

APPROVED
Engineering Department

10/20/2021 9:42:14 AM

dsdnijkamp

EPC Planning & Community
Development Department

Pavement Study Matika Subdivision, Filing 1 El Paso County, Colorado

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



A.G. WASSENAAR, INC.

3211 South Zuni Street
Englewood, Colorado 80110
www.agwco.com (303) 759-8100

CDR 21-003

Project Number 216518-P1
October 14, 2021

TABLE OF CONTENTS

1.0	EXECUTIVE SUMMARY	1
2.0	PURPOSE	1
3.0	FIELD EXPLORATION	1
4.0	LABORATORY TESTING	2
5.0	SUBGRADE DESCRIPTION	2
6.0	WATER-SOLUBLE SULFATES	2
7.0	EXPANSIVE SUBGRADE CONDITIONS	2
8.0	SUBGRADE SUPPORT	3
9.0	TRAFFIC CONSIDERATIONS	3
10.0	PAVEMENT THICKNESS RECOMMENDATIONS	3
11.0	GENERAL DISCUSSION.....	4
12.0	DRAINAGE CONSIDERATIONS	4
13.0	CONSTRUCTION RECOMMENDATIONS	5
13.1	Subgrade	5
13.2	Aggregate Base Course	5
13.3	Asphalt Concrete Surface	5
14.0	PAVEMENT MAINTENANCE	6
14.1	Flexible Pavements	6
15.0	LIMITATIONS	7

ATTACHMENTS

SITE PLAN AND VICINITY MAP	FIGURE 1
PAVEMENT THICKNESS RECOMMENDATIONS.....	FIGURE 1A
TEST BORING LOGS	FIGURES 2 AND 3
LEGEND AND NOTES	FIGURE 4
LABORATORY TEST RESULTS	APPENDIX A
PAVEMENT THICKNESS CALCULATIONS	APPENDIX B

1.0 EXECUTIVE SUMMARY

As requested, A. G. Wassenaar, Inc. (AGW) has completed the pavement study for the proposed roadway 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 roadway.

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

The pavement recommendations for Marshbern Court (local residential (rural)) consist of a composite section of 3.0 inches of asphalt concrete overlying at least 6.0 inches of aggregate base course. Based on our sampling and laboratory testing, expansive subgrade mitigation per El Paso County is required in a segment of the roadway (see Section 7.0).

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 1,700 feet of Marshbern Court (local residential (rural)). 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 seven test borings within the proposed roadway alignment 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. Representative samples were tested for water-soluble sulfate concentration. The subgrade materials exhibiting the poorest soil characteristics 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 silty to clayey sand fill with gravel, silty to clayey sand with gravel, very sandy clay, and sandstone 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), and A-6 (5). Based upon field observations, fill was encountered in five of the seven test borings to depths of approximately 1 ½ and 5 feet below rough subgrade elevation. Considering the fill was encountered along a proposed roadway alignment, it is possible compaction and moisture specifications were likely required during construction. Based on our sampling and laboratory testing, the fill likely possesses a reduced risk, however, the Client must understand that even with the engineering opinions expressed in this study, the construction of pavements on undocumented fill is a risk. We cannot and will not be held liable for work conducted by others. Silty to clayey sand with gravel was encountered in four of the test borings at surface elevation and at depths of approximately 1 ½ and 5 feet. Very sandy clay was encountered in one of the test borings at surface elevation to a depth of 5 feet. Sandstone bedrock was encountered in one of the test borings at a depth of approximately 5 feet. 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 were less than 100 and 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".

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 non-plastic to 14. Swell-consolidation tests were conducted to determine expansion potential under a surcharge load of 200 pounds per square foot (psf). These test results exhibited an expansion

potential of 0.0 and 5.2% (see Appendix A). Based on our sampling and laboratory testing, expansive subgrade mitigation is required in the area of Test Boring No. 7 (see Figure 1).

Given that this is the only area that exhibited a high expansion potential, it is our opinion that the expansive soils can be moisture treated and compacted to provide adequate subgrade support. The subgrade in the area of Test Boring No. 7 may be moisture treated to a depth of at least 2 feet below the designed pavement section. The existing A-6 soils or better soils may be used for fill. The fill should be placed in 8-inch maximum loose lifts and compacted to at least 95% of Standard Proctor (ASTM D698) at optimum to +3% of optimum moisture content for A-6 and A-7 soils. The fill should be placed in 8-inch maximum loose lifts and compacted to at least 95% of Modified Proctor (ASTM D1557) at -2% to +2% of optimum moisture content for other soils. We should be contacted to document removal of expansive subgrade materials. The areas of removal may be less or more than indicated. The moisture treatment should extend at least 1 foot beyond the proposed edge of pavement.

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. 7 (0-5') as representative of A-6 (5) soils. These soils were tested for Standard Proctor (ASTM D698) and exhibited a maximum dry density of 108.5 pcf at an optimum moisture content of 13.8%. Resilient modulus testing was performed on a sample remolded to at least 95% of Standard Proctor maximum dry density at approximately 2% above optimum moisture content. The results of the resilient modulus testing yielded a value of 7,571 psi (see Appendix A). We find this resilient modulus value to be reasonable for A-6 soils.

9.0 TRAFFIC CONSIDERATIONS

Based on the "Manual" and the plans, Marshbern Court classifies as a local residential (rural) roadway. The site contains seven residential units. The "Manual" stipulates a default Equivalent Single Axle Load (ESALs (18-kip)) value of 36,500 for low volume rural residential roadways based on a 20-year design period. We found this value to be reasonable given the intended roadway application. The following table summarizes the traffic design criteria.

Roadway Classification	ESALs	Reliability (%)	Serviceability Index
Local Residential (Rural)	36,500	75	2.0

ESAL – Equivalent Single Axle (18-kip) Load

10.0 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, the expansive subgrade mitigation, and the calculations from Figure B-1

(see Appendix B), the recommended pavement thicknesses are provided in the table below and on Figure 1A.

Roadway Classification	Alternate	ACS (in.)	ABC (in.)	Total (in.)
Local Residential (Rural) (ESAL = 36,500; M _R = 7,571 psi)	A	3.0	6.0	9.0

ACS – Asphalt Concrete Surface

ABC – Aggregate Base Course

Note: The subgrade in the area of Test Boring No. 7 should be moisture treated to a depth of at least 2 feet below the designed pavement section. The existing A-6 soils or better soils may be used for fill. The fill should be placed in 8-inch maximum loose lifts and compacted to at least 95% of Standard Proctor (ASTM D698) at optimum to +3% of optimum moisture content for A-6 and A-7 soils. The fill should be placed in 8-inch maximum loose lifts and compacted to at least 95% of Modified Proctor (ASTM D1557) at -2% to +2% of optimum moisture content for other soils. We should be contacted to document removal of expansive materials. The areas of removal may be less or more than indicated. The moisture treatment should extend at least 1 foot beyond the proposed edge of pavement.

Proper and timely maintenance will be required during the lifetime of the pavement 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. 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.

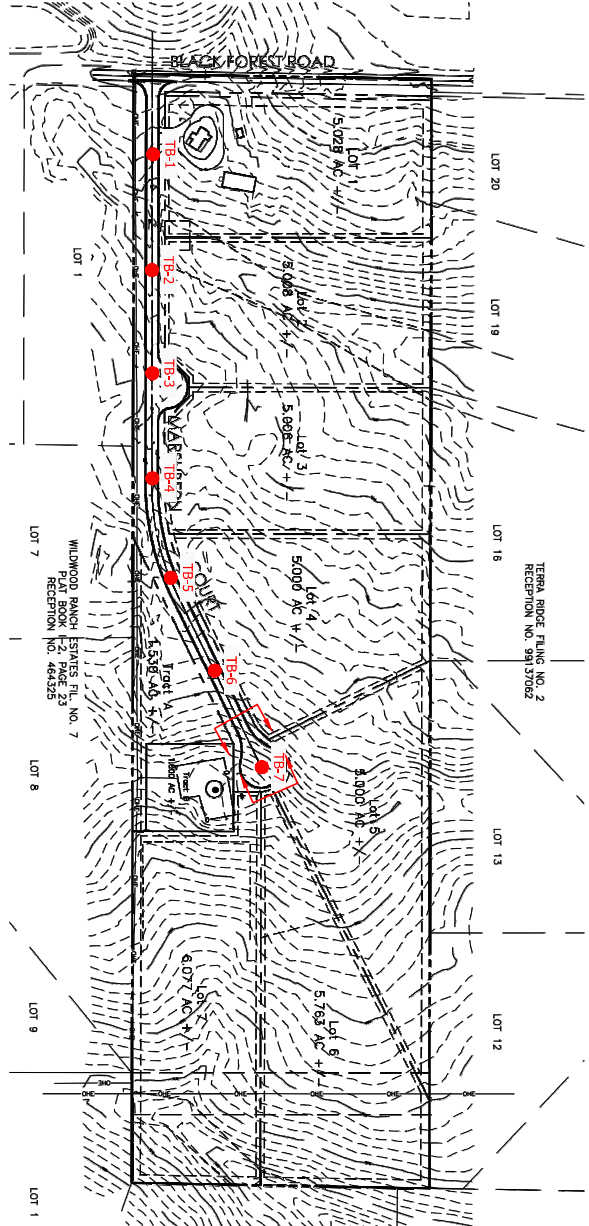
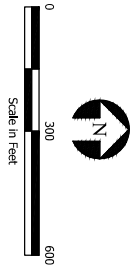

Pedro D. Manriquez, P.E.
Project Engineer

Digitally signed by: Pedro D. Manriquez
Date: 2021.10.14 15:22:23 -06'00'

PDM/TAH/pdm

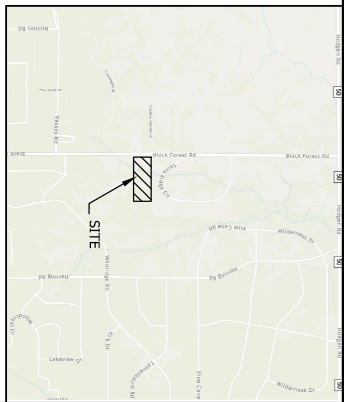


MATIKA SUBDIVISION, FILING 1
EL PASO COUNTY, COLORADO



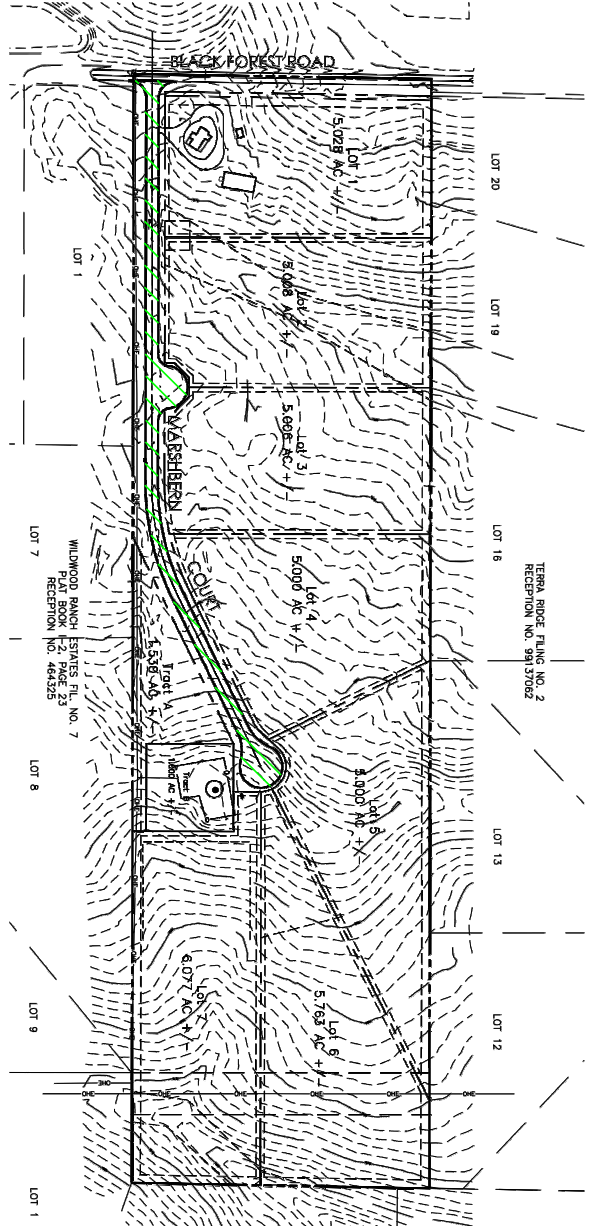
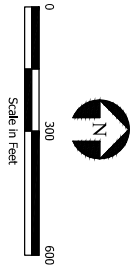
- NOTES:
1. TEST BORINGS WERE OVERLAID ON THE "CONSTRUCTION PLANS FOR MATIKA SUBDIVISION FILING NO. 1, EL PASO COUNTY", PREPARED BY WVE, INC., PROJECT/JOB NO. 61154, DATED JUNE 8, 2021.
 2. ALL LOCATIONS ARE APPROXIMATE.


MOISTURE TREATMENT IS RECOMMENDED IN THIS AREA TO A DEPTH OF AT LEAST 2 FEET BELOW THE DESIGNED PAVEMENT SECTION. THE FILL SHOULD BE PLACED IN 8-INCH MAXIMUM LOOSE LIFTS AND COMPACTED TO AT LEAST 95% OF STANDARD PROCTOR(ASTM D698) MAXIMUM DRY DENSITY AT OPTIMUM TO +3% OF OPTIMUM MOISTURE CONTENT FOR A-4 OR A-7 SOILS. THE FILL SHOULD BE PLACED IN 8-INCH MAXIMUM LOOSE LIFTS AND COMPACTED TO AT LEAST 95% MODIFIED PROCTOR (D1557) MAXIMUM DRY DENSITY AT -2% TO +2% OF OPTIMUM MOISTURE CONTENT. WE SHOULD BE CONTACTED TO OBSERVE REMOVAL OF EXPANSIVE MATERIAL. THE AREA OF REMOVAL MAY BE LESS OR MORE THAN INDICATED. THE MOISTURE TREATMENT SHOULD EXTEND TO AT LEAST 1 FOOT BEYOND EDGE OF PAVEMENT.



<p>A. G. WASSENAAR, INC.</p>	
<p>SITE PLAN AND VICINITY MAP</p>	<p>PROJECT NO. 216518 P1 FIGURE 1</p>

MATIKA SUBDIVISION, FILING 1
EL PASO COUNTY, COLORADO



 LOCAL RESIDENTIAL (RURAL) (ESAL = 36,500; MR = 7,571 psf)			
ALT	ACS (IN)	ABC (IN)	TOTAL (IN)
A	3.0	6.0	9.0

ACS - ASPHALT CONCRETE SURFACE
ABC - AGGREGATE BASE COURSE

- NOTES:
1. TEST BORINGS WERE OVERLAID ON THE "CONSTRUCTION PLANS FOR MATIKA SUBDIVISION FILING NO. 1, EL PASO COUNTY", PREPARED BY WVE, INC., PROJECT/JOB NO. 61154, DATED JUNE 8, 2021.
 2. ALL LOCATIONS ARE APPROXIMATE.

 AGW A.G. WASSENAAR, INC.	
PAVEMENT THICKNESS RECOMMENDATIONS	PROJECT NO. 216518 P1 FIGURE 1A



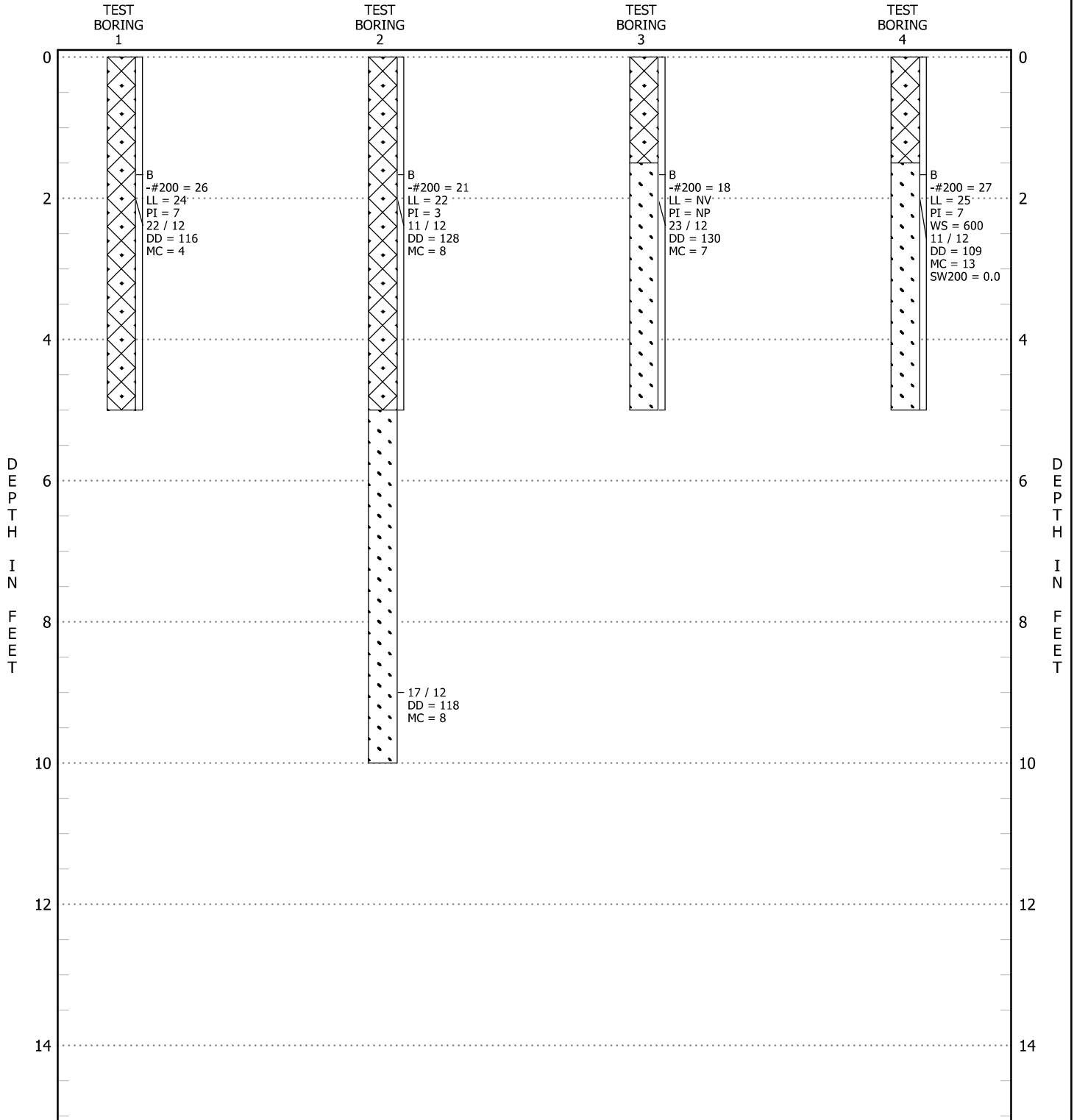
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Matika Subdivision, Filing 1

PROJECT NUMBER 216518 P1

PROJECT LOCATION El Paso County, Colorado



SEE FIGURE 4 FOR LEGEND AND NOTES

TEST BORING LOGS

FIGURE 2



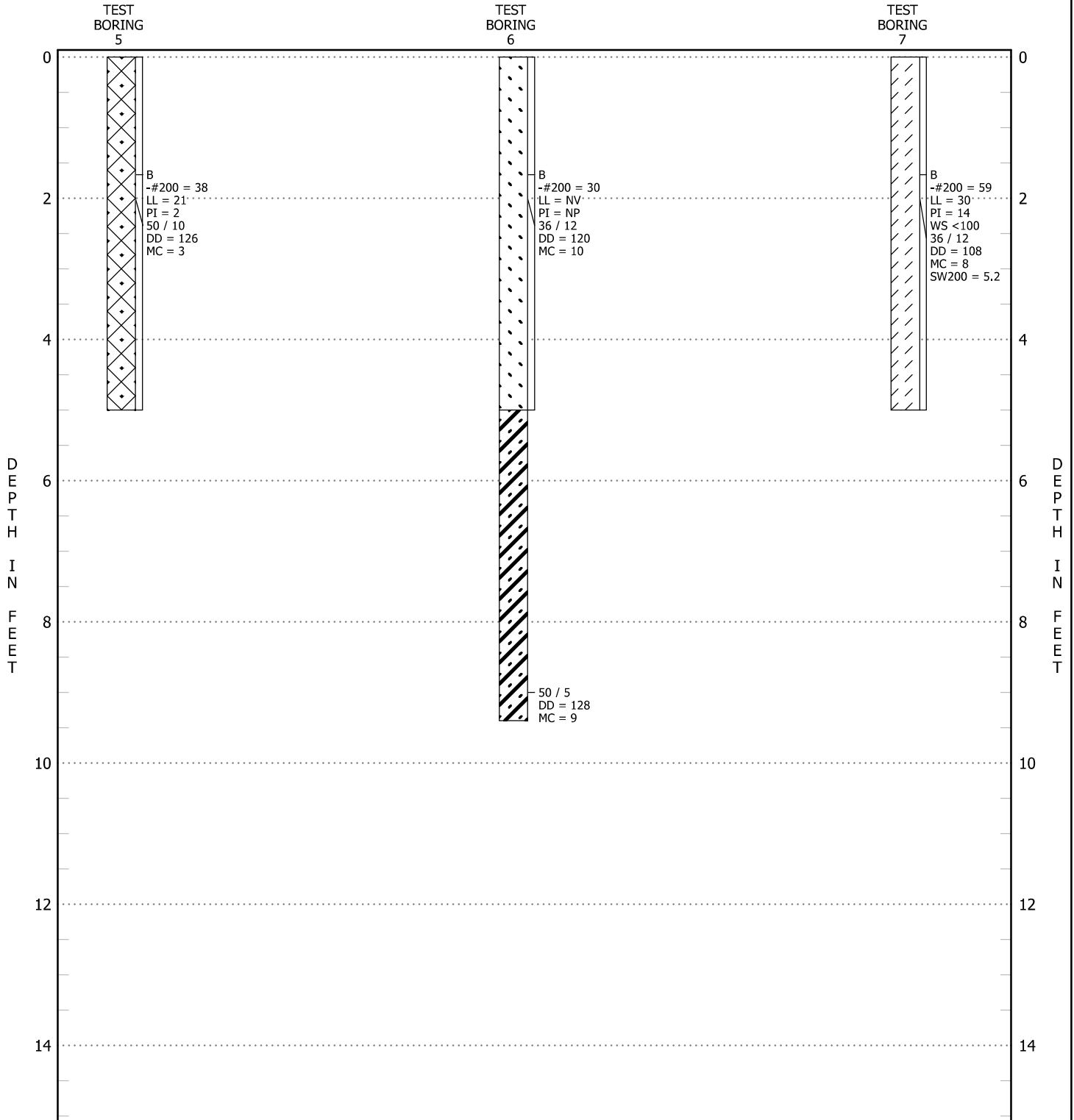
A.G. WASSENAAR, INC.

CLIENT Challenger Homes

PROJECT NAME Matika Subdivision, Filing 1

PROJECT NUMBER 216518 P1

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 Matika Subdivision, Filing 1






PROJECT NUMBER 216518 P1

PROJECT LOCATION El Paso County, Colorado

SOIL DESCRIPTIONS

-  Fill, sand, medium dense, silty, clayey, slightly gravelly
-  Clay, stiff to very stiff
-  Sand, medium dense, silty, slightly gravelly
-  Sandstone (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 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 September 17, 2021 .
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

**APPENDIX A
LABORATORY TEST RESULTS**

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

GRADATION AND ATTERBERG TEST RESULTS..... FIGURES A-1 THROUGH A-4

SWELL-CONSOLIDATION TEST RESULTS FIGURE A-5

PROCTOR TEST RESULTS..... FIGURE A-6

RESILIENT MODULUS TEST RESULTS..... FIGURE A-7



AGW

A. G. WASSENAR, INC.

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

October 14, 2021

Project Number 216518-P1
Matka Subdivision, Filing 1
El Paso County, Colorado

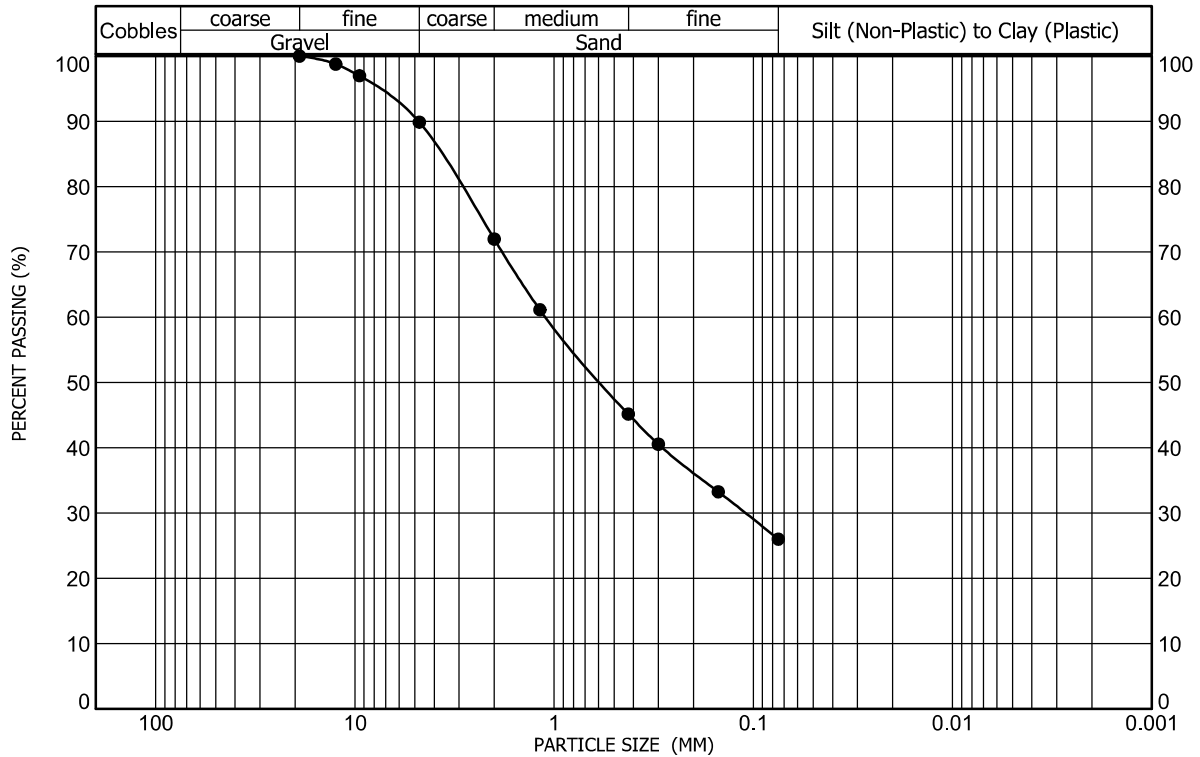
1 of 1

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, slightly gravelly	A-2-4(0)				26	24	17	7	
1	2	Fill, sand, silty/clayey, slightly gravelly		116	4						
2	0-5	Fill, sand, silty, gravelly	A-1-b(0)				21	22	19	3	
2	2	Fill, sand, silty, gravelly		128	8						
2	9	Sand, silty		118	8						
3	0-5	Fill, sand, silty, slightly gravelly	A-1-b(0)				18	NV	0	NP	
3	2	Sand, silty, slightly gravelly		130	7						
4	0-5	Fill, sand, silty/clayey, slightly gravelly	A-2-4(0)				27	25	18	7	600
4	2	Sand, silty/clayey, slightly gravelly		109	13	0.0					
5	0-5	Fill, sand, very silty	A-4(0)				38	21	19	2	
5	2	Fill, sand, very silty		126	3						
6	0-5	Sand, very silty	A-2-4(0)				30	NV	0	NP	
6	2	Sand, very silty		120	10						
6	9	Sandstone, silty		128	9						
7	0-5	Clay, very sandy	A-6(5)				59	30	16	14	<100
7	2	Clay, very sandy		108	8	5.2					

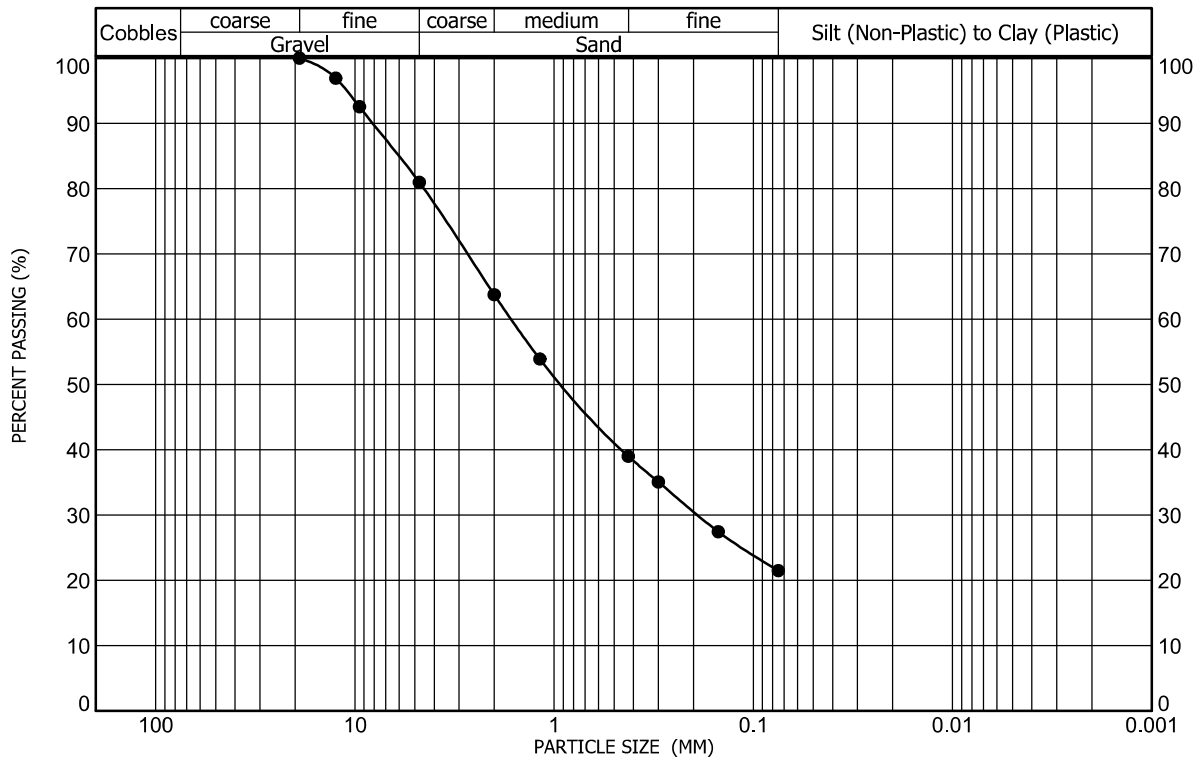
Notes:

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

NV - indicates No Value
NP - indicates Non-Plastic



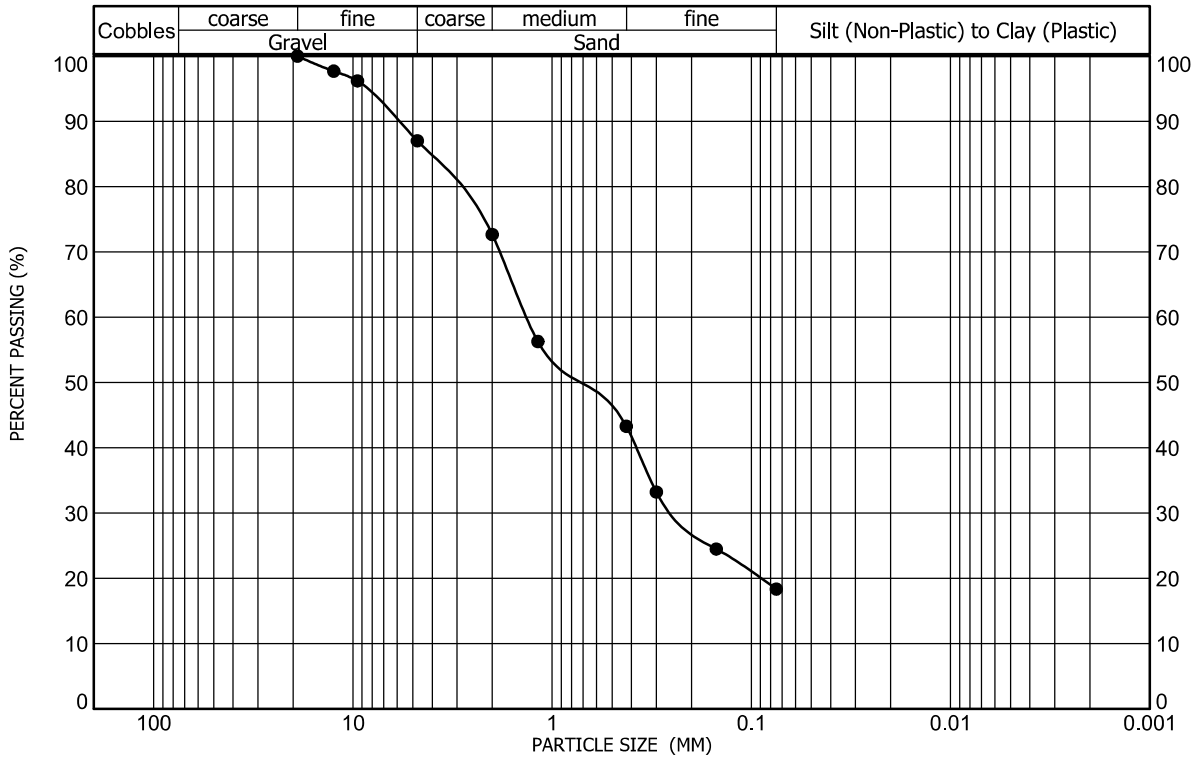
Sample Location Test Boring No. 1 at a depth of 0 feet to 5 feet Gravel (%) 10 Liquid Limit 24
 Sample Description Fill, sand, silty/clayey, slightly gravelly Sand (%) 64 Plasticity Index 7
 Classification A-2-4(0), SILTY, CLAYEY SAND(SC-SM) Clay/Silt (%) 26



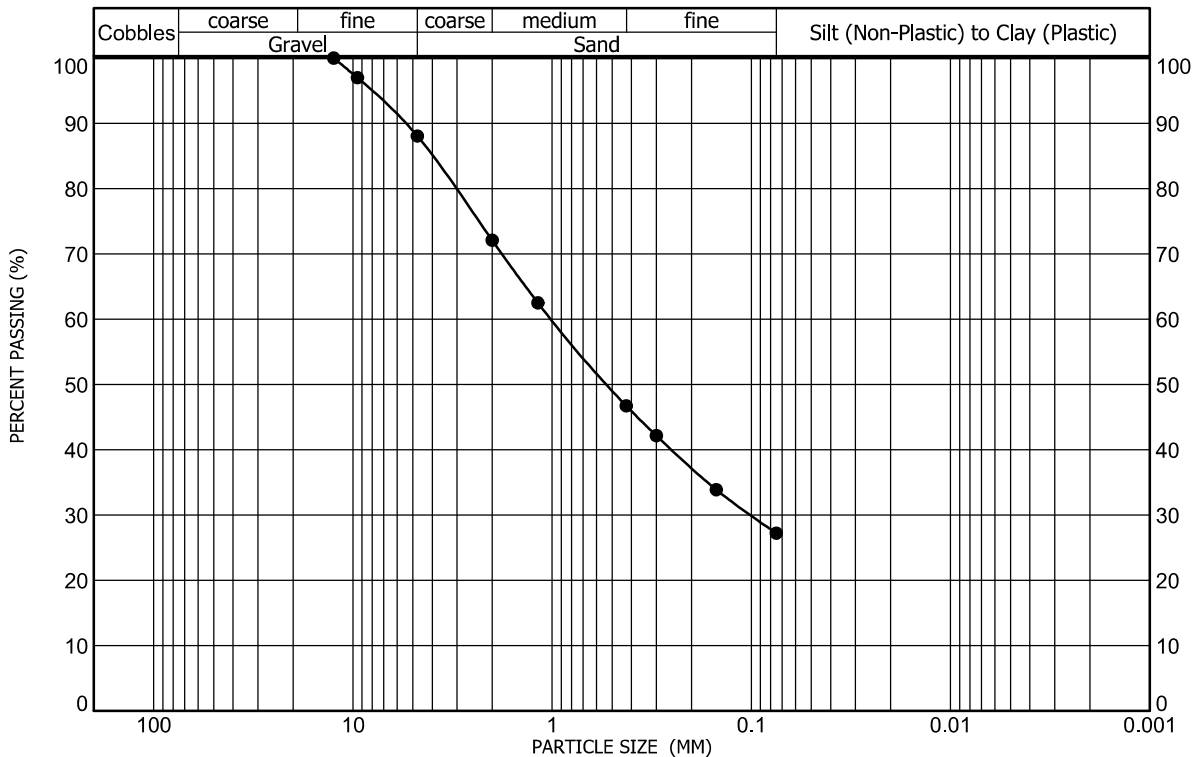
Sample Location Test Boring No. 2 at a depth of 0 feet to 5 feet Gravel (%) 19 Liquid Limit 22
 Sample Description Fill, sand, silty, gravelly Sand (%) 59 Plasticity Index 3
 Classification A-1-b(0), SILTY SAND with GRAVEL(SM) Clay/Silt (%) 21

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-1



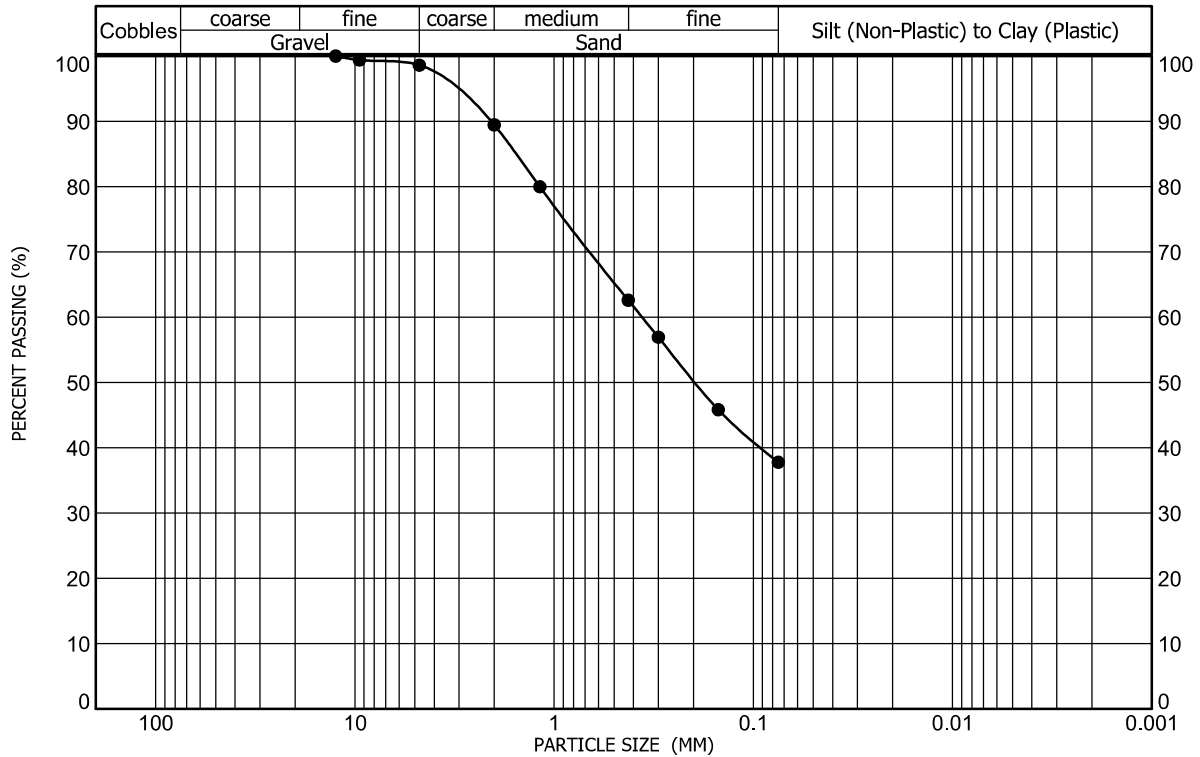
Sample Location Test Boring No. 3 at a depth of 0 feet to 5 feet Gravel (%) 13 Liquid Limit NV
 Sample Description Fill, sand, silty, slightly gravelly Sand (%) 69 Plasticity Index NP
 Classification A-1-b(0), SILTY SAND(SM) Clay/Silt (%) 18



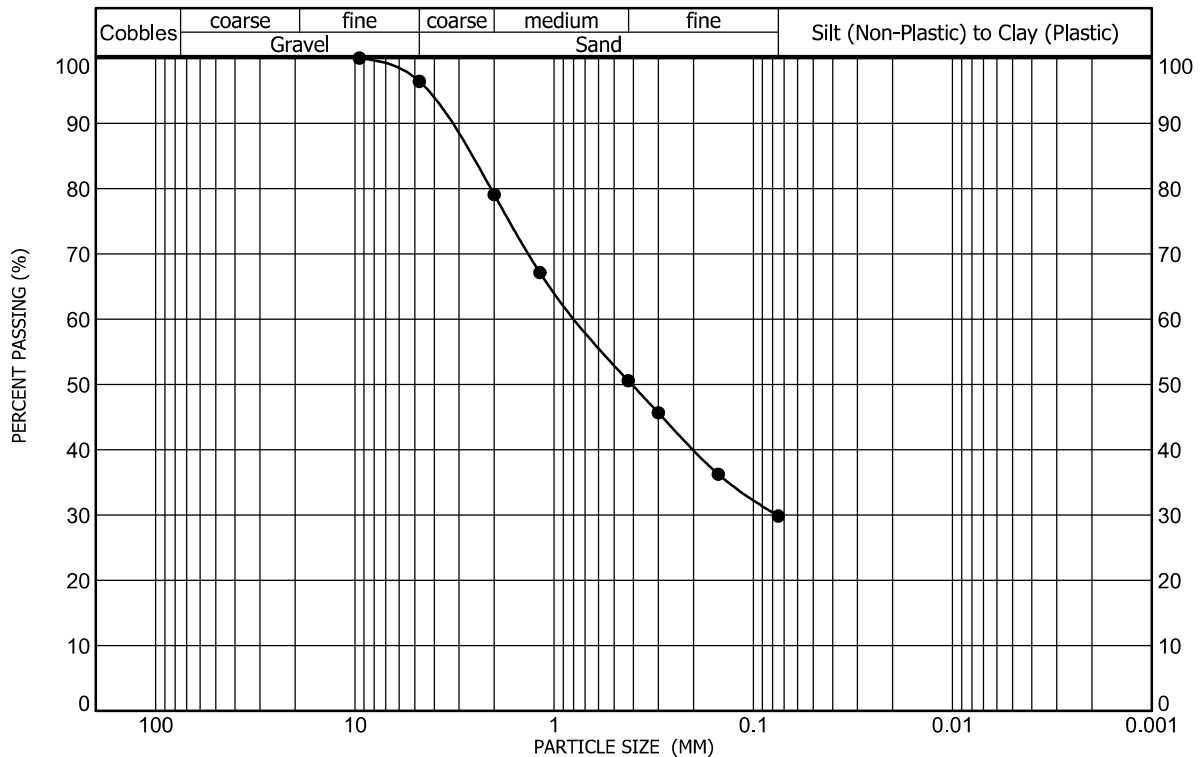
Sample Location Test Boring No. 4 at a depth of 0 feet to 5 feet Gravel (%) 12 Liquid Limit 25
 Sample Description Fill, sand, silty/clayey, slightly gravelly Sand (%) 61 Plasticity Index 7
 Classification A-2-4(0), SILTY, CLAYEY SAND(SC-SM) Clay/Silt (%) 27

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-2



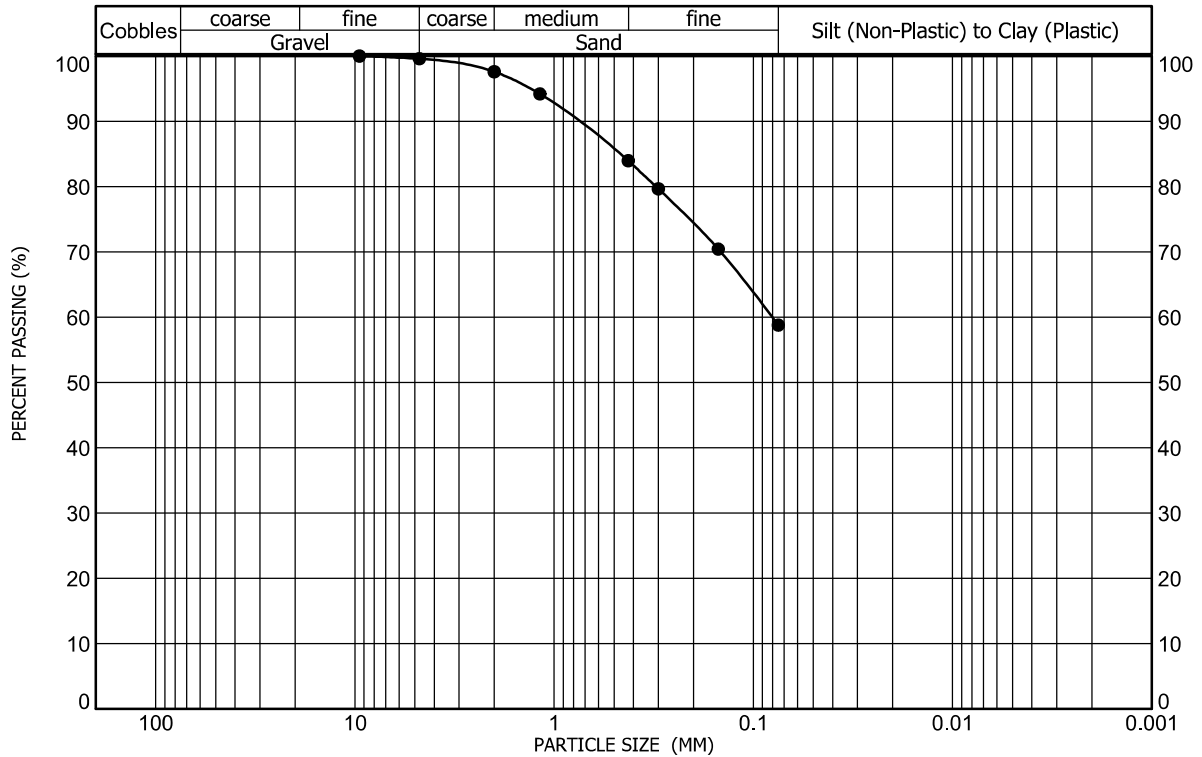
Sample Location Test Boring No. 5 at a depth of 0 feet to 5 feet Gravel (%) 1 Liquid Limit 21
 Sample Description Fill, sand, very silty Sand (%) 61 Plasticity Index 2
 Classification A-4(0), SILTY SAND(SM) Clay/Silt (%) 38



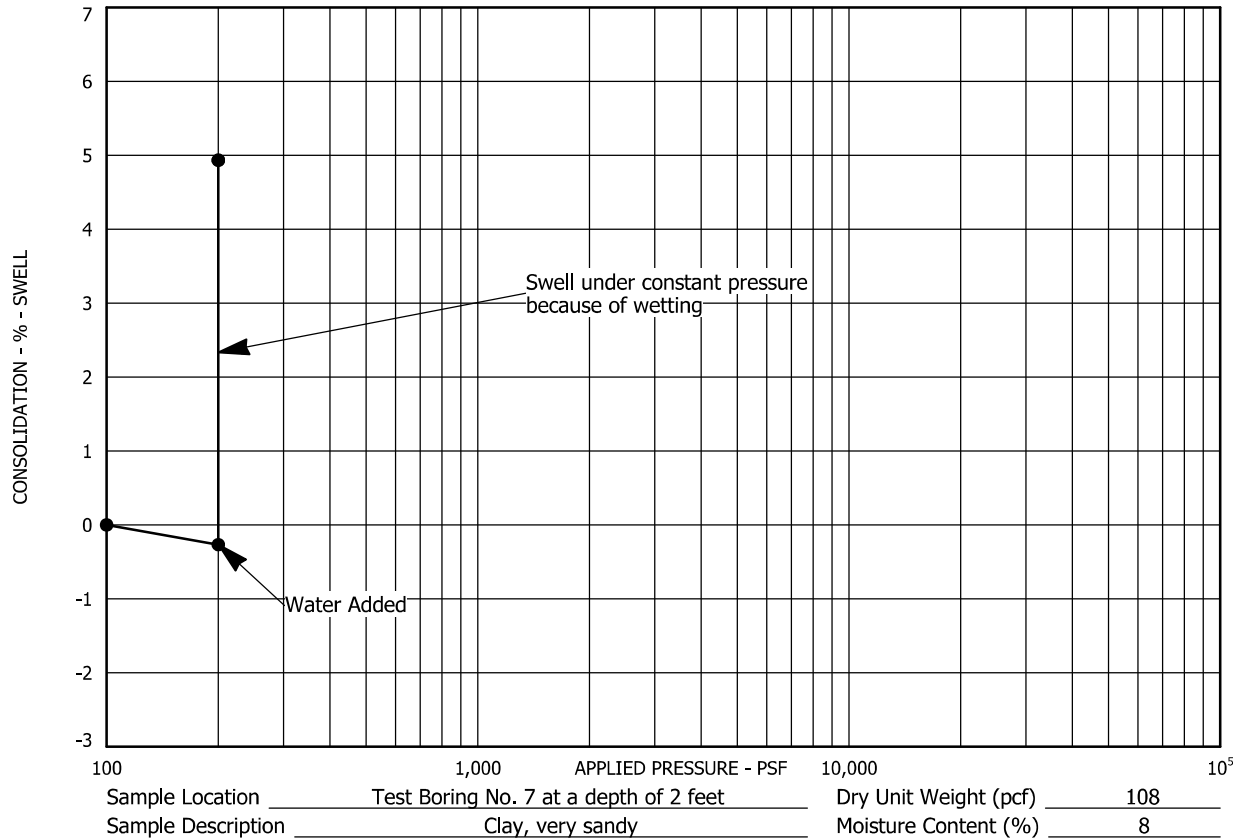
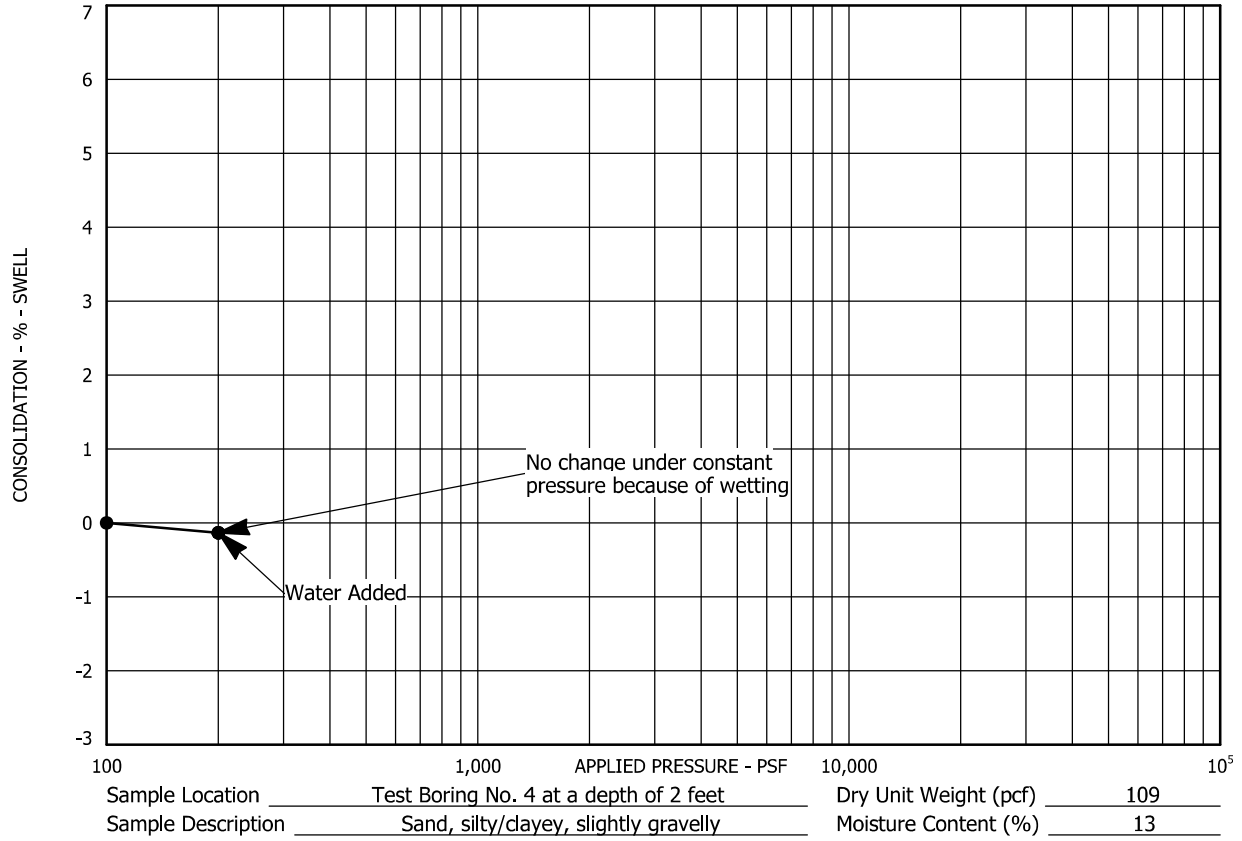
Sample Location Test Boring No. 6 at a depth of 0 feet to 5 feet Gravel (%) 4 Liquid Limit NV
 Sample Description Sand, very silty Sand (%) 67 Plasticity Index NP
 Classification A-2-4(0), SILTY SAND(SM) Clay/Silt (%) 30

GRADATION AND ATTERBERG TEST RESULTS

FIGURE A-3



Sample Location Test Boring No. 7 at a depth of 0 feet to 5 feet Gravel (%) 0 Liquid Limit 30
 Sample Description Clay, very sandy Sand (%) 41 Plasticity Index 14
 Classification A-6(5), SANDY LEAN CLAY(CL) Clay/Silt (%) 59



SWELL - CONSOLIDATION TEST RESULTS

FIGURE A-5



A.G. WASSENAAR, INC.

MOISTURE-DENSITY RELATIONSHIP

CLIENT Challenger Homes

PROJECT NAME Matika Subdivision, Filing 1

PROJECT NUMBER 216518 P1

PROJECT LOCATION El Paso County, Colorado

TEST RESULTS

Maximum Dry Density **108.5 PCF**
 Optimum Water Content **13.8 %**

Sample Location Test Boring No. 7 at a depth of 0 feet to 5 feet

Sample Source _____

AGW Description Clay, very sandy

USCS Classification SANDY LEAN CLAY(CL)

AASHTO Classification A-6(5)

Test Method D698A

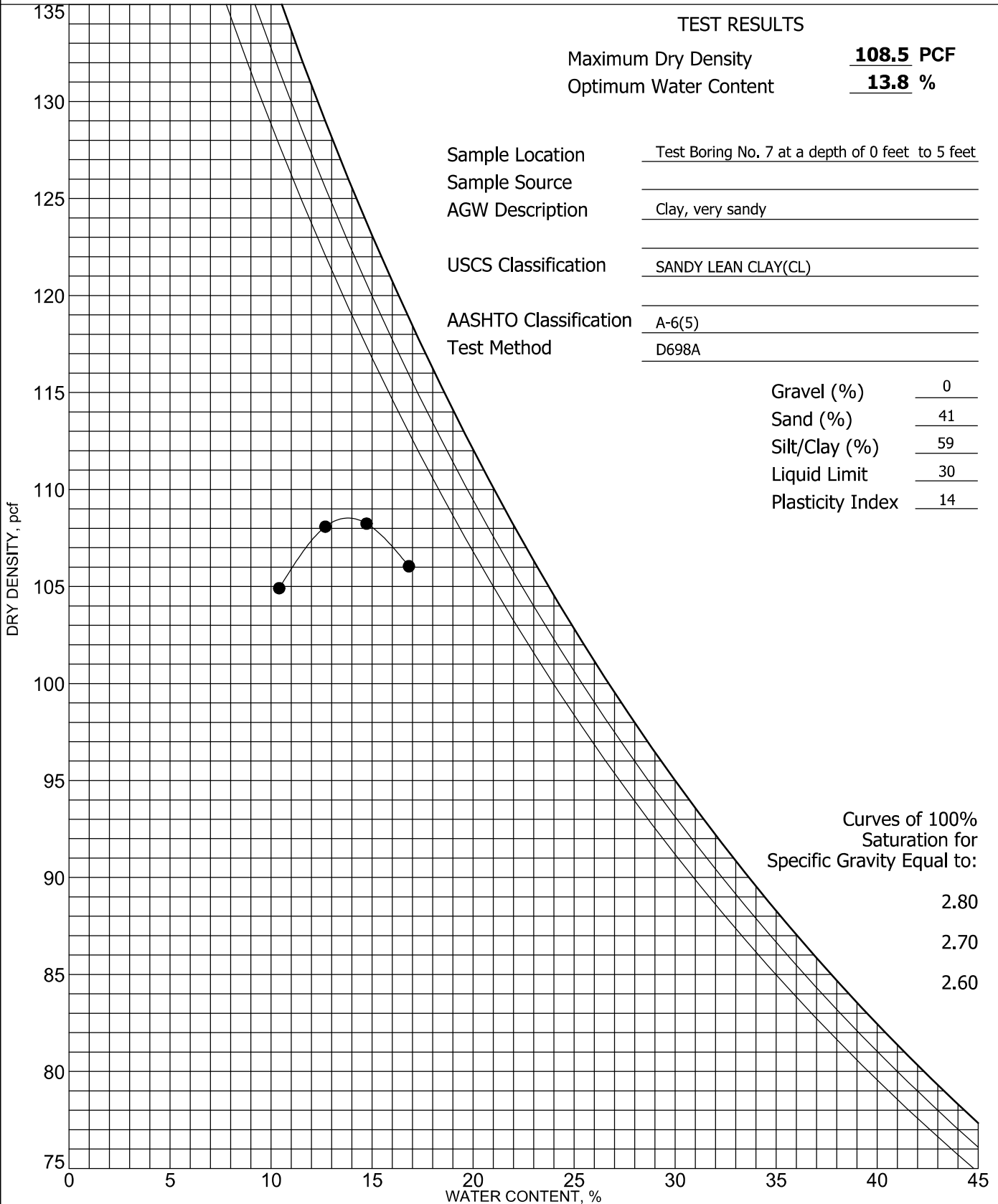
Gravel (%) 0

Sand (%) 41

Silt/Clay (%) 59

Liquid Limit 30

Plasticity Index 14



Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

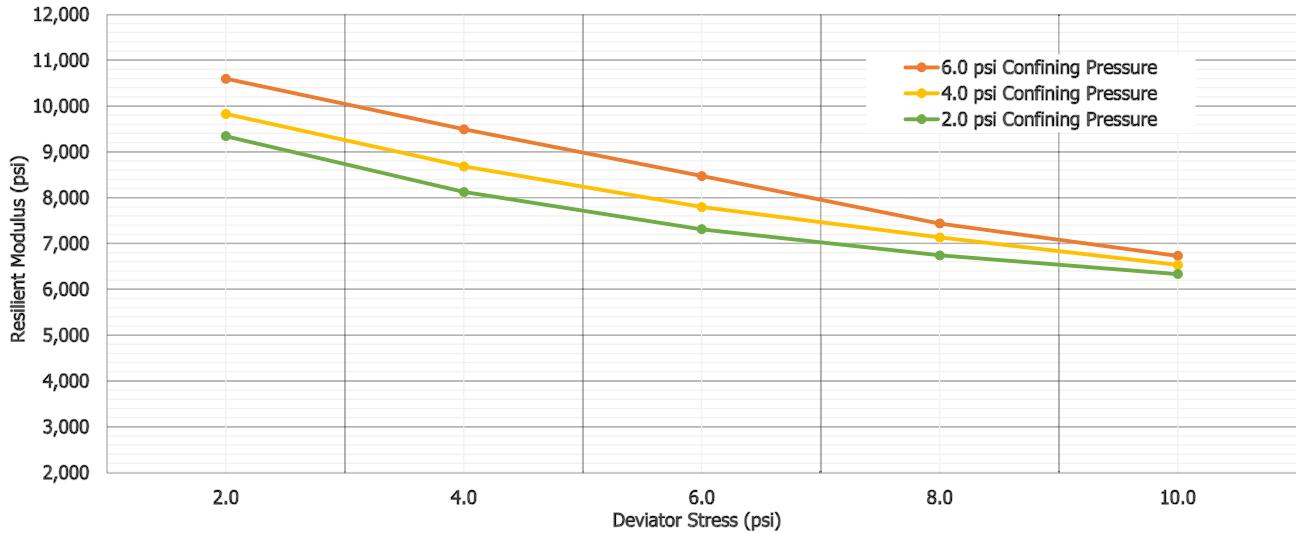
2.60

FIGURE A-6

Resilient Modulus Testing - AASHTO T307

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

Project Number 216518-P1
Project Name Matika Subdivision
Date October 14, 2021

Resilient Modulus Vs. Deviator Stress Graph


Sample Location	TB-7	AASHTO Classification	A-6 (5)
Soil Description	Clay, very sandy	-No. 200 (%)	59
Height (in)	5.6	Liquid Limit	30
Diameter (in)	2.8	Plastic Limit	16
Area (in²)	6.2	Plasticity Index	14
Volume (in³)	34.5	Proctor Type	ASTM D698
Remold Dry Density (pcf)	104.4	Proctor Max Dry Density (pcf)	108.5
Remold Moisture (%)	15.8	Optimum Moisture (%)	13.8
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	2.19	2.21	2.20	0.039	N/A
1	6.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	0.95	0.96	0.96	0.017	10,598
2	6.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.09	2.10	2.10	0.037	9,495
3	6.0	6.0	37.0	33.0	4.0	6.0	5.4	0.6	3.58	3.61	3.59	0.064	8,473
4	6.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	5.44	5.46	5.45	0.097	7,437
5	6.0	10.0	62.0	55.0	6.0	10.1	8.9	1.0	7.54	7.54	7.54	0.134	6,734
6	4.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	1.03	1.02	1.02	0.018	9,832
7	4.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.34	2.34	2.34	0.042	8,685
8	4.0	6.0	37.0	33.0	4.0	6.0	5.4	0.6	3.91	3.90	3.91	0.069	7,795
9	4.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	5.68	5.68	5.68	0.101	7,133
10	4.0	10.0	62.0	55.0	6.0	10.1	8.9	1.0	7.64	7.63	7.64	0.136	6,533
11	2.0	2.0	12.0	11.0	1.0	1.9	1.8	0.2	1.08	1.08	1.08	0.019	9,345
12	2.0	4.0	25.0	22.0	2.0	4.1	3.6	0.3	2.51	2.50	2.51	0.045	8,125
13	2.0	6.0	37.0	33.0	4.0	6.0	5.4	0.6	4.17	4.16	4.16	0.074	7,311
14	2.0	8.0	49.0	44.0	5.0	8.0	7.1	0.8	6.02	6.01	6.02	0.107	6,742
15	2.0	10.0	61.0	55.0	6.0	9.9	8.9	1.0	7.99	8.00	8.00	0.142	6,334

Resilient Modulus **7,571 psi** (average of test sequences 11, 12, 13, 14, 15)
Notes

FIGURE A-7

**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 (Rural)
 Matika Subdivision, Filing 1
 El Paso County, Colorado
 Project Number 216518-P1

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	75 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	7,571 psi
Stage Construction	1
 Calculated Design Structural Number	 1.77 in

Specified Layer Design

<u>Layer</u>	<u>Material Description</u>	Struct Coef. <u>(Ai)</u>	Drain Coef. <u>(Mi)</u>	Thickness <u>(Di)(in)</u>	Width <u>(ft)</u>	Calculated <u>SN (in)</u>
1	Hot Bituminous Pavement	0.44	1	3	-	1.32
2	Aggregate Base Course	0.11	1	6	-	0.66
Total	-	-	-	9.00	-	1.98