Structural
Geotechnical

Materials Testing
Forensic

PAVEMENT DESIGN REPORT

Falcon Meadows at Bent Grass, Filing No. 3
El Paso County, Colorado

PREPARED FOR:

Challenger Communities
8605 Explorer Drive, Suite 250
El Paso County, CO 80920

JOB NO. 195343

June 14, 2024

Respectfully Submitted,

RMG – Rocky Mountain Group

Jared McElmeel, E.I.
Geotechnical Staff Engineer

Reviewed by,

RMG – Rocky Mountain Group

COLORADO REGISTERED
ANTHONY P. MUNGER
6/20/24
39818
PROFESSIONAL ENGINEER

Tony Munger, P.E.
Sr. Geotechnical Project Manager

PCD File No. SF Number 2216 and PCD File No. PAV247

Accepted for File
By: Gilbert LaForce, P.E.
Engineering Manager
Date: 11/07/2024 9:12:57 AM
El Paso County Department of Public Works

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GENERAL SITE AND PROJECT DESCRIPTION

Location

Falcon Meadows at Bent Grass, Filing No. 3 is generally located north of E Woodmen Road and west of Meridian Rd in the direction portion of El Paso County, Colorado. The location of the site is shown on the Site Vicinity Map, Figure 1.

Existing Site Conditions

At the time of our investigation the project site was overlot graded, the roadways were rough graded and utilities had been installed. Curb and gutter had not been installed.

Project Description

This Pavement Design Report was performed to determine the subsurface conditions present along the roadway alignments within the proposed development, and to develop recommendations for the design and construction of the proposed flexible pavements.

The proposed streets included in this investigation are shown on Figure 2.1 and 2.2. The streets considered herein are classified as Urban Local and Urban Local Low Volume.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Drilling

The subsurface conditions on the site were investigated by drilling six exploratory test borings. The approximate locations of the test borings are presented in the Test Boring Location Plan, Figure 2.1.

The test borings were advanced with a power-driven, continuous-flight auger drill rig to depths of about 5 to 10 feet below the existing ground surface. Samples were obtained in general accordance with ASTM D-3550 utilizing a 2½-inch OD modified California sampler. Representative bulk samples of subsurface materials were obtained from each boring at a depth of approximately 0 to 2 feet below the existing ground surface. An Explanation of Test Boring Logs is presented in Figure 3. The Test Boring Logs are presented in Figures 4 through 6.

Subsurface Materials

The subsurface materials encountered in the test borings consisted of silty to clayey sand, sandy clay, sandy claystone, and clayey sandstone. Combined bulk samples of the material classified as SM according to the Unified Classification System. For pavement design purposes the combined bulk soil samples classified as A-2-4 in accordance with the American Association of State

Highway and Transportation Officials (AASHTO) classification system. This soil classification is considered "Good" as subgrade material.

A composite bulk sample from the TB-1, TB-4, and TB-6 Test Borings, A-2-4 soil, was tested to determine its moisture-density relationship curve in accordance with ASTM D1557 (Modified Proctor compaction test). Maximum Dry Density proved to be 128.3 pcf at 7.9 percent moisture. A CBR test was performed at varying densities at moisture content near optimum. At 95% of the maximum Modified Proctor density, 121.9 pcf, the CBR of the bulk sample was 34.7.

Composite Sample Derived From	Composite Sample Classification	% Passing #200 Sieve	LL	PI	Maximum Dry Density (pcf)	Optimum Moisture (%)	Resulting CBR
TB-1, TB-4, and TB-6	A-2-4	23.9	NP	NP	128.3	7.9	34.7

Groundwater

Groundwater was encountered in one the test borings, at a depth of 9 feet, at the time of drilling. Groundwater is not expected to affect the construction of the pavements. Fluctuations in groundwater and subsurface moisture conditions may occur due to variations in precipitation and other factors not readily apparent at this time. Development of the property and adjacent properties may also affect groundwater levels.

Laboratory Testing

Laboratory Testing

The moisture content for the recovered samples was obtained in the laboratory. Grain-size analysis and Atterberg Limits tests were performed on selected samples for purposes of classification and to develop pertinent engineering properties. A Summary of Laboratory Test Results is presented in Figure 7. Soil Classification Data are presented in Figures 8 and 9.

A combined bulk sample of A-2-4 soil was tested to determine the optimum moisture-density relationship in accordance with ASTM D-1557 (Standard Proctor compaction test). California Bearing Ratio, CBR tests were performed at varying densities with moisture content near optimum. At 95% of the maximum Standard Proctor density, the CBR of the bulk sample was 34.7. The Moisture-Density Relation Curve is presented in Figure 10. The CBR Test Results are presented in Figures 11 and 12.

The developer intends to install a composite roadway section consisting of Hot Mix Asphalt over Aggregate Base Course (ABC).

PAVEMENT DESIGN

The following pavement design is based on the subsurface conditions encountered in the test borings and on the project characteristics previously described. If conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and adjust them, if necessary.

Pavement Design

This pavement design was prepared in accordance with the El Paso County Pavement Design Criteria Manual.

Street Classification – Urban Local

1) Sophia Lane, and Henzlee Place
   ESAL = 292,000 (Table D-2)
   Serviceability Index = 2.0 (Table D-1)

2) Strength coefficients (Table D-3)
   Asphalt (HMA): $a_1 = 0.44$
   Aggregate Base Course: $a_2 = 0.11$

3) Subgrade
   M_r = CBR x 1500 = 34.7 x 1500 = 52,050 psi

4) Structural number (SN) = 1.18 (per 1993 AASHTO Empirical Equation for Flexible Pavements, presented in Appendix A)

5) Composite asphalt/base course section
   Minimum HMA thickness = D_1 = 3 inches (Table D-2)
   ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{1.18 – (3 \times 0.44)\} / 0.11 < 0$ inches
   Minimum ABC thickness = 8 inches (Table D-2)
   SN = (3 x 0.44) + (8 x 0.11) = 2.2 > 1.18 (Min. SN required)
   Use minimum HMA thickness = 3.5 inches over minimum ABC thickness = 8 inches (Paragraph D.4.1-F: base course thickness cannot exceed 2.5 times the HMA thickness)

Street Classification – Urban Local-Low Volume

1) Isabel Place, Kittrick Place, Sophia Lane, and Henzlee Place
   ESAL = 36,500 (Table D-2)
   Serviceability Index = 2.0 (Table D-1)

2) Strength coefficients (Table 6)

Asphalt (HMA): $a_1 = 0.44$
Aggregate Base Course: $a_2 = 0.11$

3) Subgrade
M_r = CBR x 1500 = 34.7 x 1500 = 52,050 psi

4) Structural number (SN) = 0.745 (per 1993 AASHTO Empirical Equation for Flexible Pavements, presented in Appendix A)

5) Composite asphalt/base course section
Minimum HMA thickness = D_1 = 3 inches (Table D-2)
ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{0.745 – (3 \times 0.44)\} / 0.11 < 0$ inches
Minimum ABC thickness = 4 inches (Table D-2)
SN = (3 x 0.44) + (4 x 0.11) = 1.76 > 0.745 (Min. SN required)
Use minimum HMA thickness = 3 inches over minimum ABC thickness = 4 inches

Pavement Thickness

Based on the design calculations, the recommended pavement sections are presented below and on Figure 2.2.

Street	Sample	Required SN	HMA (in.)	ABC (in.)	CTS (in.)	Calculated SN	OK
Isabel Place, Kittrick Place, Sophia Lane, and Henzlee Place	CBR-Proctor	0.745	3	4	0	1.76	Y
Sophia Lane, and Henzlee Place	CBR-Proctor	1.18	3.5	8	0	2.42	Y

Pavement Materials

Pavement materials should be selected, prepared, and placed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. Tests should be performed in accordance with the applicable procedures presented in the specifications.

Expansive Soil Mitigation

The PDCM notes that mitigation measures may be required for expansive soils, shallow ground water, subgrade instability, etc. Based on the AASHTO classification for the soils in this subdivision, the subgrade soils evaluated for this pavement design can be expected to be non-expansive. Neither groundwater nor wet and unstable soils were encountered in the borings. Therefore, special mitigation measures do not appear to be necessary for subgrade preparation.

Subgrade Preparation

All fill placed below pavements should be moisture conditioned and compacted in accordance with El Paso County *Standard Specifications Manual*. Prior to placement of the pavement section, the final subgrade should be scarified to a depth of 12 inches, adjusted to within 2 percent of the optimum moisture content and compacted to City specifications. The subgrade should then be proofrolled with a heavy, pneumatic tired vehicle. Areas which deform under wheel loads should be removed and replaced. Base course place atop prepared subgrade should be compacted to at least 95 percent of the maximum modified Proctor density (ASTM D1557).

Surface Drainage

Surface drainage is important for the satisfactory performance of pavement. Wetting of the subgrade soils or base course will cause a loss of strength which can result in pavement distress. Surface drainage should provide for efficient removal of storm-water runoff. Water should not pond on the pavement or at the edges of the pavement.

Subgrade Observations and Testing

The pavement thicknesses presented above assume pavement construction is completed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. RMG should be present at the site during subgrade preparation, placement of fill, and construction of pavements to perform site observations and testing.

CLOSING

Our field exploration was conducted to provide geotechnical information for pavement thickness design. Variations in subsurface conditions not indicated by the borings may be encountered. This report has been prepared for **Challenger Communities** for application as an aid in the design of the proposed development in accordance with generally accepted geotechnical engineering practices. The analyses and recommendations in this report are based in part upon data obtained from exploratory borings and test pits, site observations and the information presented in referenced reports. The nature and extent of variations may not become evident until construction. If variations then become evident, RMG should be retained to re-evaluate the recommendations of this report, if necessary.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by geotechnical engineers practicing in this or similar localities. RMG Engineers does not warrant the work of regulatory agencies or other third parties supplying information which may have been used during the preparation of this report. No warranty, express or implied is made. Any contractor reviewing this report for bidding purposes must draw his own conclusions regarding site conditions and specific construction techniques to be used on this project.

This report is for the exclusive purpose of providing geotechnical information and pavement thickness design recommendations. The scope of services for this project does not include, either

specifically or by implication, environmental assessment of the site or identification of contaminated or hazardous materials or conditions. Development of recommendations for the mitigation of environmentally related conditions, including but not limited to biological or toxicological issues, are beyond the scope of this report. If the Client desires investigation into the potential for such contamination or conditions, other studies should be undertaken.

If we can be of further assistance in discussing the contents of this report or analysis of the proposed development, from a geotechnical engineering point-of-view, please feel free to contact us.

FIGURES

APPENDIX A

NOT TO SCALE

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2910 AUSTIN BLUFFS PKWY, SUITE 100,
COLORADO SPRINGS, CO 80918
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
Southern Colorado, Denver Metro, Northern Colorado

SITE VICINITY MAP

FALCON MEADOWS AT BENT GRASS,
FILING NO. 3
EL PASO COUNTY, COLORADO
CHALLENGER COLORADO, LLC

JOB No. 195343

FIG No. 1

DATE 6-14-2024

Revise to add a scale to the drawing.

NOT TO SCALE

TB-# DENOTES LOTS WHERE TEST BORINGS WERE PERFORMED

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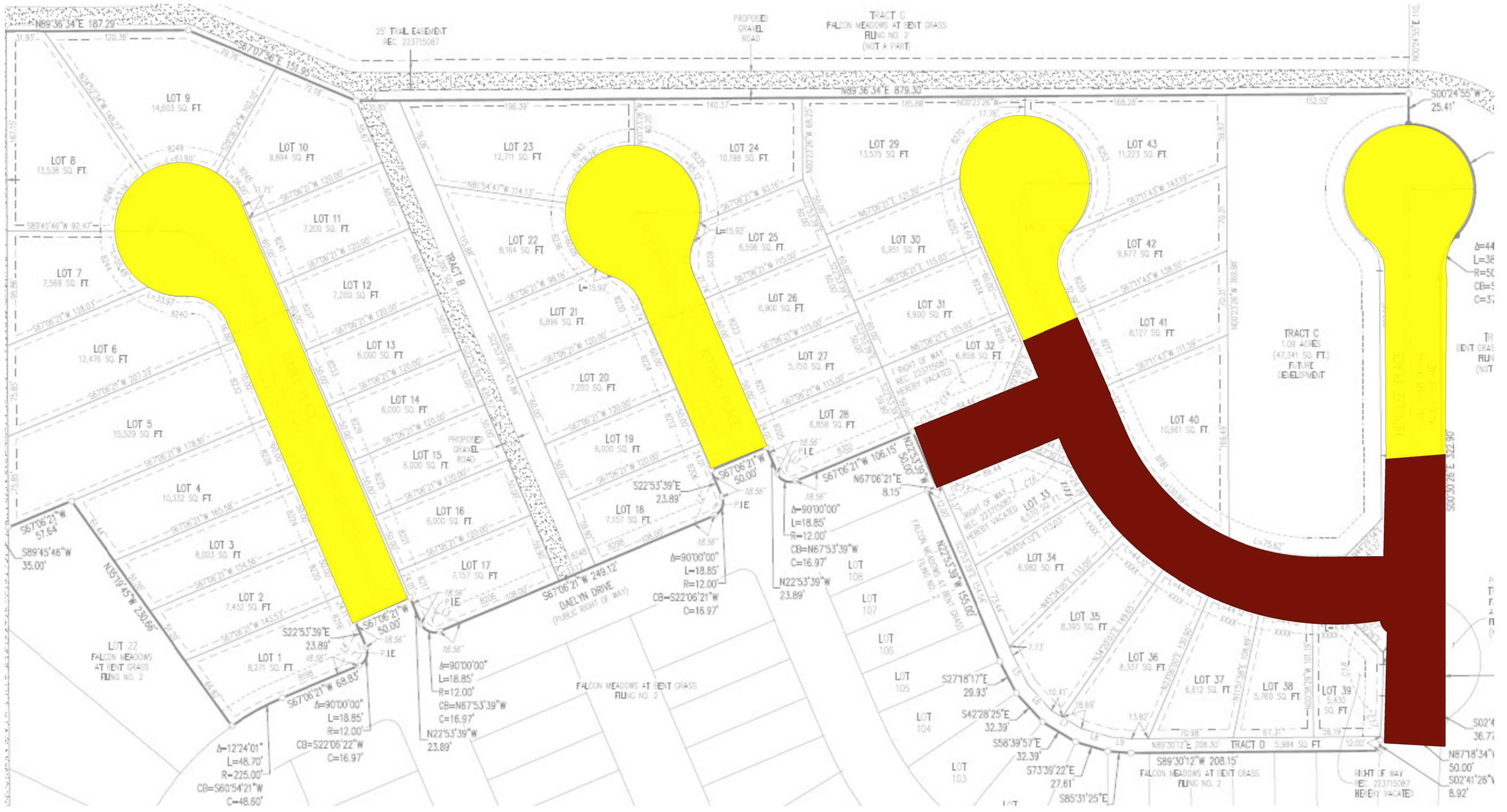
COLORADO SPRINGS, CO 80918
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

FALCON MEADOWS AT BENT GRASS, FILING NO. 3
EL PASO COUNTY, COLORADO
CHALLENGER COLORADO, LLC

ENGINEER:	TM
DRAWN BY:	JM
CHECKED BY:	TM
ISSUED:	6-14-2024

TEST BORING LOCATION PLAN

SHEET No.
FIG-2.1



Urban Local low volume: 3" HMA over 4" ABC

Urban Local: 3.5" HMA over 8" ABC

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COLORADO SPRINGS, CO 80918
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
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CHECKED BY:	TM
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PAVEMENT RECOMMENDATIONS

SHEET No.
FIG-2.2

SOILS DESCRIPTION


CLAYSTONE


SANDSTONE


SANDY CLAY


SILTY SAND


SILTY TO CLAYEY SAND

UNLESS NOTED OTHERWISE, ALL LABORATORY
TESTS PRESENTED HEREIN WERE PERFORMED BY:
RMG - ROCKY MOUNTAIN GROUP
2910 AUSTIN BLUFFS PARKWAY
COLORADO SPRINGS, COLORADO

SYMBOLS AND NOTES


XX — STANDARD PENETRATION TEST - MADE BY DRIVING A SPLIT-BARREL SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-1586. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


XX — UNDISTURBED CALIFORNIA SAMPLE - MADE BY DRIVING A RING-LINED SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-3550. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


FREE WATER TABLE


DEPTH AT WHICH BORING CAVED


BULK — DISTURBED BULK SAMPLE


AUG — AUGER "CUTTINGS"

4.5 — WATER CONTENT (%)

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Colorado Springs: (Corporate Office)
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Colorado Spings, CO 80918
(719) 548-0600
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EXPLANATION OF TEST BORING LOGS

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FIGURE No. 3

DATE Jun/14/2024

TEST BORING: **1** DATE DRILLED: 4/16/24 NO GROUNDWATER ON 4/16/24	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SANDSTONE, SILTY TO CLAYEY, with gravel, tan to brown and gray, medium hard, moist	2.5			50/9"	9.1
CLAYSTONE, SANDY, with gravel, tan to brown, medium hard, moist	5.0			50/7"	13.0

TEST BORING: **2** DATE DRILLED: 4/16/24 NO GROUNDWATER ON 4/16/24	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SANDSTONE, SILTY TO CLAYEY, with gravel, tan to brown, firm to medium hard, moist	2.5			42	6.3
	5.0			50/8"	11.8

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TEST BORING LOG

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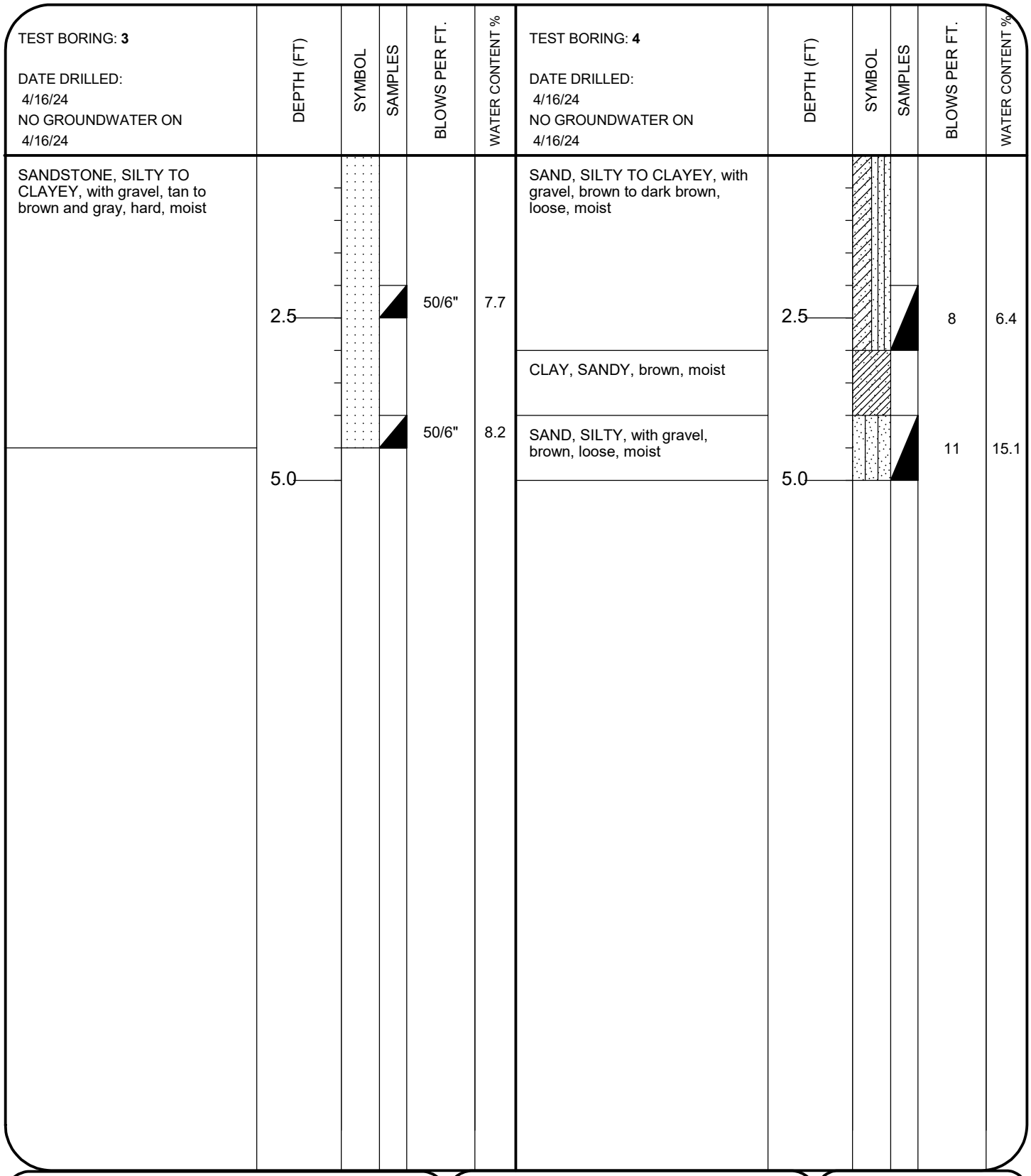
FIGURE No. 4

DATE Jun/14/2024



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TEST BORING LOG

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FIGURE No. 5

DATE Jun/14/2024

TEST BORING: **5**

DATE DRILLED:
4/16/24
GROUNDWATER @ 9.0 '
4/16/24

SAND, SILTY TO CLAYEY, with gravel, tan to brown, loose to medium dense, moist

SANDSTONE, SILTY, with gravel, tan to gray, medium hard, moist to wet

DEPTH (FT)	BLOWS PER FT.	WATER CONTENT %
2.5	7	7.4
5.0	22	5.4
7.5	50/10"	13.6
10.0		

TEST BORING: **6**

DATE DRILLED:
4/16/24
NO GROUNDWATER ON
4/16/24

SAND, SILTY, with gravel, tan, loose, moist

DEPTH (FT)	BLOWS PER FT.	WATER CONTENT %
2.5	15	6.0
5.0	17	5.6

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TEST BORING LOG

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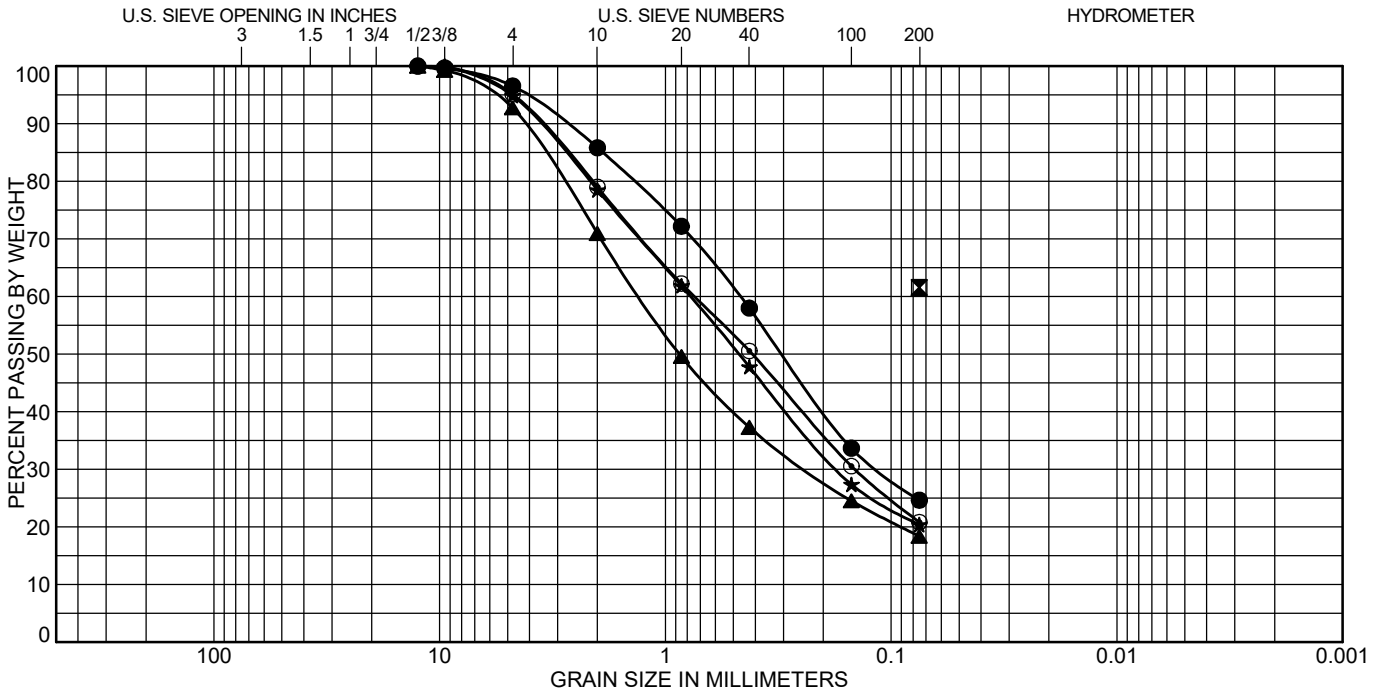
FIGURE No. 6

DATE Jun/14/2024

Test Boring No.	Depth	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% Retained No.10 Sieve	% Retained No.40 Sieve	% Passing No. 200 Sieve	% Swell @ 100 psf	AASHTO Classification
1	0.0			NP	NP	14.2	42.3	24.6		A-2-4 (0)
1	2.0	9.1								
1	4.0	13.0		37	18			61.6		A-6 (9)
2	0.0			NP	NP	29.1	62.9	18.4		A-1-b (0)
2	2.0	6.3								
2	4.0	11.8								
3	0.0			NP	NP	21.5	52.4	20.4		A-1-b (0)
3	2.0	7.7								
3	4.0	8.2								
4	0.0			NP	NP	21.0	49.7	20.8		A-2-4 (0)
4	2.0	6.4		NP	NP	24.4	67.1	16.8		A-1-b (0)
4	4.0	15.1								
5	0.0			NP	NP	21.5	54.0	20.2		A-1-b (0)
5	2.0	7.4								
5	4.0	5.4								
5	9.0	13.6								
6	0.0			NP	NP	13.8	36.1	26.2		A-2-4 (0)
6	2.0	6.0								
6	4.0	5.6								

SUMMARY OF LABORATORY TEST RESULTS

JOB No. 195343
FIGURE No. 7
PAGE 1 OF 1
DATE Jun/14/2024



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Test Boring	Depth (ft)	Classification	LL	PL	PI
●	1	0.0	SILTY SAND(SM)	NP	NP	NP
⊠	1	4.0	SANDY LEAN CLAY(CL)	37	19	18
▲	2	0.0	SILTY SAND(SM)	NP	NP	NP
★	3	0.0	SILTY SAND(SM)	NP	NP	NP
⊙	4	0.0	SILTY SAND(SM)	NP	NP	NP

	Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	1	0.0	3.5	71.9	24.6	
⊠	1	4.0			61.6	
▲	2	0.0	7.3	74.4	18.4	
★	3	0.0	5.1	74.5	20.4	
⊙	4	0.0	4.9	74.3	20.8	

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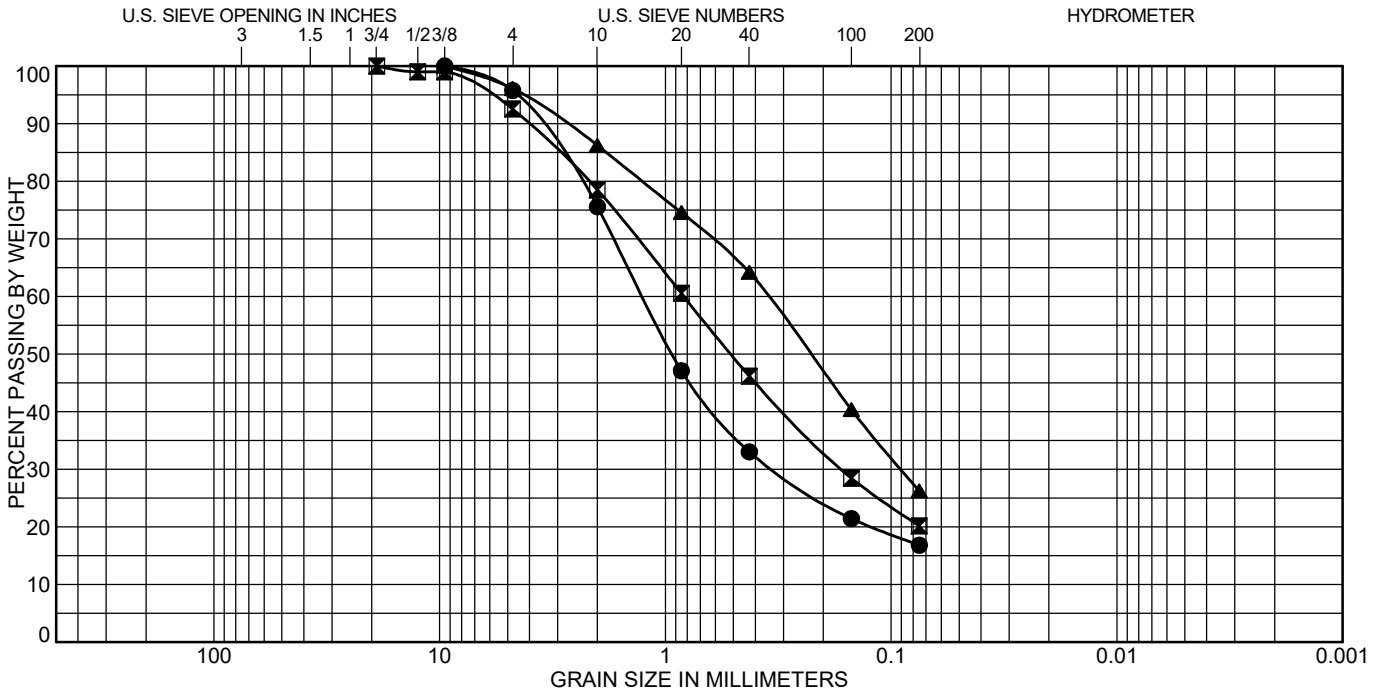
SOIL CLASSIFICATION DATA

JOB No. 195343

FIGURE No. 8

DATE Jun/14/2024



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Test Boring	Depth (ft)	Classification	LL	PL	PI
●	4	2.0	SILTY SAND(SM)	NP	NP	NP
⊠	5	0.0	SILTY SAND(SM)	NP	NP	NP
▲	6	0.0	SILTY SAND(SM)	NP	NP	NP

	Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	4	2.0	4.2	78.9	16.8	
⊠	5	0.0	7.5	72.4	20.2	
▲	6	0.0	3.9	69.8	26.2	

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SOIL CLASSIFICATION DATA

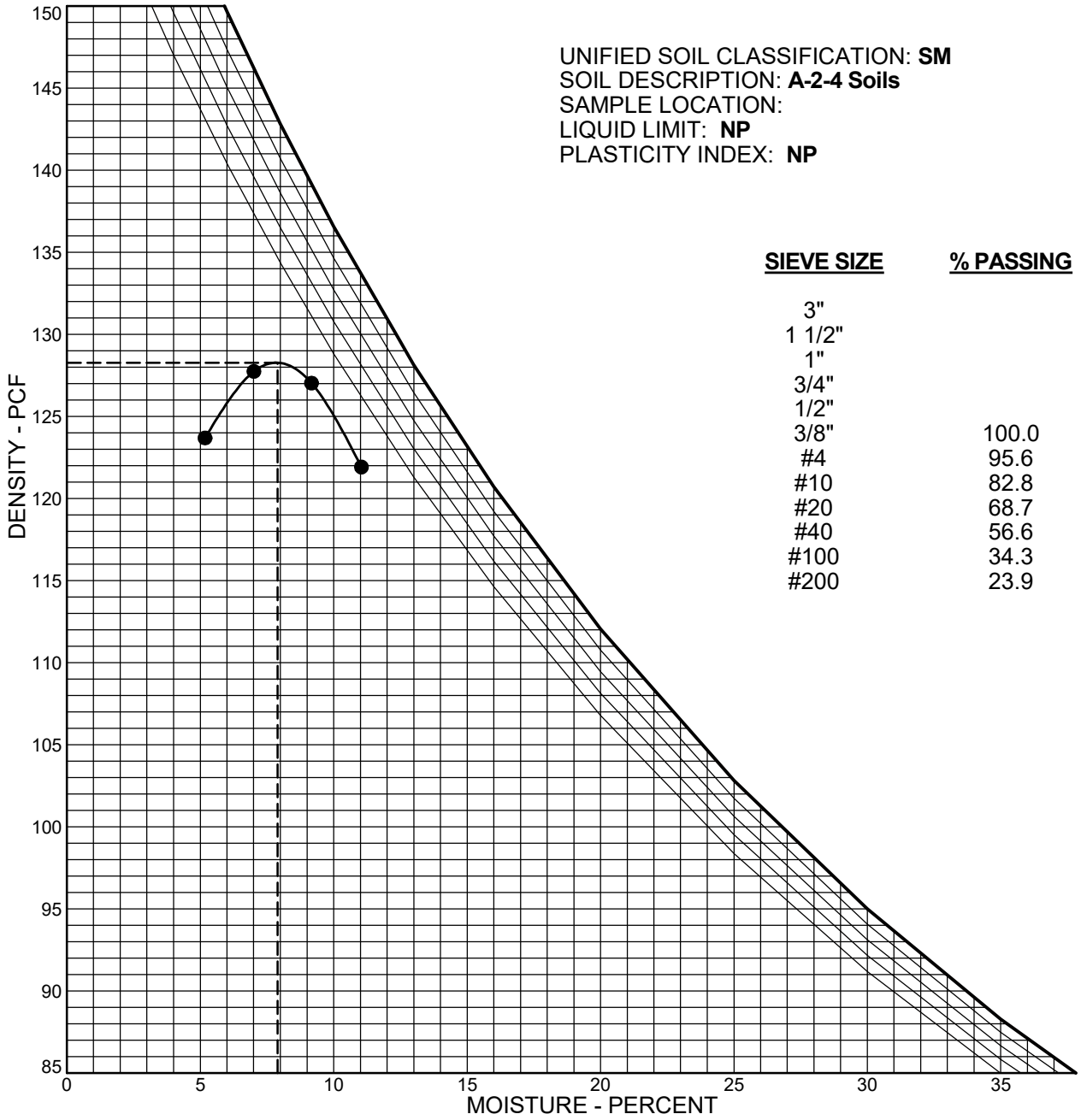
JOB No. 195343

FIGURE No. 9

DATE Jun/14/2024

CLIENT: Challenger Colorado, LLC **SAMPLE NUMBER:** A-2-4 Proctor

PROJECT: **Falcon Meadows at Bent Grass, Filing No. 3, El Paso County, Colorado**



UNIFIED SOIL CLASSIFICATION: **SM**
SOIL DESCRIPTION: **A-2-4 Soils**
SAMPLE LOCATION:
LIQUID LIMIT: **NP**
PLASTICITY INDEX: **NP**

SIEVE SIZE	% PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	100.0
#4	95.6
#10	82.8
#20	68.7
#40	56.6
#100	34.3
#200	23.9

DESIGNATION **ASTM D-1557A**
MAX. DRY DENSITY **128.3 pcf**
OPTIMUM MOISTURE **7.9 %**
FRACTION USED **#4**
MOLD VOLUME **0.0333 cu.ft.**

NOTE: ZERO AIR VOIDS CURVES PLOTTED FOR:
Gs = 2.60
Gs = 2.65
Gs = 2.70
Gs = 2.75
Gs = 2.80

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MOISTURE-DENSITY RELATION CURVE

JOB No. 195343

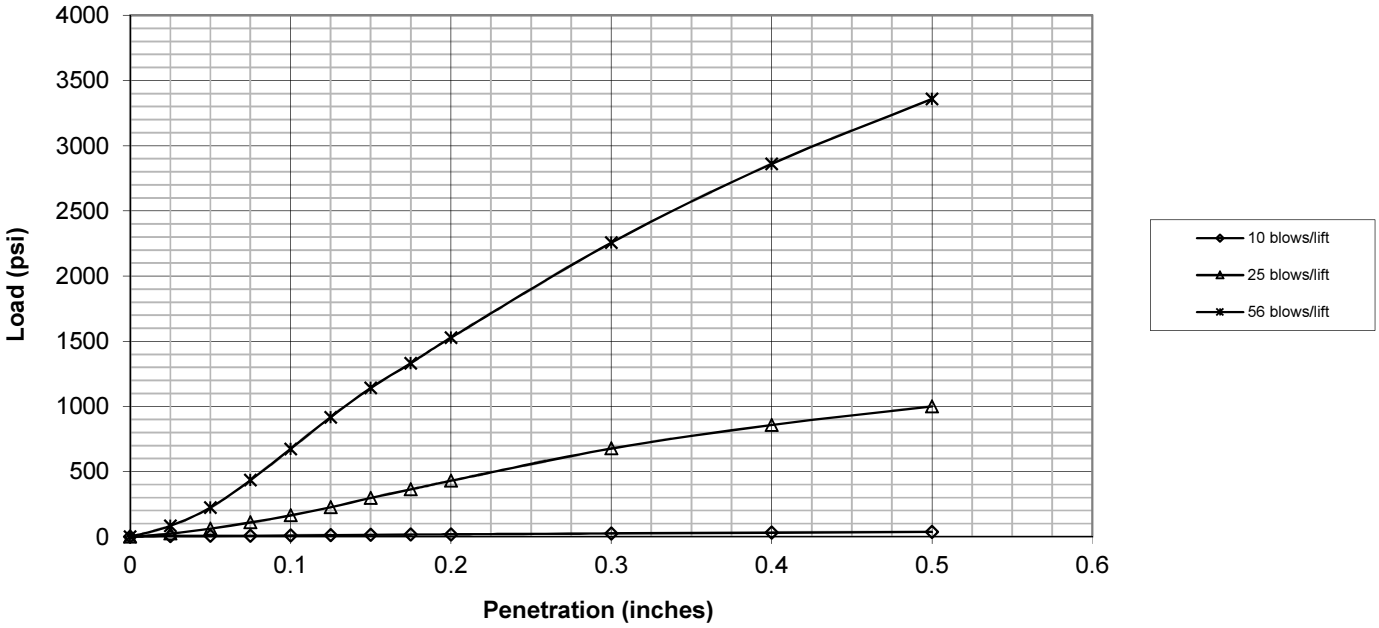
FIGURE No. 10

DATE June/14/2024

CALIFORNIA BEARING RATIO TEST RESULTS

Project: Falcon Meadows at Bent Grass, Filing No. 3
Job No.: 195343
AASHTO Classification" A-2-4
Sample Number: CBR
Sample Location: Combined Bulk Sample
Soil Description: Silty Sand

Penetration (in)	10 blows/lift Load (psi)	25 blows/lift Load (psi)	56 blows/lift Load (psi)
0.000	0.0	0.0	0.0
0.025	6.0	23.9	83.3
0.050	6.7	62.1	224.1
0.075	7.7	109.5	434.0
0.100	9.4	163.6	673.5
0.125	11.8	225.7	917.1
0.150	14.4	297.6	1141.2
0.175	16.8	362.8	1331.6
0.200	18.5	429.7	1527.2
0.300	25.5	676.6	2255.5
0.400	31.2	857.6	2859.8
0.500	36.6	999.1	3359.3



	Corrected Penetration (in)	Corrected Load (psi)
10 blows/lift	0.100	0.9
25 blows/lift	0.100	16.4
56 blows/lift	0.100	67.4

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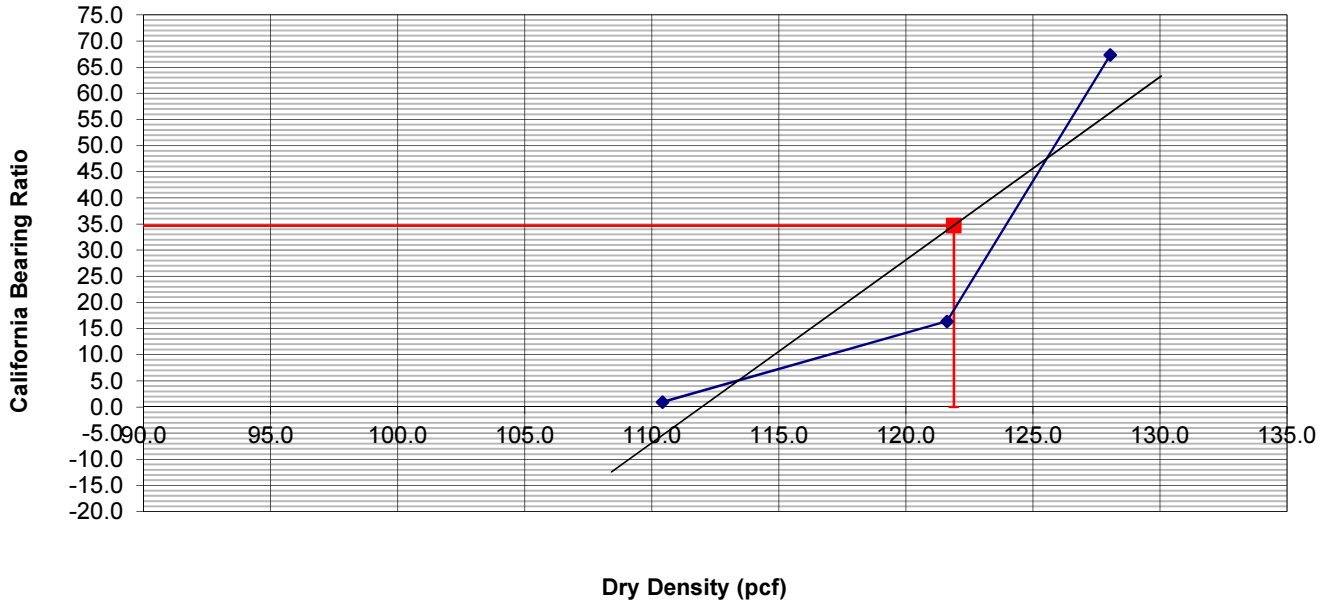
Figure No. 11

CALIFORNIA BEARING RATIO TEST RESULTS

Project: Falcon Meadows at Bent Grass, Filing No. 3
Job No.: 195343
AASHTO Classification" A-2-4
Sample Number: CBR
Sample Location: Combined Bulk Sample
Soil Description: Silty Sand

	10 blows/lift	25 blows/lift	56 blows/lift
Corrected California Bearing Ratio	0.9	16.4	67.4
Dry Density (pcf)	110.4	121.6	128.0
Percent Compaction	86	95	100
Percent Moisture After Soaking	14.0	12.2	10.6
Percent Expansion (+) / Compression (-)	0.1%	-0.1%	0.0%
Surcharge Weight (lbs)	12.60	12.60	12.60



California Bearing Ratio	**34.7**
Dry Density (pcf)	128.3
Percent Compaction	95%
Target Dry Density	121.9
Compaction Test Method	ASTM D-1557A
Condition of sample	Soaked

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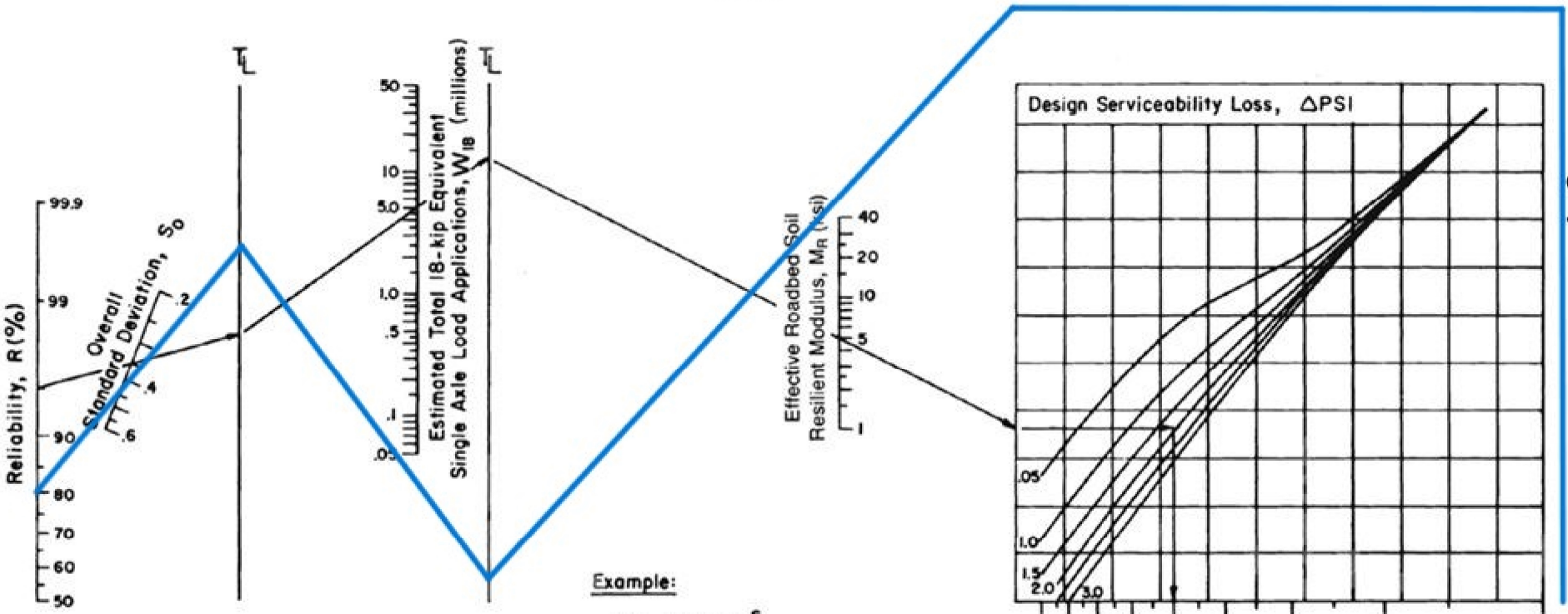
Figure No. 12

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$



Example:

$W_{18} = 5 \times 10^6$

R = 95 %

$S_o = 0.35$

$M_R = 5000$ psi

ΔPSI = 1.9

Solution: SN = 5.0

Figure D-1. Flexible Pavement Nomograph

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

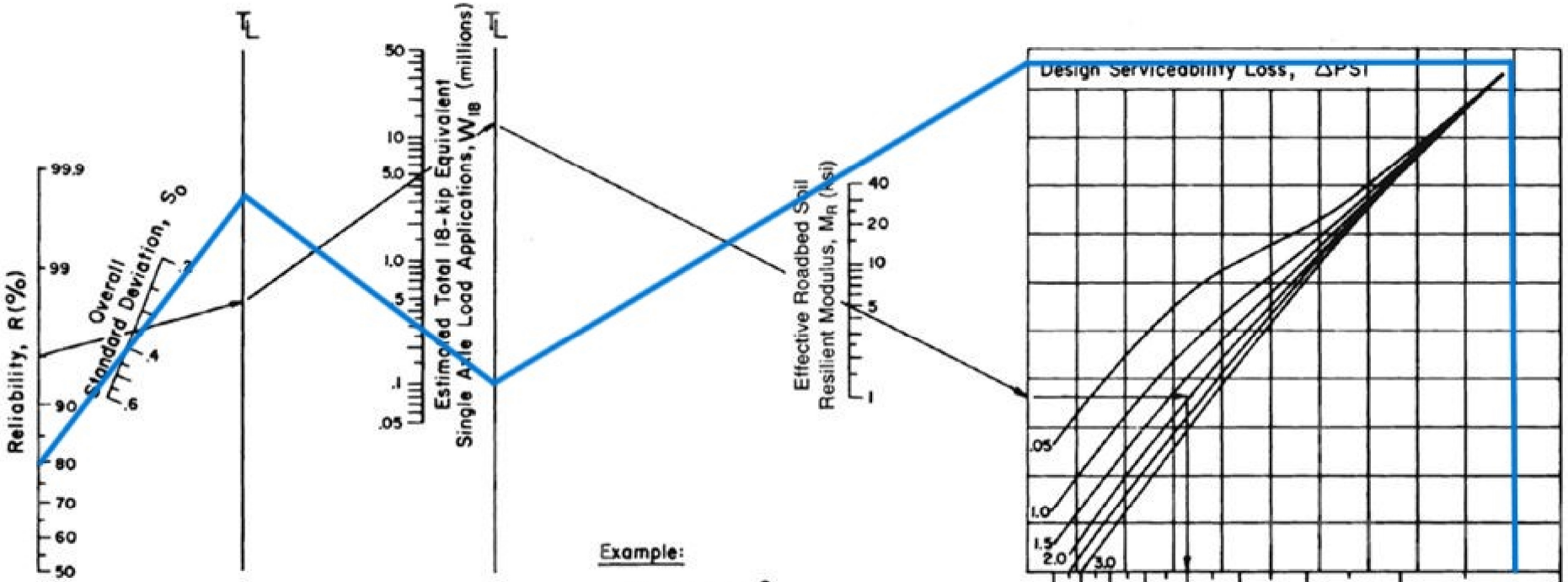


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Figure D-1. Flexible Pavement Nomograph