

Approved

by Jeff Rice

El Paso County Planning and Community Development
on behalf of Elizabeth Nijkamp, Engineering Review Manager



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Pavement Study

Falcon Meadows at Bent Grass, Filing No. 1

El Paso County, Colorado

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

SF-21-020



A.G. WASSENAAR, INC.

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Project Number 214061-P2
September 15, 2021
Revised October 1, 2021

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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 revised to address the review comments from El Paso County. We understand the review comments consisted of clarifying the subgrade support data (Section 8.0) and revising the design traffic load (Section 9.0), and pavement thicknesses (Section 10.0, Figure 1A, and Figure B-1). No other changes were made to this study. 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, very clayey sand fill with gravel, silty to clayey sand, and clayey to very clayey sand. No ground water was encountered at the time of drilling. Based on our sampling and laboratory testing, expansive soil mitigation per El Paso County is not required.

The revised pavement recommendations for the local residential streets consist of a composite section of 3.5 inches of asphalt concrete overlying at least 9.0 inches of aggregate base course.

We encourage reading this report 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 2,000 feet of local residential roadways. Factual data gathered during the field and laboratory work and our analyses are summarized on Figures 1 through 4 and in Appendices A and B. Our opinions and recommendations presented in this report are based on the data generated during this field exploration, laboratory testing, and our experience with similar projects.

3.0 FIELD EXPLORATION

The subgrade soils were sampled by drilling eight 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 4. Ground water was not encountered at the time of drilling.

4.0 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. The dry density from Test Boring No. 8 at a depth of approximately 2 feet may not be accurate as the sample classified as sand and may have been disturbed during transport to our laboratory. Representative samples were tested for water-soluble sulfate concentration. Selected subgrade materials were tested for Standard Proctor and resilient modulus to determine the subgrade support strength. The test results are summarized on Figures 2 through 4 and presented in Appendix A.

5.0 SUBGRADE DESCRIPTION

The subgrade soils encountered consisted of very sandy clay fill, very clayey sand fill with gravel, silty to clayey sand, and clayey to very clayey sand. According to the AASHTO Soil Classification system, the soils from the bulk samples collected classified as A-2-4 (0), A-4 (0), A-6 (1 to 7), and A-7-6 (7). Based upon field observations, fill was encountered in six of the eight test borings to depths ranging from approximately 2 to 6 feet below rough subgrade elevation. The fill encountered is considered documented as representatives from AGW performed moisture and density testing during mass grading of the site. Silty to clayey sand was encountered in two of the test borings at surface elevation and at a depth of approximately 2 feet. Clayey to very clayey sand was encountered in four test borings at surface elevation and at depths of approximately 2 and 6 feet. Bedrock was not encountered to the depths drilled. Ground water was not encountered at the time of drilling.

6.0 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 600 to 2,100 parts per million (ppm). Based on these results, the sulfate concentration of the samples tested represents a Class 2 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".

7.0 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 4 to 24. 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 0.8 to 1.9% expansion potential (see Appendix A). Based on our sampling and laboratory testing, expansive subgrade mitigation is not required per the "Manual" as the expansion potential was below 2%.

8.0 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. The poorest soils were encountered in Test Boring No. 1 (0-5') as representative of A-7-6 (7) soils. These soils were tested for Standard Proctor (ASTM D698) and exhibited a maximum dry density of 111.9 pcf at an optimum moisture content of 14.7%. Resilient modulus testing was performed on a sample remolded to at least 95% of Standard Proctor (ASTM D698) maximum dry density at approximately optimum moisture content. The results of the resilient modulus testing yielded a value of 7,953 psi (see Appendix A). We find this resilient modulus value to be reasonable. We understand the El Paso County review comments indicated to provide the R-value that was used for the calculations. A direct resilient modulus test was performed rather than an R-value test, which is typically converted to a resilient modulus value. For this reason, we cannot provide an exact R-value test result.

9.0 TRAFFIC CONSIDERATIONS

Based on the "Manual" and the plans, the roadways at the site classify as local residential roadways. The site contains 82 residential units with two entries (Rowena Way and Henzlee Place). The review comments from El Paso County indicated to use an ESAL value of 292,000, which is stipulated for urban local roadways based on a 20-year design period. The following table summarizes the traffic design criteria.

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

ESAL – Equivalent Single Axle (18-kip) Load

10.0 PAVEMENT THICKNESS RECOMMENDATIONS

The pavement thickness recommendations have been 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 revised recommended pavement thicknesses are provided in the table below and on Figure 1A.

Roadway Classification	Alternate	ACS (in.)	ABC (in.)	Total (in.)
Local Residential (ESAL = 292,000; M_R = 7,953 psi)	A	3.5	9.0	12.5

ACS – Asphalt Concrete Surface

ABC – Aggregate Base Course

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.

11.0 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.

12.0 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.

13.0 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”.

13.1 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. Chemically treated subgrade should be compacted to at least 95% maximum dry density (ASTM D558) at optimum to +3.0% of optimum moisture content. 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.

13.2 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.

13.3 Asphalt Concrete Surface

Asphalt material should conform to an agency approved mix design that states the SHRP Gyrotory 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.

14.0 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.

14.1 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.

15.0 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 report 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.

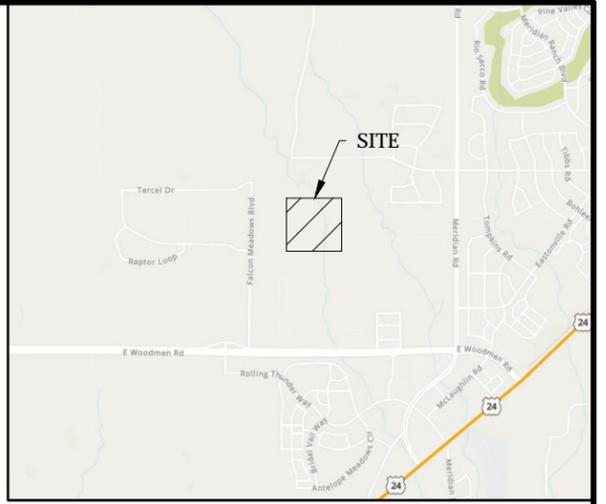
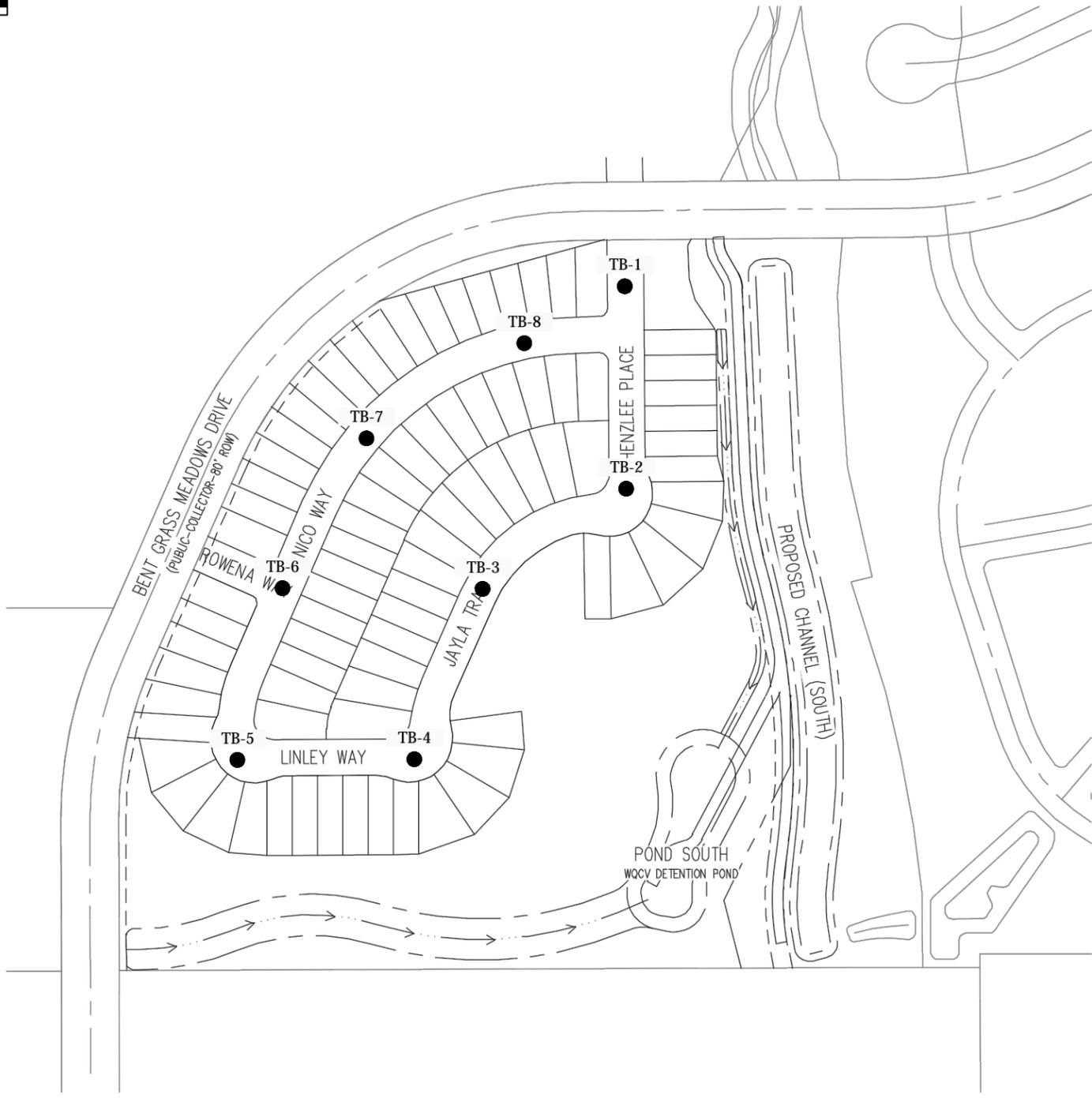
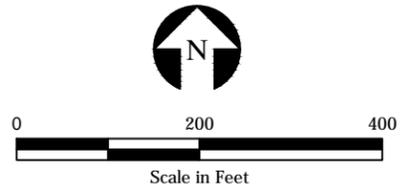


Pedro D. Manriquez, P.E.
Project Engineer

Digitally signed by: Pedro D. Manriquez
Date: 2021.10.05 07:34:00 -06'00'

PDM/pdm

FALCON MEADOWS AT BENT GRASS, FILING 1
EL PASO COUNTY, COLORADO



VICINITY MAP
NOT TO SCALE

NOTES:

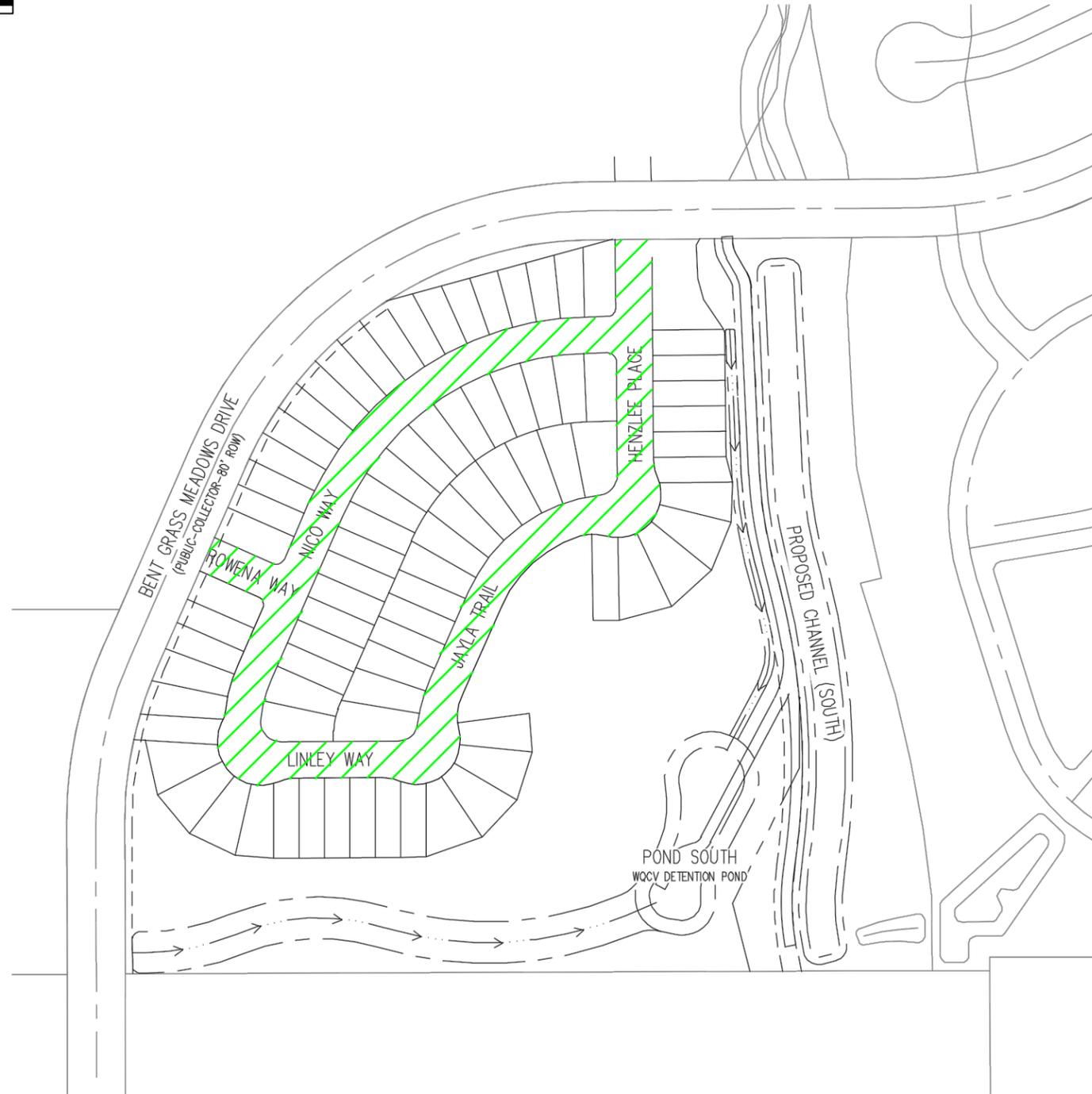
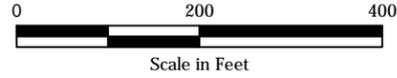
1. TEST BORINGS WERE OVERLAID ON THE "WATER AND WASTE WATER CONSTRUCTION PLANS BENT GRASS RESIDENTIAL FILING NO. 3", PREPARED BY GALLOWAY, PROJECT/JOB NUMBER CLH000018, DATED FEBRUARY 18, 2021.
2. ALL LOCATIONS ARE APPROXIMATE.



SITE PLAN AND
VICINITY MAP

PROJECT NO. 214061 P2
FIGURE 1

FALCON MEADOWS AT BENT GRASS, FILING 1
EL PASO COUNTY, COLORADO



 LOCAL RESIDENTIAL (ESAL = 292,000; MR = 7,953 psi)			
ALT	ACS (IN)	ABC (IN)	TOTAL (IN)
A	3.5	9.0	12.5

ACS - ASPHALT CONCRETE SURFACE
ABC - AGGREGATE BASE COURSE

NOTE: SEE TEXT OF REPORT FOR
PAVEMENT MAINTENANCE
RECOMMENDATIONS

NOTES:

1. TEST BORINGS WERE OVERLAID ON THE "WATER AND WASTE WATER CONSTRUCTION PLANS BENT GRASS RESIDENTIAL FILING NO. 3", PREPARED BY GALLOWAY, PROJECT/JOB NUMBER CLH000018, DATED FEBRUARY 18, 2021.
2. ALL LOCATIONS ARE APPROXIMATE.



PAVEMENT THICKNESS
RECOMMENDATIONS

PROJECT NO. 214061 P2
FIGURE 1A



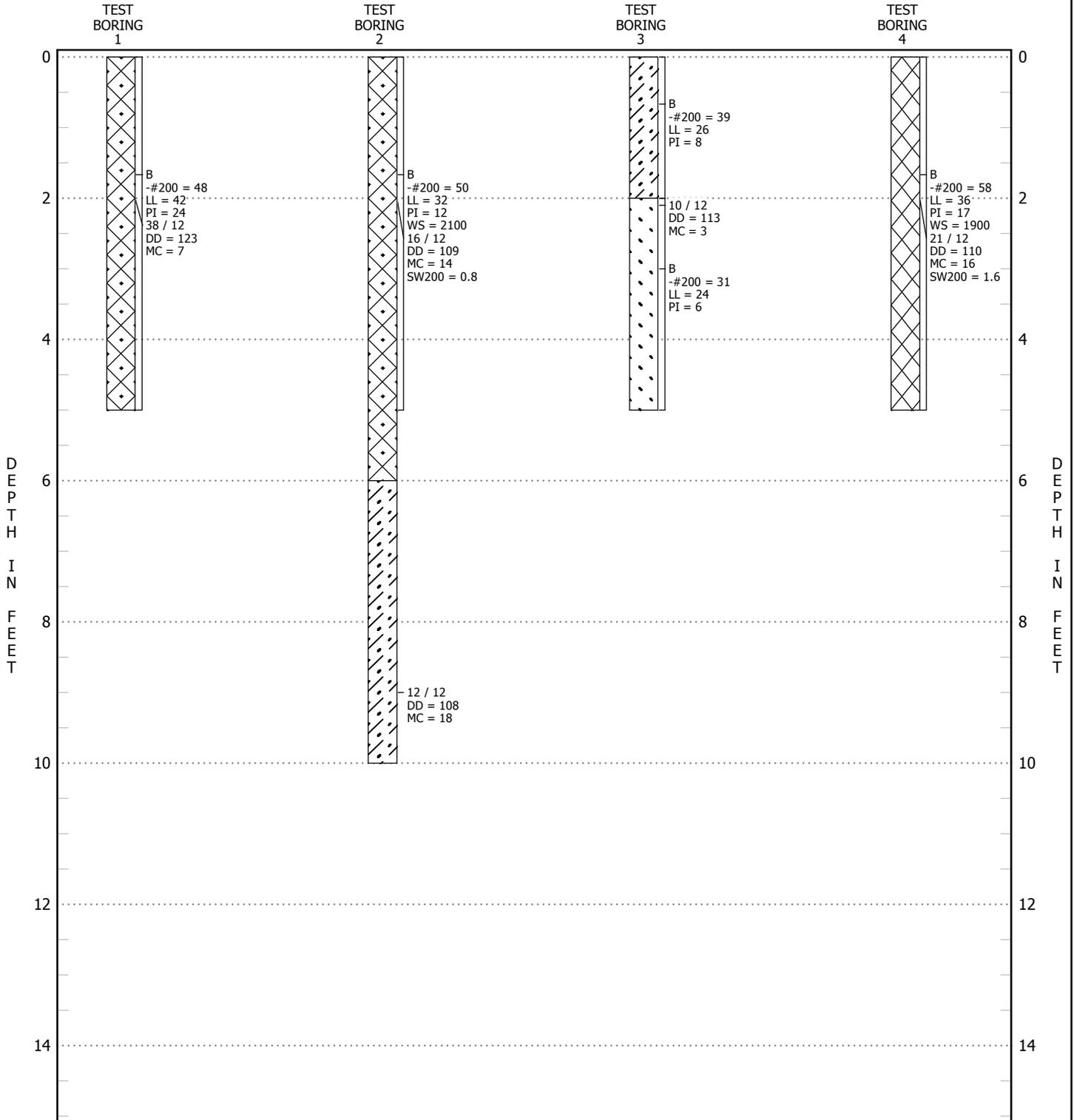
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Falcon Meadows at Bent Grass, Filing 1

PROJECT NUMBER 214061 P2

PROJECT LOCATION El Paso County, Colorado



SEE FIGURE 4 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 2



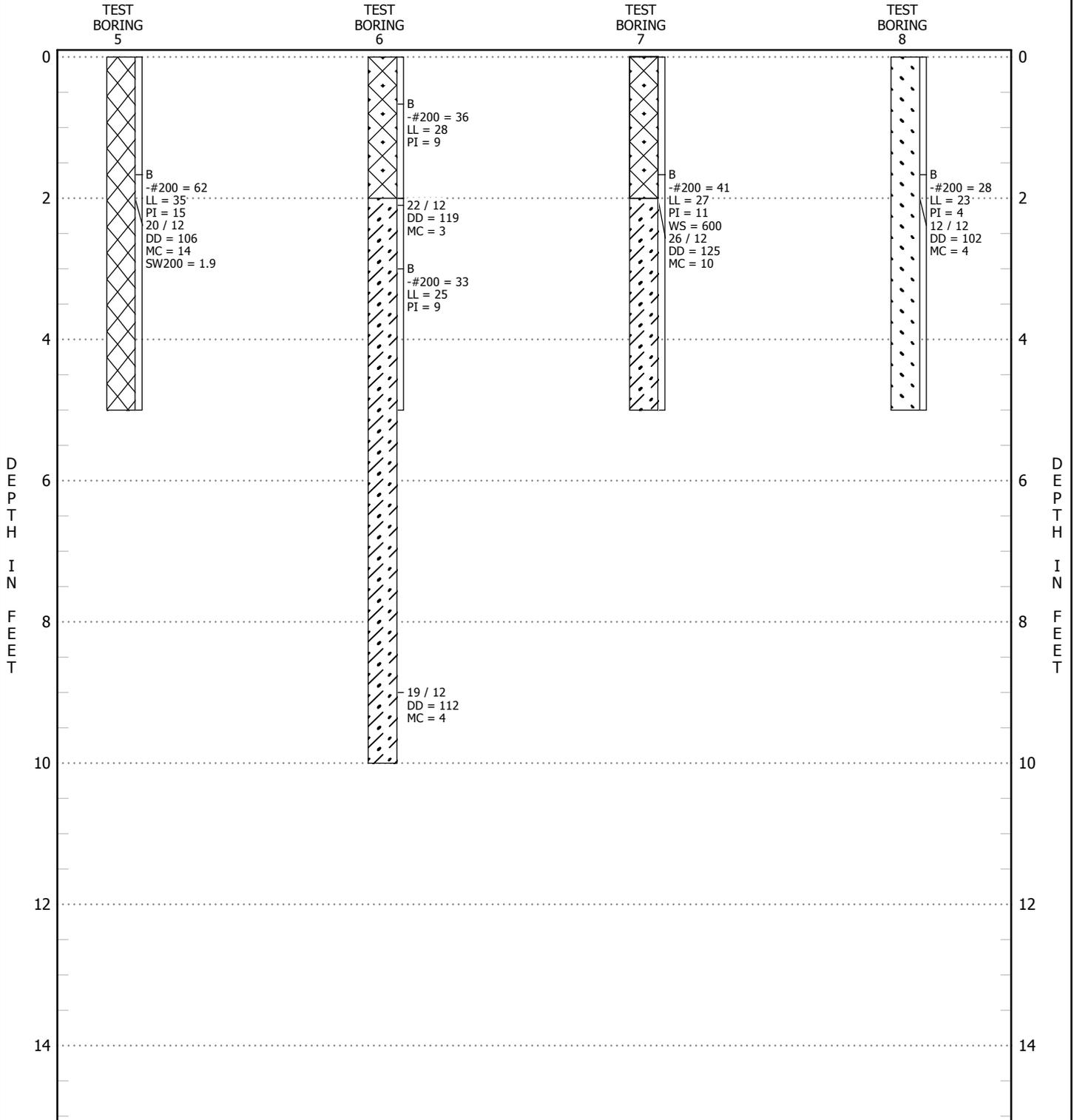
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Falcon Meadows at Bent Grass, Filing 1

PROJECT NUMBER 214061 P2

PROJECT LOCATION El Paso County, Colorado



SEE FIGURE 4 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 3



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

SOIL DESCRIPTIONS

-  Fill, clay, stiff to very stiff, silty, sandy
-  Fill, sand, medium dense, silty, clayey
-  Sand, medium dense, silty
-  Sand, medium dense, silty, clayey

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 sulfates 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 July 19, 2021 .
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 4

**APPENDIX A
LABORATORY TEST RESULTS**

SUMMARY OF LABORATORY TEST RESULTS.....TABLE A-1

GRADATION AND ATTERBERG TEST RESULTS..... FIGURES A-1 THROUGH A-5

SWELL-CONSOLIDATION TEST RESULTS FIGURES A-6 AND A-7

PROCTOR TEST RESULTS..... FIGURE A-8

RESILIENT TEST RESULTS..... FIGURE A-9

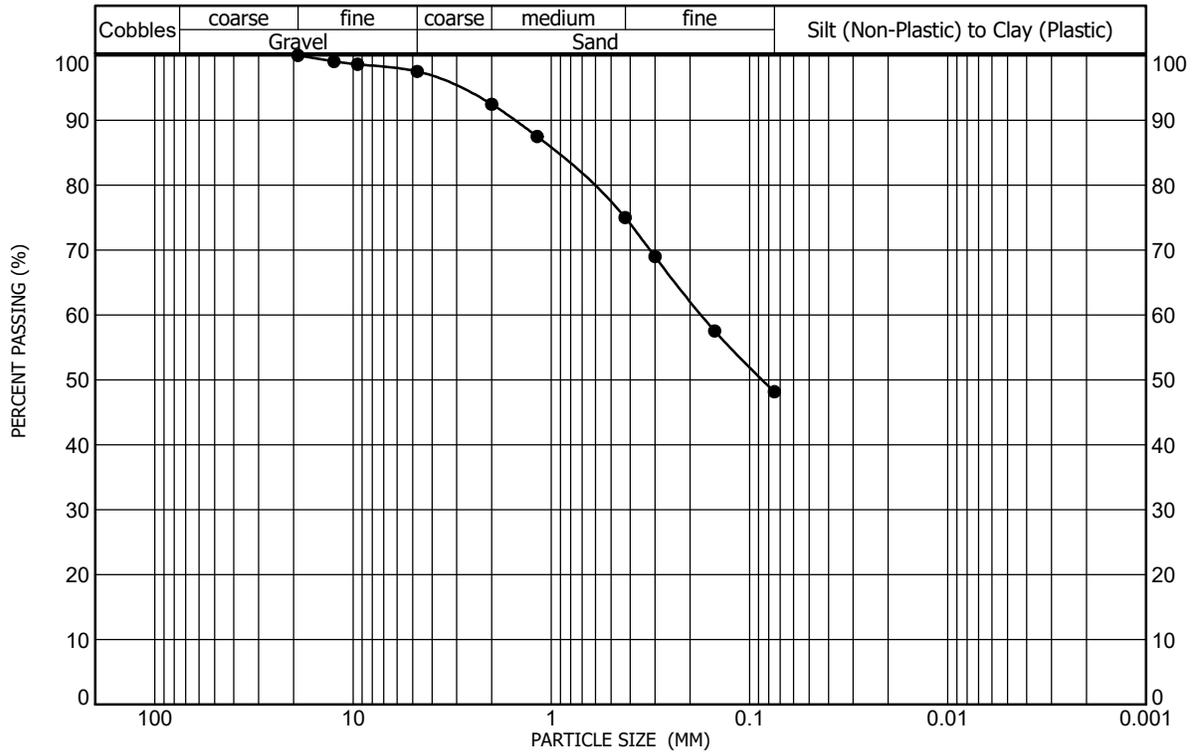
TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS
 September 15, 2021; Revised October 1, 2021

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						

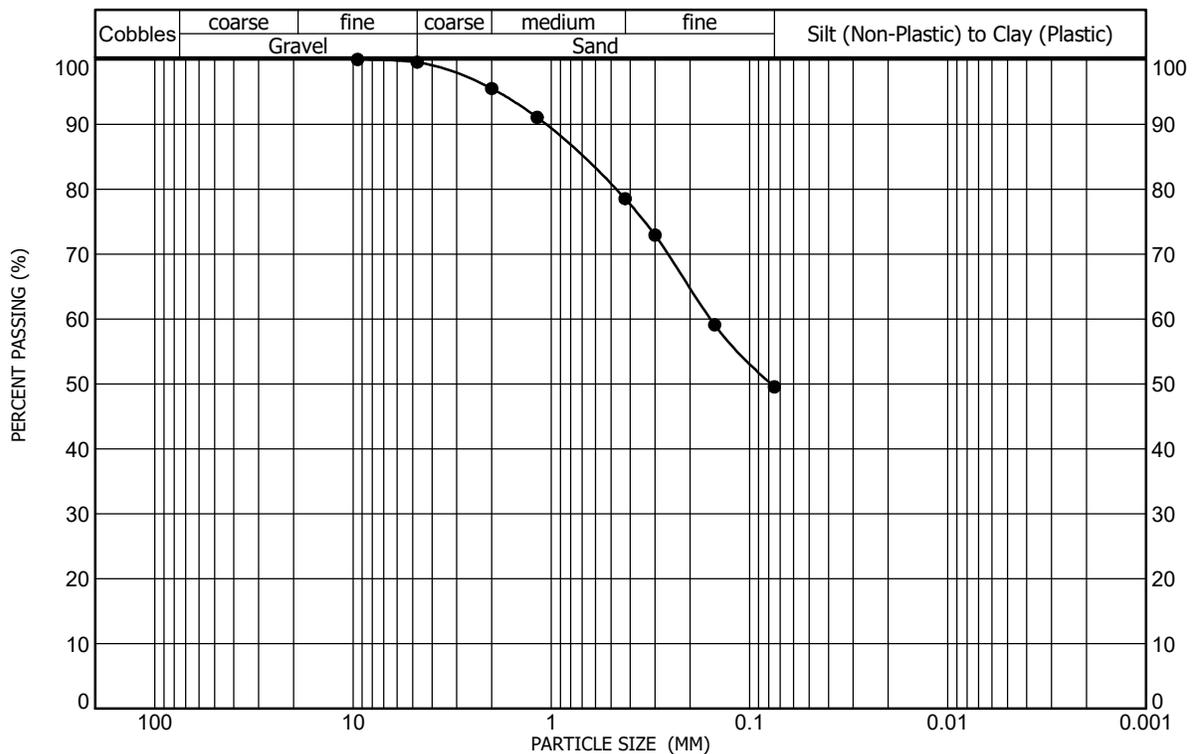
Notes:

¹ Indicates Percent Swell or Consolidation (-) when wetted under a 200 psf load, unless otherwise noted.

NV - indicates No Value
 NP - indicates Non-Plastic



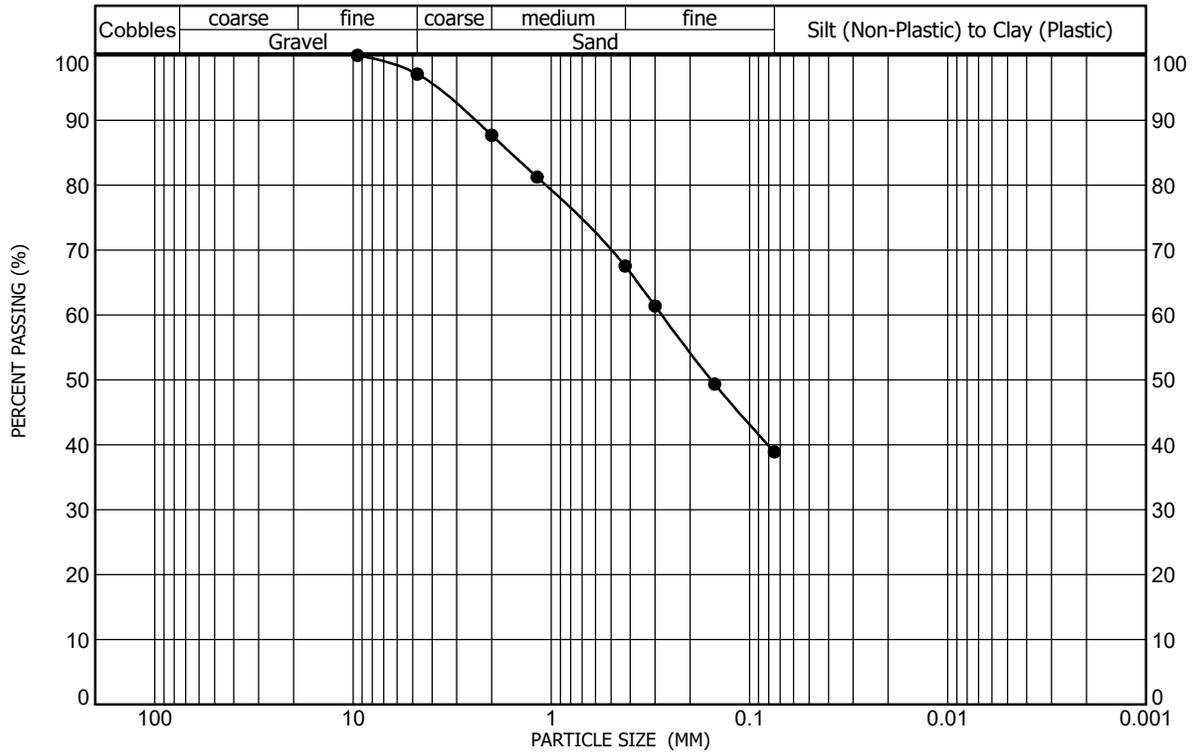
Sample Location Test Boring No. 1 at a depth of 0 feet to 5 feet Gravel (%) 2 Liquid Limit 42
 Sample Description Fill, sand, very clayey Sand (%) 49 Plasticity Index 24
 Classification A-7-6(7), CLAYEY SAND(SC) Clay/Silt (%) 48



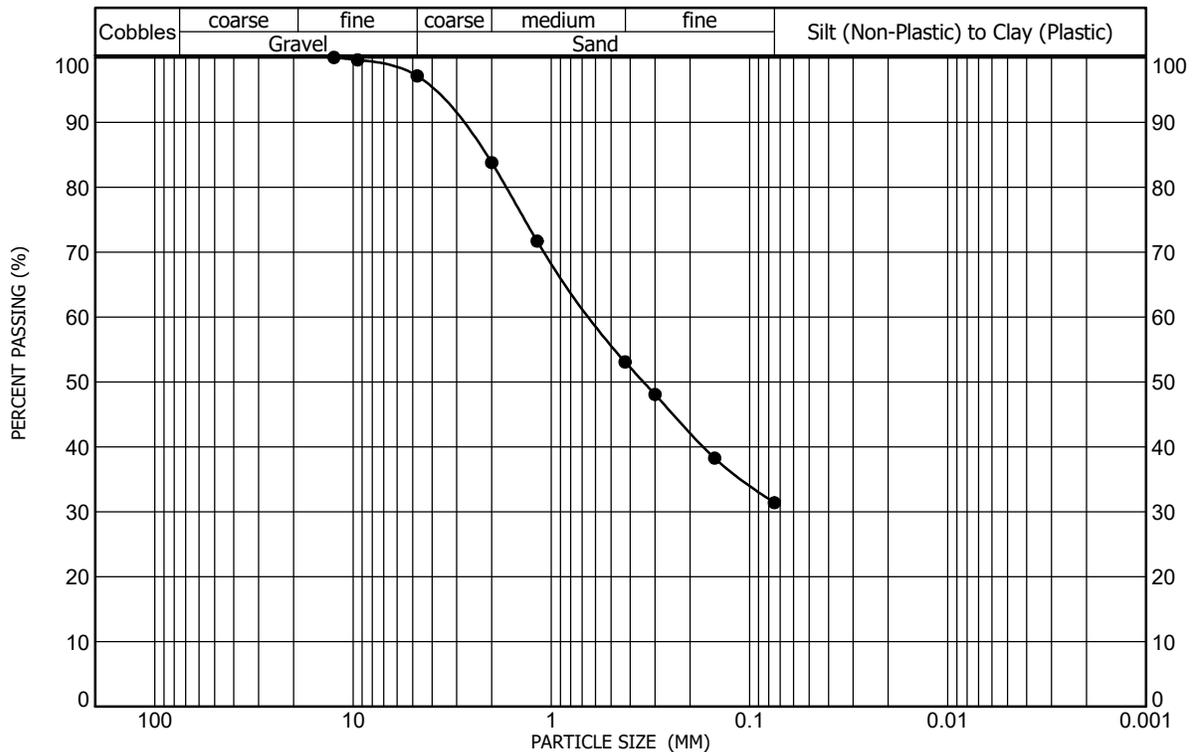
Sample Location Test Boring No. 2 at a depth of 0 feet to 5 feet Gravel (%) 0 Liquid Limit 32
 Sample Description Fill, sand, very clayey Sand (%) 50 Plasticity Index 12
 Classification A-6(3), CLAYEY SAND(SC) Clay/Silt (%) 50

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-1



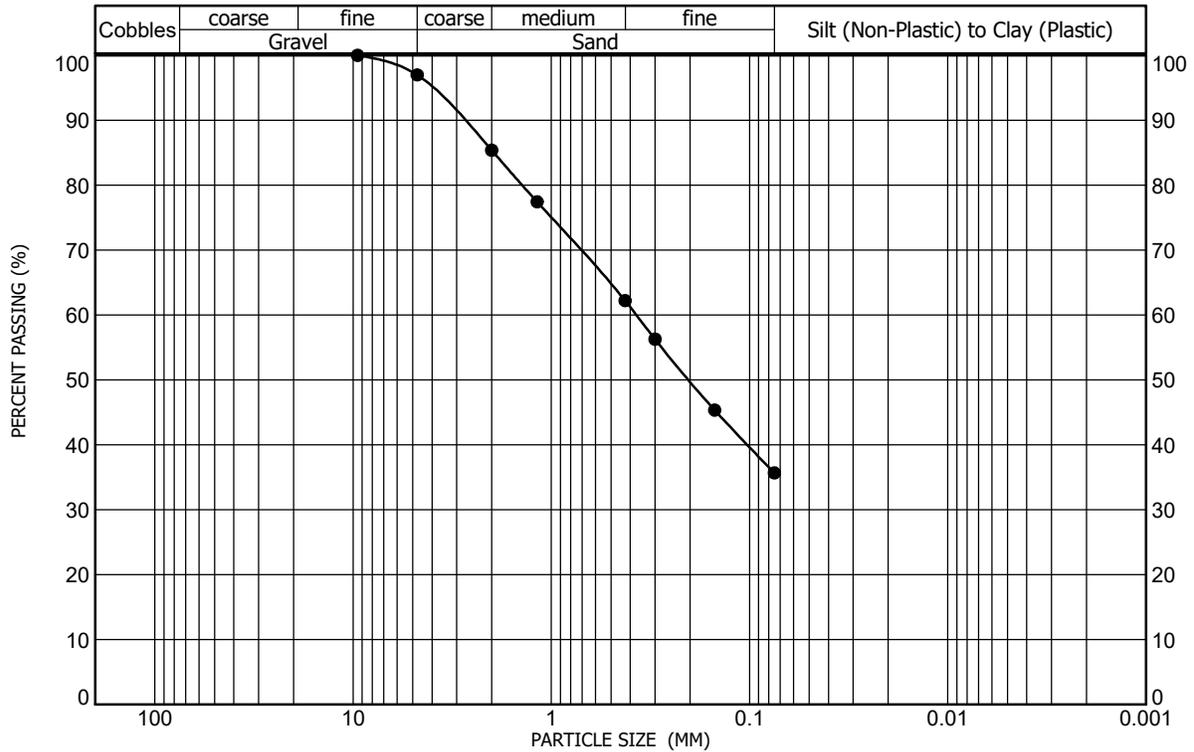
Sample Location Test Boring No. 3 at a depth of 0 feet to 2 feet Gravel (%) 3 Liquid Limit 26
 Sample Description Sand, very clayey Sand (%) 58 Plasticity Index 8
 Classification A-4(0), CLAYEY SAND(SC) Clay/Silt (%) 39



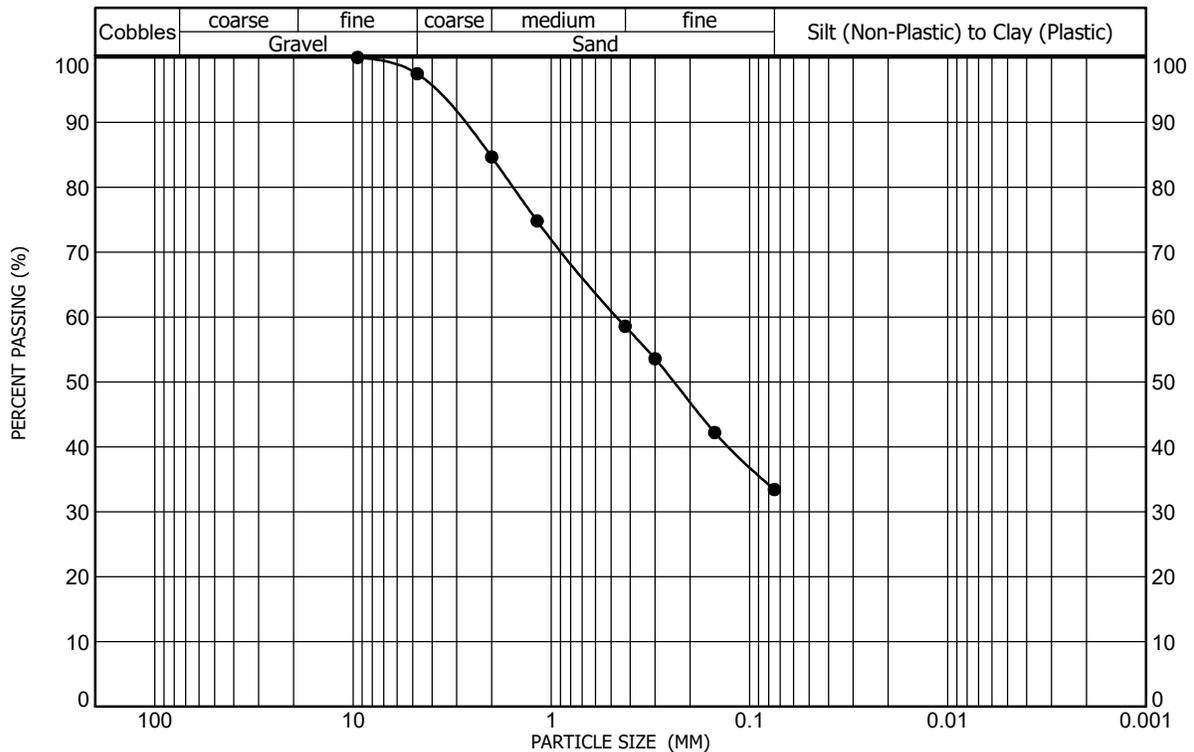
Sample Location Test Boring No. 3 at a depth of 2 feet to 5 feet Gravel (%) 3 Liquid Limit 24
 Sample Description Sand, silty/clayey Sand (%) 66 Plasticity Index 6
 Classification A-2-4(0), SILTY, CLAYEY SAND(SC-SM) Clay/Silt (%) 31

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-2



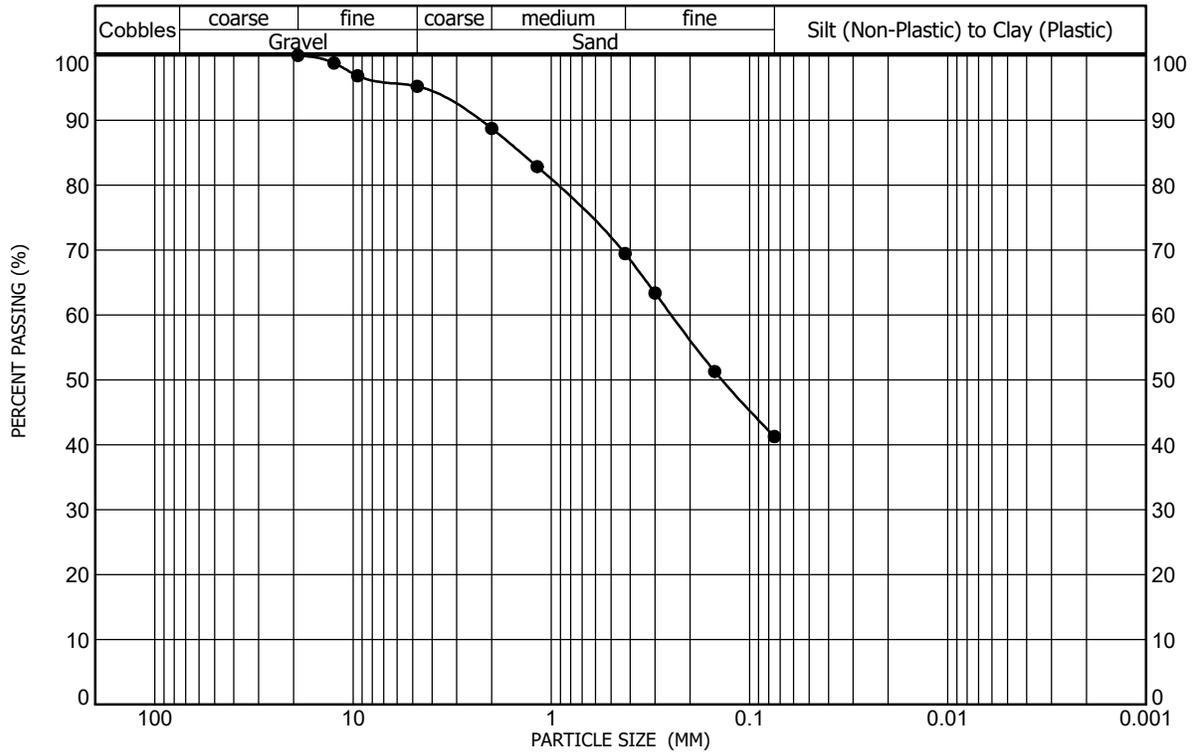
Sample Location Test Boring No. 6 at a depth of 0 feet to 2 feet Gravel (%) 3 Liquid Limit 28
 Sample Description Fill, sand, very clayey Sand (%) 61 Plasticity Index 9
 Classification A-4(0), CLAYEY SAND(SC) Clay/Silt (%) 36



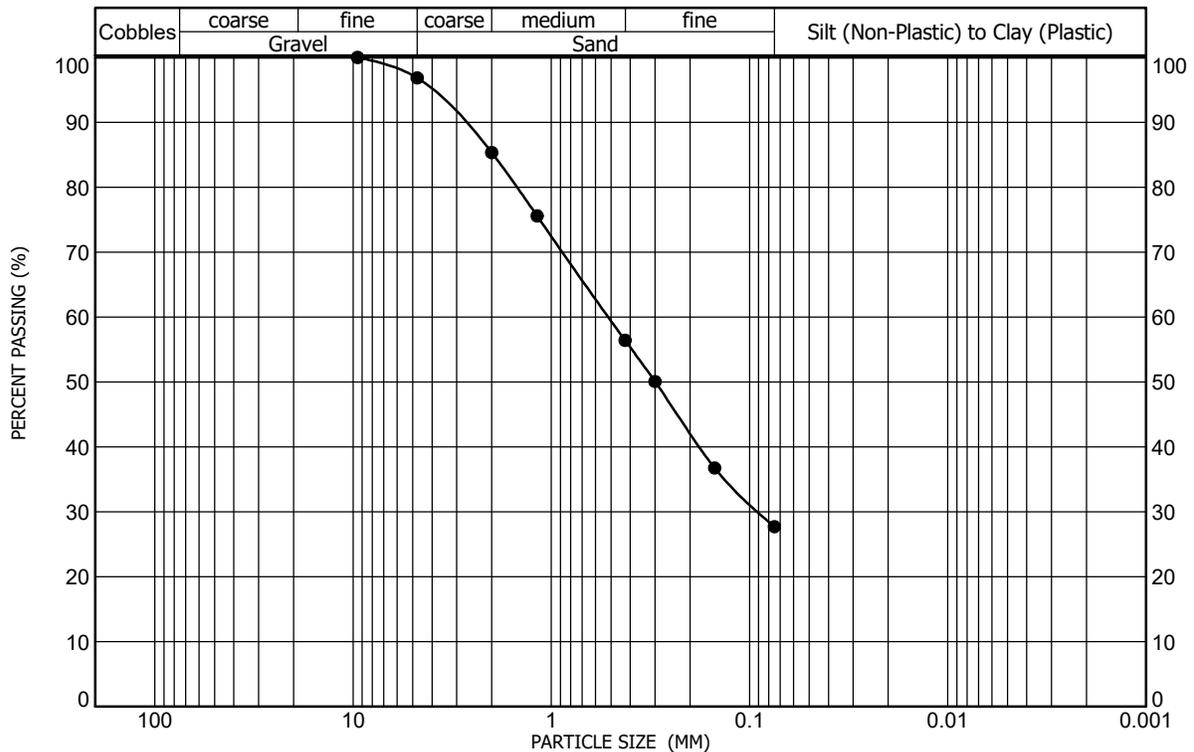
Sample Location Test Boring No. 6 at a depth of 2 feet to 5 feet Gravel (%) 3 Liquid Limit 25
 Sample Description Sand, very clayey Sand (%) 64 Plasticity Index 9
 Classification A-2-4(0), CLAYEY SAND(SC) Clay/Silt (%) 33

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-4



Sample Location Test Boring No. 7 at a depth of 0 feet to 5 feet Gravel (%) 5 Liquid Limit 27
 Sample Description Fill, sand, very clayey, slightly gravelly Sand (%) 54 Plasticity Index 11
 Classification A-6(1), CLAYEY SAND(SC) Clay/Silt (%) 41



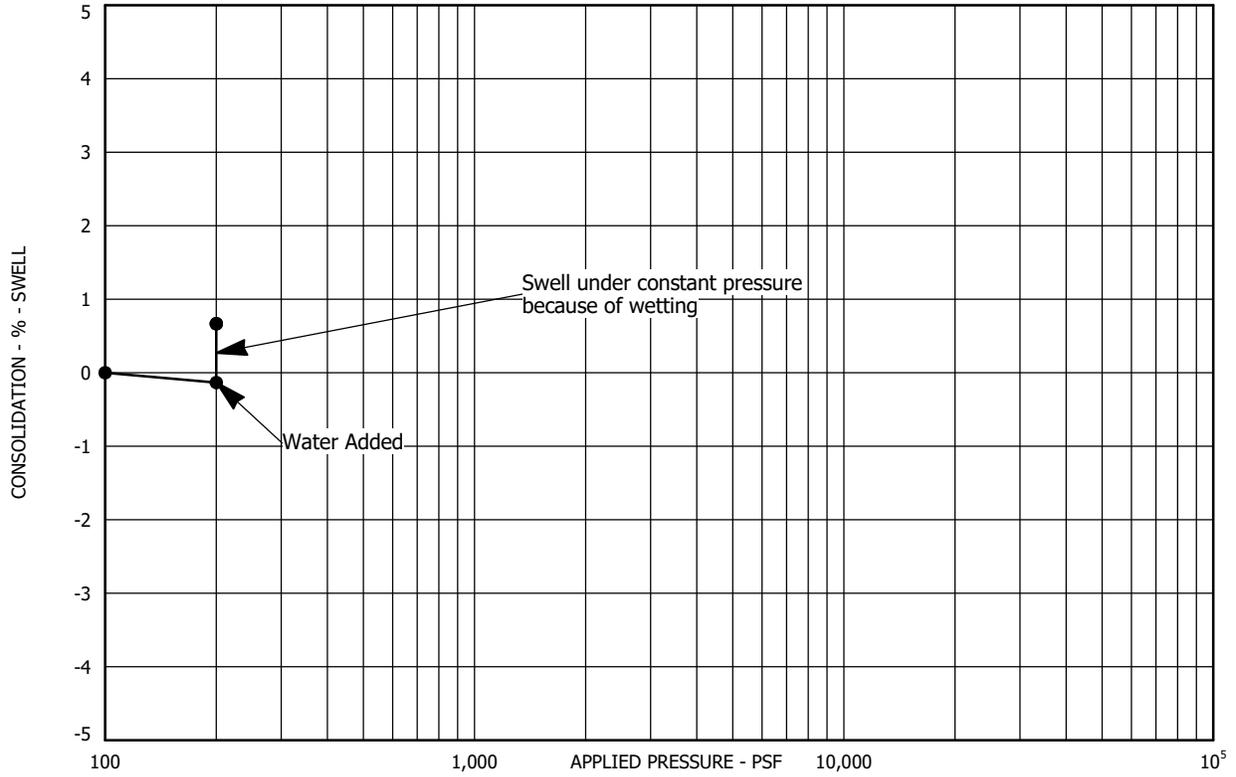
Sample Location Test Boring No. 8 at a depth of 0 feet to 5 feet Gravel (%) 3 Liquid Limit 23
 Sample Description Sand, silty/clayey Sand (%) 69 Plasticity Index 4
 Classification A-2-4(0), SILTY, CLAYEY SAND(SC-SM) Clay/Silt (%) 28

GRADATION AND ATTERBERG TEST RESULTS

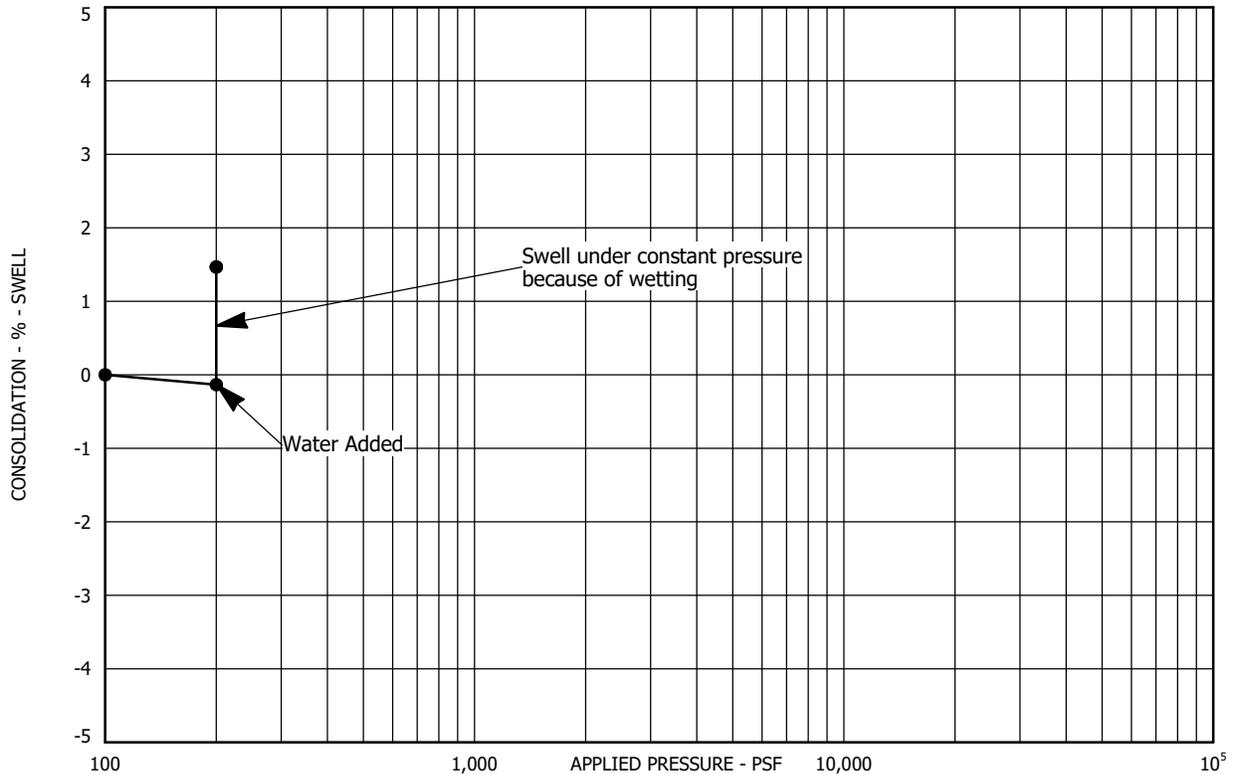
FIGURE A-5



A.G. WASSENAAR, INC.



Sample Location Test Boring No. 2 at a depth of 2 feet Dry Unit Weight (pcf) 109
 Sample Description Fill, sand, very clayey Moisture Content (%) 14



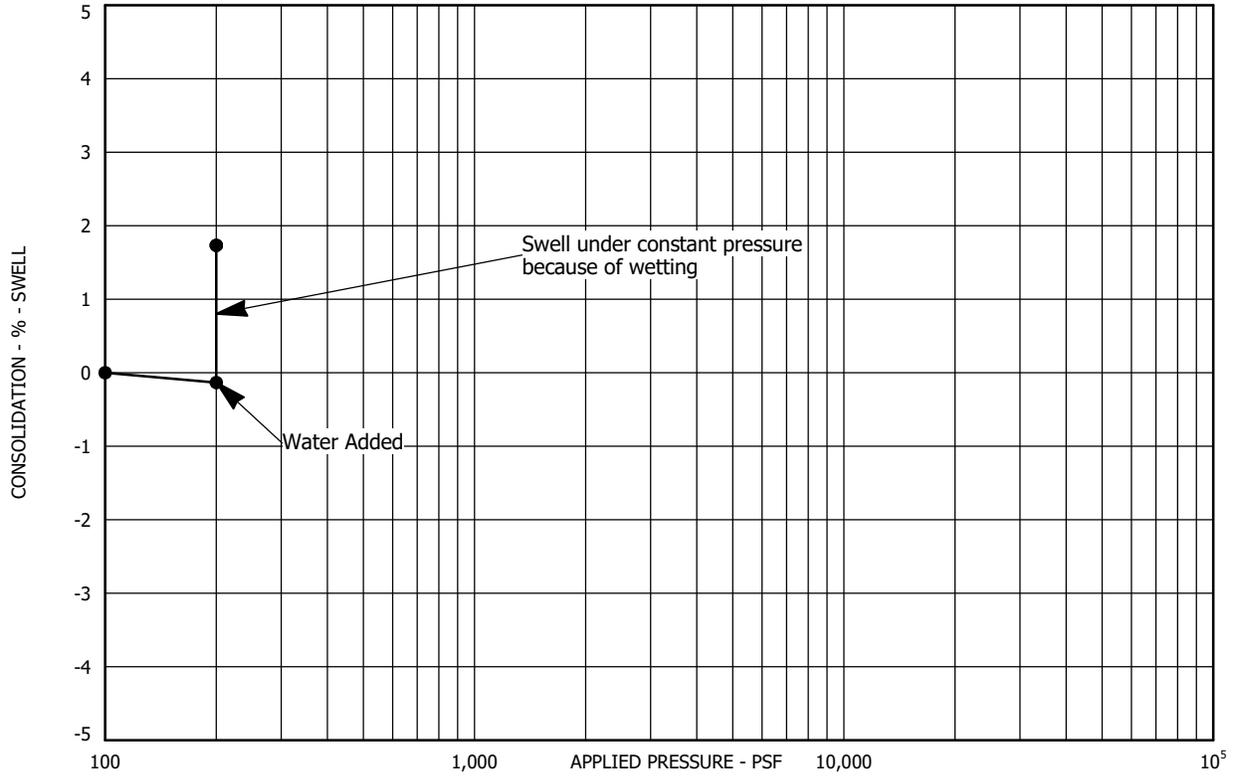
Sample Location Test Boring No. 4 at a depth of 2 feet Dry Unit Weight (pcf) 110
 Sample Description Fill, clay, very sandy Moisture Content (%) 16

SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-6



A.G. WASSENAAR, INC.



Sample Location	<u>Test Boring No. 5 at a depth of 2 feet</u>	Dry Unit Weight (pcf)	<u>106</u>
Sample Description	<u>Fill, clay, very sandy</u>	Moisture Content (%)	<u>14</u>

SWELL - CONSOLIDATION TEST RESULTS
FIGURE A-7



A.G. WASSENAAR, INC.

MOISTURE-DENSITY RELATIONSHIP

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 _____

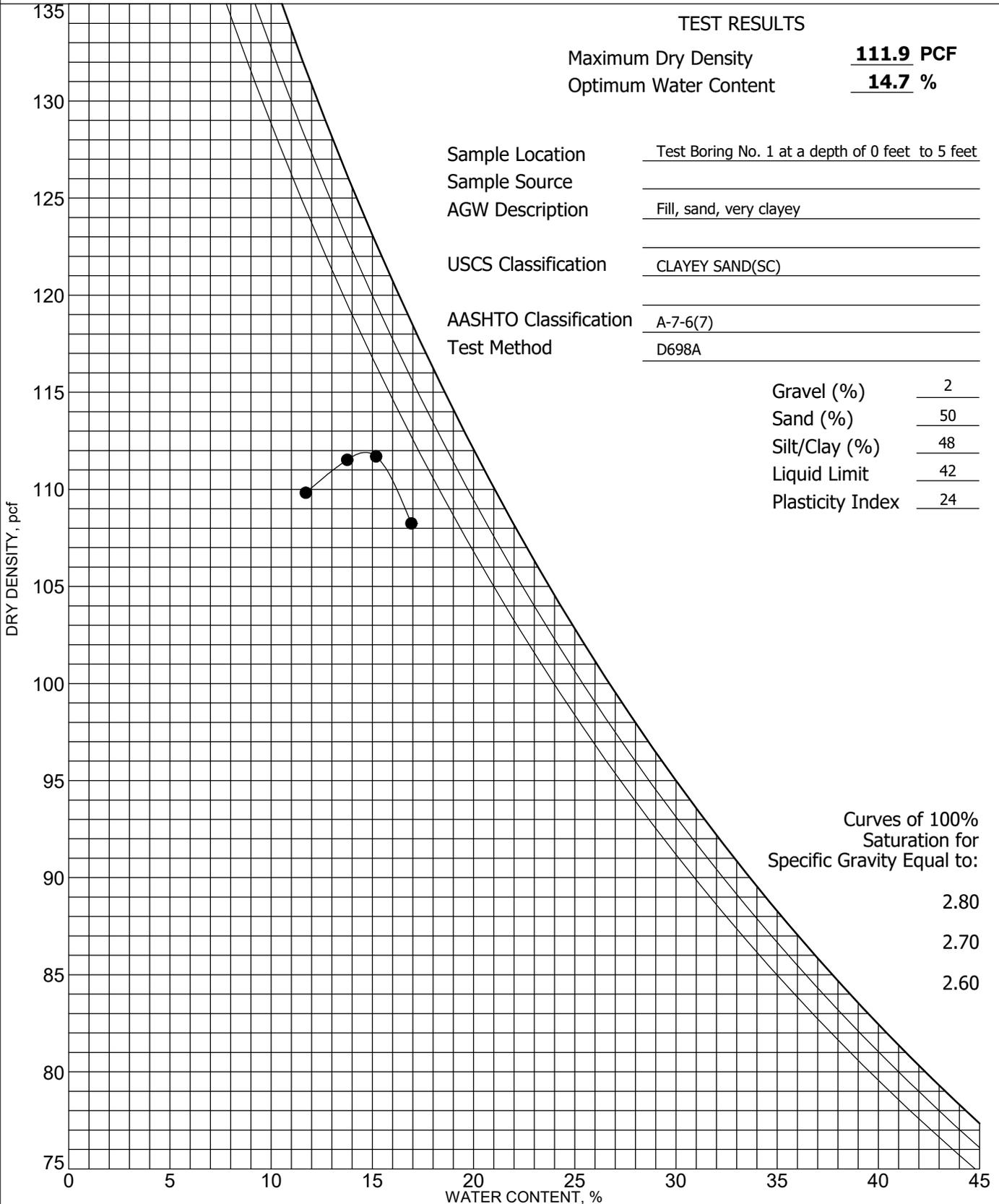
AGW Description Fill, sand, very clayey

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



Curves of 100% Saturation for Specific Gravity Equal to:
 2.80
 2.70
 2.60

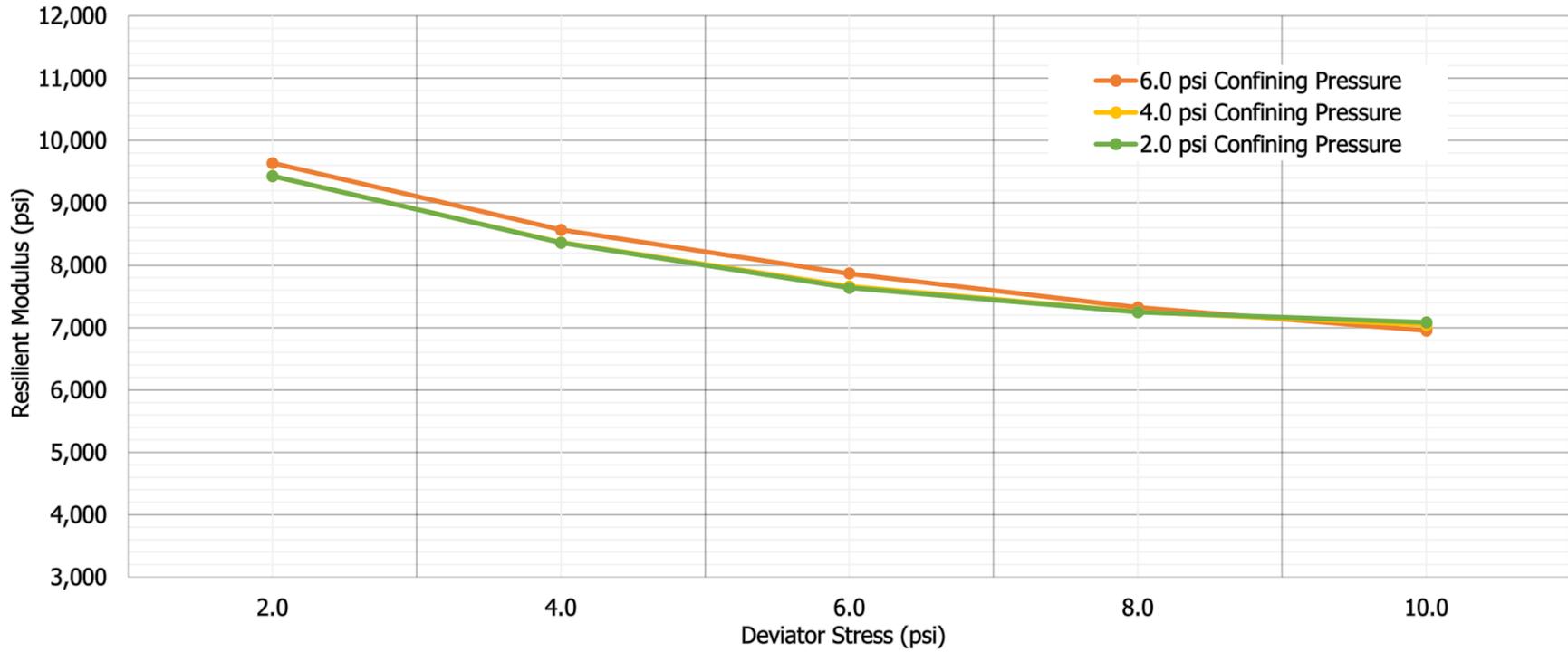
FIGURE A-8

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	AASHTO Classification	A-7-6 (7)
Soil Description	Sand, very clayey	-No. 200 (%)	48
Height (in)	5.6	Liquid Limit	42
Diameter (in)	2.8	Plastic Limit	18
Area (in^2)	6.2	Plasticity Index	24
Volume (in^3)	34.5	Proctor Type	ASTM D698
Remold Dry Density (pcf)	107.4	Proctor Max Dry Density (pcf)	111.9
Remold Moisture (%)	15.1	Optimum Moisture (%)	14.7
Percent Compaction (%)	96	Material Type	2
Moisture Content after (%)	-		

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

FIGURE A-9

**APPENDIX B
PAVEMENT THICKNESS CALCULATIONS**

DARWin FLEXIBLE PAVEMENT CALCULATIONS FIGURE B-1

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
Bent Grass, Filing 3
El Paso, Colorado
Project Number 214061-P2

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

<u>Layer</u>	<u>Material Description</u>	<u>Struct Coef. (Ai)</u>	<u>Drain Coef. (Mi)</u>	<u>Thickness (Di)(in)</u>	<u>Width (ft)</u>	<u>Calculated SN (in)</u>
1	Hot Bituminous Pavement	0.44	1	3.5	-	1.54
2	Aggregate Base Course	0.11	1	9	-	0.99
Total	-	-	-	12.50	-	2.53