Architectural
Structural
Geotechnical

RMG
Engineers / Architects

Materials Testing
Forensic
Civil/Planning

PAVEMENT DESIGN REPORT

Copper Chase at Sterling Ranch, Filing No. 1
Phase 1
El Paso County, Colorado

PREPARED FOR:

Challenger Colorado, LLC
8605 Explorer Drive, Suite 250
Colorado Springs, CO 80920

JOB NO. 193596

February 26, 2024
REV: March 8, 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
4/9/24
39818
PROFESSIONAL ENGINEER

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

PCD File No. SF Number 2316 and PCD File No. PAV242

Accepted for File
By: Gilbert LaForce, P.E.
Engineering Manager
Date: 05/20/2024 2:22:36 PM
El Paso County Department of Public Works

TABLE OF CONTENTS

GENERAL SITE AND PROJECT DESCRIPTION

Location

Copper Chase at Sterling Ranch, Filing No. 1 is generally located south of the intersection of Vollmer Road and Alzada Drive in the northeastern portion of El Paso County, Colorado. The location of the site is shown on the Site Vicinity Map, Figure 1.

Existing Conditions

At the time of our field investigation, the proposed streets were close to grade and utility mains and services 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 Phase I of the 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.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Drilling

The subsurface conditions on the site were investigated by drilling four 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 and 5.

Subsurface Materials

The subsurface materials encountered in the test borings consisted of silty sand, clayey sandstone, and sandy claystone. Combined bulk samples of the material classified as CL according to the

Unified Classification System. For pavement design purposes the combined bulk soil samples classified as A-6 in accordance with the American Association of State Highway and Transportation Officials (AASHTO) classification system. This soil classification is considered "Poor" as subgrade material.

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 6. Soil Classification Data are presented in Figures 7 and 8. Swell/Consolidation test results are presented in Figure 9.

A combined bulk sample of A-6 soil was tested to determine the optimum moisture-density relationship in accordance with ASTM D-698 (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 1.24. 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 discussion presented below is based on the subsurface conditions encountered in the test borings, laboratory test results and the project characteristics previously described. If the subsurface conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and modify them, if necessary. The conclusions and recommendations presented in this report should be verified by RMG during construction.

The pavement design was performed using the El Paso County Engineering Criteria Manual, Appendix D. The pavement design parameters and design calculations are presented below.

Street Classification – Urban Local

1) Outcrop Drive, Salt Fork Drive, and Blue Feather Loop
   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 (ABC): $a_2 = 0.11$

3) Subgrade
   M_r = CBR x 1500 = 1.24 x 1500 = 1,860 psi

4) Structural number (SN) = 4.04 (per 1993 AASHTO Empirical Equation for Flexible Pavements, presented in Appendix A)

5) Composite asphalt/base course section
   Minimum HMA thickness = D_1 = 6.5 inches
   ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{4.04 – (6.5 \times 0.44)\} / 0.11$ = 10.7 inches
   Minimum ABC thickness = 13.25 inches
   SN = (6.5 x 0.44) + (10.75 x 0.11) = 4.0425 > 4.04 (Min. SN required)
   Use HMA thickness = 6.5 inches over ABC thickness = 10.75 inches (Paragraph D.4.1-F: base course thickness cannot exceed 2.5 times the HMA thickness)

Pavement Thickness

Based on the design calculations, the recommended pavement section is presented below and on Figure 2.2

Recommended Pavement Sections

Outcrop Drive, Salt Fork Drive, and Blue Feather Loop	6.5” HMA	10.75” ABC

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.

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 of A-6 for the soils in the subdivision, the subgrade soils evaluated for this pavement design can be expected to be slightly expansive. Groundwater or wet and unstable soils were not encountered in the borings at depths anticipated to affect the design. Therefore, special mitigation measures do not appear to be necessary for subgrade preparation.

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

This report has been prepared for the exclusive purpose of providing geotechnical engineering information and recommendations for development described in this report. RMG should be retained to review the final construction documents prior to construction to verify our findings, conclusions and recommendations have been appropriately implemented.

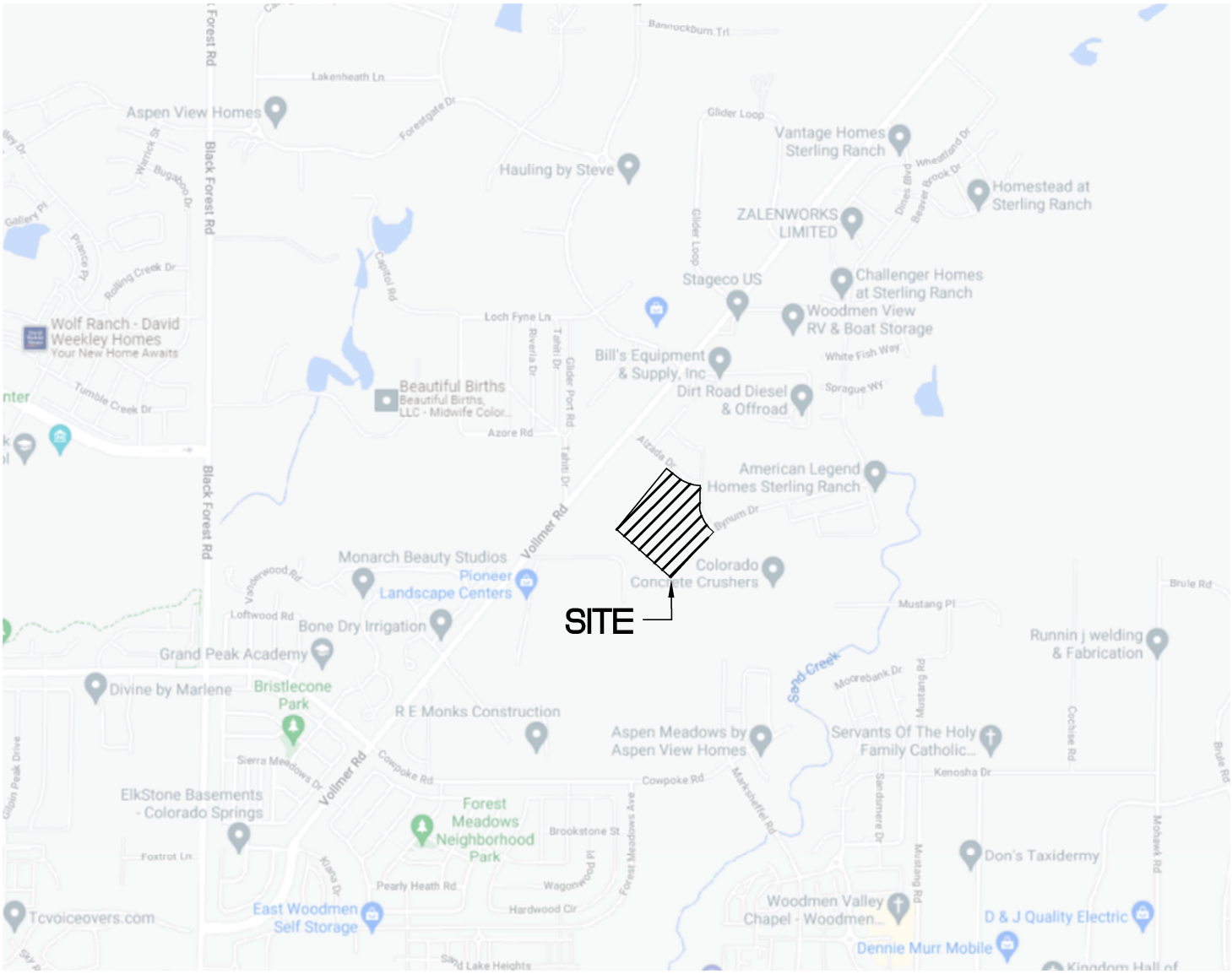
This report has been prepared for the exclusive use by the **Challenger Colorado, LLC** for application as an aid in the design and construction of the proposed development in accordance with generally accepted geotechnical engineering practices. The analyses and recommendations in this report are based in part upon data obtained from test borings, 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 review the recommendations presented in this report considering the varied condition, and either verify or modify them in writing.

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 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 by the preparation of this report. Third parties reviewing this report should draw their own conclusions regarding site conditions and specific construction techniques to be used on this project.

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



NOT TO SCALE

Architecture
Structural
Geotechnical

RMG

Materials Testing
Forensics
Civil / Planning

Engineers / Architects

SOUTHERN COLORADO OFFICE
5085 LIST DRIVE, SUITE 200,
COLORADO SPRINGS, CO 80919
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

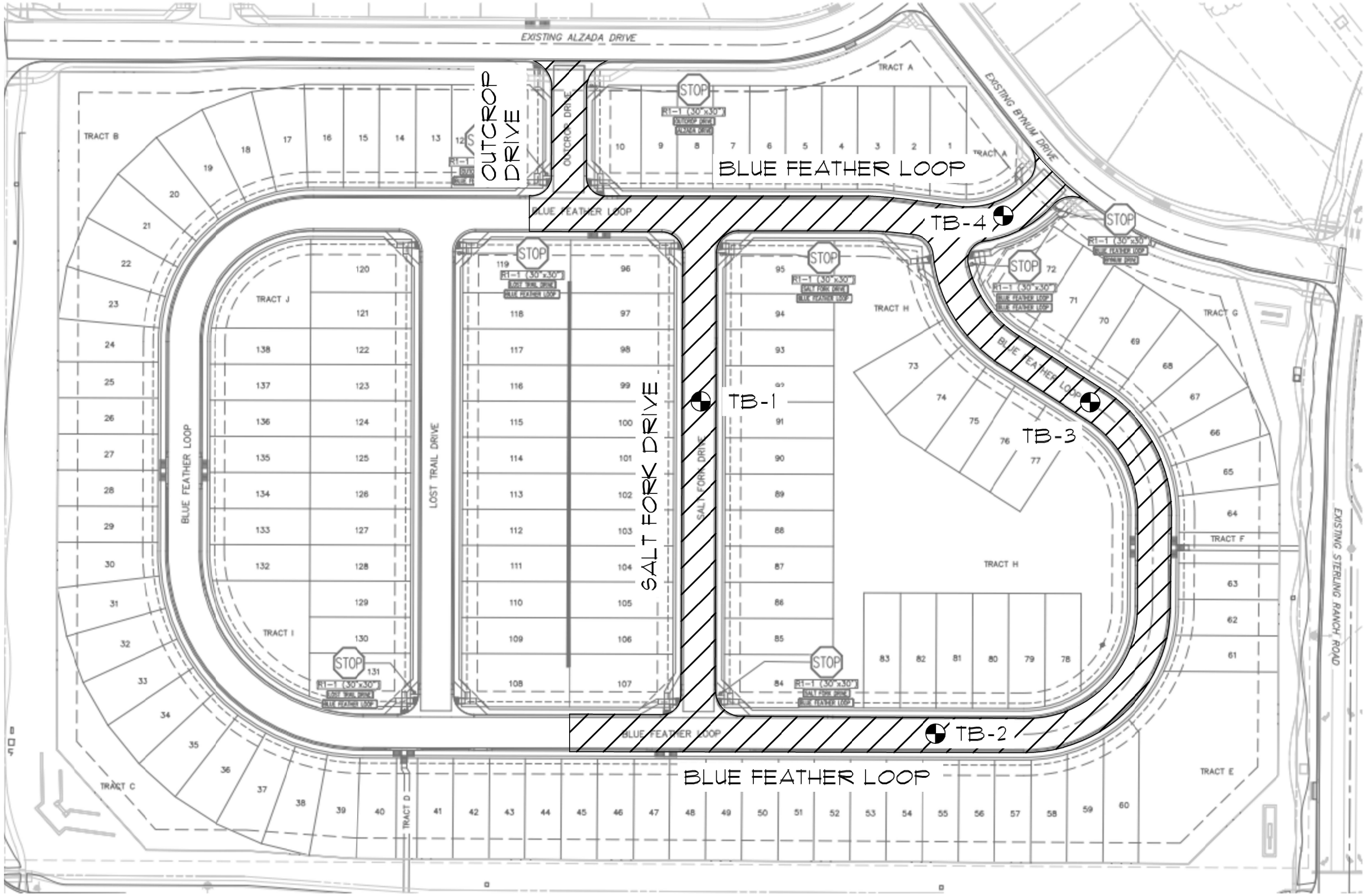
SITE VICINITY MAP

COPPER CHASE AT STERLING RANCH
FILING NO. 1, PHASE I
EL PASO COUNTY, COLORADO
CHALLENGER COLORADO, LLC

JOB No. 193596

FIG No. 1

DATE 2-26-2024



INDICATES AREAS INCLUDED IN THIS REPORT

0 25 50 100
SCALE IN FEET

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

JOB No. 193596

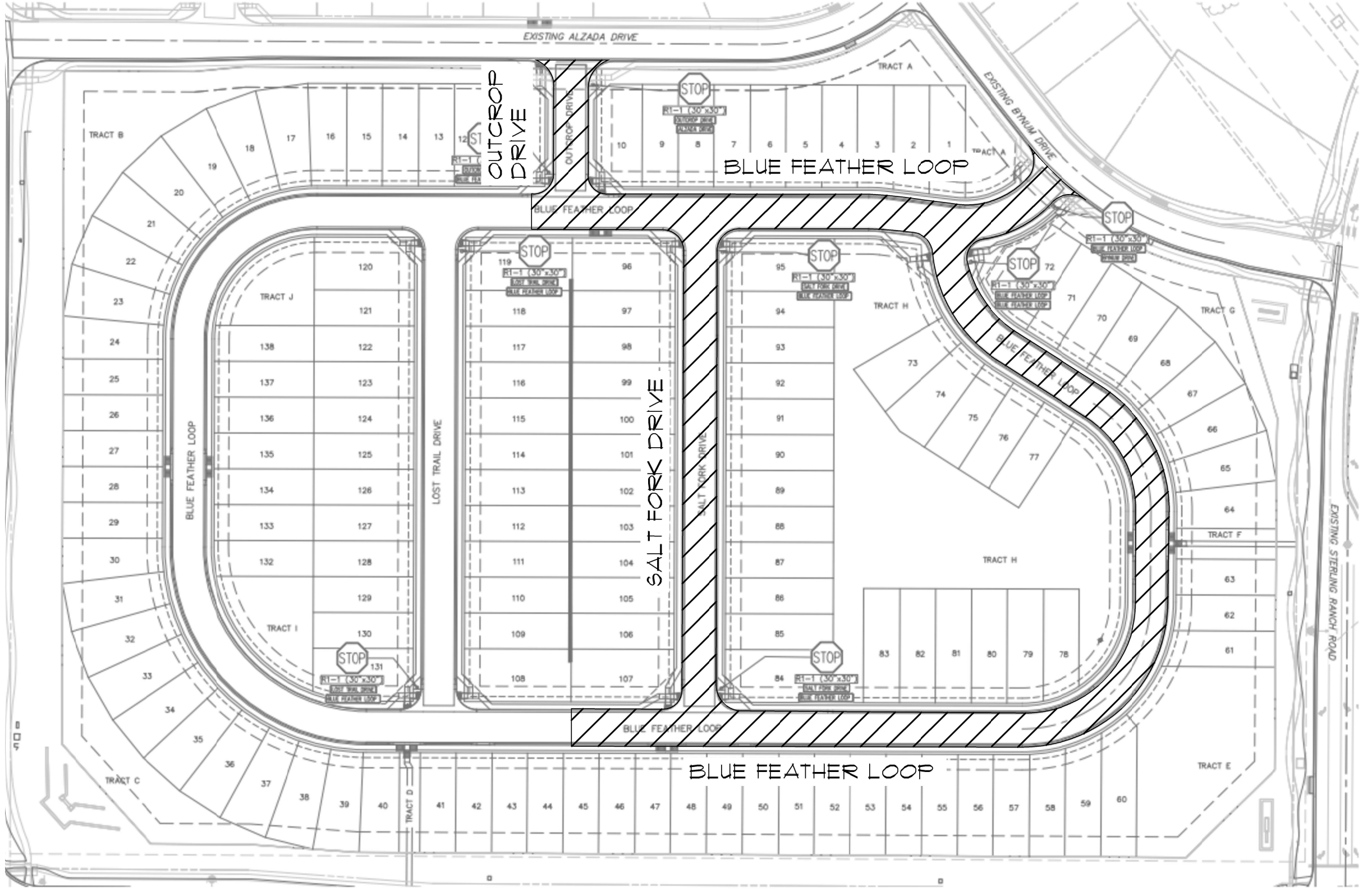
RMG
Materials Testing
Forensics
Civil / Planning
Architecture
Structural
Geotechnical
Engineers / Architects
SOUTHERN COLORADO OFFICE
5085 LIST DRIVE, SUITE 200,
COLORADO SPRINGS, CO 80919
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

COPPER CHASE AT STERLING RANCH
FILING NO. 1, PHASE I
EL PASO COUNTY, COLORADO
CHALLENGER COLORADO, LLC

ENGINEER:	TM
DRAWN BY:	NM
CHECKED BY:	TM
ISSUED:	2-26-2024

TEST BORING LOCATION PLAN

SHEET No.
FIG-2.1



Urban Local: Outcrop Drive, Salt Fork Drive, and Blue Feather Loop
ESAL - 292,000

6.5" HMA
OVER
10.75" ABC

0 25 50 100
SCALE IN FEET

JOB No. 193596

RMG
Materials Testing
Forensics
Civil / Planning
Architecture
Structural
Geotechnical
Engineers / Architects
SOUTHERN COLORADO OFFICE
5085 LIST DRIVE, SUITE 200,
COLORADO SPRINGS, CO 80919
(719) 548-0600 ~ WWW.RMGENGINEERS.COM
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

COPPER CHASE AT STERLING RANCH
FILING NO. 1, PHASE I
EL PASO COUNTY, COLORADO
CHALLENGER COLORADO, LLC

ENGINEER:	TM
DRAWN BY:	NM
CHECKED BY:	TM
ISSUED:	2-26-2024
REVISION:	2-28-2024

PAVEMENT RECOMMENDATIONS

SHEET No.
FIG-2.2

SOILS DESCRIPTION


INTERBEDDED SANDSTONE AND SHALE/CLAYSTONE


CLAYSTONE


SILTY 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 (%)

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

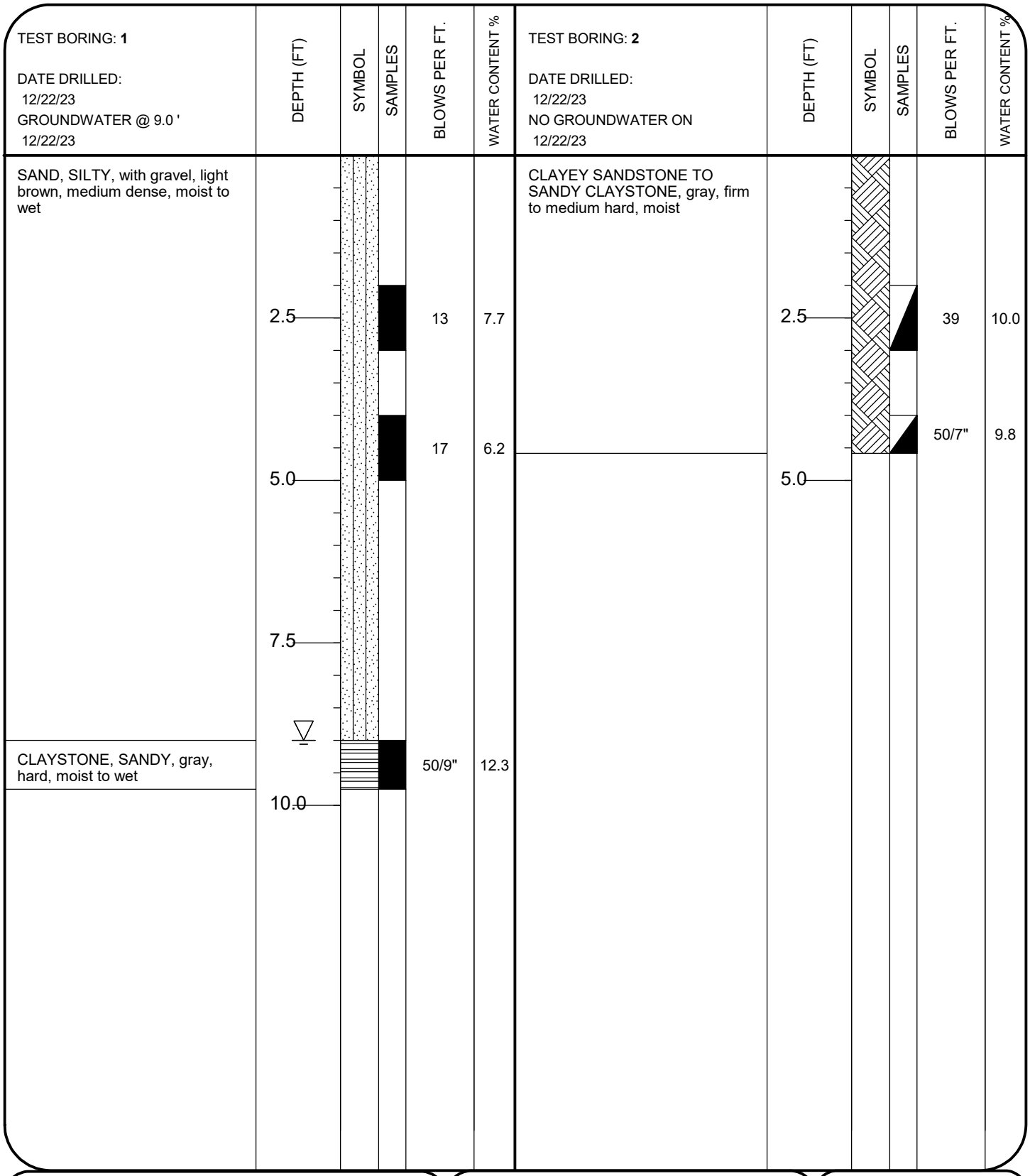
Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

EXPLANATION OF TEST BORING LOGS

JOB No. 193596

FIGURE No. 3

DATE Feb/26/2024



ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

TEST BORING LOG

JOB No. 193596

FIGURE No. 4

DATE Feb/26/2024

TEST BORING: **3** DATE DRILLED: 12/22/23 NO GROUNDWATER ON 12/22/23	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
CLAYEY SANDSTONE TO SANDY CLAYSTONE, gray, firm to medium hard, moist	2.5			46	10.2
				50/9"	11.1
	5.0				

TEST BORING: **4** DATE DRILLED: 12/22/23 NO GROUNDWATER ON 12/22/23	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
CLAYEY SANDSTONE TO SANDY CLAYSTONE, gray, medium hard, moist	2.5			50/8"	7.9
				50/8"	10.0
	5.0				

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

TEST BORING LOG

JOB No. 193596

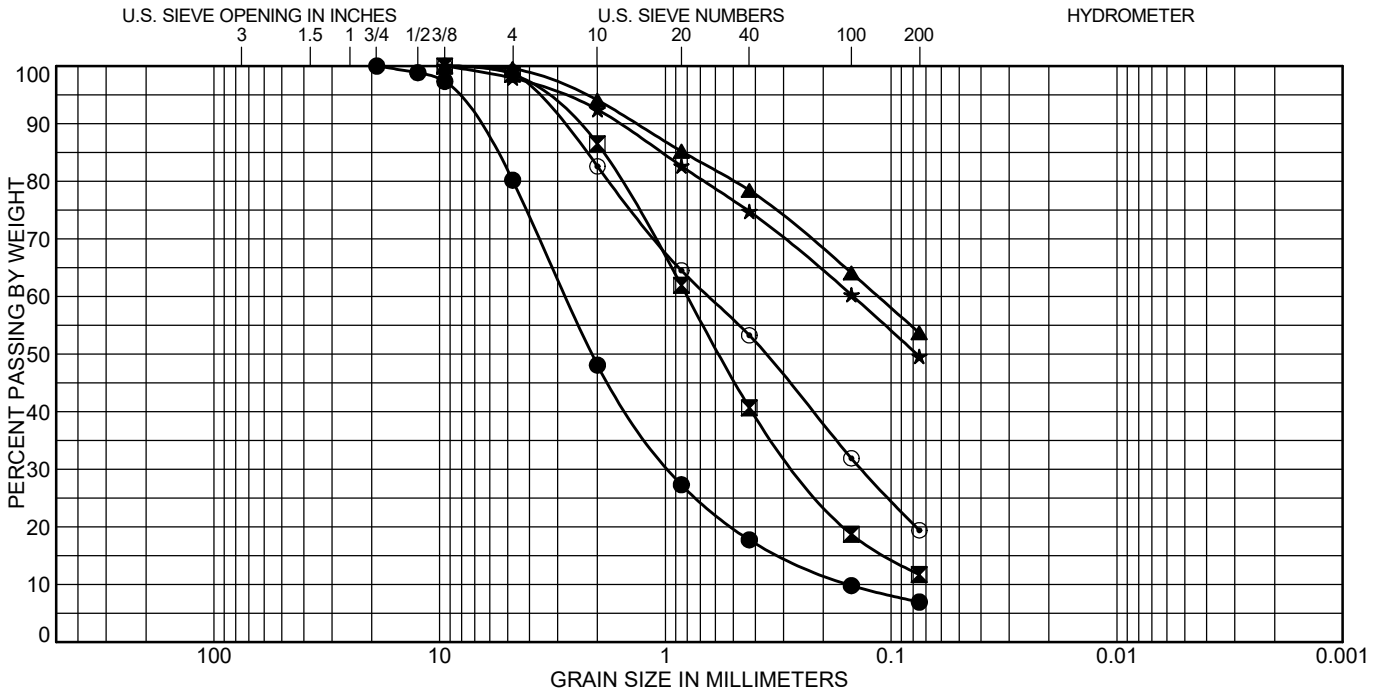
FIGURE No. 5

DATE Feb/26/2024

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			28	11	51.9	82.3	6.9		A-2-6 (0)
1	2.0	7.7				13.5	59.6	11.7		
1	4.0	6.2								
1	9.0	12.3								
2	0.0			36	20	5.9	21.7	53.7		A-6 (7)
2	2.0	10.0		22	10	7.6	25.4	49.6		A-4 (2)
2	4.0	9.8								
3	0.0			35	15	17.4	47.0	19.4		A-2-6 (0)
3	2.0	10.2		37	15	24.2	54.3	18.7		A-2-6 (0)
3	4.0	11.1								
4	0.0			36	17	9.2	25.3	55.5		A-6 (6)
4	2.0	7.9	121.2	38	15	13.5	36.2	44.2	0.6	A-6 (3)
4	4.0	10.0								
A-6 Proctor	0.0			36	22	5.7	19.3	61.7		A-6 (11)
Combined	0.0	1.1		38	18	5.7	19.3	61.7		A-6 (9)

SUMMARY OF LABORATORY TEST RESULTS

JOB No. 193596
FIGURE No. 6
PAGE 1 OF 1
DATE Feb/26/2024



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Test Boring	Depth (ft)	Classification	LL	PL	PI
●	1	0.0	WELL-GRADED SAND with CLAY and GRAVEL(SW-SC)	28	17	11
⧓	1	2.0				
▲	2	0.0	SANDY LEAN CLAY(CL)	36	16	20
★	2	2.0	CLAYEY SAND(SC)	22	12	10
⊙	3	0.0	CLAYEY SAND(SC)	35	20	15

	Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	1	0.0	19.8	73.2	6.9	
⧓	1	2.0	1.4	86.9	11.7	
▲	2	0.0	0.5	45.9	53.7	
★	2	2.0	2.1	48.3	49.6	
⊙	3	0.0	1.1	79.5	19.4	

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

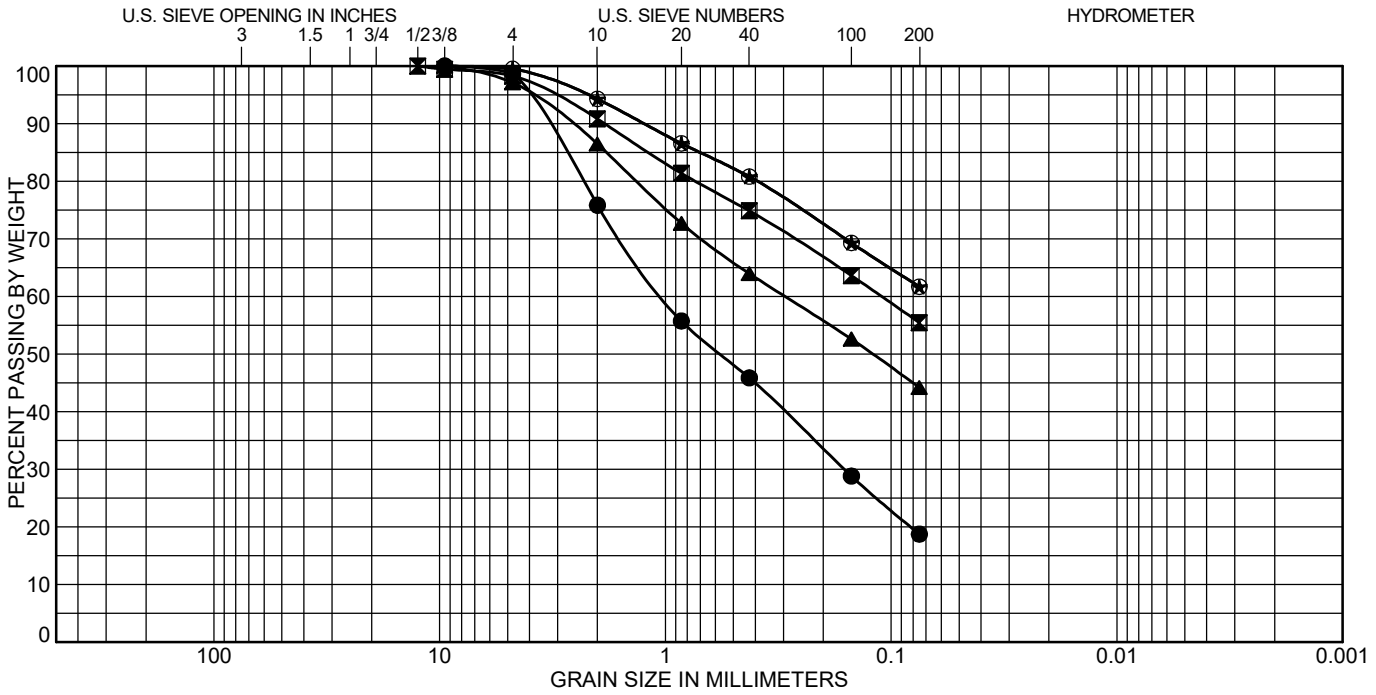
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

SOIL CLASSIFICATION DATA

JOB No. 193596

FIGURE No. 7

DATE Feb/26/2024



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Test Boring	Depth (ft)	Classification	LL	PL	PI
●	3	2.0	CLAYEY SAND(SC)	37	22	15
⧓	4	0.0	SANDY LEAN CLAY(CL)	36	19	17
▲	4	2.0	CLAYEY SAND(SC)	38	23	15
★	A-6 Proctor	0.0	SANDY LEAN CLAY(CL)	36	14	22
⊙	Combined	0.0	SANDY LEAN CLAY(CL)	38	20	18

	Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	3	2.0	1.3	80.0	18.7	
⧓	4	0.0	1.7	42.8	55.5	
▲	4	2.0	2.9	52.9	44.2	
★	A-6 Proctor	0.0	0.5	37.8	61.7	
⊙	Combined	0.0	0.5	37.8	61.7	

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

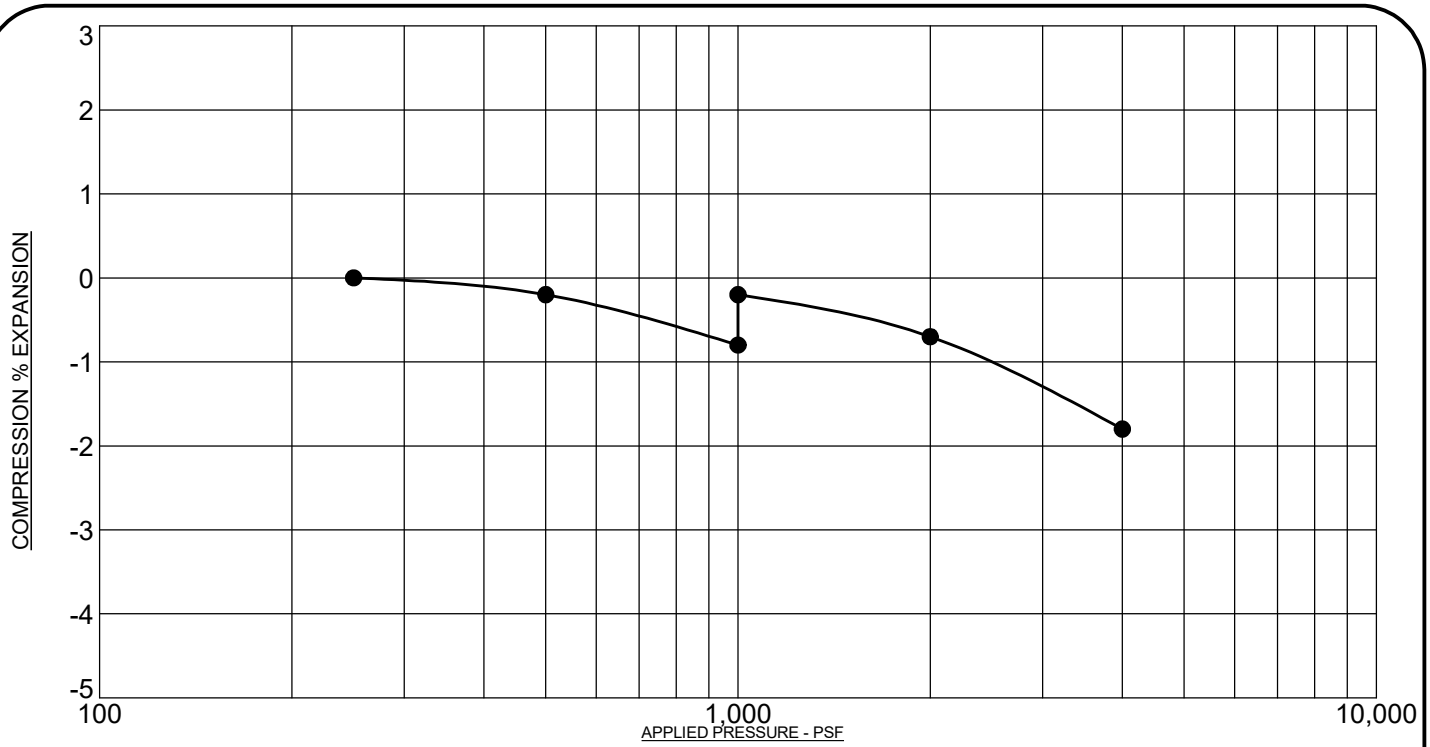
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

SOIL CLASSIFICATION DATA

JOB No. 193596

FIGURE No. 8

DATE Feb/26/2024



PROJECT: **Copper Chase at Sterling Ranch, Filing No. 1, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYEY SANDSTONE**
NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF

SAMPLE LOCATION: **4 @ 2 FT**
NATURAL DRY UNIT WEIGHT: **121.2 PCF**
NATURAL MOISTURE CONTENT: **7.9%**
PERCENT SWELL/COMPRESSION: **0.6**

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

RMG
Engineers / Architects

Geotechnical
Materials Testing
Civil, Planning

SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

SWELL/CONSOLIDATION TEST RESULTS

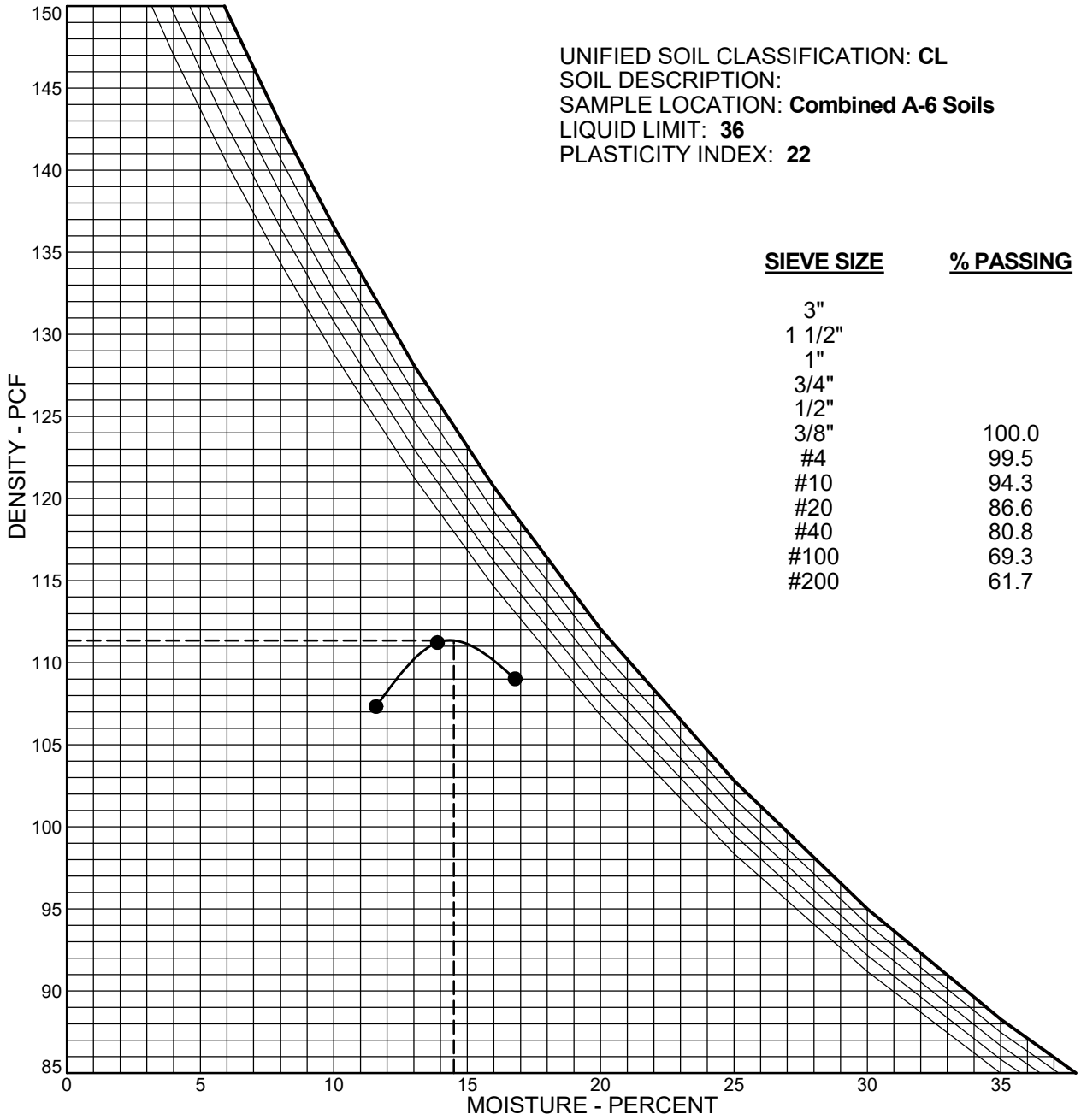
JOB No. 193596

FIGURE No. 9

DATE Feb/26/2024

CLIENT: Challenger Colorado, LLC **SAMPLE NUMBER:** A-6 Proctor

PROJECT: **Copper Chase at Sterling Ranch, Filing No. 1, El Paso County, Colorado**



UNIFIED SOIL CLASSIFICATION: **CL**
SOIL DESCRIPTION:
SAMPLE LOCATION: **Combined A-6 Soils**
LIQUID LIMIT: **36**
PLASTICITY INDEX: **22**

SIEVE SIZE	% PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	100.0
#4	99.5
#10	94.3
#20	86.6
#40	80.8
#100	69.3
#200	61.7

DESIGNATION **ASTM D-698**
MAX. DRY DENSITY **111.4 pcf**
OPTIMUM MOISTURE **14.5 %**
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

ROCKY MOUNTAIN GROUP
Architectural Structural Forensics
RMG Engineers / Architects
Geotechnical Materials Testing Civil, Planning
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

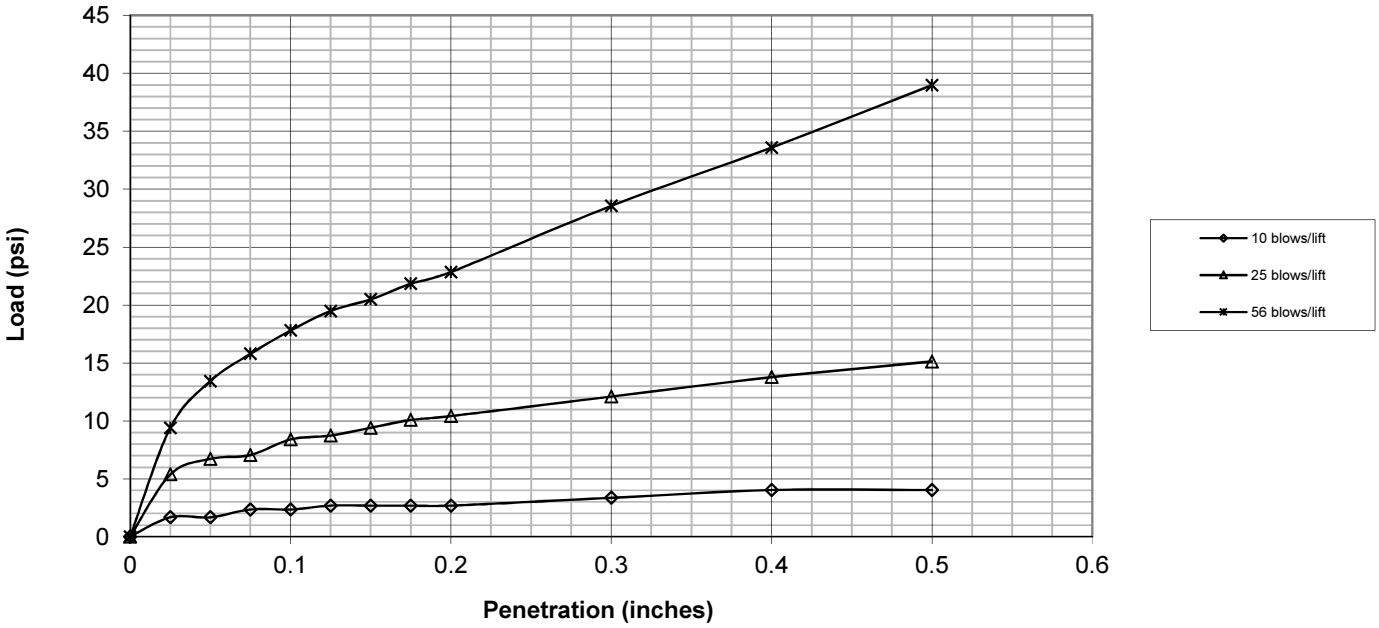
MOISTURE-DENSITY RELATION CURVE

JOB No. 193596
FIGURE No. 10
DATE Feb/26/2024

CALIFORNIA BEARING RATIO TEST RESULTS

Project:	Copper Chase at Sterling Ranch, Filing No. 1
Job No.:	193596
AASHTO Classification"	A-6
Sample Number:	CBR
Sample Location:	Combined Bulk Sample
Soil Description:	Sandy Clay

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	1.7	5.4	9.4
0.050	1.7	6.7	13.4
0.075	2.4	7.1	15.8
0.100	2.4	8.4	17.8
0.125	2.7	8.7	19.5
0.150	2.7	9.4	20.5
0.175	2.7	10.1	21.8
0.200	2.7	10.4	22.8
0.300	3.4	12.1	28.6
0.400	4.0	13.8	33.6
0.500	4.0	15.1	39.0



	Corrected Penetration (in)	Corrected Load (psi)
10 blows/lift	0.100	0.2
25 blows/lift	0.100	0.8
56 blows/lift	0.100	1.8

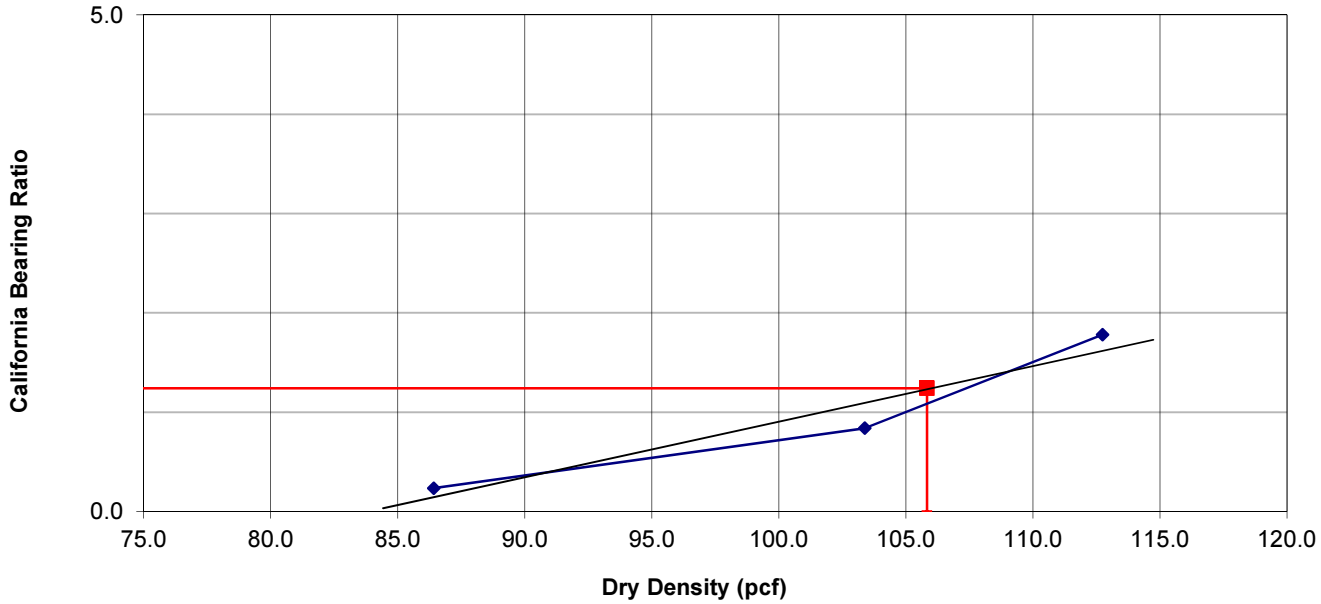
Structural • Geotechnical
RMG
ENGINEERS

Figure No. 11

CALIFORNIA BEARING RATIO TEST RESULTS

Project: Copper Chase at Sterling Ranch, Filing No. 1
Job No.: 193596
AASHTO Classification" A-6
Sample Number: CBR
Sample Location: Combined Bulk Sample
Soil Description: Sandy Clay

	10 blows/lift	25 blows/lift	56 blows/lift
Corrected California Bearing Ratio	0.2	0.8	1.8
Dry Density (pcf)	86.4	103.4	112.7
Percent Compaction	78	93	101
Percent Moisture After Soaking	27.9	26.5	21.8
Percent Expansion (+) / Compression (-)	0.1%	3.7%	2.7%
Surcharge Weight (lbs)	12.60	12.60	12.60



California Bearing Ratio	**1.24**
Dry Density (pcf)	111.4
Percent Compaction	95%
Target Dry Density	105.8
Compaction Test Method	ASTM D-698
Condition of sample	Soaked

Structural • Geotechnical
RMG ENGINEERS

Figure No. 12

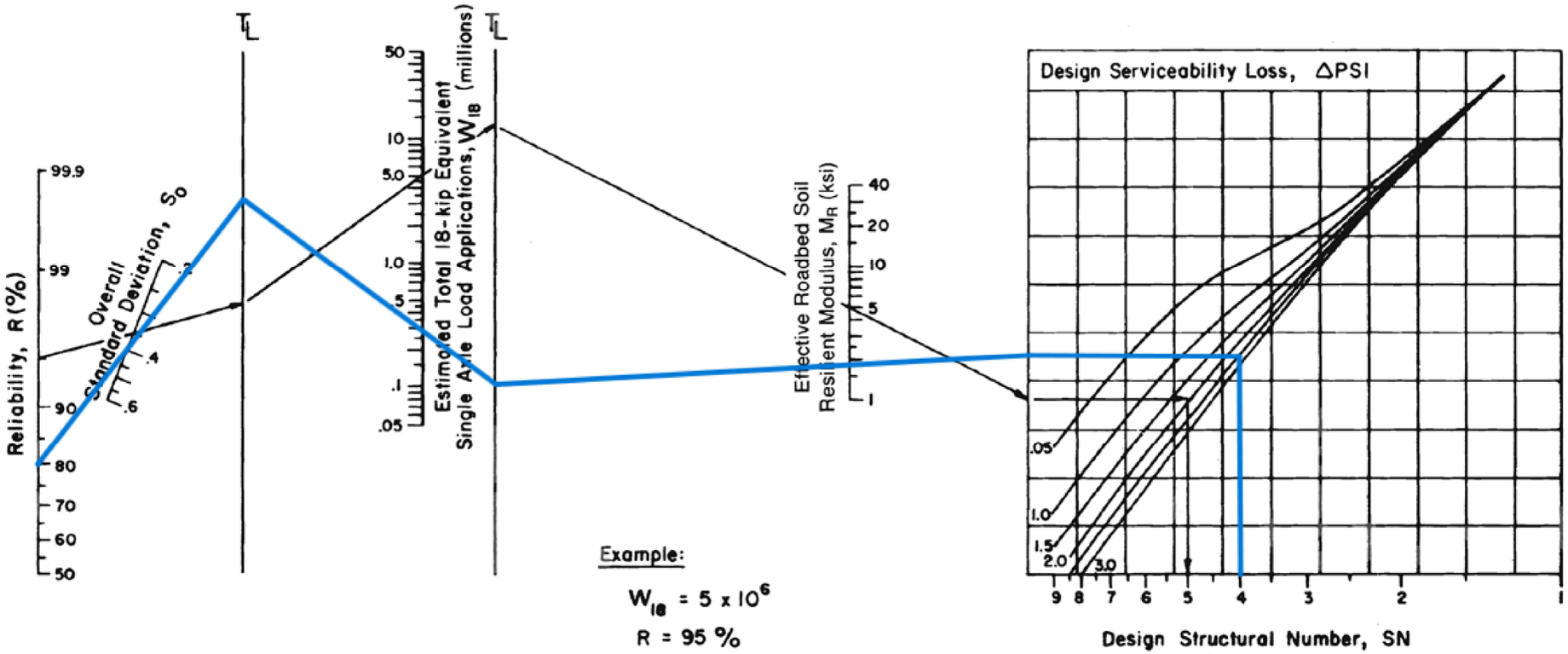
APPENDIX A

The pavement design nomograph should be for the design provided. Please provide a nomograph for the proposed design per ECM Appendix D.6 criteria.

This is the nomograph for this project. Using the parameters presented in our report results in a Structural Number of approximately 4.0. Our calculated SN was 4.04.

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