Pavement Study
Falcon Meadows at Bent Grass, Filing No. 2
El Paso County, Colorado

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PCD File No. SF-21-034
Project Number 221950-P1
June 13, 2022
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ATTACHMENTS

1.0 EXECUTIVE SUMMARY

As requested, A. G. Wassenaar, Inc. (AGW) has completed the pavement study for the proposed roadways to be located at the subject site. This study was conducted in general conformance with El Paso County pavement design procedures. The following pavement study summarizes the field exploration, subsurface conditions encountered, laboratory tests performed, and pavement recommendations for the proposed roadways.

In general, the subgrade materials encountered consisted of very sandy clay fill, silty to clayey sand fill, silty to very clayey sand with gravel, sandy clay, and claystone bedrock. No ground water was encountered at the time of drilling.

The pavement recommendations for the local residential (urban) streets consist of a composite section of 3.75 inches of asphalt concrete overlying at least 8.0 inches of aggregate base course. Based on our sampling and laboratory testing, expansive subgrade mitigation per El Paso County is not required.

We encourage reading this study in its entirety and not solely relying on the cursory information contained in this summary.

2.0 PURPOSE

The purpose of this study was to provide pavement thickness recommendations for the subject site in general conformance with Appendix D of El Paso County's "Engineering Criteria Manual (Revised 2016)" ("Manual"). This study presents the analysis of approximately 4,000 feet of local residential (Urban) roadways. Factual data gathered during the field and laboratory work and our analyses are summarized on Figures 1 through 5 and in Appendices A and B. Our opinions and recommendations presented in this study are based on the data generated during this field exploration, laboratory testing, and our experience with similar projects. A reference used during the development of this study was the "Pavement Study for Falcon Meadows at Bent Grass, Filing No. 1, El Paso County, Colorado", Project Number 214061-P1, completed September 15, 2021, by AGW. The "subgrade support" laboratory test results utilized in design of the pavement thicknesses provided in this study are presented in Appendix C (see Figure 1 for test boring location of referenced test results).

3.0 PROPOSED CONSTRUCTION

Based on the plans, the site is being developed for residential construction. The streets included in this study are Henzlee Place, Kittrick Place, Daelyn Drive, Isabel Place, Raylan Way, Jolie Court, and Romena Way. These streets are local urban with a right-of-way width of 50 feet and curb and gutter/sidewalk combo on both sides. The streets are to be paved with asphalt concrete.

4.0 FIELD EXPLORATION

The subgrade soils were sampled by drilling 15 test borings within the proposed roadway alignments approximately 250 lineal feet apart (see Figure 1). The test borings were drilled using a 4-inch diameter continuous flight auger powered by a truck-mounted drill rig. The test borings were drilled to depths of approximately 5 or 10 feet with disturbed bulk samples collected in the upper 5 feet of rough subgrade elevation. Samples of the subsurface materials were also obtained using a Modified California sampler which was 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 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 subsurface materials encountered. Results of the penetration tests are presented on the "Test Boring Logs", Figures 2 through 5. Ground water was not encountered at the time of drilling.

5.0 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 gradation analysis and Atterberg limits to evaluate grain size distribution and plasticity. Swell-consolidation tests were conducted to evaluate the effect of wetting under load on selected samples. Representative samples were tested for water-soluble sulfate concentration. The test results are summarized on Figures 2 through 5 and presented in Appendix A.

6.0 SUBGRADE DESCRIPTION

The subgrade soils encountered consisted of very sandy clay fill, silty to clayey sand fill, silty to very clayey sand with gravel, sandy clay, and claystone bedrock. According to the AASHTO Soil Classification system, the soils from the bulk samples collected classified as A-1-b (0), A-2-4 (0), A-4 (0), A-6 (1 and 5). Based upon field observations, fill was encountered in four of the 15 test borings to depths of approximately 5 and 6 feet below rough subgrade elevation. Silty to very clayey sand with gravel was encountered in was encountered in 12 of the test borings at surface elevation and at a depth of approximately 6 feet. Sandy clay was encountered in one of the test borings at a depth of approximately 5 feet. Claystone bedrock was encountered in one of the test borings at a depth of approximately 7 feet. Ground water was not encountered at the time of drilling.

7.0 WATER-SOLUBLE SULFATES

The Colorado Department of Transportation (CDOT) stipulates requirements for the risk of sulfate exposure on concrete structures based on Table 601-2 of the "Standard Specifications for Road and Bridge Construction". The water-soluble sulfate concentration of the samples tested ranged from 100 to 600 parts per million (ppm). Based on these results, the sulfate concentration of the samples tested represents a Class 1 risk of sulfate exposure. We recommend concrete structures bearing upon onsite materials meet the requirements stipulated in Section 601.04 of the CDOT "Standard Specifications for Road and Bridge Construction".

8.0 EXPANSIVE SUBGRADE CONDITIONS

The "Manual" stipulates subgrade soils requiring expansive subgrade mitigation should be addressed in the pavement design. The soils encountered at the site exhibited Plasticity Indices (PI) ranging from non-plastic to 13. These soils are considered to exhibit low to moderate plasticity. Swell-consolidation tests were conducted to determine expansion potential under a surcharge load of 200 pounds per square foot (psf). These test results exhibited compression of 1.1 to 2.1% and an expansion potential of 0.9% (see Appendix A). The compression in Test Boring Nos. 7 and 11 is likely due to disturbance of the samples during transport to our laboratory as the samples classified as silty sand. In addition, based on the blow counts from these samples exhibited medium dense to dense relative density. The subgrade in the area of Test Boring No. 8 may need to be prepared per Section 13.1 and will need to pass a proof-roll observation. Based on our sampling and laboratory testing, expansive subgrade mitigation is not required.

9.0 SUBGRADE SUPPORT

The pavement subgrade support strength of soils is based on the resilient modulus (M_R). The resilient modulus is a measure of the elastic property of soil, which is dependent upon moisture content, density, and the applied stress level. Based on our laboratory test results, most of the soils encountered classified as A-6 (5) and better. These soils are considered to provide better subgrade support characteristics than the A-7-6 (7) soils from Test Boring No. 1 (0-5') of the referenced study. The A-7-6 (7) soils from this boring were tested for Standard Proctor and resilient modulus. The resilient modulus testing was performed on a sample remolded to at least 95% of Standard Proctor (ASTM D698) maximum dry density at approximately 2% above optimum moisture content (see Appendix C). The test results exhibited a resilient modulus of 7,953 psi. Based on the soil classification of these test borings, we find it acceptable to utilize the subgrade support data from the referenced study.

10.0 TRAFFIC CONSIDERATIONS

Based on the "Manual" and the plans, the roadways at the site classify as local residential (urban) roadways. The site contains 108 residential units with two entries (Rowena Way and Henzlee Place). Four other access points are located on the north portion of the site but are expected to be local streets. The "Manual" stipulates a default Equivalent Single Axle Load (ESALs (18-kip)) value of 292,000 for urban local roadways based on a 20-year design period. We found this value to be high for local residential roadways but was used in the pavement design based on the traffic load values provided on Table D-2 of the "Manual". The following table summarizes the traffic design criteria.

Roadway Classification	**ESALs**	**Reliability (%)**	**Serviceability Index**
Local Residential (Urban)	292,000	80	2.0

11.0 PAVEMENT THICKNESS RECOMMENDATIONS

The pavement thickness recommendations were calculated using the 1993 AASHTO Pavement Design, DARWin Pavement Design and Analysis System computer program. Based on the design criteria referenced above and the calculations from Figure B-1 (see Appendix B), the recommended pavement thicknesses are provided in the table below and on Figure 1A. These pavement sections exceed the minimum pavement thicknesses provided on Table D-2 of the "Manual".

Roadway Classification	Alternate	ACS (in.)	ABC (in.)	Total (in.)
Local Residential (Urban) (ESAL = 292,000; M_R = 7,953 psi)	A	3.75	8.0	11.75

ACS – Asphalt Concrete Surface
ABC – Aggregate Base Course

As indicated above, an asphalt thickness of 3.75 inches is presented, however, we suggest the Client considers increasing the asphalt thickness to 4.0 inches to reduce future maintenance costs. Proper and timely maintenance will be required during the lifetime of the pavement in order to reach the designed service life. Pavement maintenance recommendations are provided in the Section 14.0.

12.0 GENERAL DISCUSSION

We understand several municipalities in the region allow "vertical" residential construction prior to the completion of the designed pavement structure (i.e., after placement of the bottom lift of asphalt). Our experience indicates construction traffic during the buildout phase often exceeds the anticipated daily traffic volume on residential streets. Pavement distress may occur on incomplete pavement structures as a result of construction traffic. It is our recommendation to consider full placement of the designed pavement structure prior to vertical residential construction. In addition, bottom lift only paving allows accumulation of water since the drainage structures cannot be effectively utilized. This could result in wetting of the subgrade soils and may result in weakening of the pavement structure.

13.0 DRAINAGE CONSIDERATIONS

Long-term pavement performance is aided by proper drainage. Surface drainage is necessary for water to drain into the proper collection system instead of fully infiltrating into the subgrade soils below the pavement structure. If the pavement is not properly drained, the soils below the pavement structure may become saturated, and the subgrade will lose strength, ultimately affecting the performance of the pavement layers above (generally from imposed traffic loads). A drain system may aid pavement performance near irrigated areas. Excessive irrigation could negatively impact the pavement structure. In addition, xeriscaping the landscaped areas is recommended.

14.0 CONSTRUCTION RECOMMENDATIONS

The following recommendations are intended as a guideline and not as replacement to the jurisdictional standards and specifications. Ultimately, it shall be the responsibility of the Contractor to abide by the standards and specifications stipulated in the "Manual".

14.1 Subgrade

Prior to paving operations, the subgrade must be prepared in a manner that allows for adequate pavement support. The entire subgrade should be proof-rolled with a loaded 988 front-end loader or similar heavy rubber-tired vehicle (GVW of 50,000 pounds with 18-kip per axle at tire pressures of 90 pounds per square inch (psi)) to detect any soft or loose areas. All areas exhibiting unstable subgrade conditions such as loose soils, pumping, or excessive movement, should be overexcavated to a firm soil layer or to a maximum depth of 2 feet, whichever is shallowest, and replaced with suitable compacted fill. If unstable subgrade conditions persist, AGW should be contacted for our opinion. The subgrade should only be prepared when ambient conditions are such that they will not impede the Contractor from achieving the required density and moisture content. Frozen soil should never be used as subgrade fill.

If no unstable areas are observed during the proof-roll or after removal and replacement of unsuitable soils, the entire subgrade may be prepared by windrowing, tilling or by removing at least 12 inches of subgrade from proposed pavement subgrade elevation. If necessary, add or reduce moisture to the required moisture content. The subgrade fill should be placed in maximum 8-inch loose lifts and compacted to at least 95% of Standard Proctor (ASTM D698) maximum dry density at optimum to +3.0% of optimum moisture content for compaction of A-6 to A-7-6 soils. The fill should be compacted to at least 95% of Modified Proctor (ASTM D1557) maximum dry density at −2.0% to +2.0% of optimum moisture content for compaction of other soils. If additional fill is required to reach the pavement subgrade elevation, the fill should have a soil classification similar to or better than the poorest soils encountered during this study. The subgrade should be free of organics, vegetation, large rocks, or any other deleterious materials. The pavement subgrade should be crowned to the appropriate grade lines. Additional compactive effort should be applied along edged concrete structures such as curbs and crosspans.

14.2 Aggregate Base Course

The aggregate base course (ABC) should consist of aggregate which meets particular specifications for gradation, plasticity, abrasion wear, and strength. We recommend the use of a material meeting CDOT "Class 6" specifications and having an R-value equal to or exceeding 78. The ABC should be tested to determine compliance with these specifications prior to use. If the material used does not meet the required specifications, then the thickness calculations and recommendations should be revised. The ABC should be placed in loose lifts not exceeding 8 inches and should be compacted to a minimum of 95% of Modified Proctor maximum dry density (ASTM D1557). Aggregate thicknesses exceeding 8 inches should be placed and compacted in two separate lifts. The ABC should not be placed when weather conditions impede achievement of the required compaction.

14.3 Asphalt Concrete Surface

Asphalt material should conform to an agency approved mix design that states the SHRP Gyratory design properties (i.e., maximum density, optimum asphalt content, job mix formula, recommended mixing and placing temperatures, etc.). We recommend that the aggregate used in the asphalt meet Colorado Department of Transportation "Grading S", "Grading SX", "Grading SG", or equivalent regulatory aggregate specifications. If the material does not meet or exceed these specifications, the asphalt thickness should be revised. The asphalt material should be placed in lifts a minimum of three times the aggregate size and should be compacted to 92 to 96% of Theoretical Maximum Specific Gravity for Super Pave Mixes. Longitudinal joints should be compacted to 88 to 96% of Theoretical Maximum Specific Gravity. Materials standards and specifications per the "Manual" are required. Asphalt binder selection should be appropriate for each roadway classification. The paving contractor is responsible for mix submittal to the agency.

Asphalt concrete should not be placed when weather conditions are such that the materials cannot be properly placed or compacted. The asphalt concrete should be placed on a prepared surface, graded to the appropriate elevation. In no case should the asphalt concrete be placed on frozen subgrade or base. When applicable, a tack coat should be applied at joints, adjacent to curbs, gutters or crosspans. The Contractor is responsible for establishing rolling patterns to determine the amount of effort required to meet the compaction requirements. Field testing conducted by AGW will not relieve the Contractor from proper compaction and construction of the pavement.

15.0 PAVEMENT MAINTENANCE

Flexible pavement structures are typically designed for service periods of 20 years. However, timely and proper maintenance during the life of the pavement is essential to reach the designed service period and to possibly extend the serviceability of the pavement. We recommend implementing a maintenance program aimed at preserving the structural integrity of the pavement. The implementation of available maintenance operations varies depending upon pavement type and on-site conditions.

15.1 Flexible Pavements

Flexible pavements will exhibit some type of pavement distress during their service life. Periodic maintenance and rehabilitation should be anticipated in order to reach the anticipated design life. Typically, minor cracks may develop within the first three years. Crack sealant should be utilized immediately upon recognition of these cracks to reduce further deterioration and/or potential moisture induced damage. The use of crack sealants may extend the life of the pavement by two to five years before any other treatment is applied.

A variety of seal coats are available and can delay the need for a major surface structural treatment. However, careful engineering judgment should be utilized to determine the type of seal application that is most appropriate. Seal coats should not be applied on pavements with severe cracks, raveling or potholes. Fog seals typically have an estimated service life of approximately one to two years, but should only be utilized on structurally sound pavements. Slurry seals generally have a service life of four to seven years and are commonly utilized on pavements exhibiting no to low pavement distress. Chip seals aid in slowing surface oxidation, minor raveling, and sealing small cracks. Chip seals are considered to have a service life of approximately four to seven years.

Structural mill and overlay are a rehabilitation technique that generally occurs within eight to 12 years after initial construction. This technique should only be utilized on stable pavements with minor surface distress and a strong base. Conventional structural mill and overlay operations are known to have a service life of eight to 14 years.

16.0 LIMITATIONS

This pavement study was based upon laboratory testing of samples obtained at widely spaced locations. Variations in subsoil conditions could occur between sample locations. We should evaluate and test the subgrade and pavement materials during construction to determine that our recommendations have been properly interpreted. However, A. G. Wassenaar, Inc. 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. 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. The Owner should be aware that this study was prepared utilizing the "Manual" standards. Highly plastic and expansive soils pose a significant risk to pavement structures. This risk includes heave and cracking upon wetting. In addition, utility backfill settlement is a risk of development that can affect pavement performance. The Client is aware that isolated to more wide-spaced damage may occur. Longitudinal cracking parallel to the curb line may be indicative of an expansive subgrade becoming wetted. The only positive solution is removal of the subgrade materials to the depth of wetting and replacement or treatment. The "Manual" specifications do not require that the Client take these measures, but the Client should be aware that these measures are the only solution to dealing with highly plastic and expansive soils. As this is generally economically unfeasible, this design may be used as an attempt to provide a reasonable cost-effective pavement structure. The Owner assumes all liability for the performance of this pavement structure. We are available to discuss the risks associated with this design.

Sincerely,

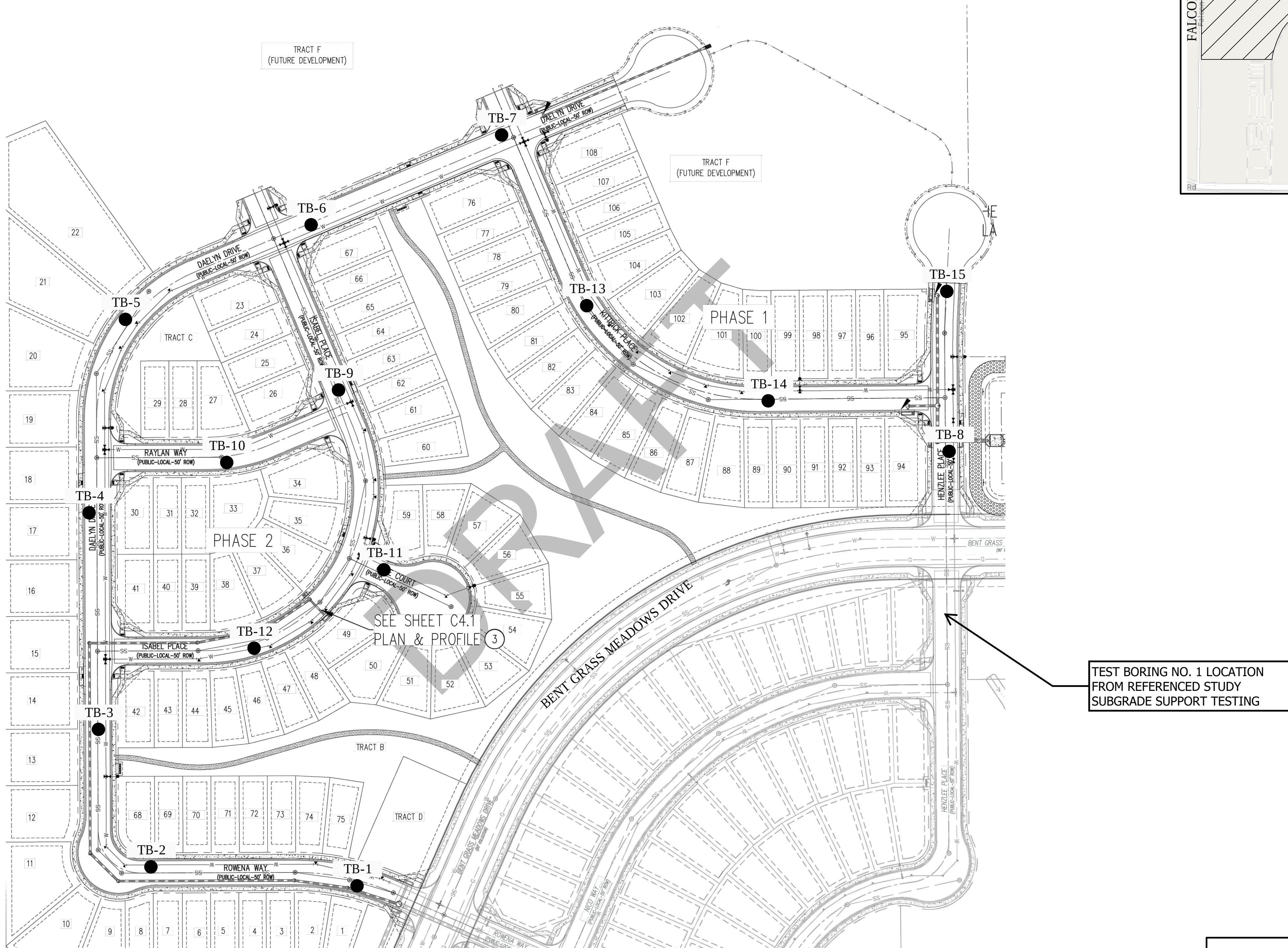
A. G. Wassenaar, Inc.

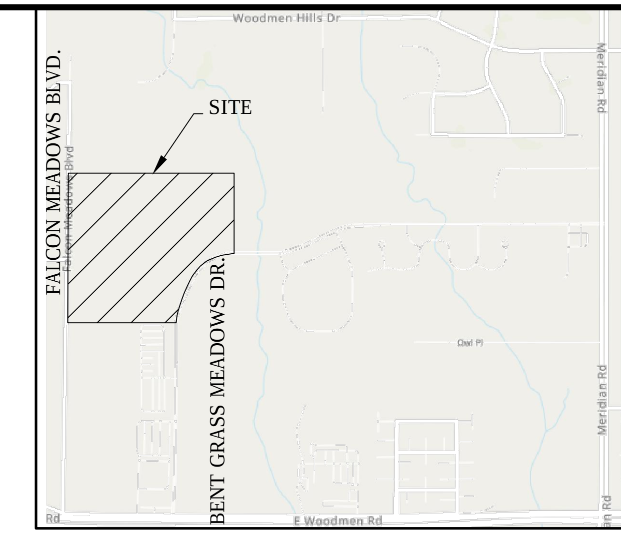
Pedro D. Manriquez, P.E.
Senior Engineer

PDM/pdm

FALCON MEADOWS AT BENT GRASS, FILING 2
FALCON, COLORADO

0 150 300
Scale in Feet
1 INCH = 150 FEET





VICINITY MAP
NOT TO SCALE

NOTES:

1. TEST BORINGS WERE OVERLAID ON THE "ROADWAY AND STORM SEWER CONSTRUCTION PLANS FALCON MEADOWS AT BENT GRASS FILING NO. 2", PROJECT NO. CLH000019. PREPARED BY GALLOWAY, DATED FEBRUARY 14, 2022.
2. ALL LOCATIONS ARE APPROXIMATE.

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SITE PLAN AND VICINITY MAP	PROJECT NO. 221950 P1 FIGURE 1

FALCON MEADOWS AT BENT GRASS, FILING 2
FALCON, COLORADO

0 150 300
Scale in Feet
1 INCH = 150 FEET

LOCAL RESIDENTIAL (URBAN)
(ESAL = 292,000; M_R = 7,953 psi)

ALT	ACS (IN)	ABC (IN)	TOTAL (IN)
A	3.75	8.0	11.75

ACS - ASPHALT CONCRETE SURFACE
ABC - AGGREGATE BASE COURSE

NOTES:

1. TEST BORINGS WERE OVERLAID ON THE "ROADWAY AND STORM SEWER CONSTRUCTION PLANS FALCON MEADOWS AT BENT GRASS FILING NO. 2", PROJECT NO. CLH000019. PREPARED BY GALLOWAY, DATED FEBRUARY 14, 2022.
2. ALL LOCATIONS ARE APPROXIMATE.

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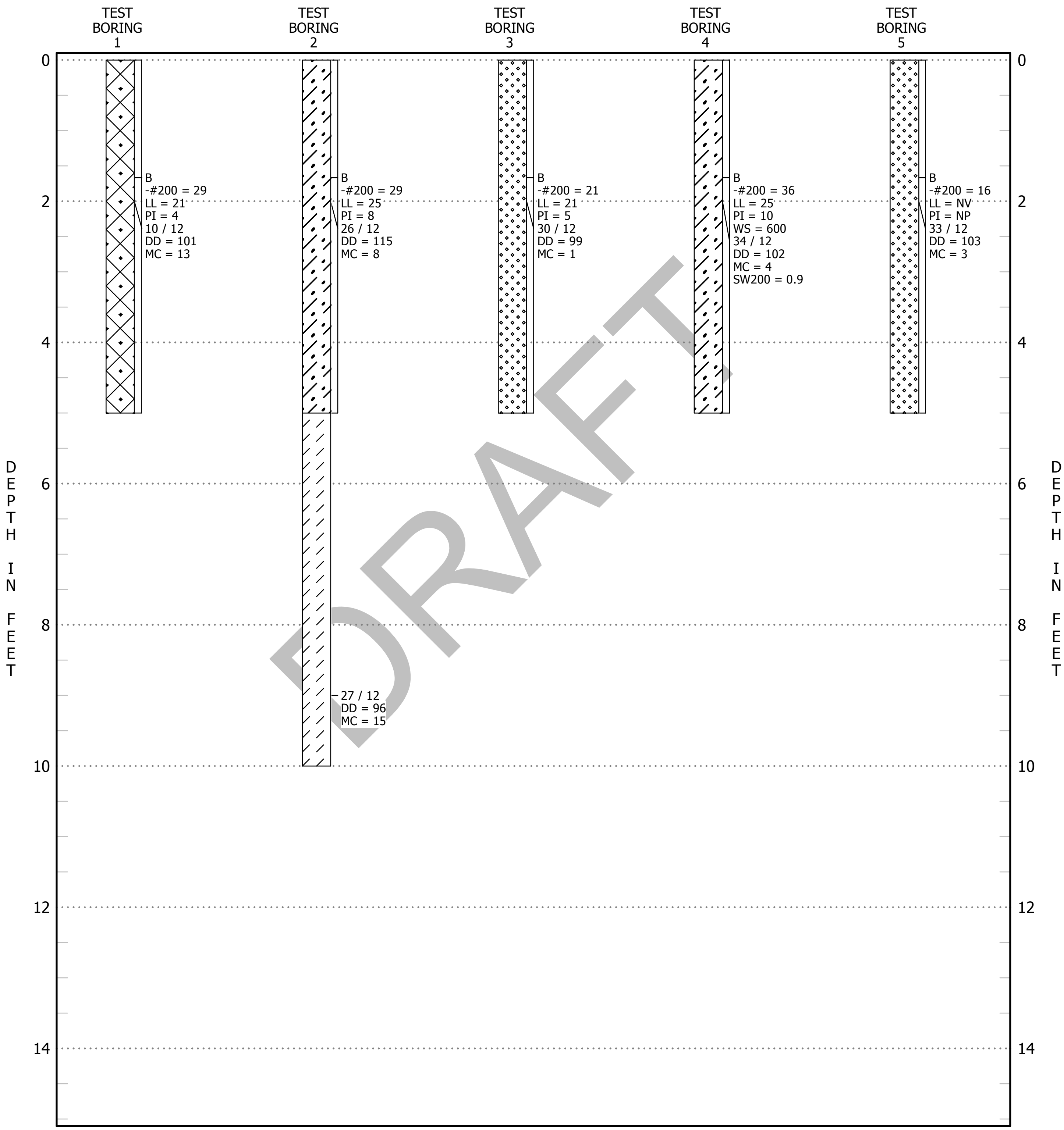
PAVEMENT THICKNESS RECOMMENDATIONS	PROJECT NO. 221950 P1 FIGURE 1A

A.G. WASSENAAR, INC.

CLIENT Challenger Homes **PROJECT NAME** Falcon Meadows At Bent Grass Filing 2

PROJECT NUMBER 221950 P1 **PROJECT LOCATION** Falcon, Colorado



SEE FIGURE 5 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 2

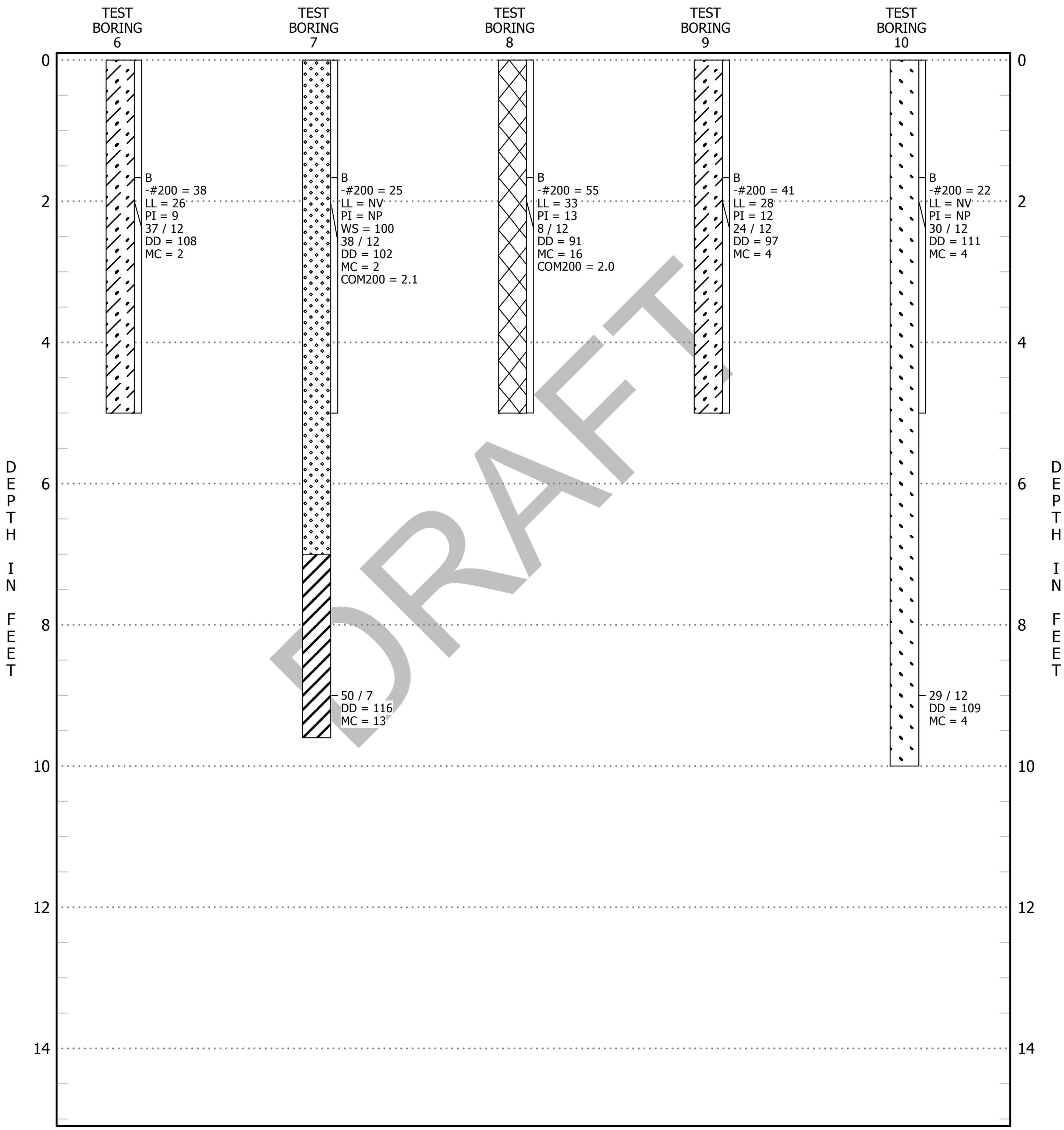
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Falcon Meadows At Bent Grass Filing 2

PROJECT NUMBER 221950 P1

PROJECT LOCATION Falcon, Colorado



SEE FIGURE 5 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 3

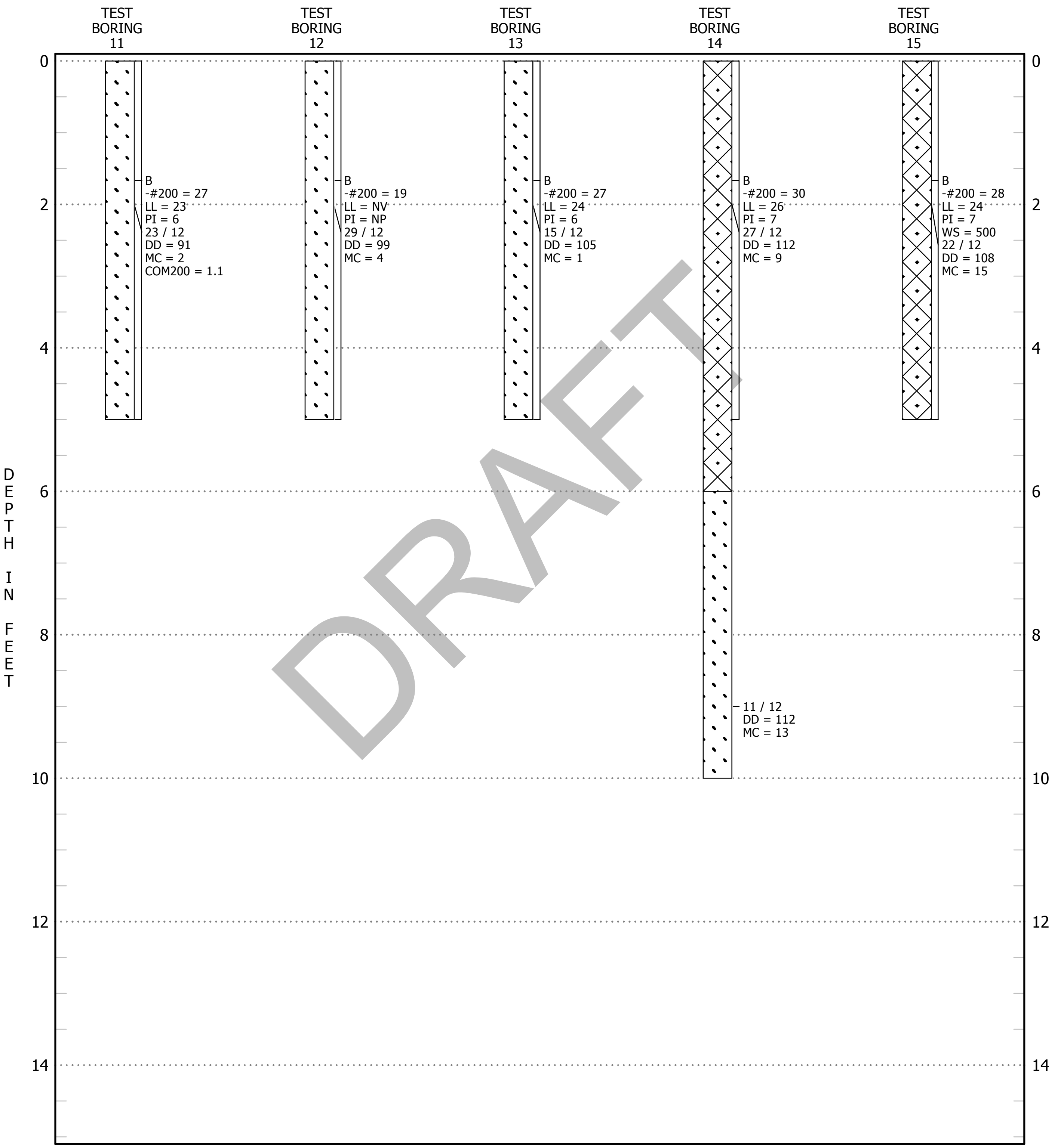
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Falcon Meadows At Bent Grass Filing 2

PROJECT NUMBER 221950 P1

PROJECT LOCATION Falcon, Colorado



SEE FIGURE 5 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 4

CLIENT Challenger Homes

PROJECT NUMBER 221950 P1

PROJECT NAME Falcon Meadows At Bent Grass Filing 2

PROJECT LOCATION Falcon, Colorado

SOIL DESCRIPTIONS

- Fill, clay, stiff to very stiff, silty, sandy
- Fill, sand, medium dense, silty, clayey
- Clay, stiff to very stiff
- Sand, medium dense, silty
- Sand, medium dense, silty, clayey
- Sand, dense to very dense, silty
- Claystone (Bedrock), 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 (%)
SW200	Percent swell under a surcharge of 200 pounds per square foot (psf) upon wetting (%)
COM200	Percent compression under a surcharge of 200 pounds per square foot (psf) upon wetting (%)
-#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
	Depth at which practical drilling refusal was encountered
	Water level at time of drilling
	Water level
	Caved depth

Notes:

1. Test borings were drilled May 2, 2022 .
2. Location of the test borings were measured by pacing from features shown on the site plan.
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 not provided.
5. Boring logs shown in this report are subject to the limitations, explanations, and conclusions of this report.

LEGEND AND NOTES

FIGURE 5

APPENDIX A
LABORATORY TEST RESULTS

A.G. WASSENAAR, INC.

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
June 13, 2022; Revised June 24, 2022

Project Number 221950-P1
Falcon Meadows at Bent Grass, Filing 2
El Paso County, Colorado

Test Boring Number	Depth (feet)	Soil Type	AASHTO Soil Classification	Dry Density (pcf)	Moisture (%)	Swell / Consolidation (-) (%) [1]	% Passing #200 Sieve	Atterberg Limits			Water Soluble Sulfates (ppm)
								Liquid Limit	Plastic Limit	Plasticity Index	
1	0-5	Fill, sand, silty/clayey	A-2-4(0)				29	21	17	4	
1	2	Fill, sand, silty/clayey		101	13						
2	0-5	Sand, clayey	A-2-4(0)				29	25	17	8	
2	2	Sand, clayey		115	8						
2	9	Clay, sandy		96	15						
3	0-5	Sand, silty/clayey, slightly gravelly	A-1-b(0)				21	21	16	5	
3	2	Sand, silty/clayey, slightly gravelly		99	1						
4	0-5	Sand, very clayey	A-4(0)				36	25	15	10	600
4	2	Sand, very clayey		102	4	0.9					
5	0-5	Sand, silty	A-1-b(0)				16	NV	0	NP	
5	2	Sand, silty		103	3						
6	0-5	Sand, very clayey, slightly gravelly	A-4(0)				38	26	17	9	
6	2	Sand, very clayey, slightly gravelly		108	2						
7	0-5	Sand, silty	A-2-4(0)				25	NV	0	NP	100
7	2	Sand, silty		102	2	-2.1					
7	9	Claystone, sandy		116	13						
8	0-5	Fill, clay, very sandy	A-6(5)				55	33	20	13	
8	2	Fill, clay, very sandy		91	16	-2.0					
9	0-5	Sand, very clayey	A-6(1)				41	28	16	12	
9	2	Sand, very clayey		97	4						
10	0-5	Sand, silty, slightly gravelly	A-1-b(0)				22	NV	0	NP	
10	2	Sand, silty, slightly gravelly		111	4						
10	9	Sand, silty, slightly gravelly		109	4						

Notes:
[1] Indicates Percent Swell or Consolidation (–) when wetted under a 200 psf load, unless otherwise noted.

NV - indicates No Value
NP - indicates Non-Plastic

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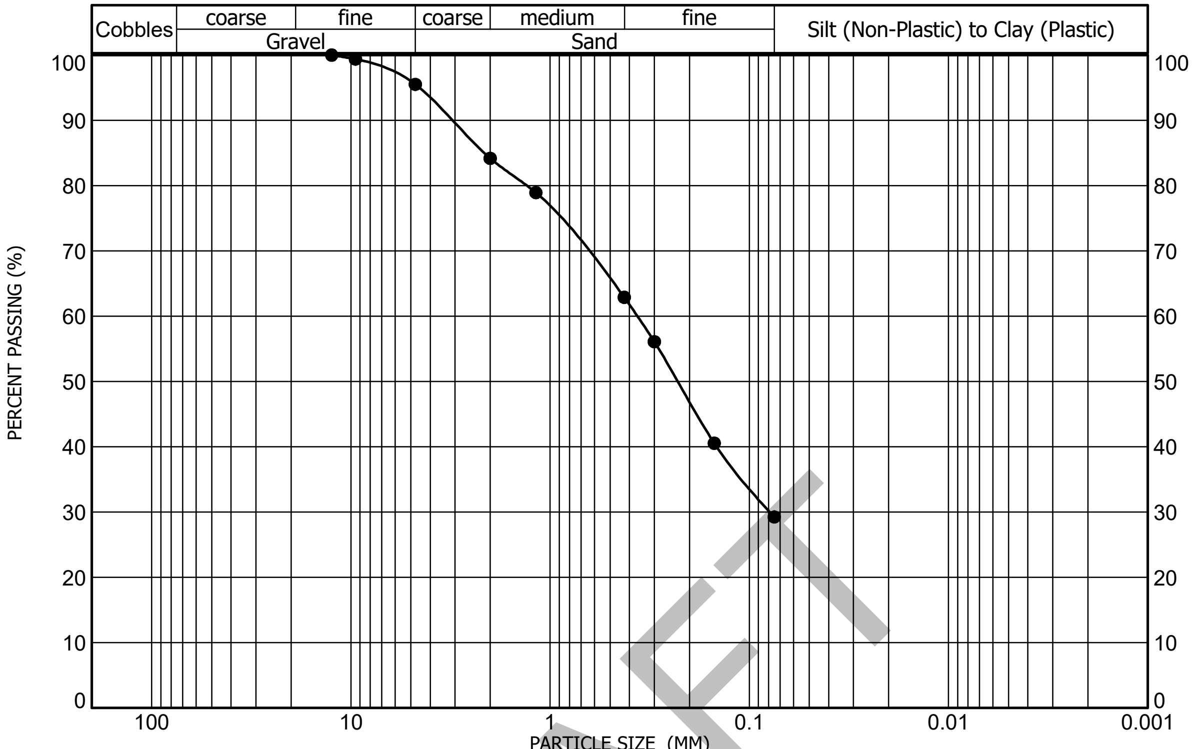
TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
June 13, 2022; Revised June 24, 2022

Test Boring Number	Depth (feet)	Soil Type	AASHTO Soil Classification	Dry Density (pcf)	Moisture (%)	Swell / Consolidation (-) (%) [1]	% Passing #200 Sieve	Atterberg Limits: Liquid Limit	Atterberg Limits: Plastic Limit	Atterberg Limits: Plasticity Index	Water Soluble Sulfates (ppm)
11	0-5	Sand, silty/clayey, slightly gravelly	A-2-4(0)				27	23	17	6	
11	2	Sand, silty/clayey, slightly gravelly		91	2	-1.1					
12	0-5	Sand, silty	A-1-b(0)				19	NV	0	NP	
12	2	Sand, silty		99	4						
13	0-5	Sand, silty/clayey, slightly gravelly	A-2-4(0)				27	24	18	6	
13	2	Sand, silty/clayey, slightly gravelly		105	1						
14	0-5	Fill, sand, silty/clayey	A-2-4(0)				30	26	19	7	
14	2	Fill, sand, silty/clayey		112	9						
14	9	Sand, silty/clayey		112	13						
15	0-5	Fill, sand, silty/clayey	A-2-4(0)				28	24	17	7	500
15	2	Fill, sand, silty/clayey		108	15						

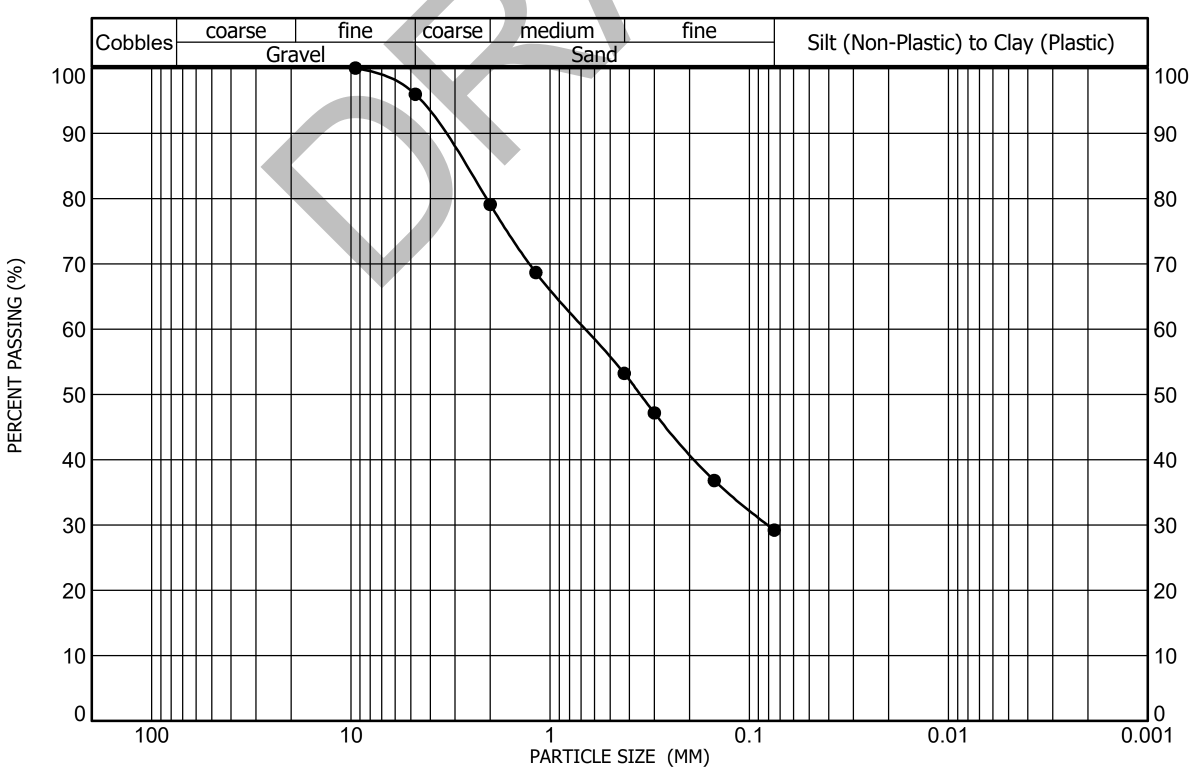
Notes:
[1] Indicates Percent Swell or Consolidation (–) when wetted under a 200 psf load, unless otherwise noted.

NV - indicates No Value
NP - indicates Non-Plastic

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 1 at a depth of 0 feet to 5 feet
Sample Description: Fill, sand, silty/clayey
Classification: A-2-4(0), SILTY, CLAYEY SAND(SC-SM)
Gravel (%): 4
Sand (%): 66
Clay/Silt (%): 29
Liquid Limit: 21
Plasticity Index: 4



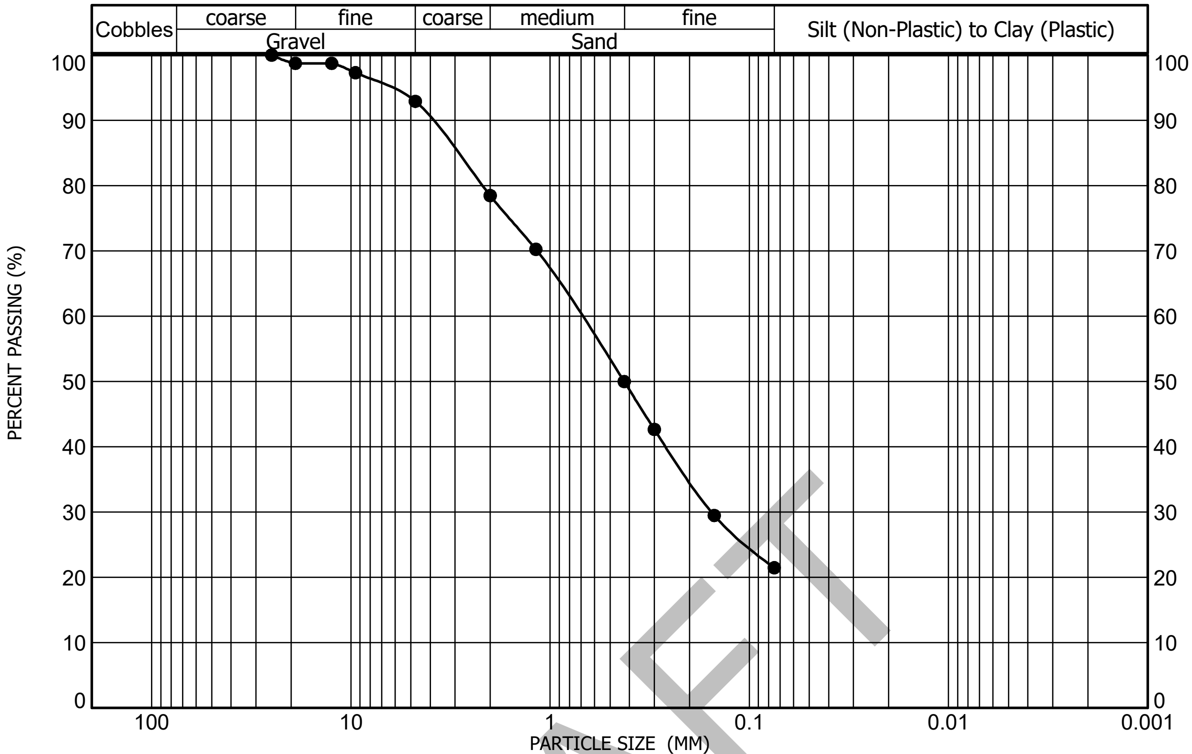
Sample Location: Test Boring No. 2 at a depth of 0 feet to 5 feet
Sample Description: Sand, clayey
Classification: A-2-4(0), CLAYEY SAND(SC)
Gravel (%): 4
Sand (%): 67
Clay/Silt (%): 29
Liquid Limit: 25
Plasticity Index: 8

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-1

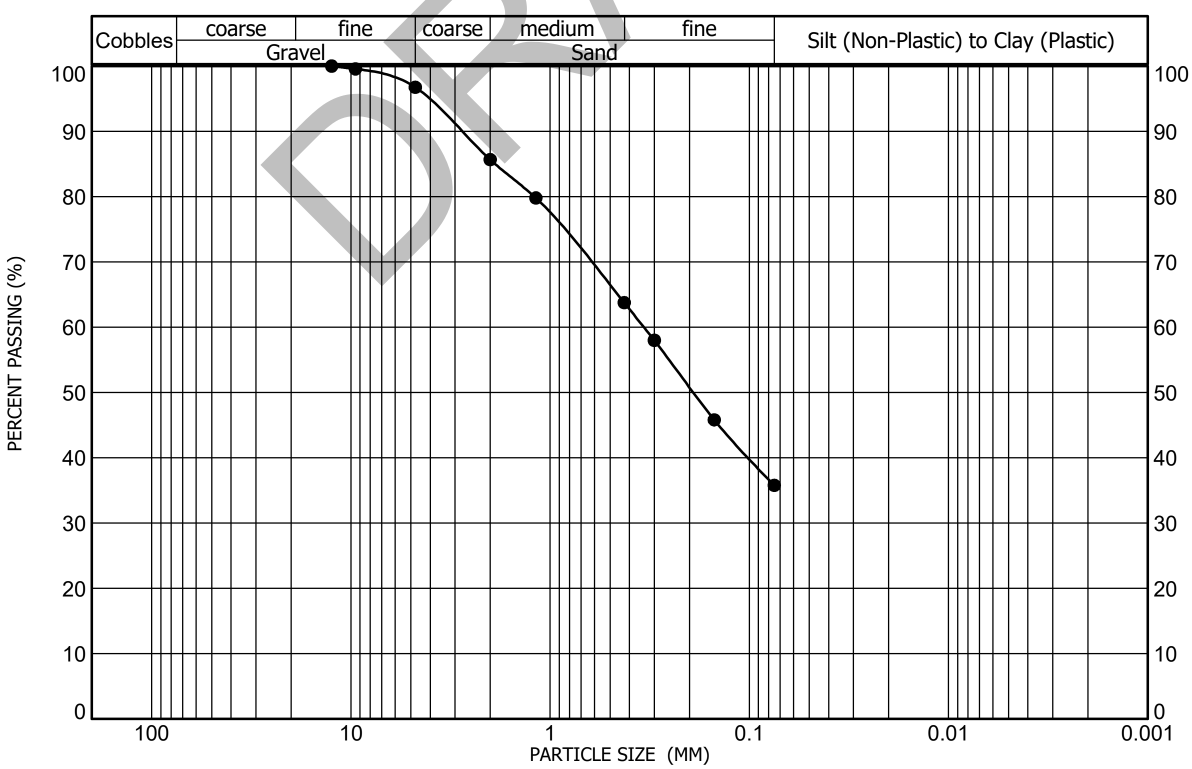
PROJECT NO. 221950 P1

A.G. WASSENAAR, INC.



Sample Location Test Boring No. 3 at a depth of 0 feet to 5 feet
Sample Description Sand, silty/clayey, slightly gravelly
Classification A-1-b(0), SILTY, CLAYEY SAND(SC-SM)

Gravel (%) 7
Sand (%) 71
Clay/Silt (%) 21
Liquid Limit 21
Plasticity Index 5



Sample Location Test Boring No. 4 at a depth of 0 feet to 5 feet
Sample Description Sand, very clayey
Classification A-4(0), CLAYEY SAND(SC)

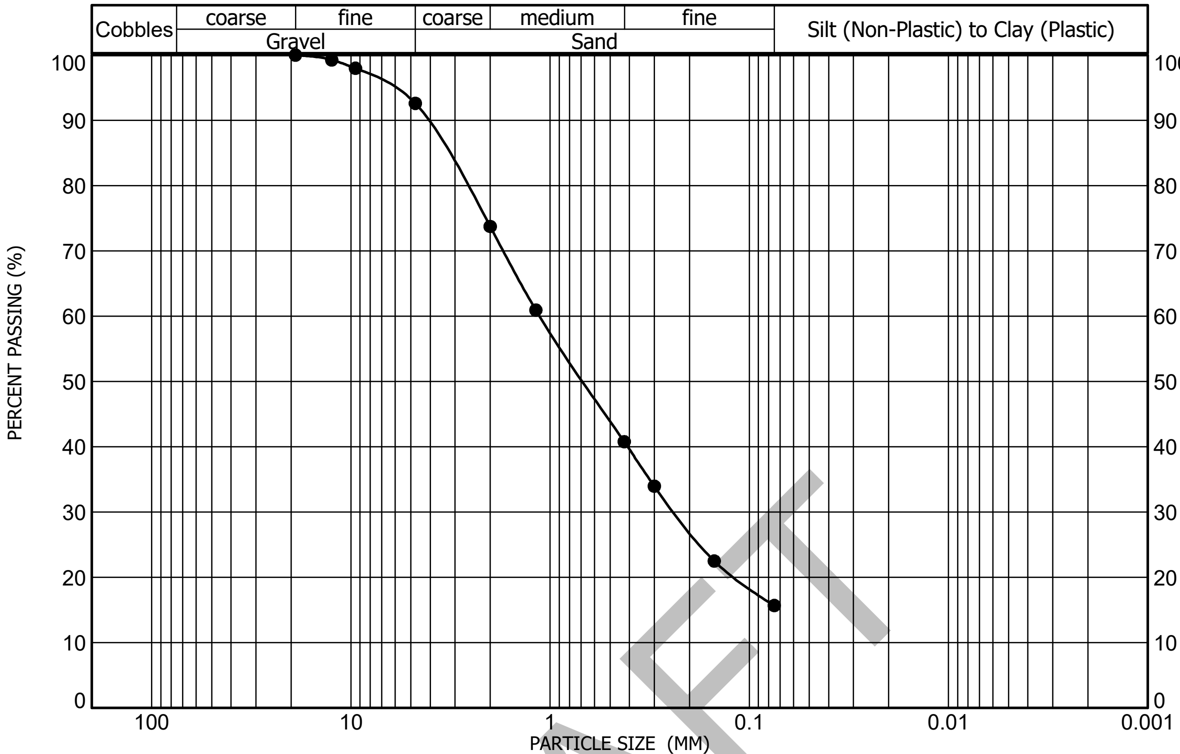
Gravel (%) 3
Sand (%) 61
Clay/Silt (%) 36
Liquid Limit 25
Plasticity Index 10

GRADATION AND ATTERBERG TEST RESULTS

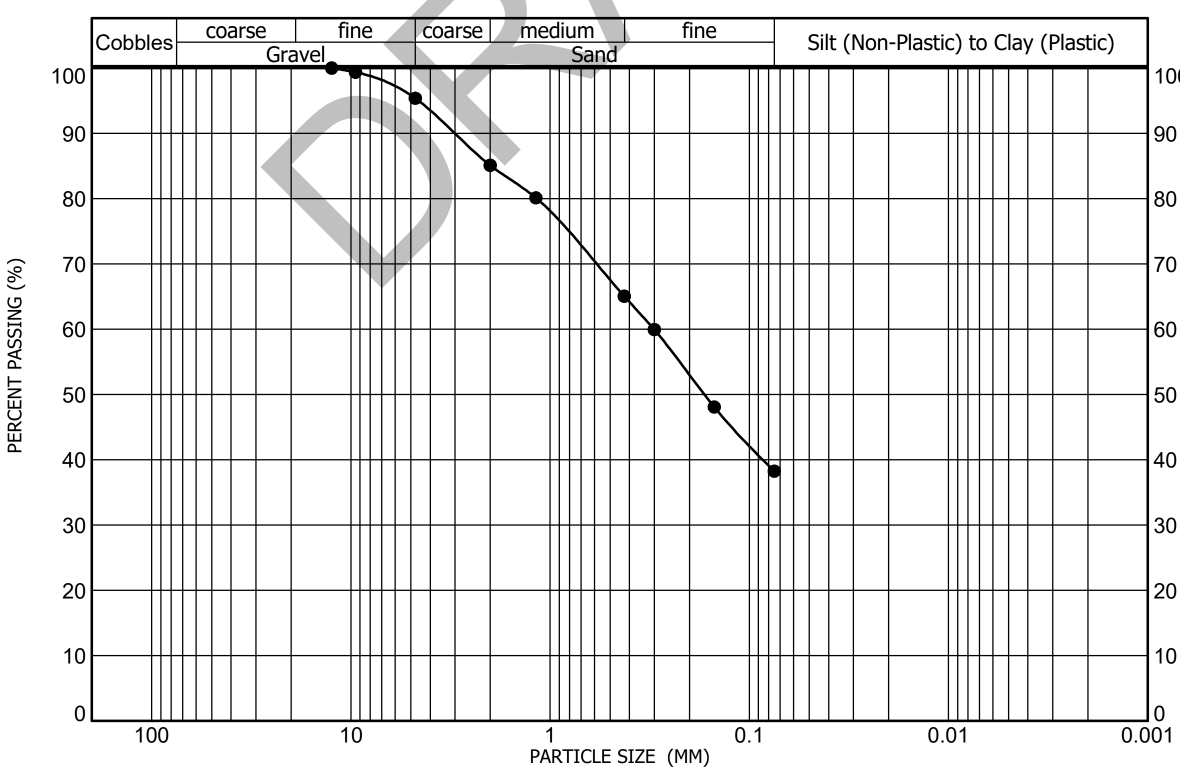
FIGURE A-2

PROJECT NO. 221950 P1

A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 5 at a depth of 0 feet to 5 feet	Gravel (%) 7	Liquid Limit NV
Sample Description	Sand, silty	Sand (%) 77	Plasticity Index NP
Classification	A-1-b(0), SILTY SAND(SM)	Clay/Silt (%) 16	



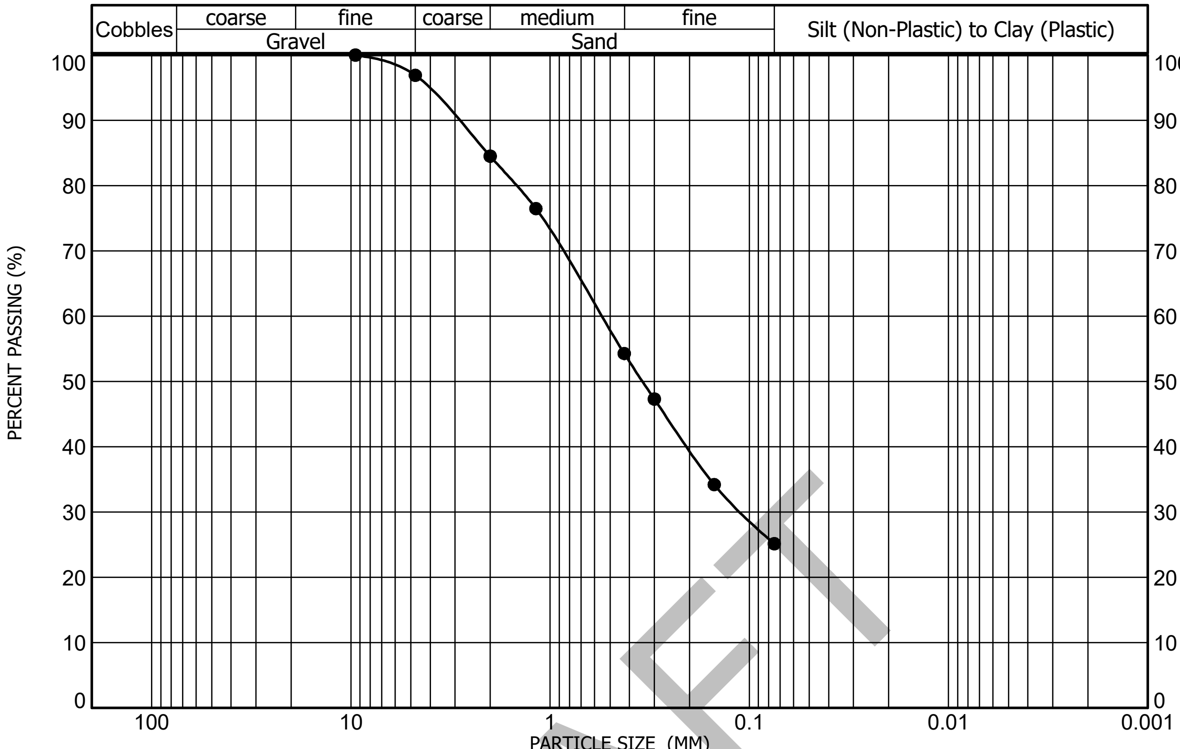
Sample Location	Test Boring No. 6 at a depth of 0 feet to 5 feet	Gravel (%) 5	Liquid Limit 26
Sample Description	Sand, very clayey, slightly gravelly	Sand (%) 57	Plasticity Index 9
Classification	A-4(0), CLAYEY SAND(SC)	Clay/Silt (%) 38	

GRADATION AND ATTERBERG TEST RESULTS

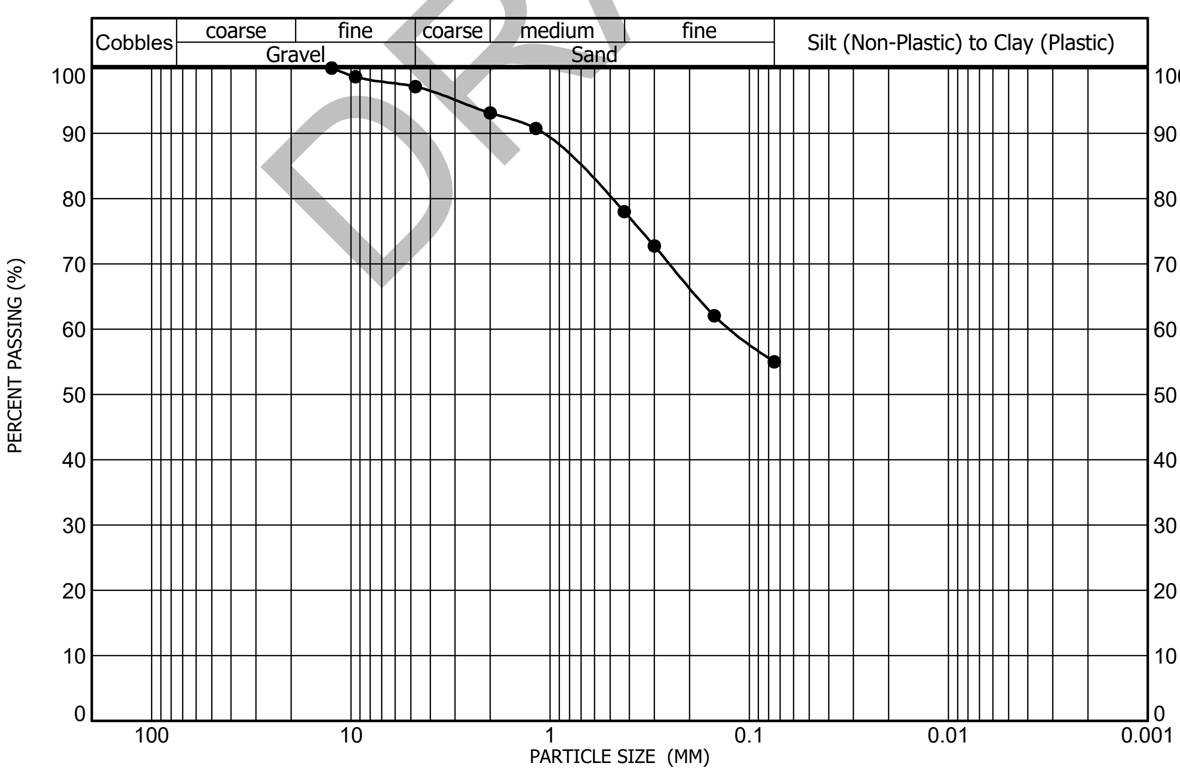
FIGURE A-3

PROJECT NO. 221950 P1

AGW
A.G. WASSENAAR, INC.



Sample Location	Test Boring No. 7 at a depth of 0 feet to 5 feet	Gravel (%) 3	Liquid Limit NV
Sample Description	Sand, silty	Sand (%) 72	Plasticity Index NP
Classification	A-2-4(0), SILTY SAND(SM)	Clay/Silt (%) 25	



Sample Location	Test Boring No. 8 at a depth of 0 feet to 5 feet	Gravel (%) 3	Liquid Limit 33
Sample Description	Fill, clay, very sandy	Sand (%) 42	Plasticity Index 13
Classification	A-6(5), SANDY LEAN CLAY(CL)	Clay/Silt (%) 55	

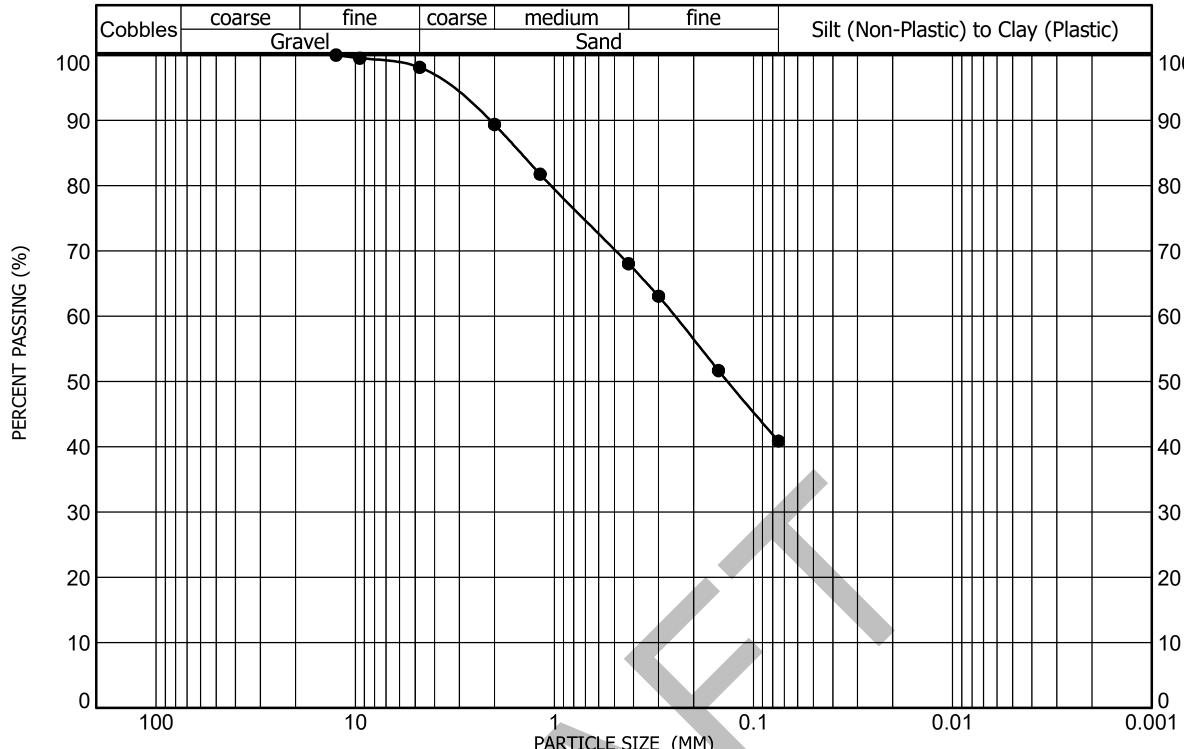
GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-4

PROJECT NO. 221950 P1

AGW

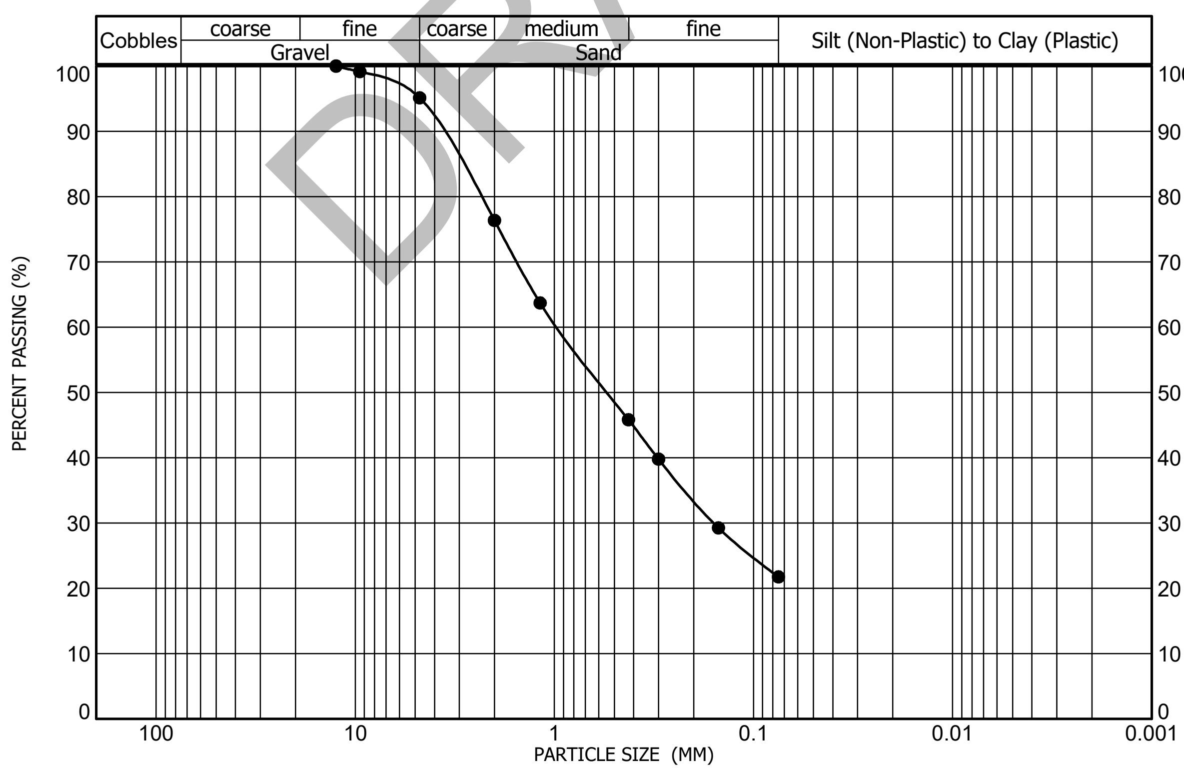
A.G. WASSENAAR, INC.



Sample Location Test Boring No. 9 at a depth of 0 feet to 5 feet Gravel (%) 2 Liquid Limit 28

Sample Description Sand, very clayey Sand (%) 57 Plasticity Index 12

Classification A-6(1), CLAYEY SAND(SC) Clay/Silt (%) 41



Sample Location Test Boring No. 10 at a depth of 0 feet to 5 feet Gravel (%) 5 Liquid Limit NV

Sample Description Sand, silty, slightly gravelly Sand (%) 73 Plasticity Index NP

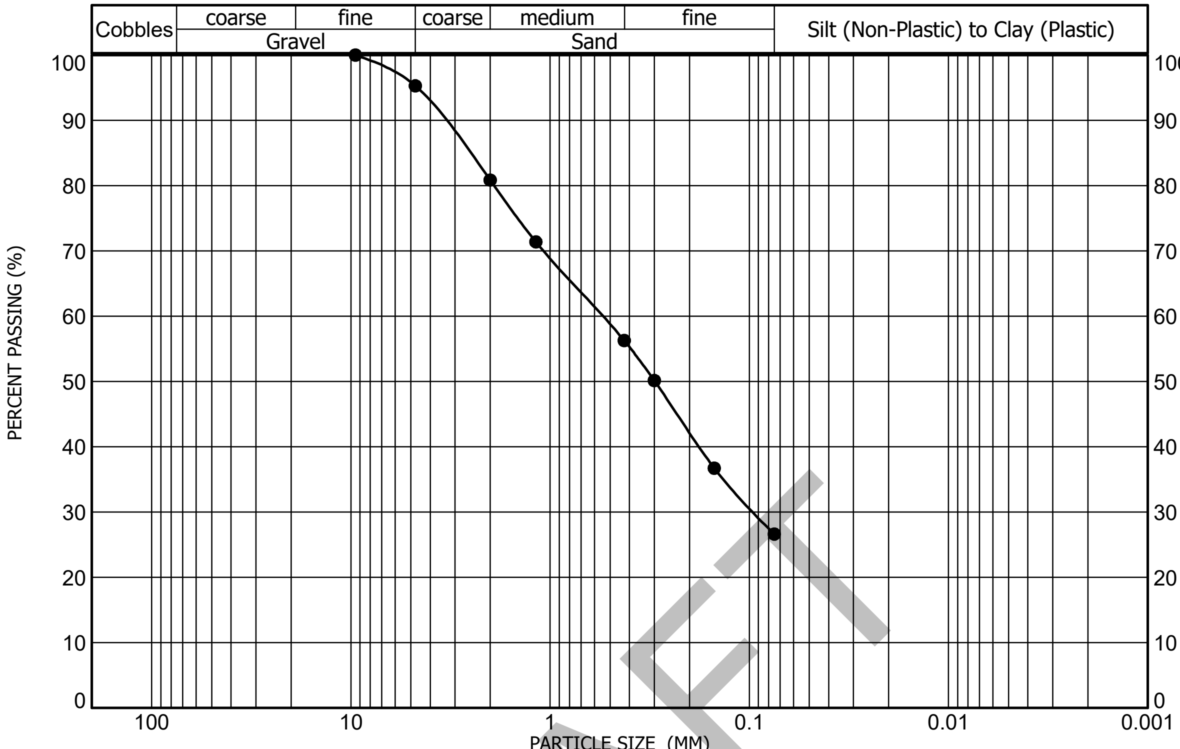
Classification A-1-b(0), SILTY SAND(SM) Clay/Silt (%) 22

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-5

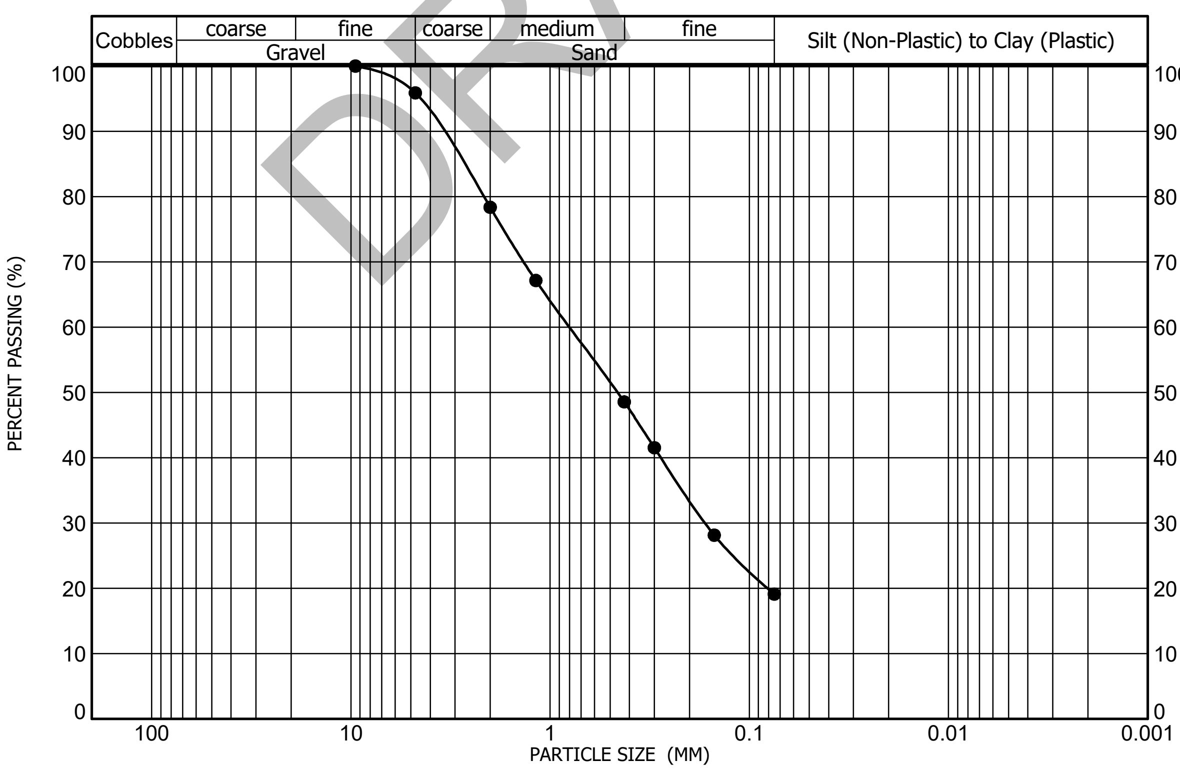
PROJECT NO. 221950 P1

A.G. WASSENAAR, INC.



Sample Location: Test Boring No. 11 at a depth of 0 feet to 5 feet
Sample Description: Sand, silty/clayey, slightly gravelly
Classification: A-2-4(0), SILTY, CLAYEY SAND(SC-SM)

Gravel (%): 5
Sand (%): 69
Clay/Silt (%): 27
Liquid Limit: 23
Plasticity Index: 6



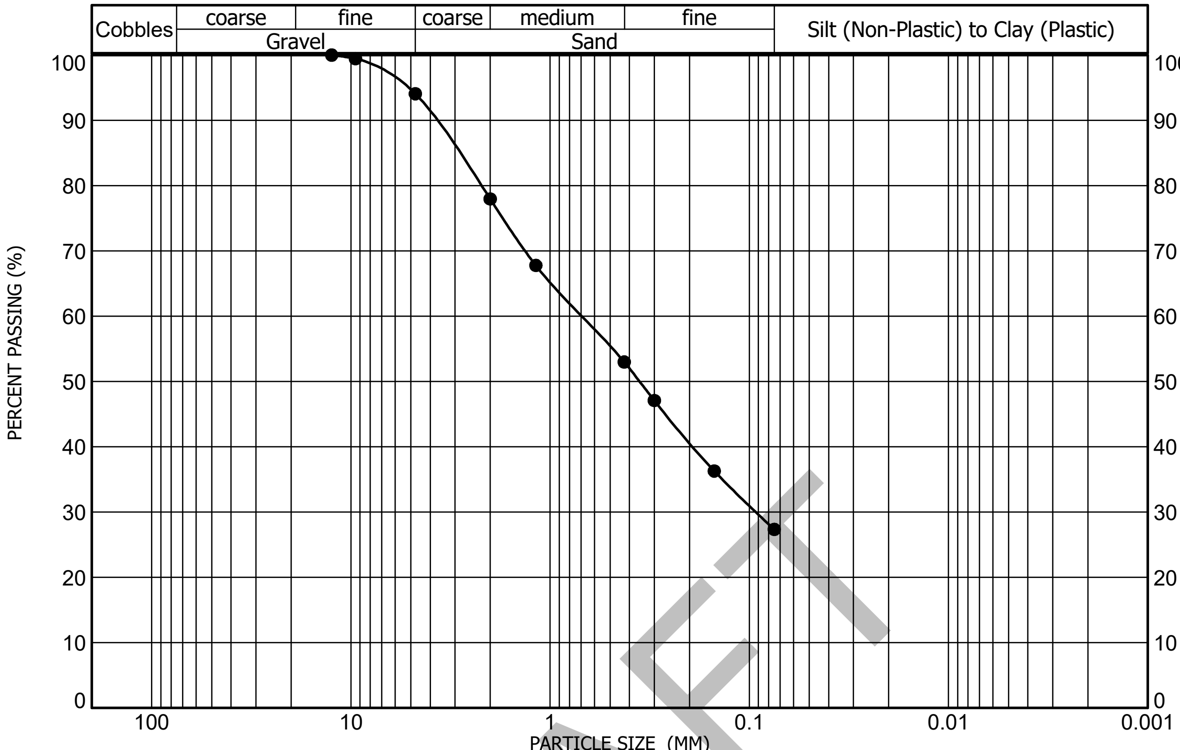
Sample Location: Test Boring No. 12 at a depth of 0 feet to 5 feet
Sample Description: Sand, silty
Classification: A-1-b(0), SILTY SAND(SM)

Gravel (%): 4
Sand (%): 77
Clay/Silt (%): 19
Liquid Limit: NV
Plasticity Index: NP

GRADATION AND ATTERBERG TEST RESULTS

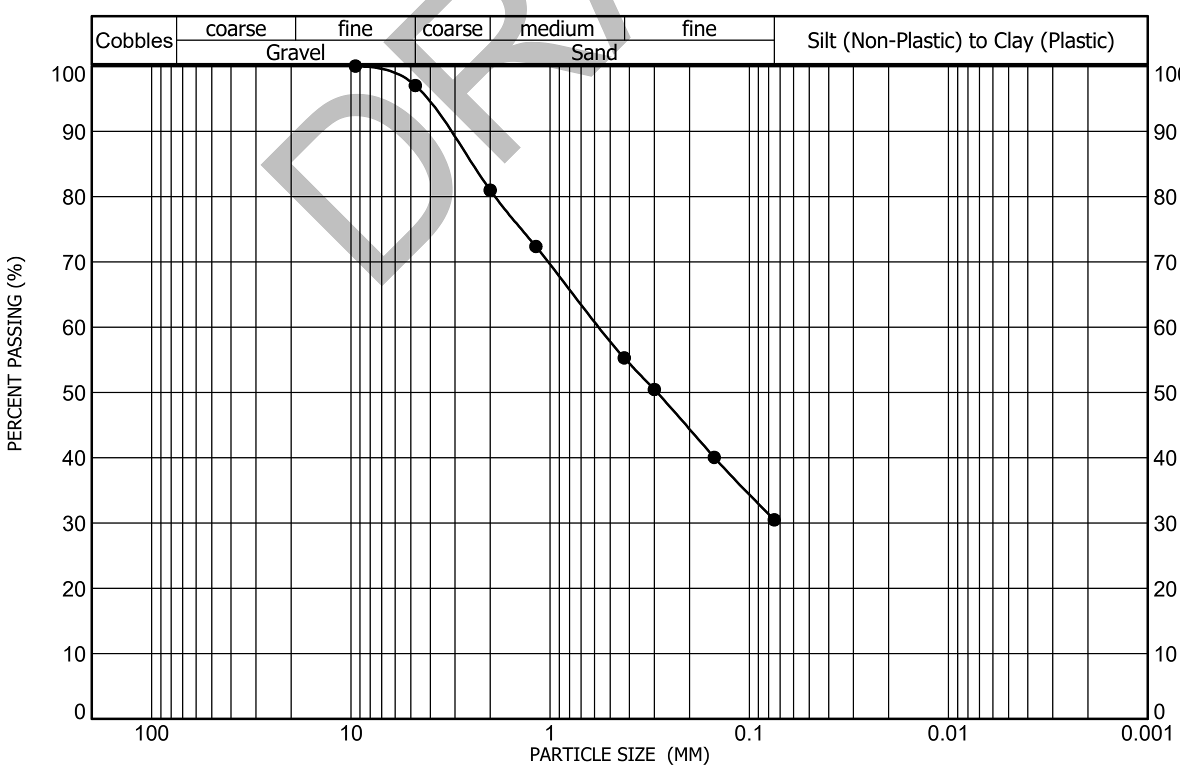
FIGURE A-6

PROJECT NO. 221950 P1



Sample Location: Test Boring No. 13 at a depth of 0 feet to 5 feet
Sample Description: Sand, silty/clayey, slightly gravelly
Classification: A-2-4(0), SILTY, CLAYEY SAND(SC-SM)

Gravel (%): 6
Sand (%): 67
Clay/Silt (%): 27
Liquid Limit: 24
Plasticity Index: 6



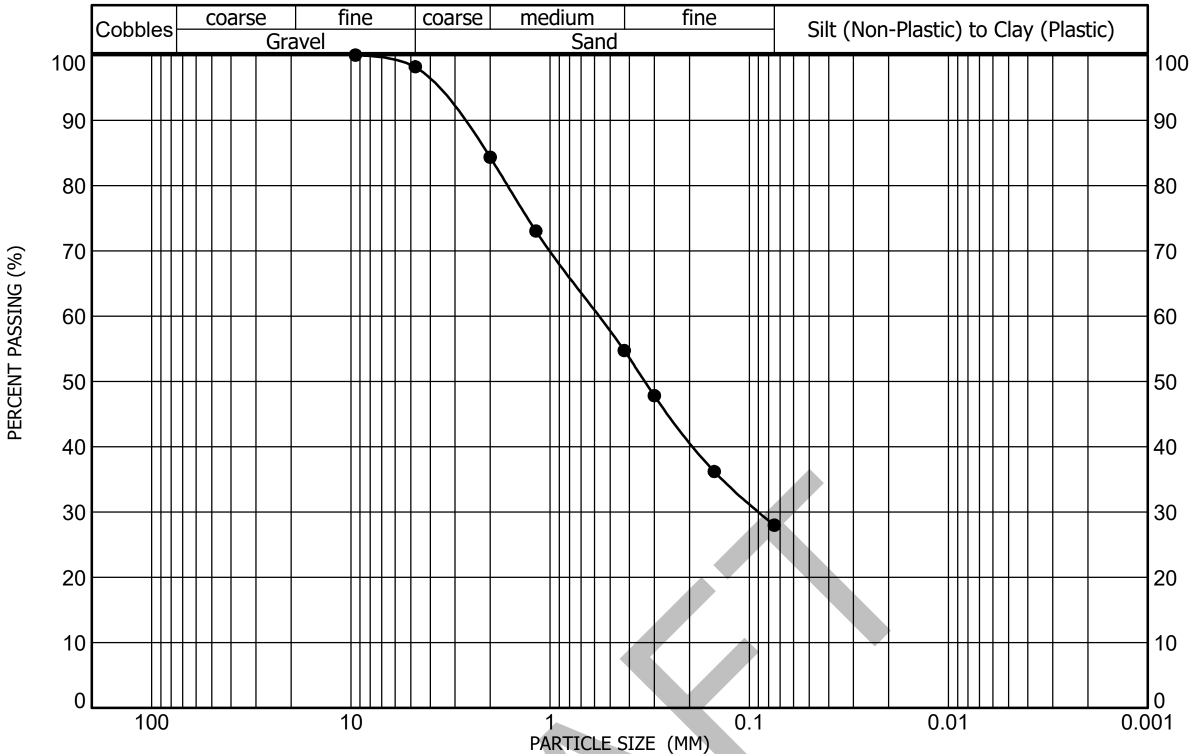
Sample Location: Test Boring No. 14 at a depth of 0 feet to 5 feet
Sample Description: Fill, sand, silty/clayey
Classification: A-2-4(0), SILTY, CLAYEY SAND(SC-SM)

Gravel (%): 3
Sand (%): 67
Clay/Silt (%): 30
Liquid Limit: 26
Plasticity Index: 7

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-7

PROJECT NO. 221950 P1



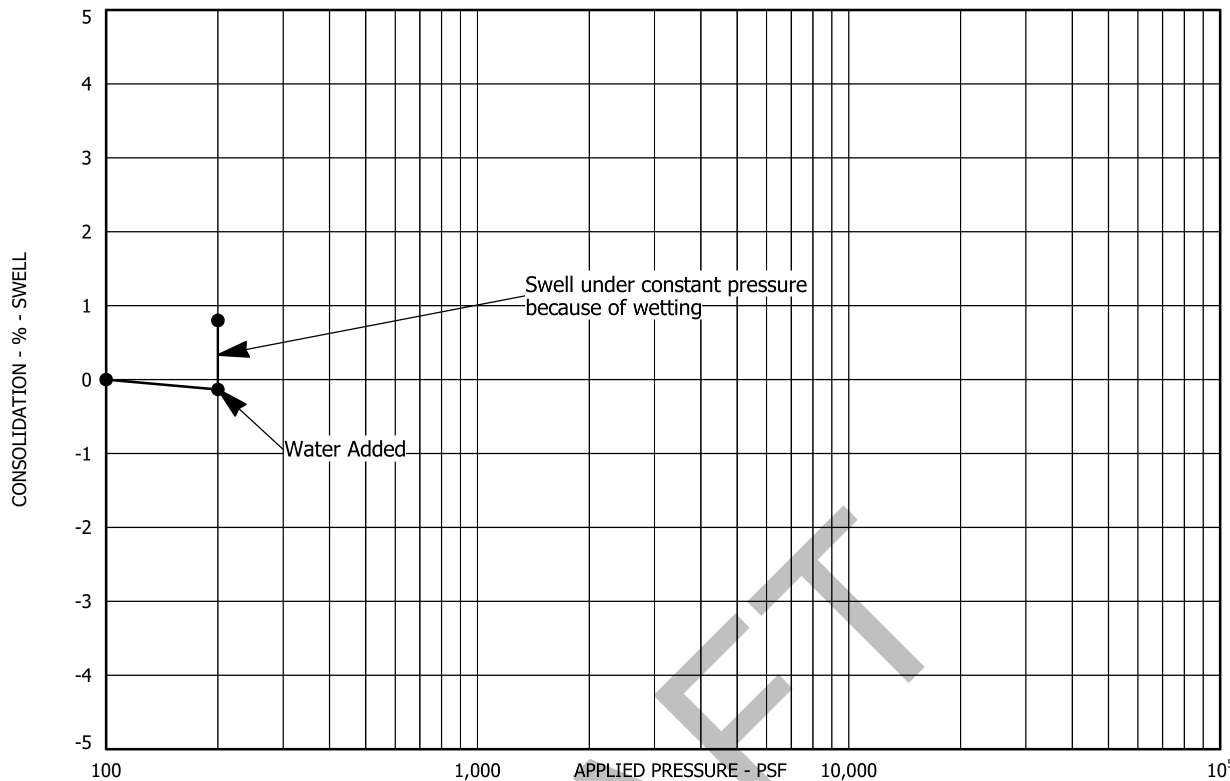
Sample Location	Test Boring No. 15 at a depth of 0 feet to 5 feet	Gravel (%)	2	Liquid Limit	24
Sample Description	Fill, sand, silty/clayey	Sand (%)	70	Plasticity Index	7
Classification	A-2-4(0), SILTY, CLAYEY SAND(SC-SM)	Clay/Silt (%)	28		

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-8

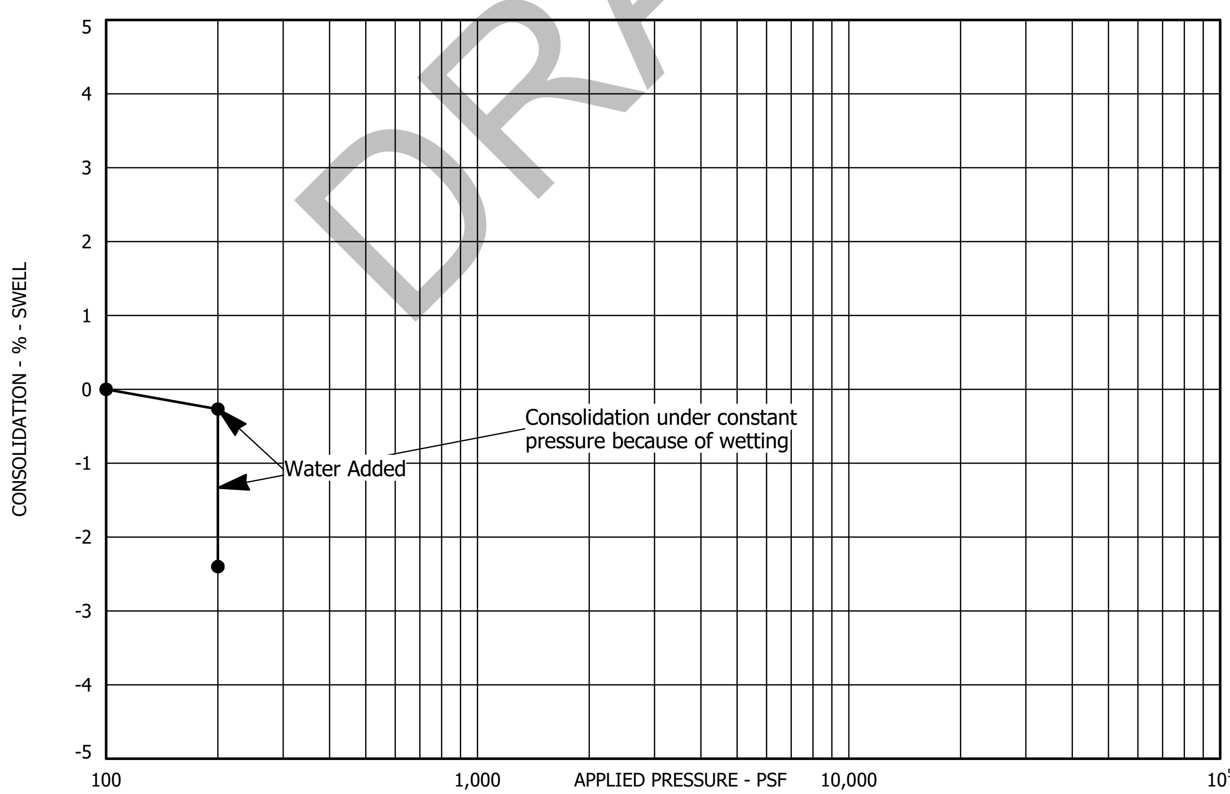
AGW

A.G. WASSENAAR, INC.



Sample Location Test Boring No. 4 at a depth of 2 feet Dry Unit Weight (pcf) 102

Sample Description Sand, very clayey Moisture Content (%) 4



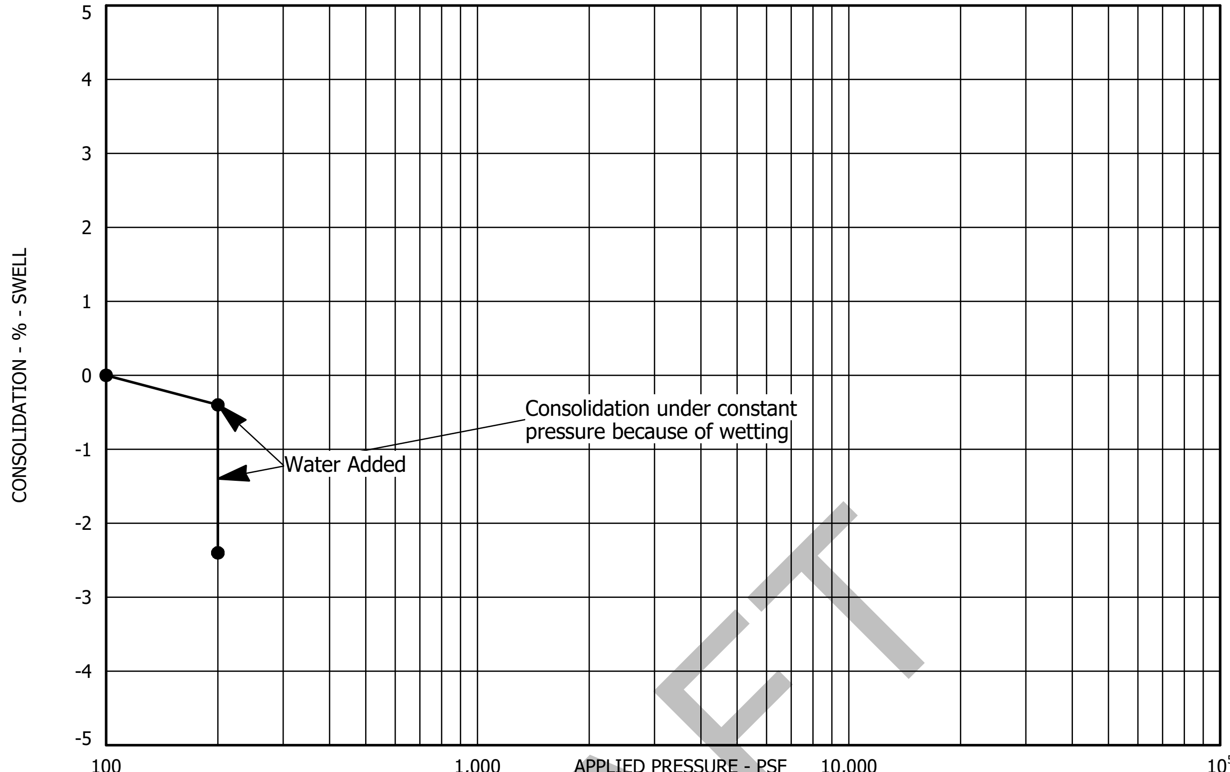
Sample Location Test Boring No. 7 at a depth of 2 feet Dry Unit Weight (pcf) 102

Sample Description Sand, silty Moisture Content (%) 2

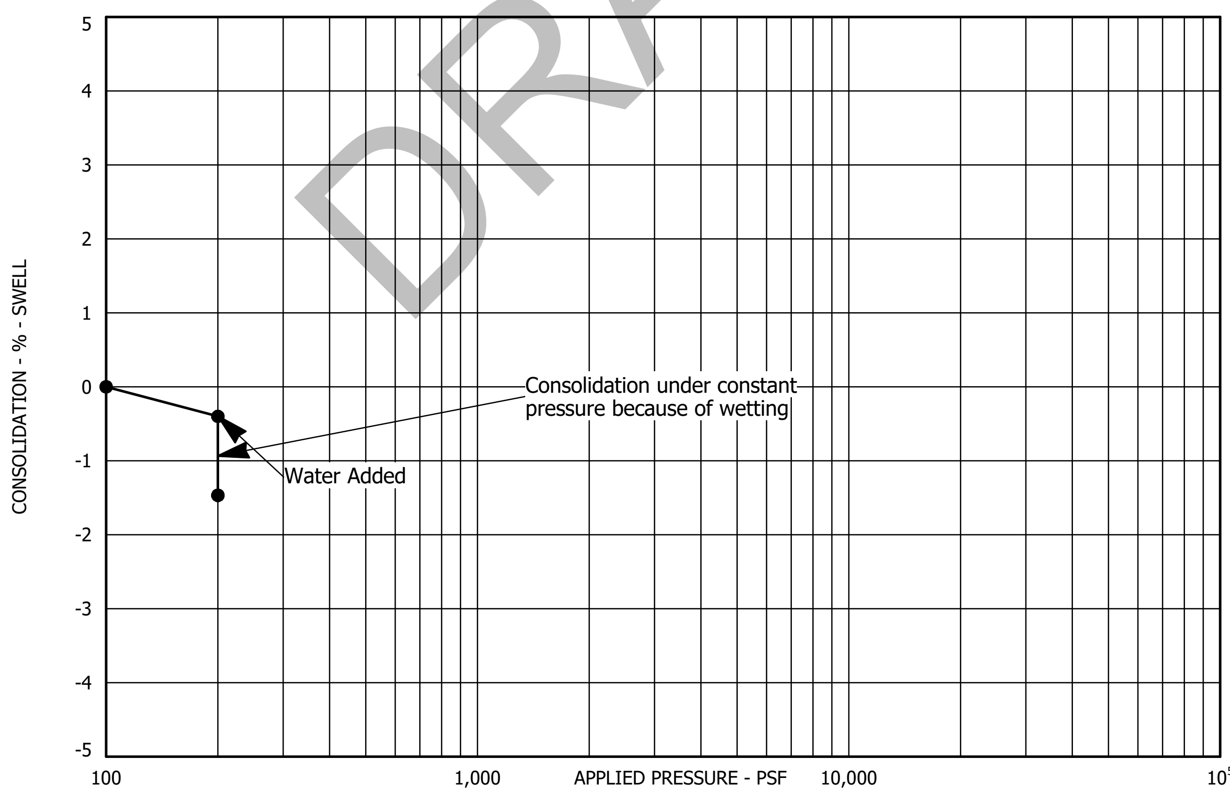
SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-9

PROJECT NO. 221950 P1



Sample Location: Test Boring No. 8 at a depth of 2 feet
Sample Description: Fill, clay, very sandy
Dry Unit Weight (pcf): 91
Moisture Content (%): 16



Sample Location: Test Boring No. 11 at a depth of 2 feet
Sample Description: Sand, silty/clayey, slightly gravelly
Dry Unit Weight (pcf): 91
Moisture Content (%): 2

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-10

PROJECT NO. 221950 P1

APPENDIX B
PAVEMENT THICKNESS CALCULATIONS

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

A. G. Wassenaar, Inc.

Flexible Structural Design Module

Local Residential (Urban)
Falcon Meadows at Bent Grass, Filing 2
El Paso County, Colorado
Project Number 221950-P1

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	292,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	7,953 psi
Stage Construction	1
Calculated Design Structural Number	2.48 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Bituminous Pavement	0.44	1	3.75	-	1.65
2	Aggregate Base Course	0.11	1	8	-	0.88
Total	-	-	-	11.75	-	2.53

APPENDIX C

LABORATORY DATA FROM
"PAVEMENT STUDY FOR
FALCON MEADOWS AT BENT GRASS, FILING NO. 1
EL PASO COUNTY, COLORADO"

PREPARED BY AGW
PROJECT NUMBER 214061-P1
DATED SEPTEMBER 15, 2021

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
September 15, 2021

Test Boring Number	Depth (feet)	Soil Type	AASHTO Soil Classification	Dry Density (pcf)	Moisture (%)	Swell / Consolidation (-) (%) [1]	% Passing #200 Sieve	Atterberg Limits			Water Soluble Sulfates (ppm)
								Liquid Limit	Plastic Limit	Plasticity Index	
1	0-5	Fill, sand, very clayey	A-7-6(7)				48	42	18	24	
1	2	Fill, sand, very clayey		123	7						
2	0-5	Fill, sand, very clayey	A-6(3)				50	32	20	12	2,100
2	2	Fill, sand, very clayey		109	14	0.8					
2	9	Sand, clayey		108	18						
3	0-5	Sand, very clayey	A-4(0)				39	26	18	8	
3	2-5	Sand, silty/clayey	A-2-4(0)				31	24	18	6	
3	2.1	Sand, silty/clayey		113	3						
4	0-5	Fill, clay, very sandy	A-6(7)				58	36	19	17	1,900
4	2	Fill, clay, very sandy		110	16	1.6					
5	0-5	Fill, clay, very sandy	A-6(7)				62	35	20	15	
5	2	Fill, clay, very sandy		106	14	1.9					
6	0-2	Fill, sand, very clayey	A-4(0)				36	28	19	9	
6	2-5	Sand, very clayey	A-2-4(0)				33	25	16	9	
6	2.1	Sand, very clayey		119	3						
6	9	Sand, very clayey		112	4						
7	0-5	Fill, sand, very clayey, slightly gravelly	A-6(1)				41	27	16	11	600
7	2	Sand, very clayey, slightly gravelly		125	10						
8	0-5	Sand, silty/clayey	A-2-4(0)				28	23	19	4	
8	2	Sand, silty/clayey		102	4						

Notes:
[1] Indicates Percent Swell or Consolidation (–) when wetted under a 200 psf load, unless otherwise noted.

NV - indicates No Value
NP - indicates Non-Plastic

MOISTURE-DENSITY RELATIONSHIP

AGW
A.G. WASSENAAR, INC.

CLIENT Challenger Homes
PROJECT NAME Falcon Meadows at Bent Grass, Filing 1
PROJECT NUMBER 214061 P2
PROJECT LOCATION El Paso County, Colorado

TEST RESULTS

Maximum Dry Density	**111.9**	**PCF**
Optimum Water Content	**14.7**	**%**

Sample Location	Test Boring No. 1 at a depth of 0 feet to 5 feet
Sample Source	
AGW Description	Fill, sand, very clayey
USCS Classification	CLAYEY SAND(SC)
AASHTO Classification	A-7-6(7)
Test Method	D698A

Gravel (%)	2
Sand (%)	50
Silt/Clay (%)	48
Liquid Limit	42
Plasticity Index	24

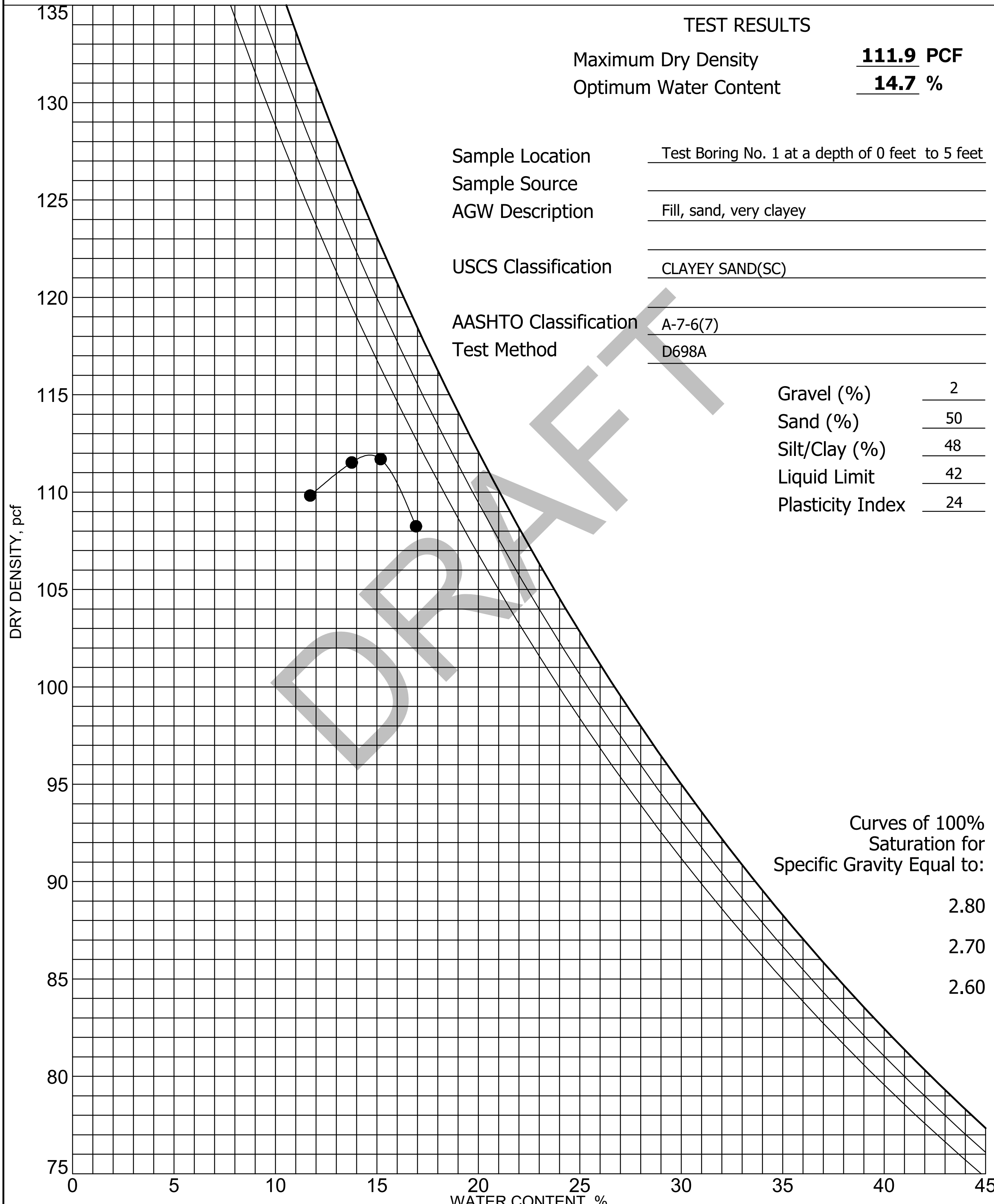


FIGURE A-8

AGW

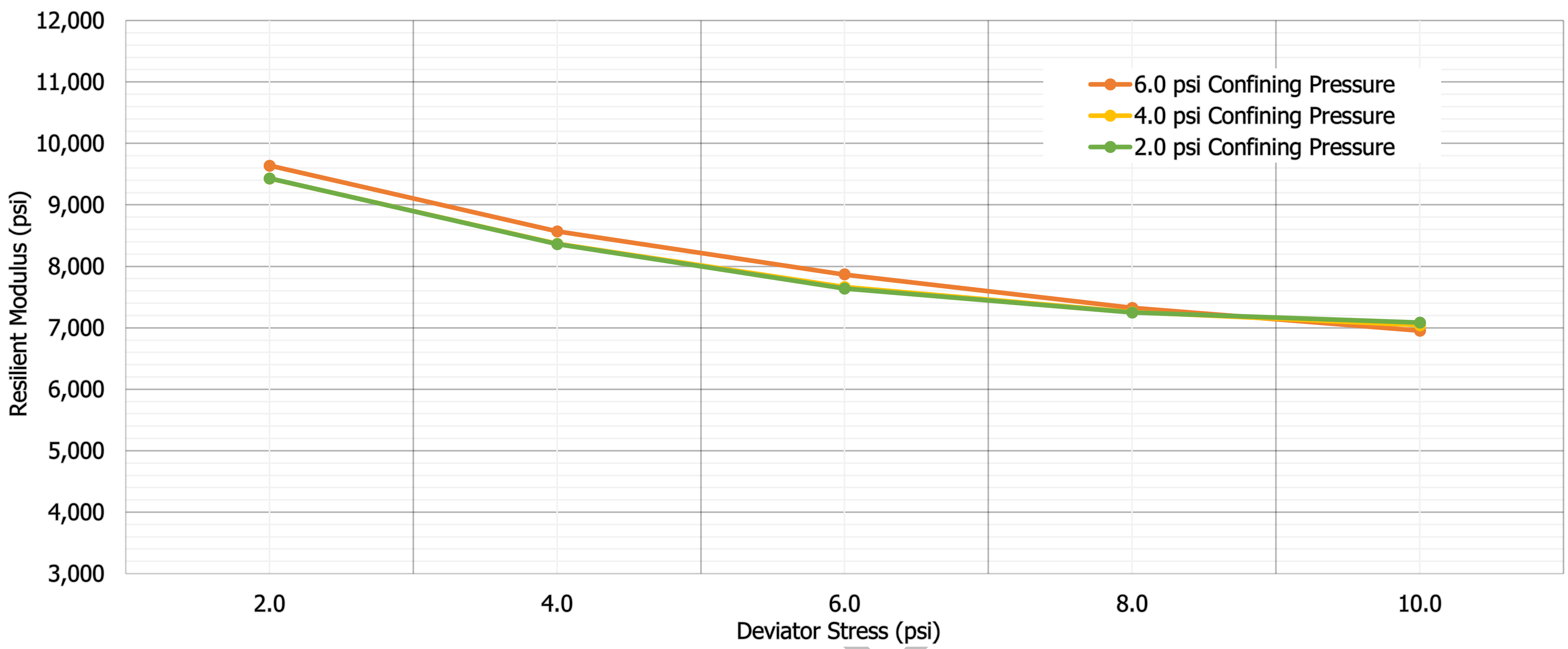
A.G. WASSENAAR, INC.

Resilient Modulus Testing - AASHTO T307

Client Challenger Homes
8605 Explorer Drive, Suite 250
Colorado Springs, Colorado 80920

Project Number 214061-P2
Project Name Bent Grass, Filing 1
Date September 15, 2021

Resilient Modulus Vs. Deviator Stress Graph



Sample Location	**TB-1**
Soil Description	**Sand, very clayey**
Height (in)	**5.6**
Diameter (in)	**2.8**
Area (in^2)	**6.2**
Volume (in^3)	**34.5**
Remold Dry Density (pcf)	**107.4**
Remold Moisture (%)	**15.1**
Percent Compaction (%)	**96**
Moisture Content after (%)	**-**

AASHTO Classification	**A-7-6 (7)**
-No. 200 (%)	**48**
Liquid Limit	**42**
Plastic Limit	**18**
Plasticy Index	**24**
Proctor Type	**ASTM D698**
Proctor Max Dry Density (pcf)	**111.9**
Optimum Moisture (%)	**14.7**
Material Type	**2**

Loading Sequence and Test Results

Test Sequence	Actual Confining Pressure (psi)	Nominal Maximum Axial Stress (psi)	Actual Maximum Axial Load (lbs)	Actual Cyclic Load (lbs)	Actual Contact Load (lbs)	Actual Max Deviator Stress (psi)	Actual Cyclic Stress (psi)	Actual Contact Stress (psi)	Recoverable Deformation			Measured Resilient Strain (%)	Resilient Modulus (psi)
									LVDT 1 (mils)	LVDT 2 (mils)	LVDT Average (mils)		
0	6.0	4.0	25.0	23.0	2.0	4.1	3.7	0.3	2.45	2.40	2.43	0.043	N/A
1	6.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	1.13	1.08	1.11	0.020	9,640
2	6.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.40	2.34	2.37	0.042	8,568
3	6.0	6.0	37.0	34.0	4.0	6.0	5.5	0.6	3.89	3.85	3.87	0.069	7,868
4	6.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	5.53	5.50	5.51	0.098	7,327
5	6.0	10.0	62.0	56.0	6.0	10.1	9.1	1.0	7.27	7.23	7.25	0.129	6,953
6	4.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	1.09	1.04	1.07	0.019	9,431
7	4.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.45	2.40	2.42	0.043	8,368
8	4.0	6.0	37.0	33.0	4.0	6.0	5.4	0.6	3.97	3.93	3.95	0.071	7,663
9	4.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	5.58	5.54	5.56	0.099	7,258
10	4.0	10.0	62.0	56.0	6.0	10.1	9.1	1.0	7.18	7.14	7.16	0.128	7,043
11	2.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	1.09	1.05	1.07	0.019	9,432
12	2.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.45	2.40	2.43	0.043	8,363
13	2.0	6.0	37.0	33.0	4.0	6.0	5.4	0.6	3.99	3.94	3.97	0.071	7,639
14	2.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	5.58	5.54	5.56	0.099	7,248
15	2.0	10.0	62.0	56.0	6.0	10.1	9.1	1.0	7.15	7.10	7.12	0.127	7,085

Resilient Modulus **7,953 psi** (average of test sequences 11, 12, 13, 14, 15)
Notes

FIGURE A-9