	Claystone, trace sand		17			97	50	28	
10	9	Clay, sandy	121	9	1.7	5,400				1400
10	14	Gravel, very sandy, slightly silty		6			12	NV	NP	
11	4	Sand, very clayey		5			39	32	12	
11	9	Gravel, very clayey, very sandy		9			34	32	12	

Notes:
NA - Not Applicable, NV - No Value, NP - Nonplastic

[1] Indicates percent swell or consolidation when wetted under a 1,000 psf load

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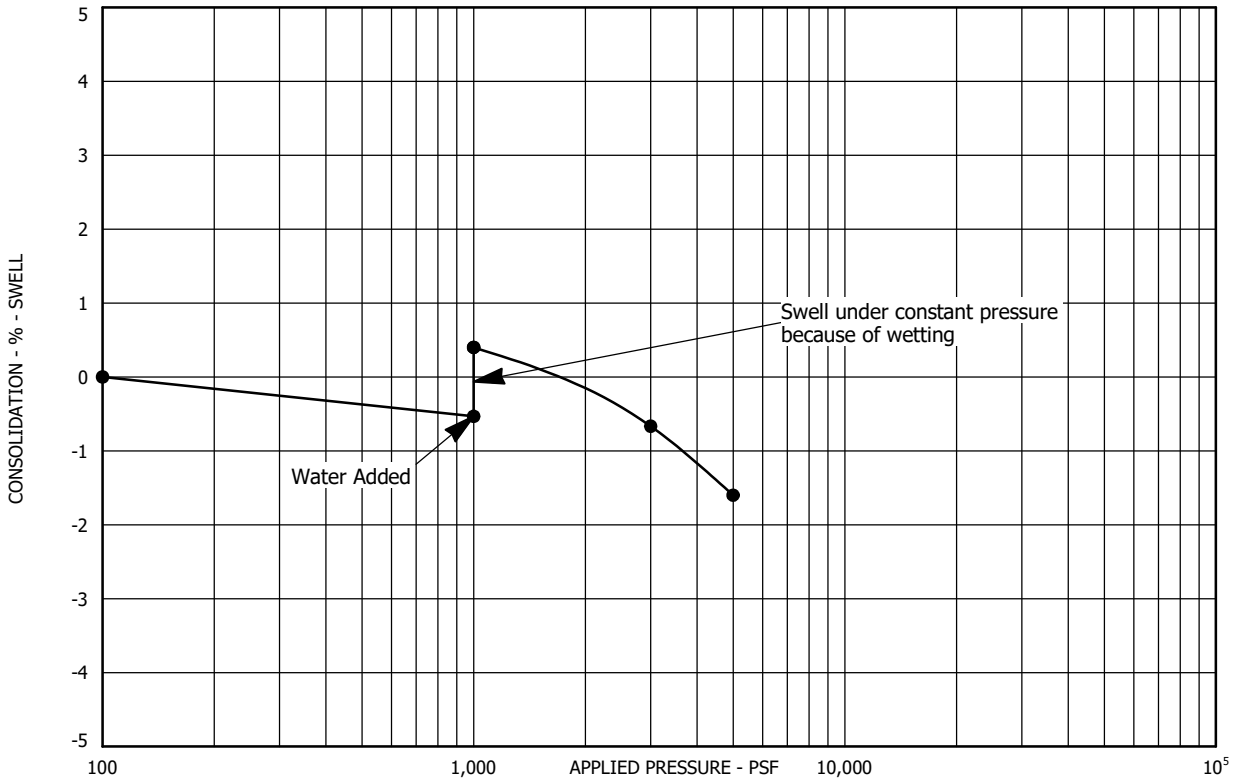
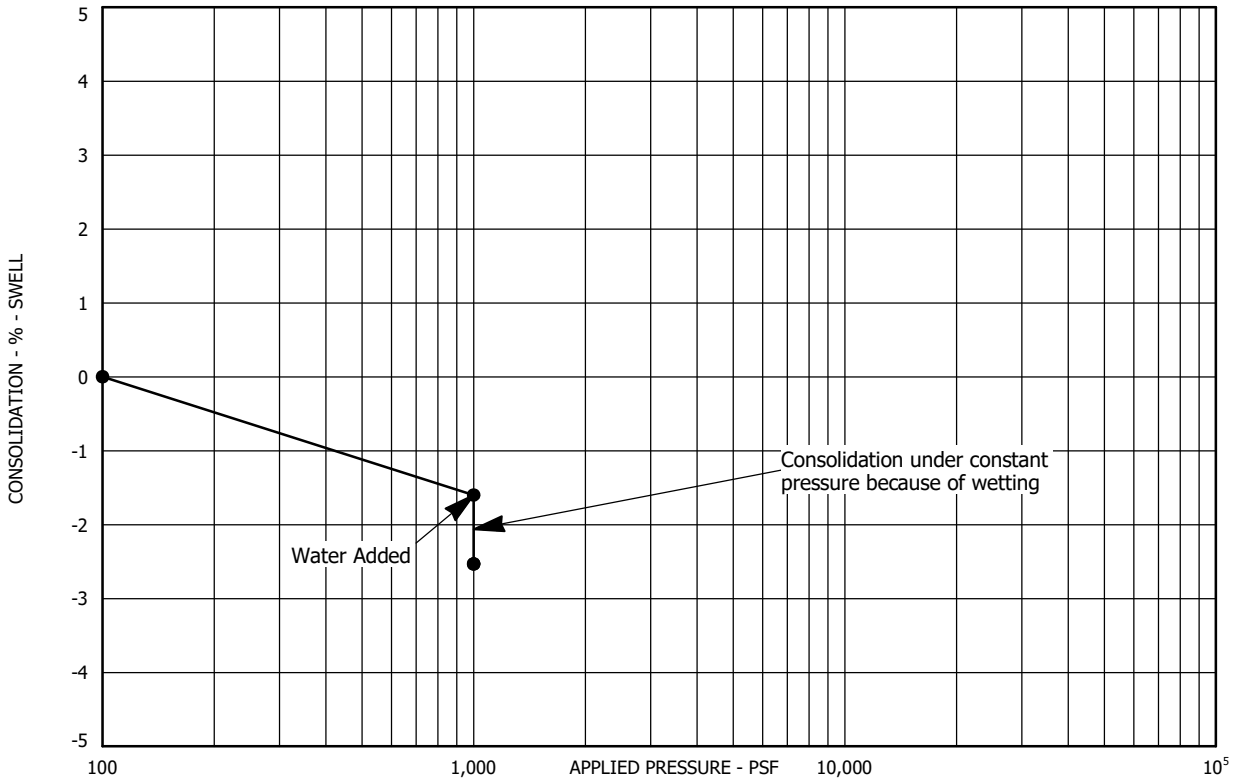


Sample Location: Test Boring No. 3 at a depth of 4 feet
Sample Description: Fill, clay, sandy
Dry Unit Weight (pcf): 106
Moisture Content (%): 22



Sample Location: Test Boring No. 4 at a depth of 9 feet
Sample Description: Sand, very clayey, gravelly
Dry Unit Weight (pcf): 109
Moisture Content (%): 13

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-1

PROJECT NO. 207623

AGW
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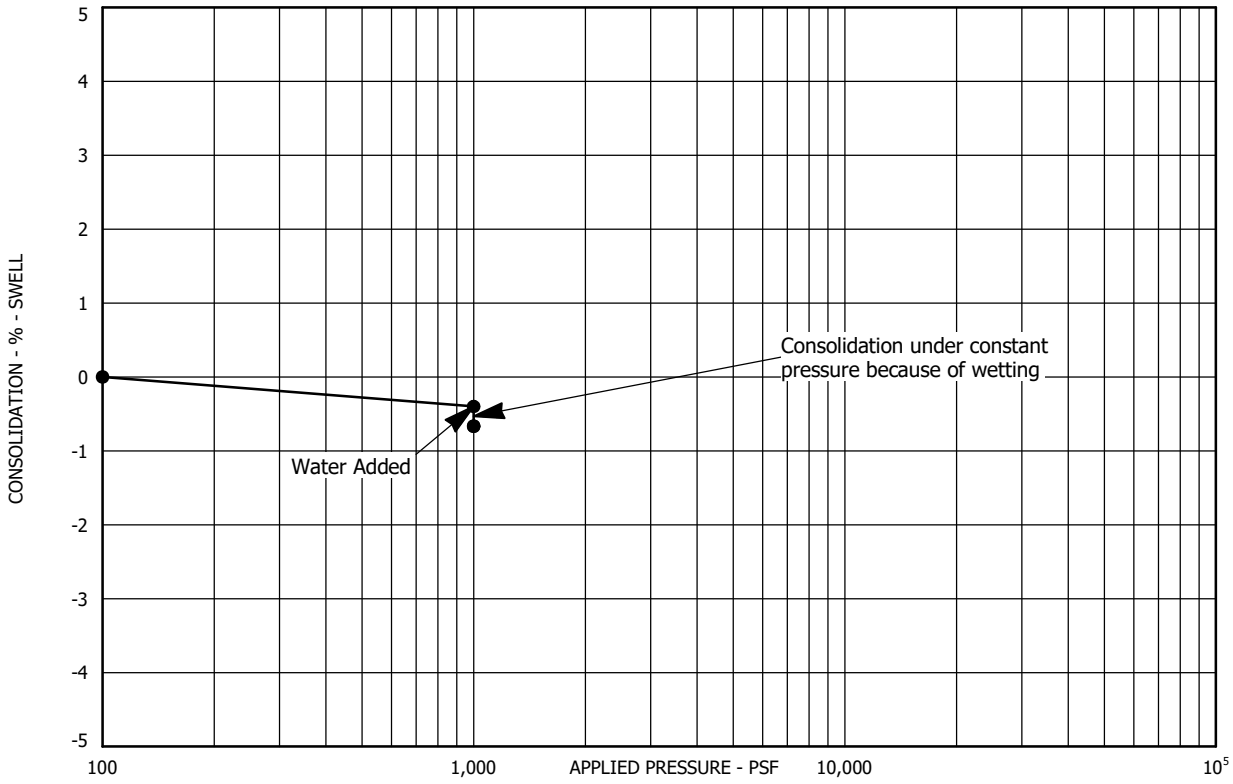
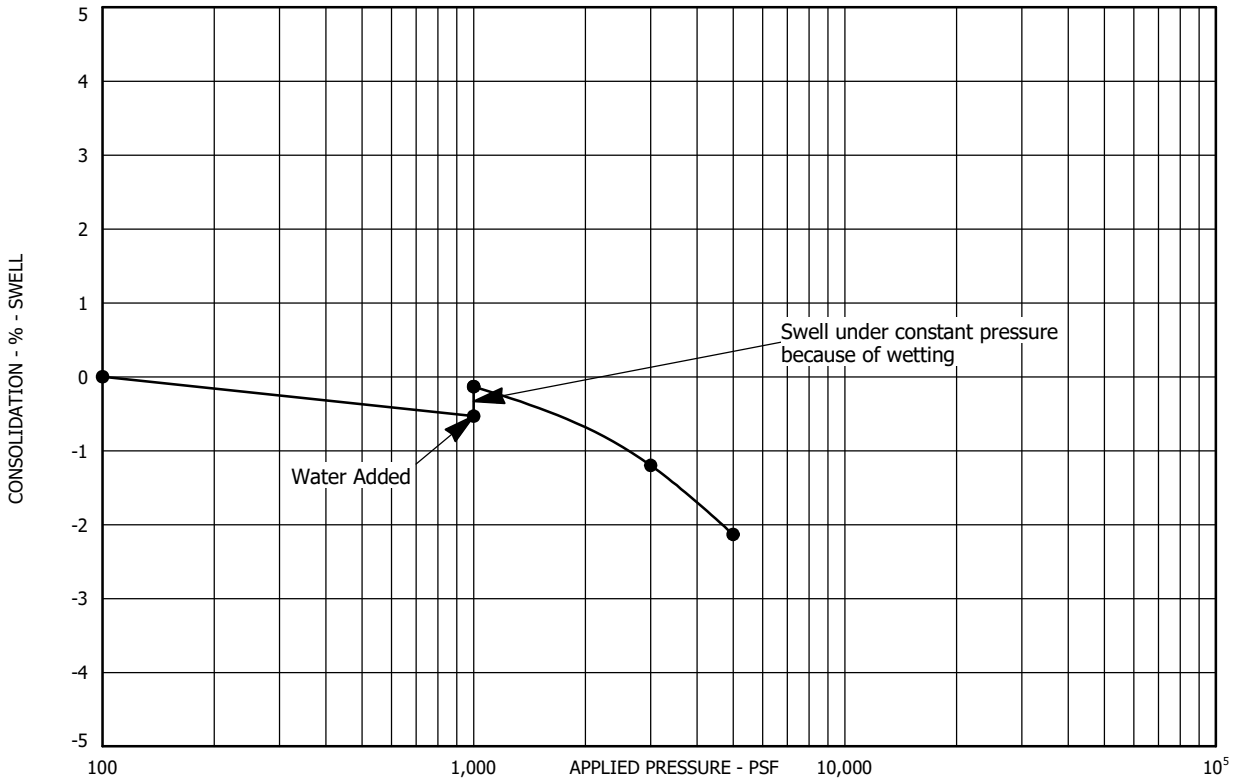


Sample Location: Test Boring No. 4 at a depth of 34 feet
Sample Description: Claystone, very sandy
Dry Unit Weight (pcf): 120
Moisture Content (%): 7

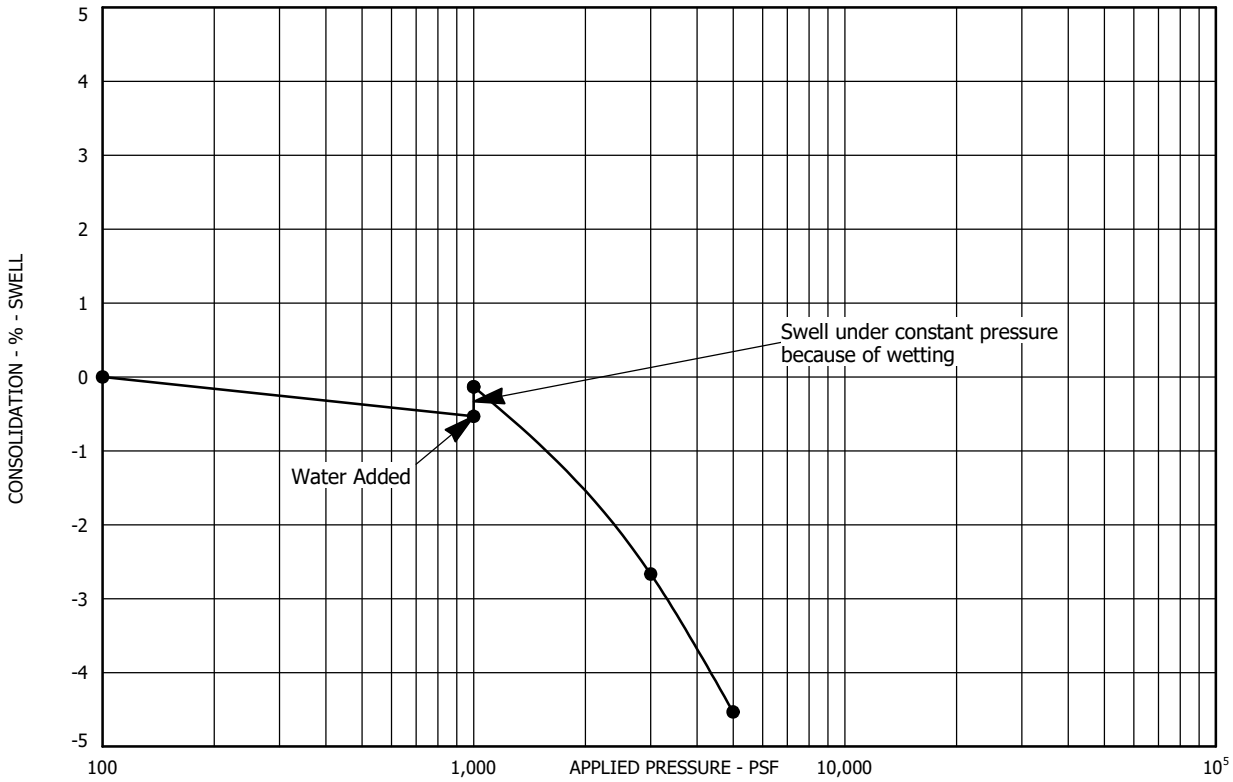


Sample Location: Test Boring No. 5 at a depth of 9 feet
Sample Description: Fill, sand, very clayey, gravelly
Dry Unit Weight (pcf): 112
Moisture Content (%): 13

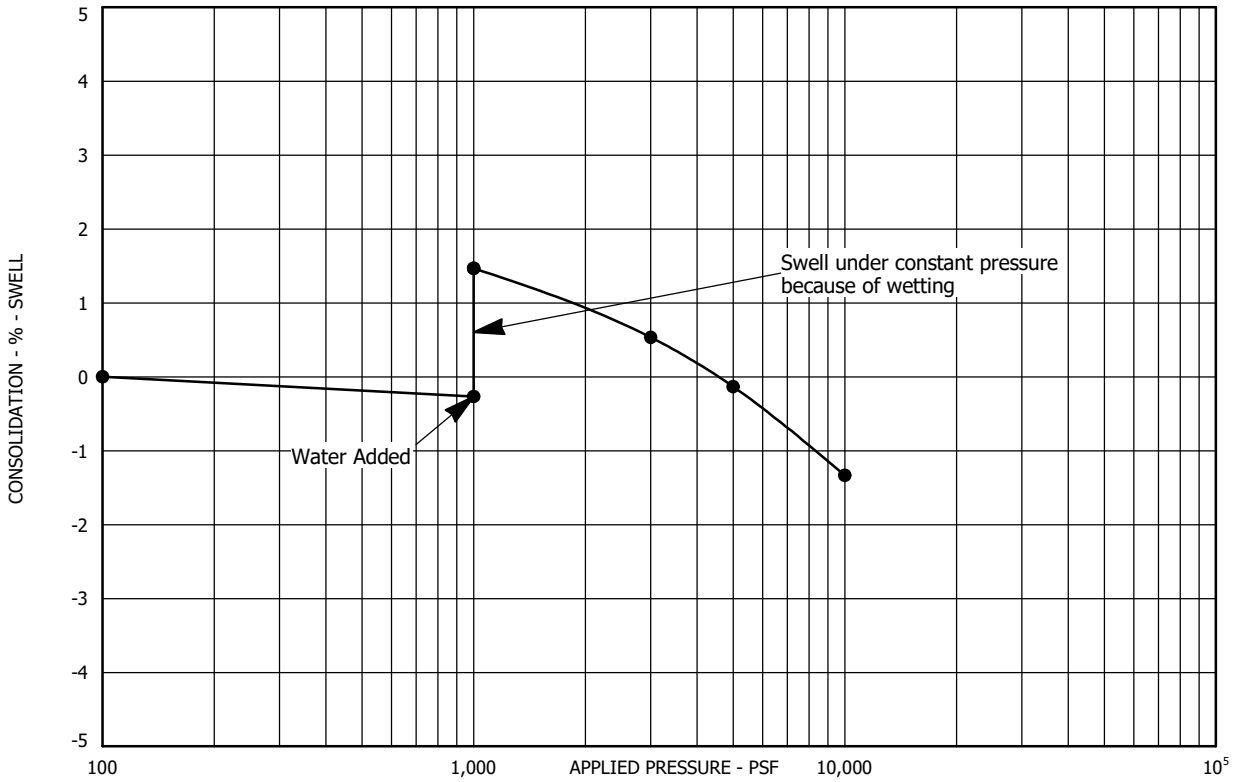
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-2

PROJECT NO. 207623



Sample Location: Test Boring No. 6 at a depth of 4 feet
Sample Description: Fill, sand, very clayey, gravelly
Dry Unit Weight (pcf): 102
Moisture Content (%): 16

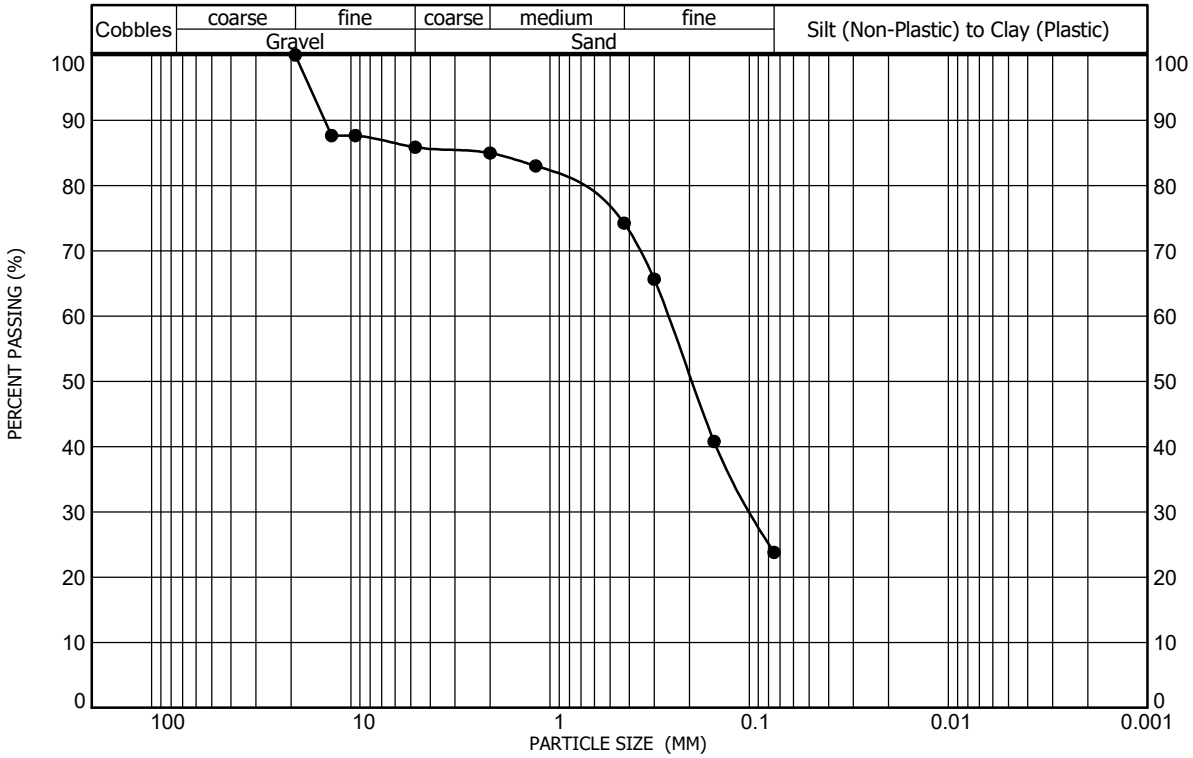


Sample Location: Test Boring No. 10 at a depth of 9 feet
Sample Description: Clay, sandy
Dry Unit Weight (pcf): 121
Moisture Content (%): 9

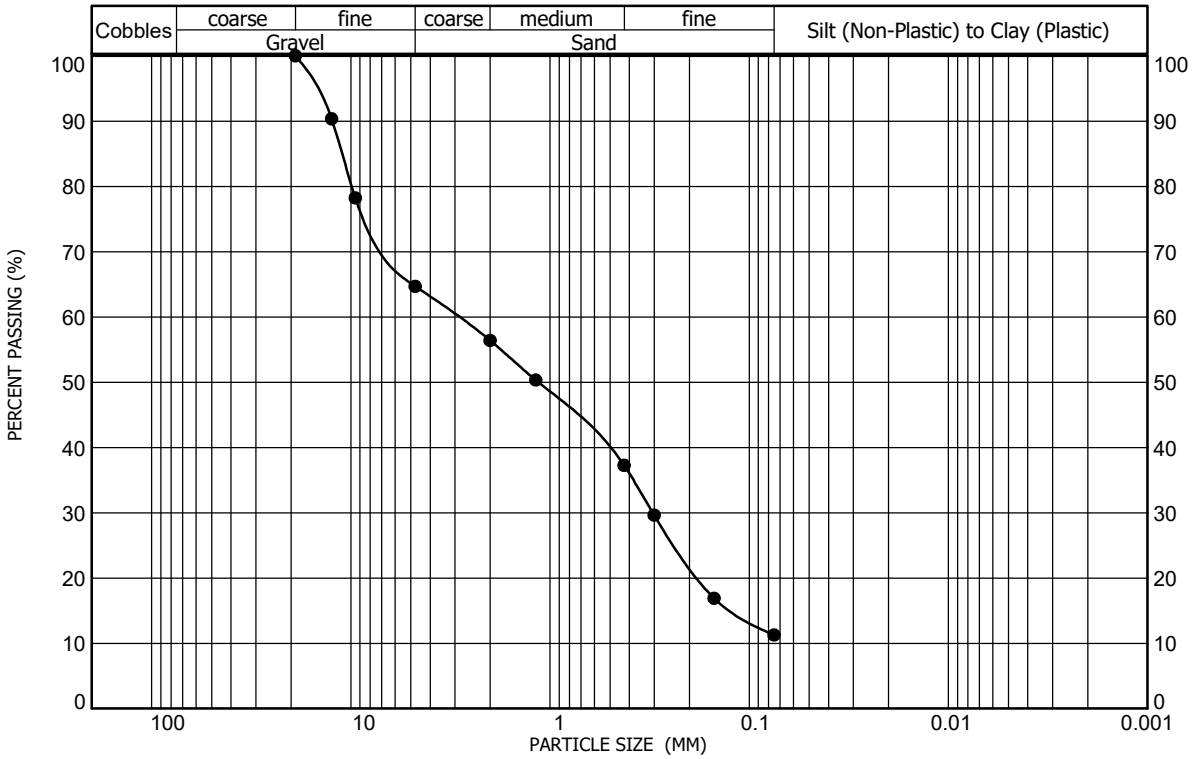
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-3

PROJECT NO. 207623



Sample Location Test Boring No. 1 at a depth of 4 feet — Gravel (%) 14 — Liquid Limit NV
Sample Description Sand, silty, slightly gravelly — Sand (%) 62 — Plasticity Index NP
Classification A-2-4(0), SILTY SAND(SM) — Clay/Silt (%) 24

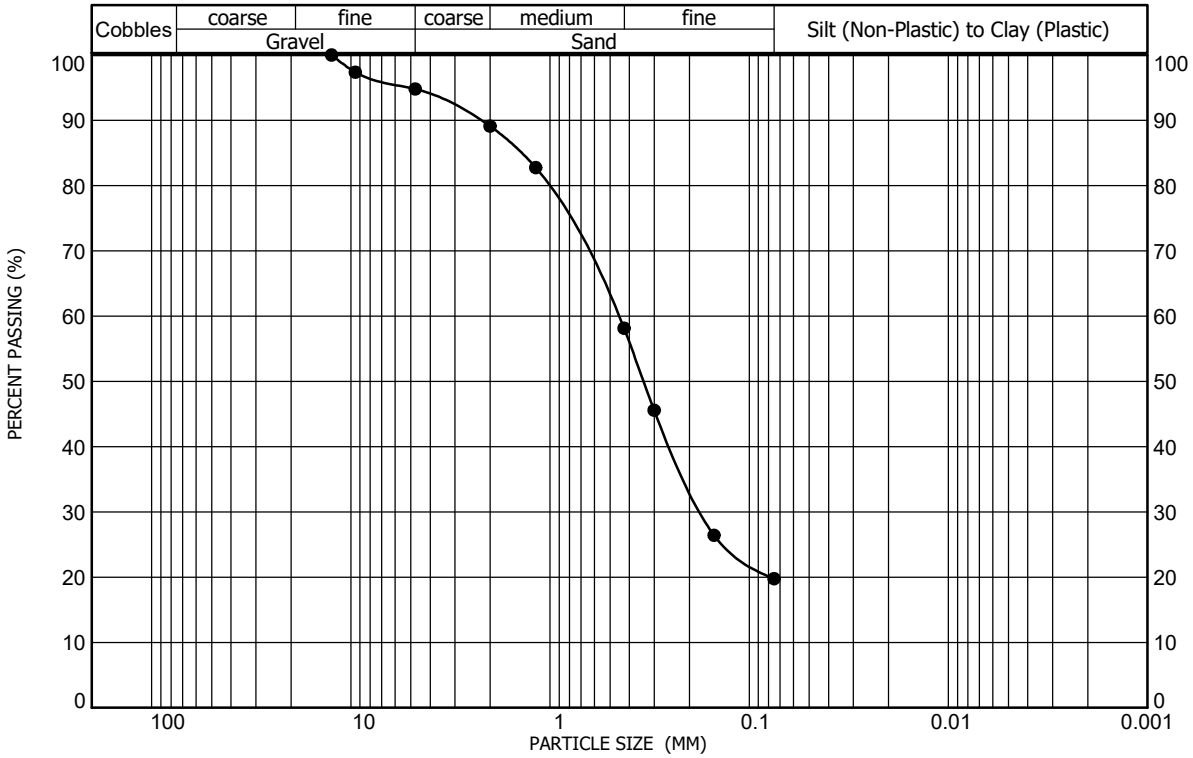


Sample Location Test Boring No. 1 at a depth of 9 feet — Gravel (%) 35 — Liquid Limit NV
Sample Description Sand, very gravelly, slightly silty — Sand (%) 53 — Plasticity Index NP
Classification A-1-b(0), POORLY GRADED SAND with SILT and GRAVEL(SP-SM) — Clay/Silt (%) 11

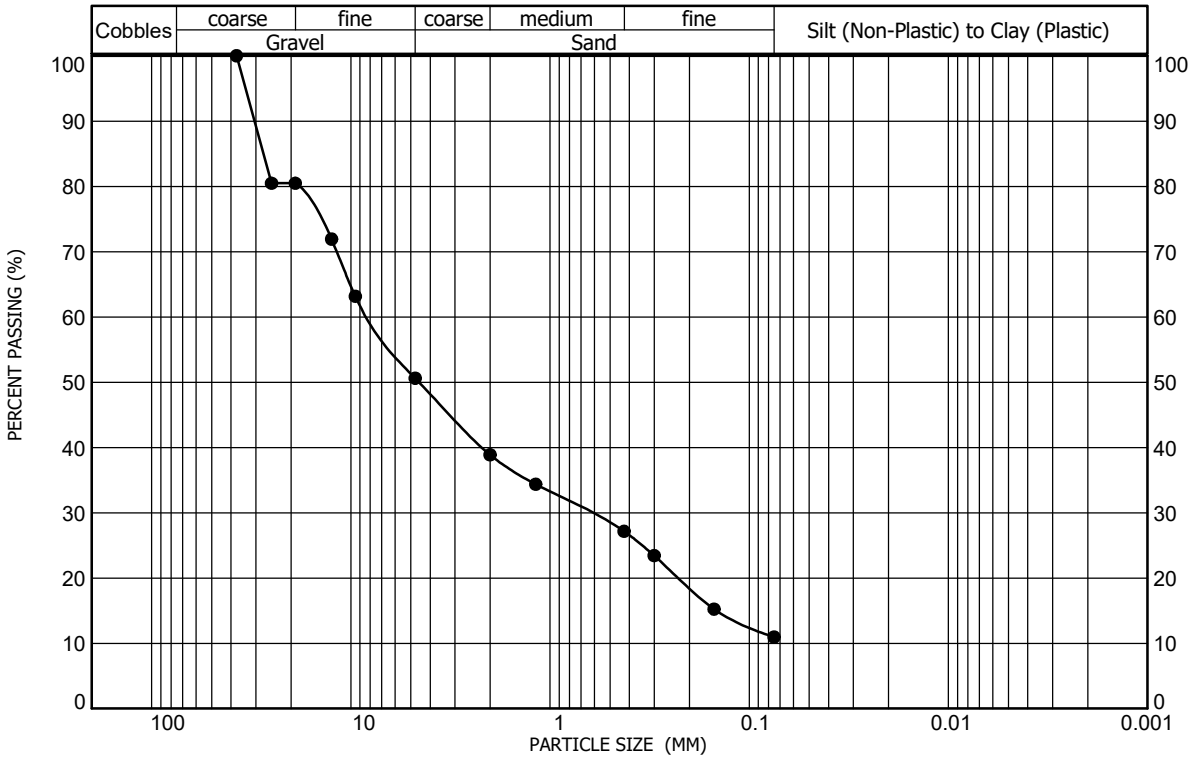
GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-4

PROJECT NO. 207623



Sample Location Test Boring No. 2 at a depth of 4 feet — Gravel (%) 5 — Liquid Limit 24
Sample Description Fill, sand, silty, clayey, slightly gravelly — Sand (%) 75 — Plasticity Index 7
Classification A-2-4(0), SILTY, CLAYEY SAND(SC-SM) — Clay/Silt (%) 20

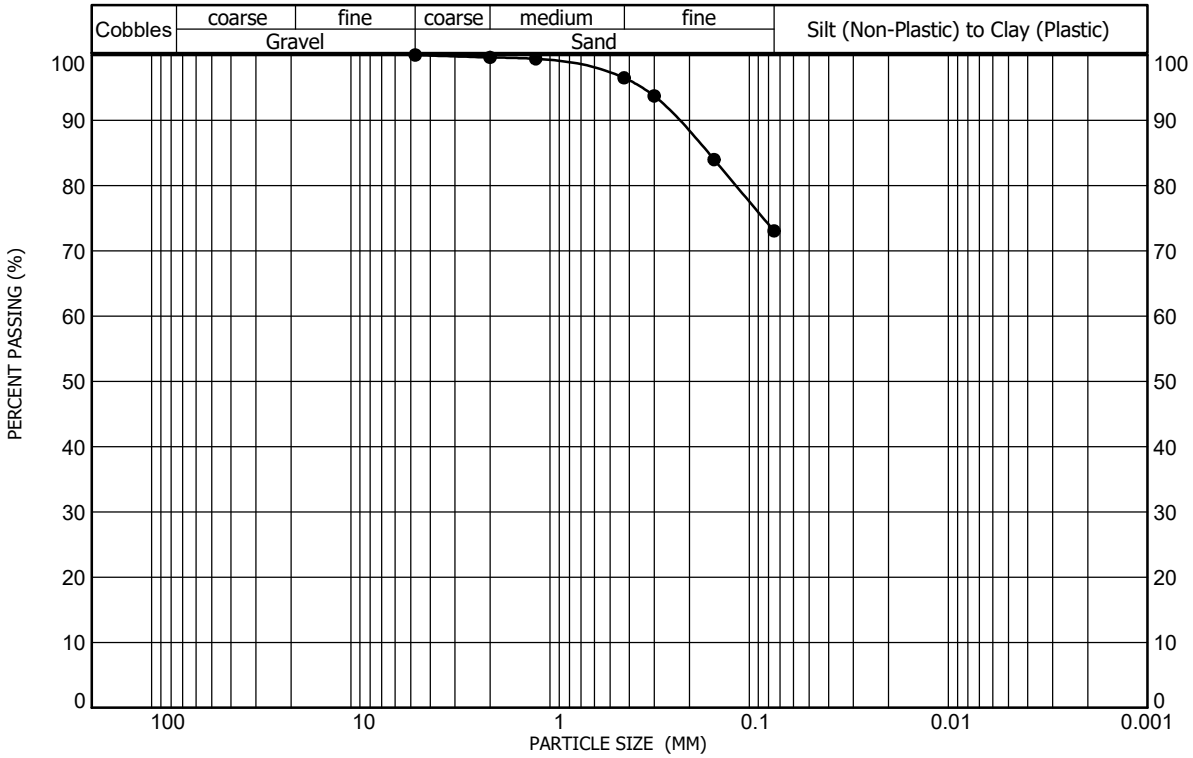


Sample Location Test Boring No. 2 at a depth of 19 feet — Gravel (%) 49 — Liquid Limit NV
Sample Description Gravel, very sandy, slightly silty — Sand (%) 40 — Plasticity Index NP
Classification A-1-a(0), POORLY GRADED GRAVEL with SILT and SAND(GP-GM) — Clay/Silt (%) 11

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-5

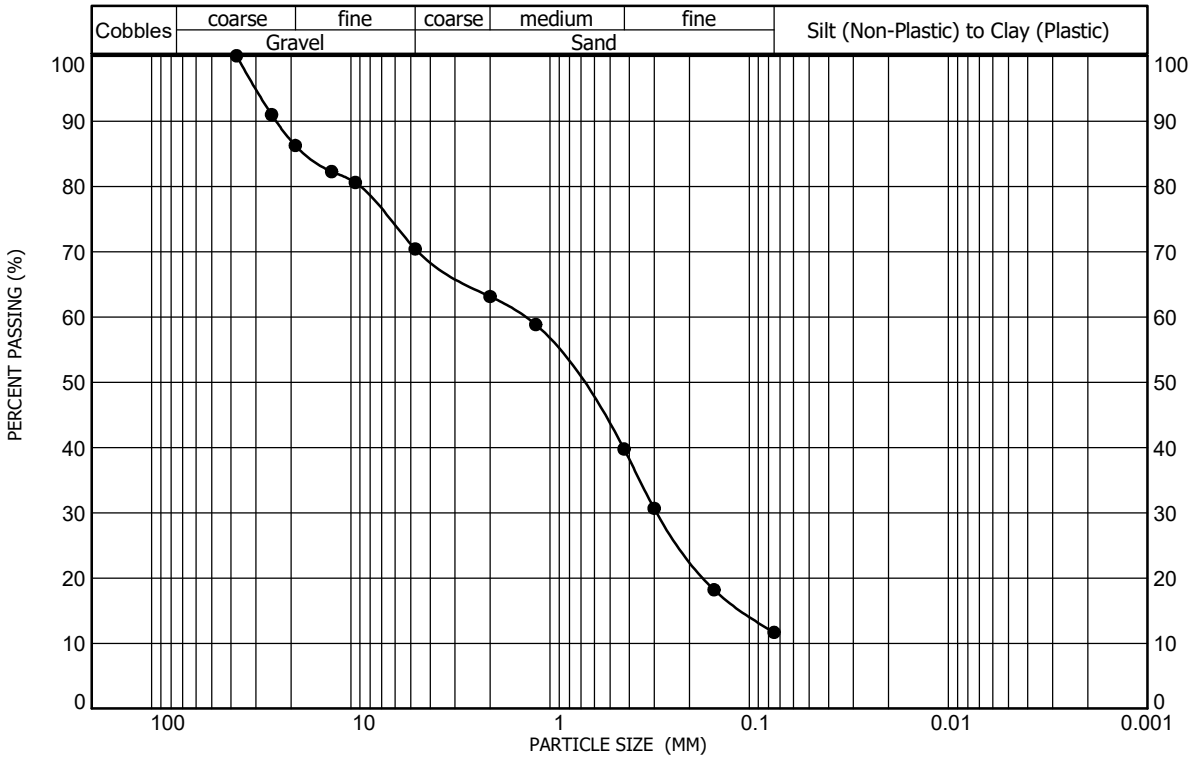
PROJECT NO. 207623



Sample Location: Test Boring No. 3 at a depth of 4 feet
Sample Description: Fill, clay, sandy
Classification: A-7-6(21), FAT CLAY with SAND(CH)

Gravel (%): 0
Sand (%): 27
Clay/Silt (%): 73

Liquid Limit: 50
Plasticity Index: 30



Sample Location: Test Boring No. 3 at a depth of 10 feet
Sample Description: Sand, gravelly, slightly silty
Classification: A-1-b(0), POORLY GRADED SAND with SILT and GRAVEL(SP-SM)

Gravel (%): 30
Sand (%): 59
Clay/Silt (%): 12

Liquid Limit: NV
Plasticity Index: NP

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-6

PROJECT NO. 207623

AGW
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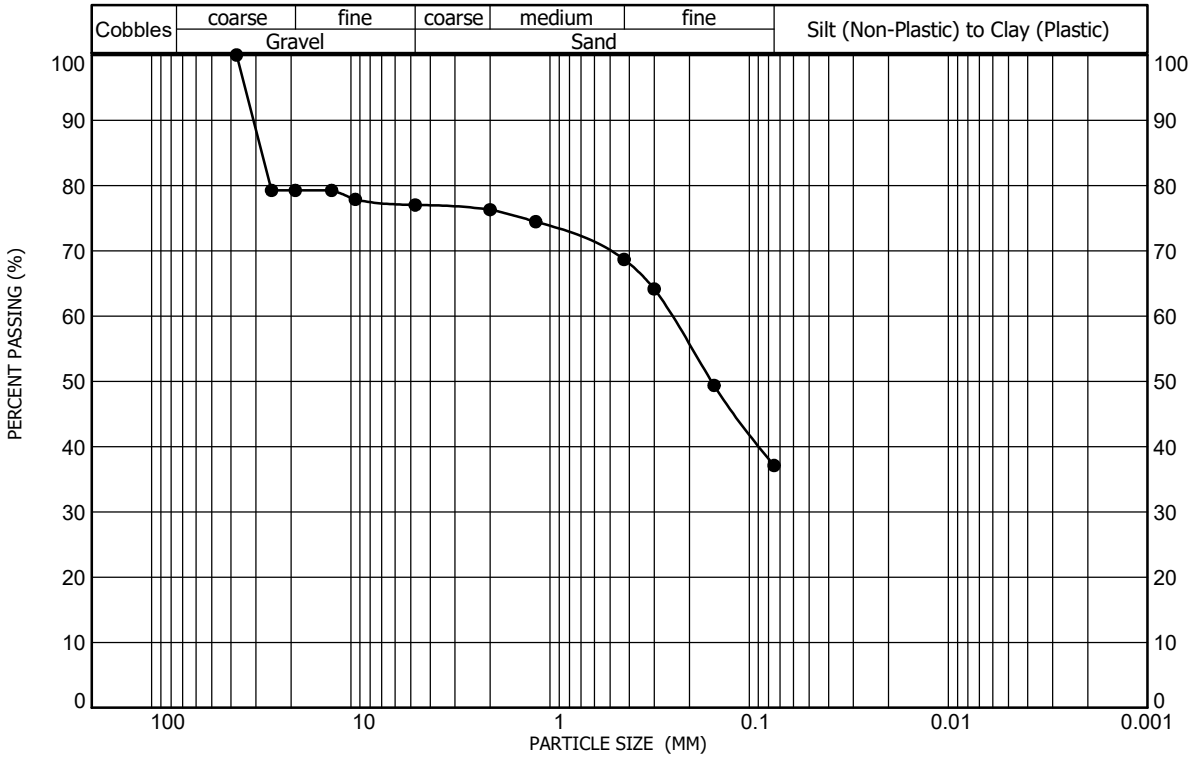
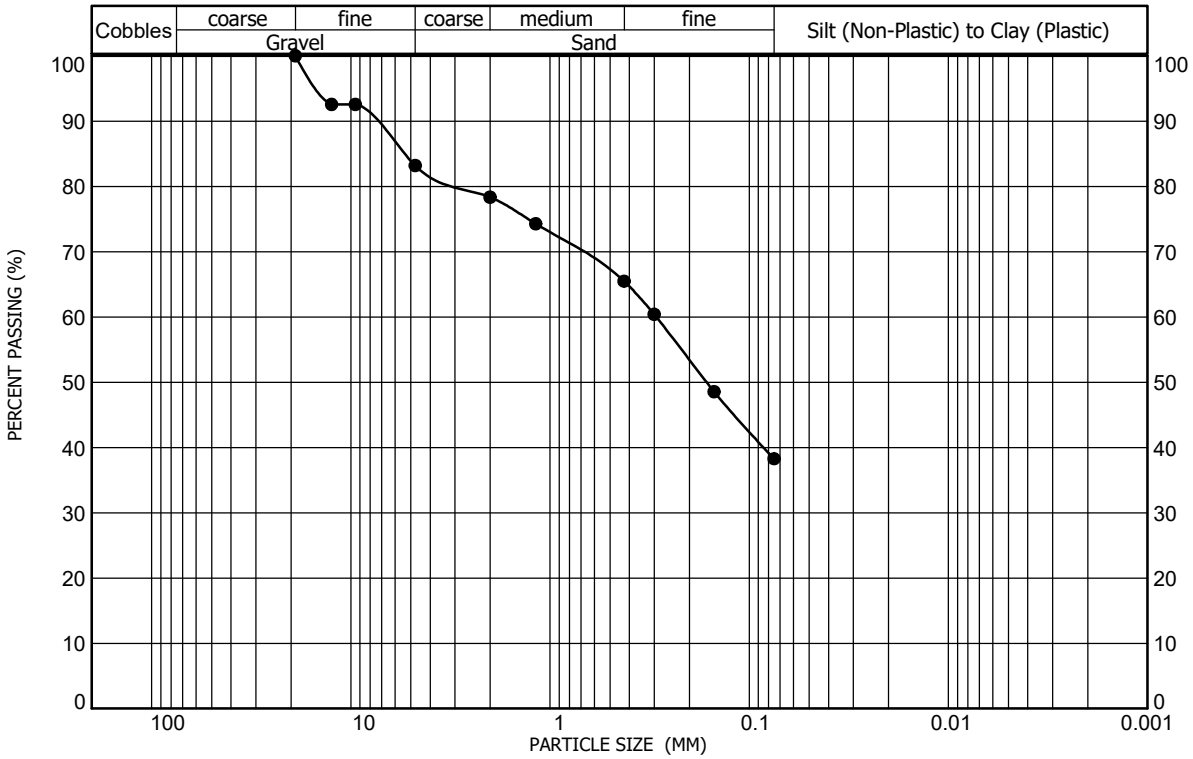


Sample Location: Test Boring No. 4 at a depth of 9 feet
Sample Description: Sand, very clayey, gravelly
Classification: A-6(2), CLAYEY SAND with GRAVEL(SC)
Gravel (%): 23
Sand (%): 40
Clay/Silt (%): 37
Liquid Limit: 36
Plasticity Index: 18



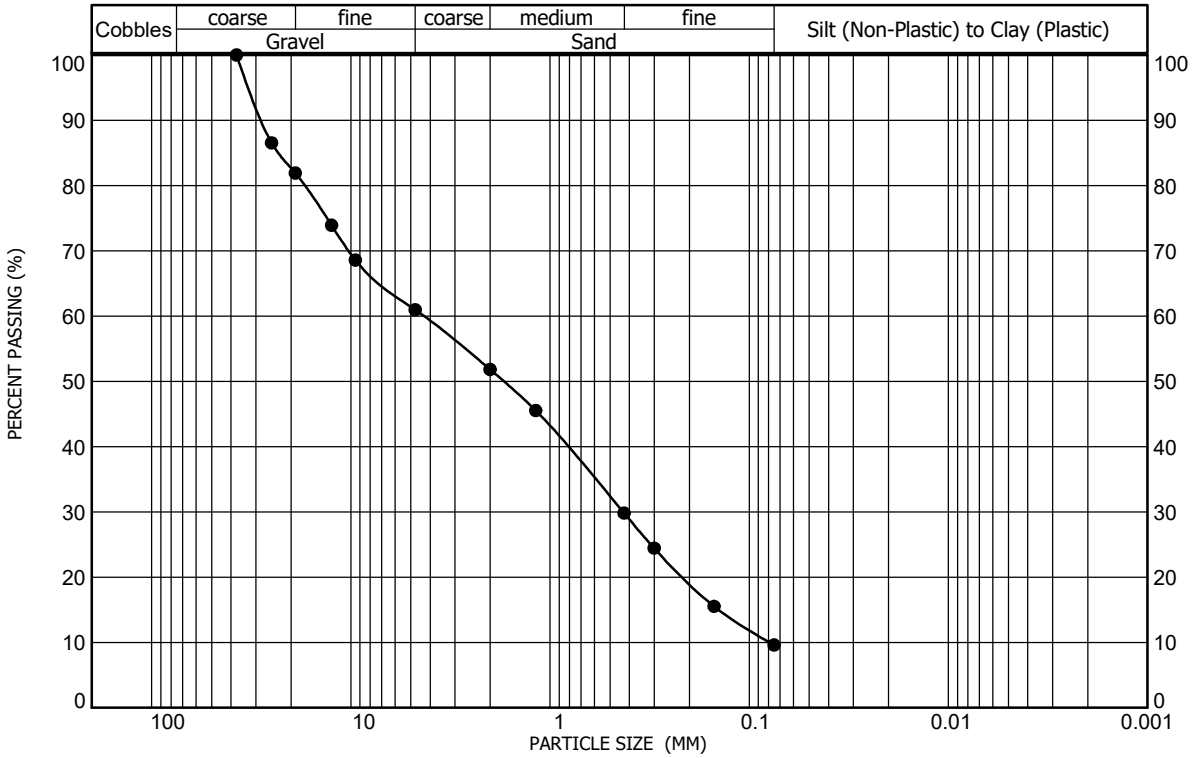
Sample Location: Test Boring No. 5 at a depth of 4 feet
Sample Description: Fill, sand, very clayey, gravelly
Classification: A-6(1), CLAYEY SAND with GRAVEL(SC)
Gravel (%): 17
Sand (%): 45
Clay/Silt (%): 38
Liquid Limit: 33
Plasticity Index: 14

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-7

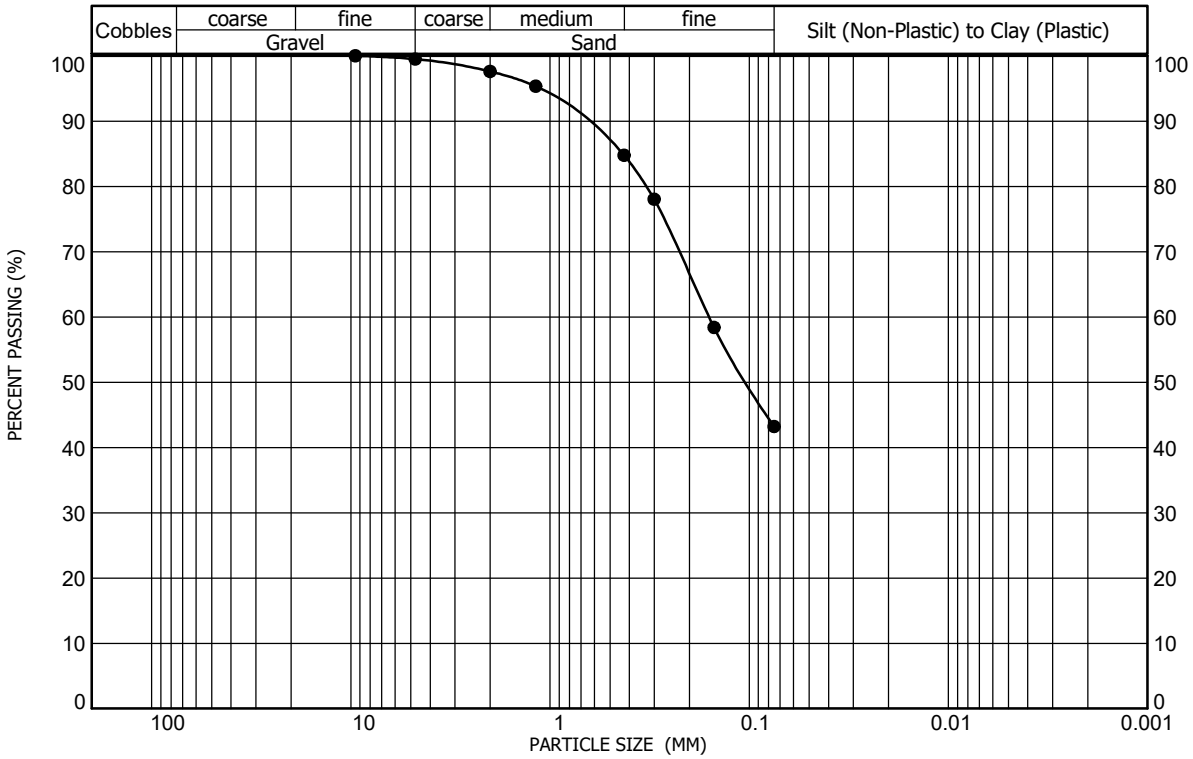
PROJECT NO. 207623

AGW
A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 6 at a depth of 14 feet
Sample Description: Sand, very gravelly, slightly silty
Classification: A-1-b(0), POORLY GRADED SAND with SILT and GRAVEL(SP-SM)

Gravel (%): 39
Sand (%): 51
Clay/Silt (%): 10
Liquid Limit: NV
Plasticity Index: NP



Sample Location: Test Boring No. 7 at a depth of 9 feet
Sample Description: Sand, very clayey, trace gravel
Classification: A-4(1), CLAYEY SAND(SC)

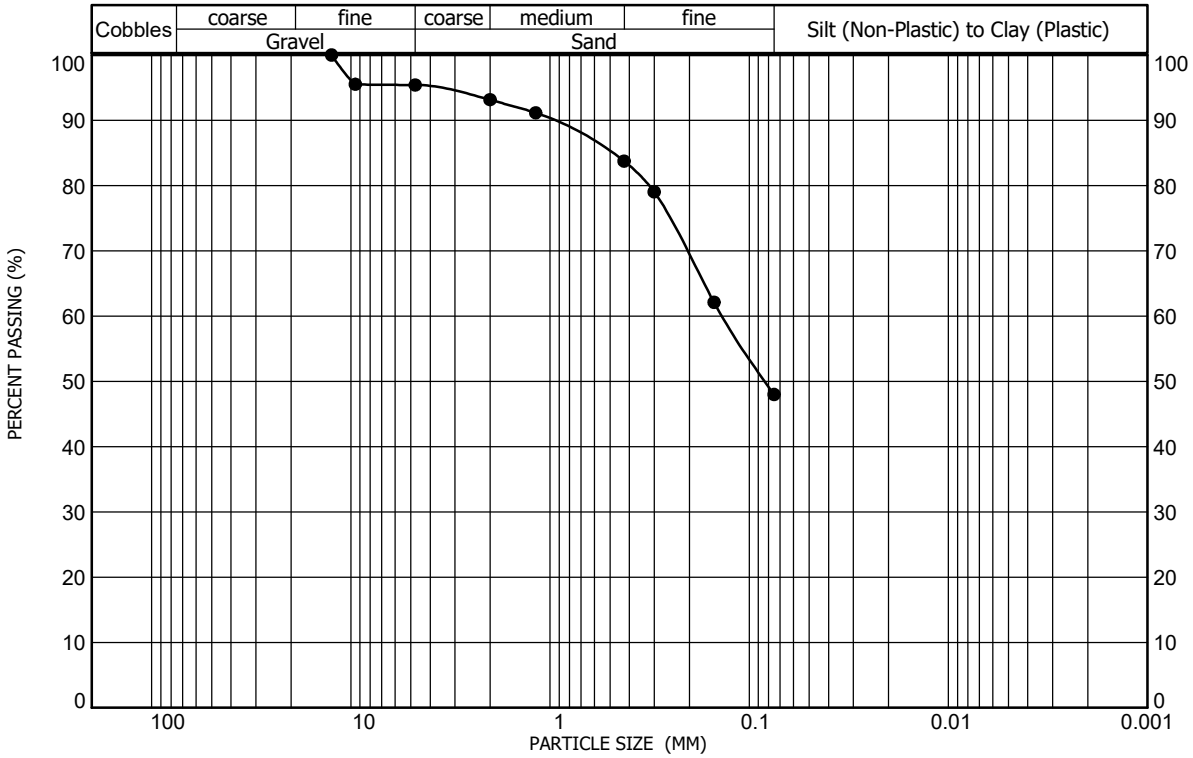
Gravel (%): 1
Sand (%): 56
Clay/Silt (%): 43
Liquid Limit: 30
Plasticity Index: 10

GRADATION AND ATTERBERG TEST RESULTS

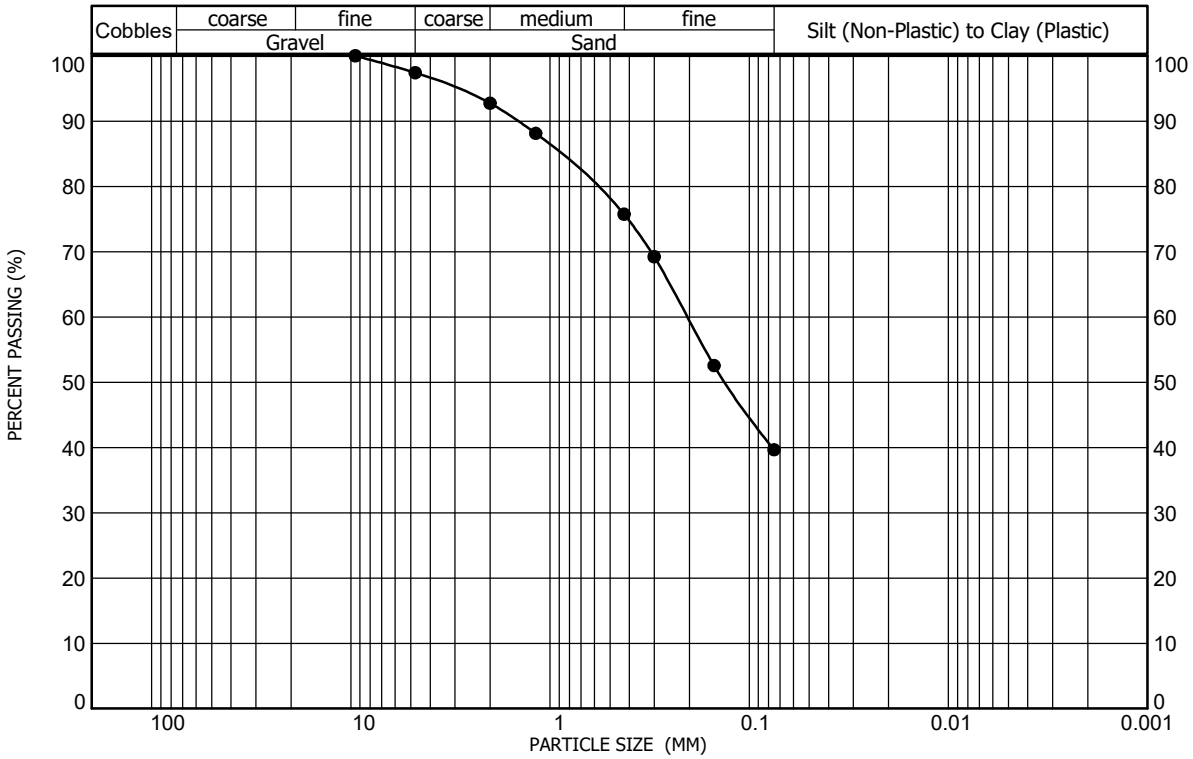
FIGURE A-8

PROJECT NO. 207623

AGW
A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 7 at a depth of 14 feet
Sample Description: Clay, very sandy, slightly gravelly (lens)
Classification: A-6(3), CLAYEY SAND(SC)
Gravel (%): 5
Sand (%): 47
Clay/Silt (%): 48
Liquid Limit: 33
Plasticity Index: 13

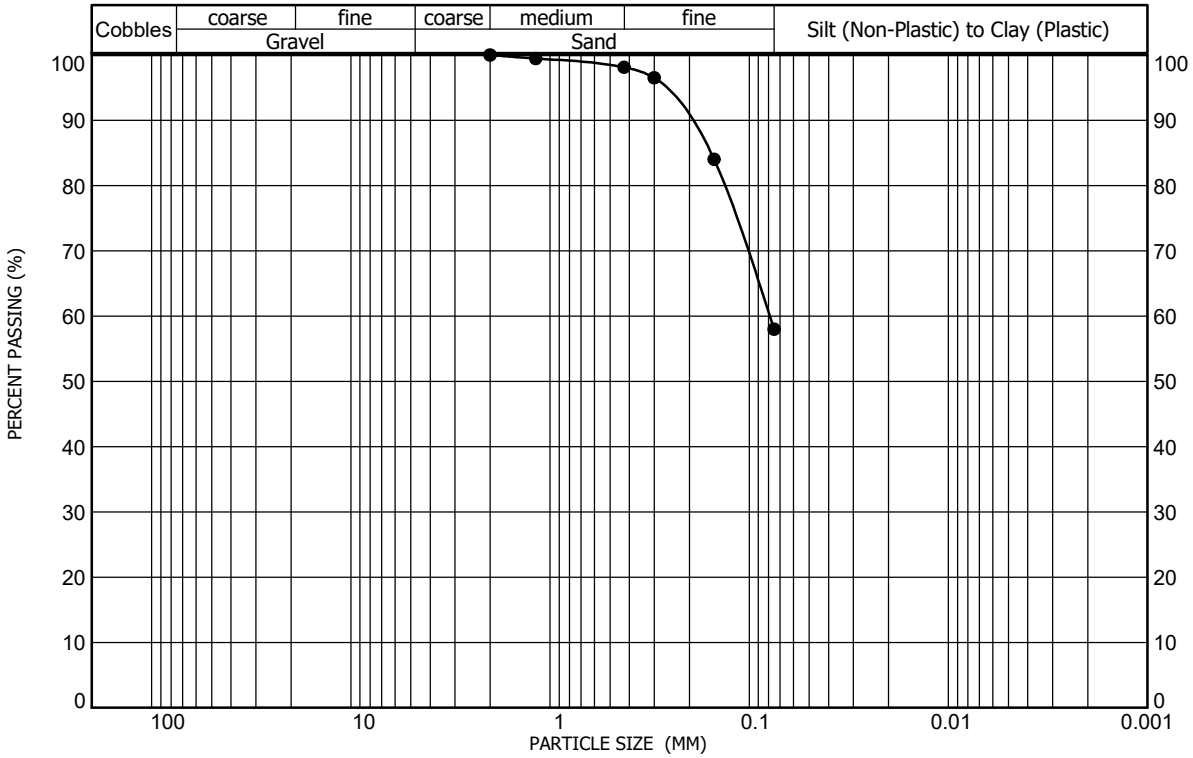


Sample Location: Test Boring No. 8 at a depth of 4 feet
Sample Description: Sand, very clayey, trace gravel
Classification: A-6(2), CLAYEY SAND(SC)
Gravel (%): 3
Sand (%): 58
Clay/Silt (%): 40
Liquid Limit: 34
Plasticity Index: 15

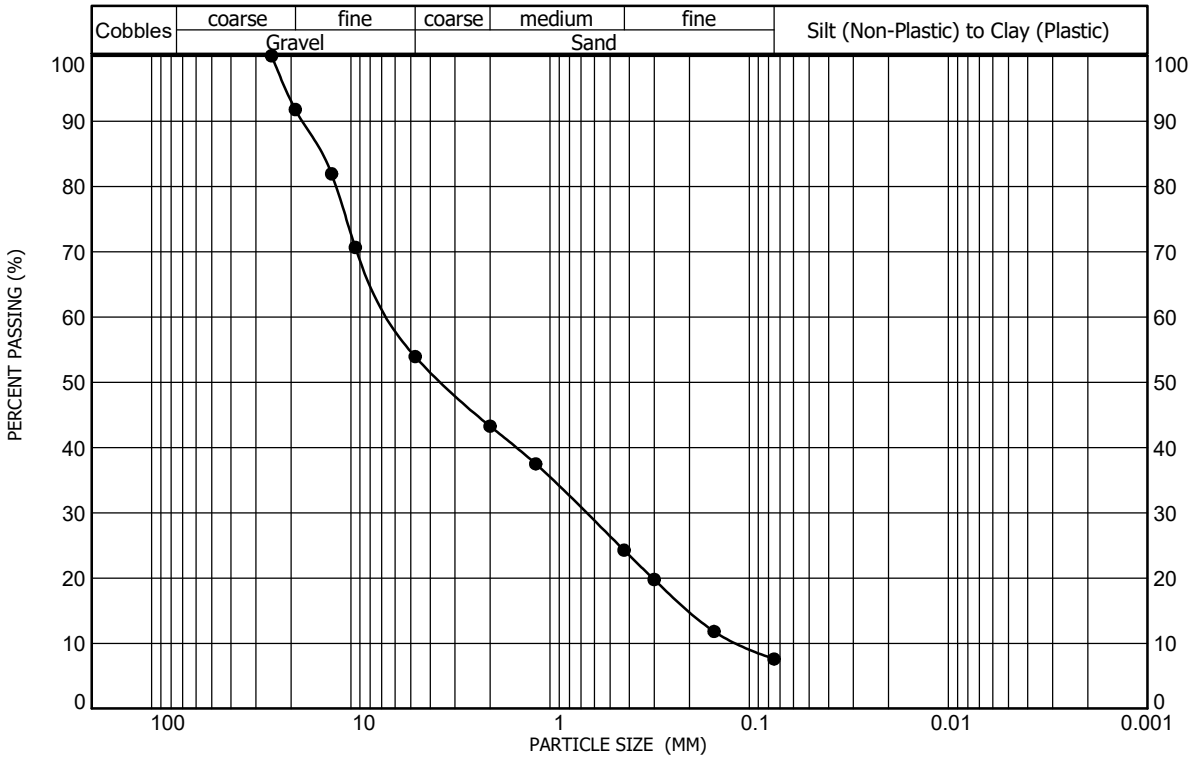
GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-9

PROJECT NO. 207623



Sample Location Test Boring No. 8 at a depth of 29 feet — Gravel (%) 0 — Liquid Limit 30
Sample Description Claystone, very sandy — Sand (%) 42 — Plasticity Index 10
Classification A-4(3), SANDY LEAN CLAY(CL) — Clay/Silt (%) 58

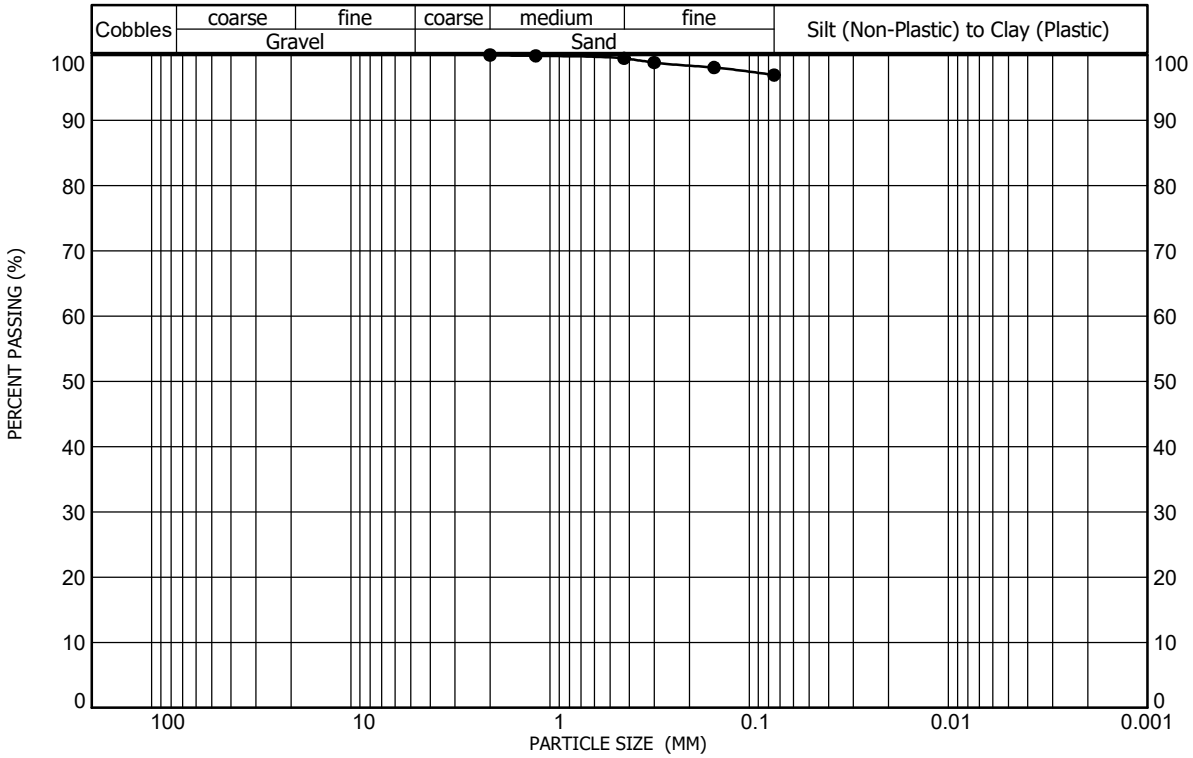


Sample Location Test Boring No. 9 at a depth of 14 feet — Gravel (%) 46 — Liquid Limit NV
Sample Description Gravel, very sandy, slightly silty — Sand (%) 46 — Plasticity Index NP
Classification A-1-a(0), POORLY GRADED SAND with SILT and GRAVEL(SP-SM) — Clay/Silt (%) 8

GRADATION AND ATTERBERG TEST RESULTS

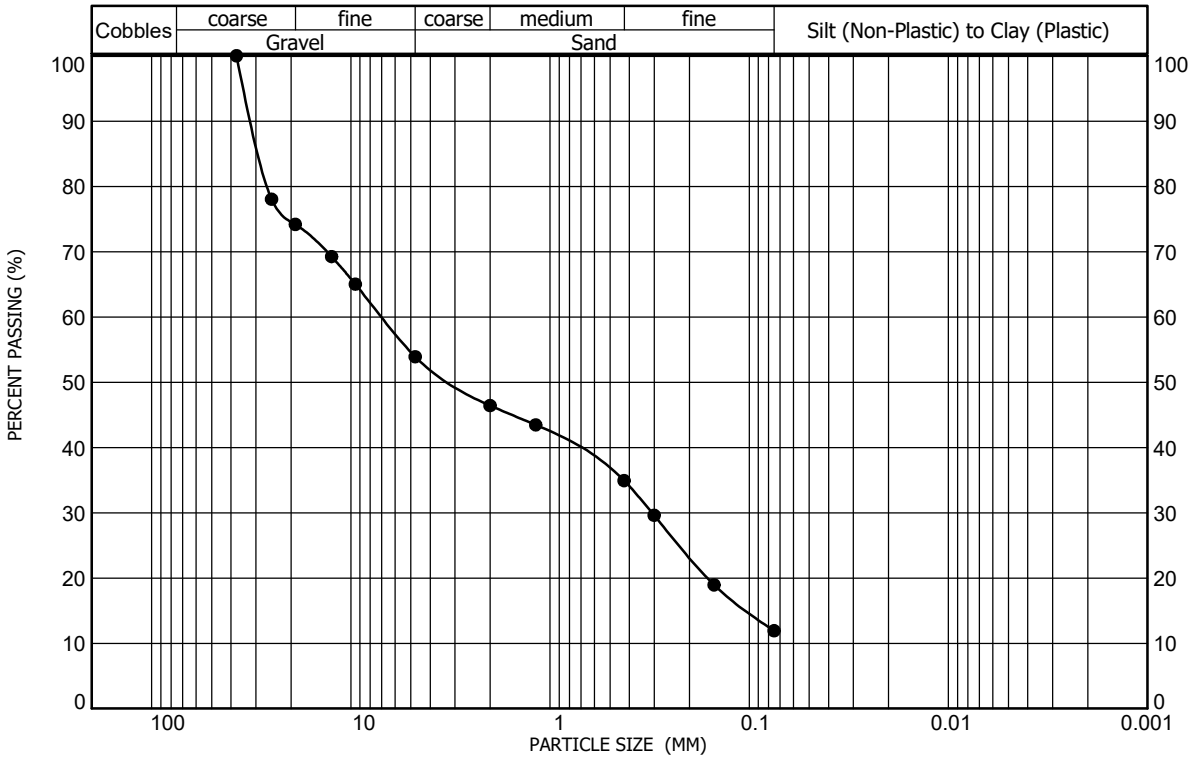
FIGURE A-10

PROJECT NO. 207623



Sample Location: Test Boring No. 9 at a depth of 24 feet
Sample Description: Claystone, trace sand
Classification: A-7-6(30), FAT CLAY(CH)

Gravel (%): 0 Liquid Limit: 50
Sand (%): 3 Plasticity Index: 28
Clay/Silt (%): 97



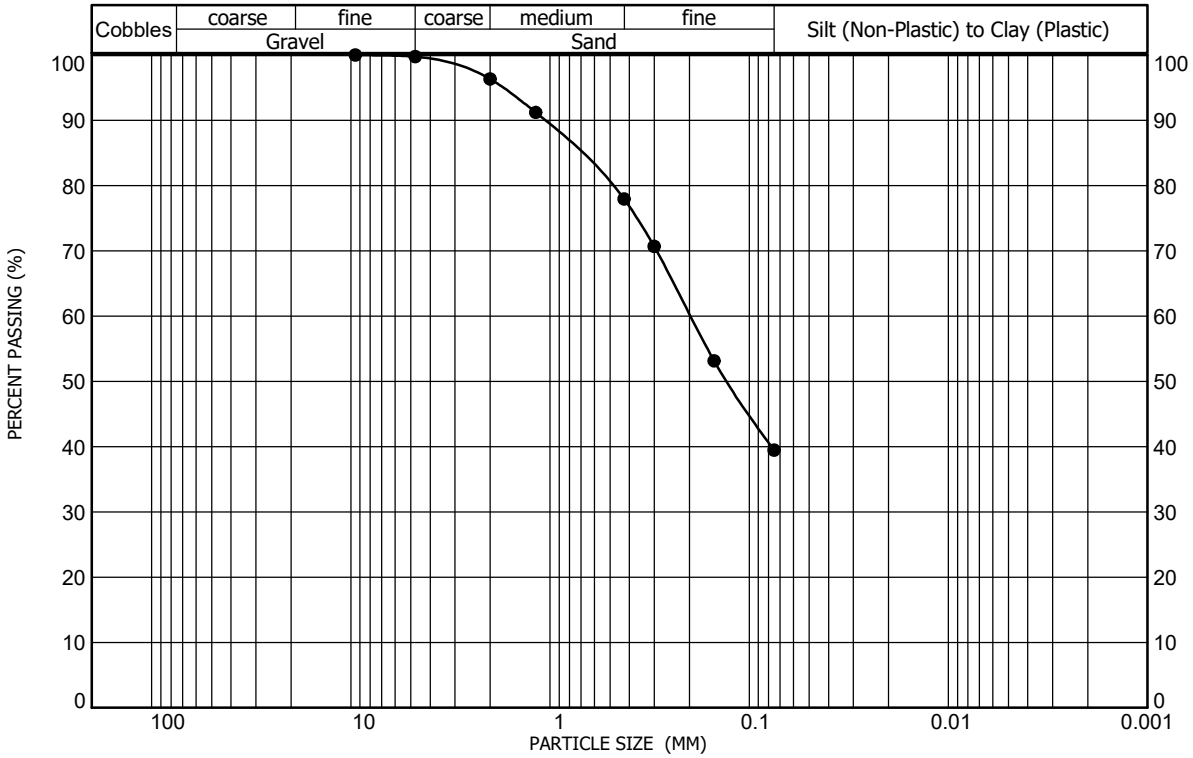
Sample Location: Test Boring No. 10 at a depth of 14 feet
Sample Description: Gravel, very sandy, slightly silty
Classification: A-1-b(0), POORLY GRADED GRAVEL with SILT and SAND(GP-GM)

Gravel (%): 46 Liquid Limit: NV
Sand (%): 42 Plasticity Index: NP
Clay/Silt (%): 12

GRADATION AND ATTERBERG TEST RESULTS

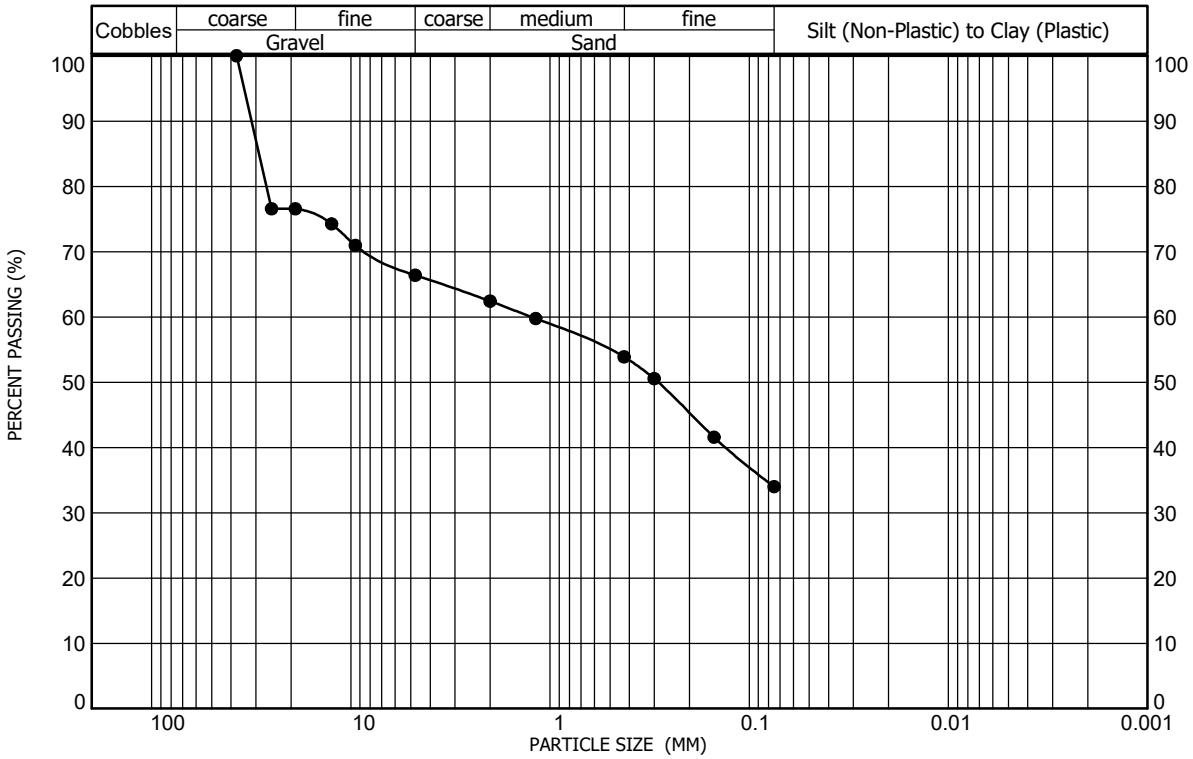
FIGURE A-11

PROJECT NO. 207623



Sample Location: Test Boring No. 11 at a depth of 4 feet
Sample Description: Sand, very clayey
Classification: A-6(1), CLAYEY SAND(SC)

Gravel (%): 0 | Sand (%): 60 | Clay/Silt (%): 39
Liquid Limit: 32 | Plasticity Index: 12



Sample Location: Test Boring No. 11 at a depth of 9 feet
Sample Description: Gravel, very clayey, very sandy
Classification: A-2-6(0), CLAYEY GRAVEL with SAND(GC)

Gravel (%): 34 | Sand (%): 32 | Clay/Silt (%): 34
Liquid Limit: 32 | Plasticity Index: 12

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-12

PROJECT NO. 207623

APPENDIX B
SPECIFICATIONS FOR PLACEMENT OF FILL

APPENDIX B
SPECIFICATIONS FOR PLACEMENT OF FILL

General
AGW, as the Client's representative, should observe fill placement and conduct tests to determine if the materials placed, methods of placement, and compaction are in reasonable conformance with these specifications. Specifications presented in this Appendix are general in nature. They should be used for construction except where specifically superseded by those presented in the attendant geotechnical study.

For the purpose of this specification, structural areas include those areas that will support constructed appurtenances (e.g., foundations, slabs, flatwork, pavements, etc.) and fill embankments or slopes that support significant fills or constructed appurtenances. Structural areas will be as defined by AGW.

Fill Material
Fill material should consist of on or off-site soils which are relatively free of vegetable matter and rubble. Off-site materials should be evaluated by AGW prior to importation. No organic, frozen, perishable, rock greater than 6 inches, or other unsuitable material should be placed in the fill. For the purpose of this specification, cohesive soil is defined as a mixture of clay, sand, and silt with more than 35% passing a U. S. Standard #200 sieve and a Plasticity Index of at least 11. These materials will classify as an A-6 or A-7 by the AASHTO Classification system. Granular soils are all materials which do not classify as cohesive.

Preparation of Fill Subgrade
Vegetation, organic topsoil, any existing fill, and any other deleterious materials should be removed from the fill area. The area to be filled should then be scarified, moistened or dried as necessary, and compacted to the moisture content and compaction level specified below prior to placement of subsequent layers of fill.

Placement of Fill Material
The materials should be delivered to the fill in a manner which will permit a well and uniformly compacted fill. Before compacting, the fill material should be properly broken down, mixed, and spread in approximately horizontal layers not greater than 8 inches in loose thickness.

Moisture Control
The material must contain uniformly distributed moisture for proper compaction. The Contractor will be required to add moisture to the materials if, in the opinion of AGW, sufficient and uniform moisture is not present in the fill. If the fill materials are too wet for proper compaction, aerating and/or mixing with drier materials will be required.

Moisture content should be controlled as a percentage deviation from optimum. Optimum moisture content is defined as the moisture content corresponding to the maximum density of a laboratory compacted sample performed according to ASTM D698 for cohesive soils or ASTM D1557 for granular soils. The moisture content specifications for the various areas are as follows:

		Cohesive Soils	Granular Soils
1.	Beneath Structural Areas:	0 to +4%	−2 to +2%
2.	Beneath Non-Structural Areas:	−3 to +3%	−3 to +3%

Compaction
When the moisture content and conditions of each layer spread are satisfactory, the fill should be compacted. Laboratory moisture-density tests should be performed on typical fill materials to determine the maximum density. Field density tests must then be made to determine fill compaction. The compaction standard to be utilized in determining the maximum density is ASTM D698 for cohesive soils or ASTM D1557 for granular soils. The following compaction specifications should be followed for each area:

1. Beneath Structural Areas: 95% of Maximum Dry Density
2. Beneath Non-Structural Areas: 90% of Maximum Dry Density

If the fill contains less than 10% passing the No. 200 sieve, it may be necessary to control compaction based on relative density (ASTM D2049). If this is the case, then compaction around the structures and beneath walkway or other slabs should be to at least 70% relative density, and compaction beneath foundations and vehicle supporting should be to at least 80% relative density.

Deep Fills
In areas where fill depths exceed 20 feet beneath structural areas, additional compaction considerations will be required to reduce fill settlement. Fill placed within 20 feet of final overlot grade should be compacted as required above. Deeper fills should be compacted to 100% of maximum dry density at a moisture content of ±2% of optimum moisture content. Relative density of at least 85% will be required when necessary.

Responsibility
Any mention of essentially full-time testing and observation does not mean AGW will accept responsibility for future fill performance. AGW shall not be responsible for constant or exhaustive inspection of the work, the means and methods of construction or the safety procedures employed by Client's contractor. Performance of construction observation services does not constitute a warranty or guarantee of any type, since even with diligent observation, some construction defects, deficiencies or omissions in the Contractor's work may occur undetected. Client shall hold its contractor solely responsible for the quality and completion of the project, including construction in accordance with the construction documents. Any duty hereunder is for the sole benefit of the Client and not for any third party, including the contractor or any subcontractor.