ENTECH
ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
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October 29, 2021
Revised November 3, 2021

Forest Lakes Residential Development
2138 Flying Horse Club Drive
Colorado Springs, Colorado 80921

Attn: Mark Sherwood

Re: Pavement Recommendations - Revised
Forest Lakes, Filing No. 6, Phase 1
Mesa Top Drive South and Timber Trek Way
El Paso County, Colorado

Dear Mr. Sherwood:

As requested, Entech Engineering, Inc. has obtained samples of the pavement subgrade soils from the roadways in the Forest Lakes Filing No. 6 subdivision. This letter presents the results of the laboratory testing and pavement recommendations for the roadway sections within the filing.

Project Description

The roadways for this project consist of a section of Mesa Top Drive South and Timber Trek Way in El Paso County, Colorado. Subsurface Soil Investigation and laboratory testing was performed in order to determine the pavement support characteristics of the soils. The approximate locations of the test borings are presented on the Test Boring Location Map, Figure 1.

Subgrade Conditions

Six test borings were drilled along the roadway to depths of approximately 5 and 10 feet below the existing subgrade surface. The soils at the roadway subgrade depth generally consisted of silty to clayey to gravelly sand fill (Soil Type 1) (SM, SM-SC, SC) and native silty to clayey to gravelly sand (Soil Type 2) (SM, SC). The Test Boring Logs are presented in Appendix A. Sieve Analyses and Atterberg Limit testing were performed on the subgrade soil samples obtained from the test borings for the purpose of classification. The percent passing the No. 200 sieve for the Type 1 soils ranged from approximately 15 to 34 percent. The percent passing the No. 200 sieve for the Type 2 soils ranged from approximately 13 to 25 percent. The Type 1 subgrade soils classified as A-1-b, A-2-4, and A-2-6 soils and the Type 2 soils classified as A-1-b, A-2-4 and A-2-6 soils, using the AASHTO classification system. Groundwater was encountered in Test Boring No. 2 at a depth of 9 feet immediately after drilling. The groundwater will not affect the pavement on this site. Water-soluble sulfate tests results indicated that the soils exhibit a negligible potential for sulfate attack.

Atterberg Limits testing resulted in liquid limits ranging from no value to 28 percent and plastic indexes of non-plastic to 12 percent. Based on these values the soils encountered are anticipated to exhibit low expansion characteristics. Based on classifications, mitigation of expansive soils on this site is not required for the site soils. Due to the similar characteristics of the Type 1 and Type 2 soils, all sections will be designed using the Soil Type 2 design parameters. Laboratory tests results are presented in Appendix B and are summarized in Table 1.

California Bearing Ratio (CBR) testing was performed on representative samples of Soil Type 2 and Soil Type 4 to determine the support characteristics of the subgrade soils for the roadway sections. The results of the CBR testing, are presented in Appendix B and summarized as follows:

Soil Type 2 – Silty Sand

R @ 90% = 76.0
R @ 95% = 84.0
Use R = 50.0 for design

Classification Testing

Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	13.2
AASHTO Classification	A-1-b
Group Index	0
Unified Soils Classification	SM

Pavement Design

CBR testing was used to determine pavement sections for the roadways. Pavement sections were determined utilizing El Paso County Engineering Criteria Manual. Timber trek Way classifies as an urban local – low volume road, which used an ESAL value of 36,500 for design purposes. Mesa Top Drive South classifies as an urban local, which used an ESAL value of 292,000 for design purposes. Alternative pavement sections were determined for asphalt supported on aggregate basecourse and asphalt on cement stabilized subgrade.

Design parameters used in the pavement analysis for the roadways are as follows:

Reliability	
Urban Local - Low Volume	80%
Urban Local	80%
Serviceability Index	
Urban Local - Low Volume	2.0
Urban Local	2.0
“R” Value Subgrade	50.0
Resilient Modulus	13,168 psi
Δpsi	2.0
Hot Bituminous Pavement	0.44
Aggregate Basecourse	0.11
Cement Stabilized Subgrade	0.11

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway sections are presented below. Any additional grading may result in subgrade soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Pavement Sections
ESAL = 36,500 – Timber Trek Way
Soil Type 1

Alternative	Asphalt (in)	Basecourse (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Basecourse	3.0*	4.0*	-
2. Asphalt Over Stabilized Subgrade	4.0*	-	10.0

ESAL = 292,000 – Mesa Top Drive South
Soil Type 1

Alternative	Asphalt (in)	Basecourse (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Basecourse	4.0*	8.0*	-
2. Asphalt Over Stabilized Subgrade	4.0*	-	10.0

*Minimum sections required per the City of Colorado Springs Engineering Criteria Manual.
Note- Full depth sections are only allowed over chemically treated or "suitable" subgrade.

Mitigation

The El Paso County Engineering pavement design criteria requires mitigation of expansive soils for roadway subgrades that have a swell of 4.0 percent or greater with a 200 pound per square foot surcharge for non-arterial streets. The swell criteria was not expected to exceed this in any of the samples obtained or tested. If clay soils are considered they likely will be suitable as they are not expected to yield high expansion values. Groundwater was encountered in Test Boring No. 2 at a depth of 9 feet. Due to its depth and that the site is being constructed with a sewer underdrain system on the mains and each service, the groundwater should not affect the pavement on this site.

Roadway Construction – Asphalt on Aggregate Basecourse Alternatives

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of the soils maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Any loose areas should be removed and replaced with suitable materials. Basecourse materials should be compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

Roadway Construction – Stabilized Subgrade Alternative

Prior to placement of the asphalt, the subgrade shall be stabilized by the addition of cement to a depth of at least 10 inches (see Pavement Sections). The amount of cement applied shall be 2 percent (by weight) of the subgrade's maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10-inch depth, as specified, such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 10 inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as

much as 2 percent more than the optimum water content as necessary to provide a compactable soil condition. Densification of the cement-stabilized subgrade should be completed to obtain a compaction of at least 95 percent of the subgrade maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

The following conditions shall be observed as part of the subgrade stabilization:

- Type I/II cement as supplied; a local supplier shall be used. All cement used for stabilization should come from the same source. If cement sources are changed a new laboratory mix design should be completed.

- Moisture conditioning of the subgrade and/or mixing of the cement into the subgrade shall not occur when soil temperatures are below 40° F. Cement treated subgrades should be maintained at a temperature of 40° F or greater until the subgrade has been compacted as required.

- Cement placement, cement mixing and compaction of the cement treated subgrade should be observed by a Soils Engineer. The Soils Engineer should complete in situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

- Pending the results of the field density testing, microfracturing of the stabilized subgrade may be required. Soil strengths in excess of 200 psi require microfracturing.

In addition to the above guidance the asphalt, cement, subgrade conditions, compaction of materials and roadway construction methods shall meet the El Paso County specifications.

We trust that this report contains the information you require. If you have questions or need additional information, please contact us.

Respectfully Submitted,

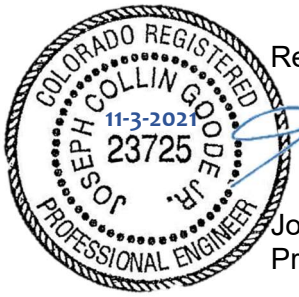
ENTECH ENGINEERING, INC.

Daniel P. Stegman

SW/bs

Encl.

Entech Job No. 212446
AAprojects/2021/212446 pr-rev



Reviewed by:

Joseph C. Goode, Jr., P.E.
President

TABLE

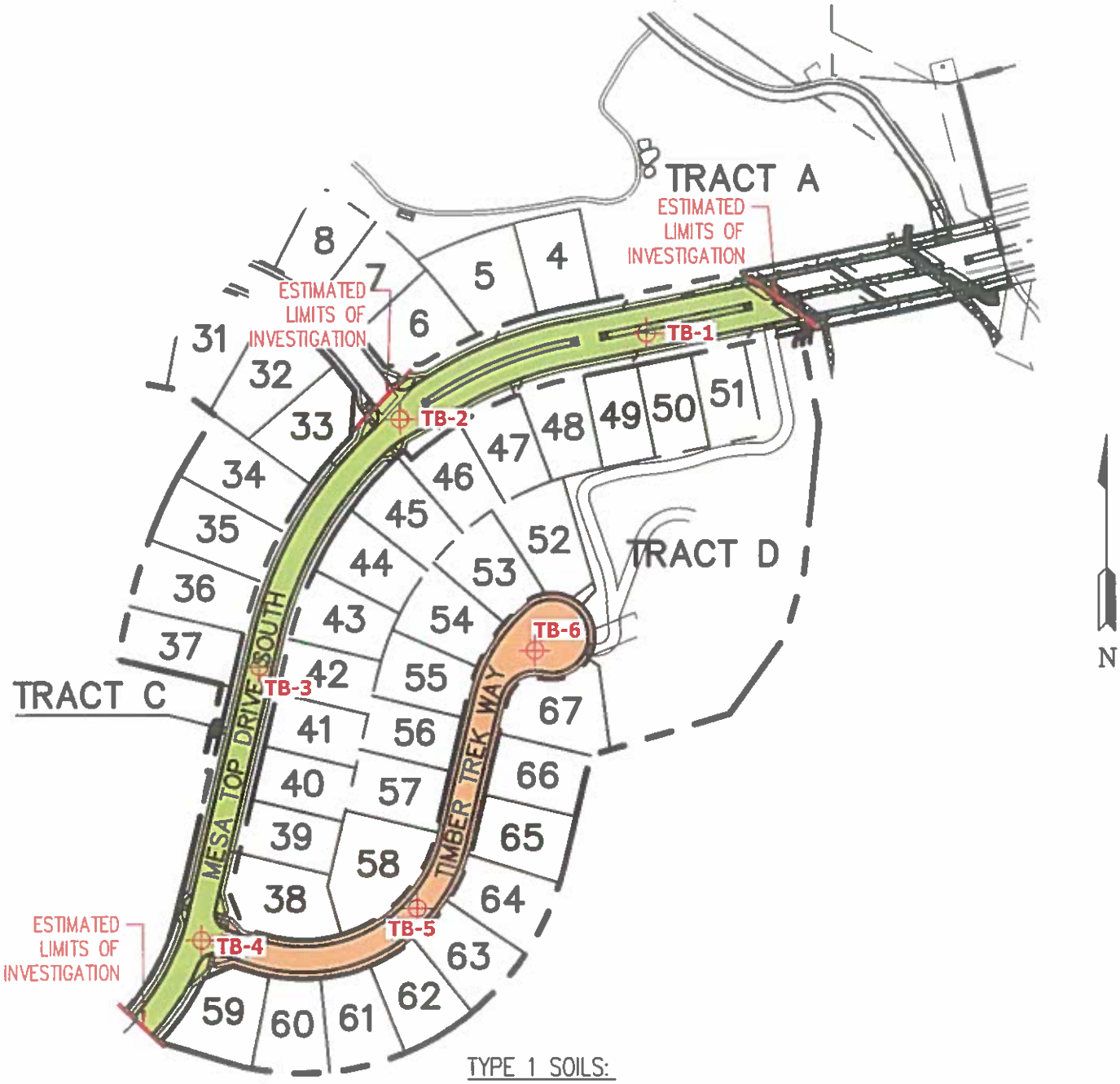
TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT FOREST LAKES RESIDENTIAL
PROJECT MESA TOP & TIMBER TREK
JOB NO. 212446

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	AASHTO CLASS.	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1	2	1-2			18.4	NV	NP	0.00	A-1-b		SM	FILL, SAND, SILTY
1	3	1-2			25.4	21	7		A-2-4		SM-SC	FILL, SAND, SILTY, CLAYEY
1	4	1-2			33.6	28	12		A-2-6		SC	FILL, SAND, CLAYEY
1	6	1-2			15.0	NV	NP		A-1-b		SM	FILL, SAND, SILTY
2, CBR	1	0-3			13.2	NV	NP		A-1-b		SM	SAND, SILTY
2	1	1-2			14.3	NV	NP		A-1-b		SM	SAND, SILTY
2	5	1-2			21.5	26	11	0.00	A-2-6		SC	SAND, CLAYEY
2	6	10			25.3	23	7	<0.01	A-2-4		SC	SAND, CLAYEY

FIGURE



TYPE 1 SOILS:

= URBAN LOCAL (ESAL=292,000)
(4" ASPHALT OVER 10" CTS)

= URBAN LOCAL–LOW VOLUME (ESAL=36,500)
(4" ASPHALT OVER 10" CTS)

50 0 100 200 400

1:200

TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS

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TEST BORE LOCATION MAP
FOREST LAKES FILING #6, PHASE #1
EL PASO COUNTY, CO.
FOR: FOREST LAKES FILING #6

DRAWN:	DATE:	CHECKED:	DATE:
LLL	11/3/21	DPS	11/3/21

JOB NO.: 212446

FIG NO.: 1

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
DATE DRILLED 9/13/2021
Job # 212446

REMARKS

DRY TO 5', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			50* / 7"	3.2	2
5			50* / 7"	1.5	2
10					
15					
20					

SAND, SILTY, GRAVELLY, FINE TO COARSE GRAINED, RED BROWN, VERY DENSE, MOIST TO DRY

* - HIGH BLOW COUNTS DUE TO GRAVEL

TEST BORING NO. 2
DATE DRILLED 9/13/2021
CLIENT FOREST LAKES RESIDENTIAL
LOCATION MESA TOP & TIMBER TREK

REMARKS

WATER @ 9', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			34	7.8	1
5			14	6.3	2
10			50* / 11"	6.7	2
15					
20					

FILL 0-4', SAND, GRAVELLY, SILTY, FINE TO COARSE GRAINED, RED BROWN, DENSE, MOIST

SAND, GRAVELLY, SILTY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE TO VERY DENSE, MOIST

* - HIGH BLOW COUNTS DUE TO GRAVEL

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TEST BORING LOG

DRAWN:	DATE:	CHECKED: DS	DATE: 10/29/21

JOB NO.: 212446
FIG NO.: A- 1

TEST BORING NO. 3
DATE DRILLED 9/13/2021
Job # 212446

REMARKS

DRY TO 5', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
						FILL 0-5', SAND, SILTY, CLAYEY, GRAVELLY, FINE TO COARSE GRAINED, RED BROWN, DENSE TO MEDIUM DENSE, MOIST
			42	4.5	1	
5			21	4.9	1	
10						
15						
20						

TEST BORING NO. 4
DATE DRILLED 9/13/2021
CLIENT FOREST LAKES RESIDENTIAL
LOCATION MESA TOP & TIMBER TREK

REMARKS

DRY TO 5', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	
						FILL 0-5', SAND, GRAVELLY, CLAYEY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST
			19	7.0	1	
5			26	6.7	1	
10						
15						
20						

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TEST BORING LOG

DRAWN:	DATE:	CHECKED: DS	DATE: 10/22/21

JOB NO.: 212446
FIG NO.: A- 2

TEST BORING NO. 5
DATE DRILLED 9/13/2021
Job # 212446

REMARKS

DRY TO 5', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			15	5.6	2
5			13	7.8	2
10					
15					
20					

SAND, CLAYEY, GRAVELLY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST

TEST BORING NO. 6
DATE DRILLED 9/13/2021
CLIENT FOREST LAKES RESIDENTIAL
LOCATION MESA TOP & TIMBER TREK

REMARKS

DRY TO 10', 9/13/21

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			50*	5.1	1
5			20	11.1	2
10			12	6.4	2
15					
20					

FILL 0-4', SAND, GRAVELLY, SILTY, FINE TO COARSE GRAINED, RED BROWN, VERY DENSE, MOIST

SAND, GRAVELLY, CLAYEY, FINE TO COARSE GRAINED, RED BROWN, MEDIUM DENSE, MOIST

* - HIGH BLOW COUNTS DUE TO GRAVEL

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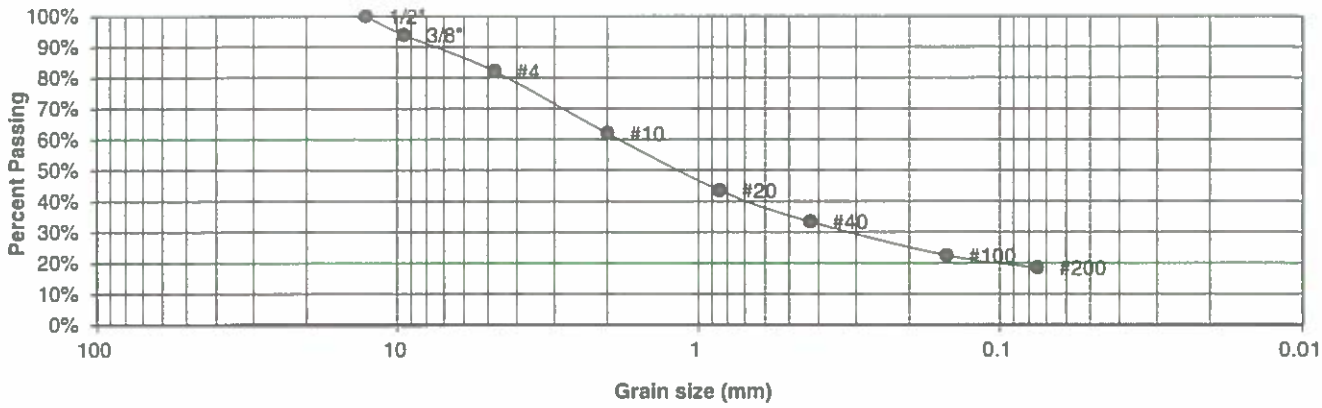
TEST BORING LOG

DRAWN:	DATE:	CHECKED: DJ	DATE: 10/15/21

JOB NO: 212446
FIG NO: A-3

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	1	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	2	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	93.9%
4	82.1%
10	62.0%
20	43.5%
40	33.4%
100	22.4%
200	18.4%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start

Moisture at finish

Moisture increase

Initial dry density (pcf)

Swell (psf)

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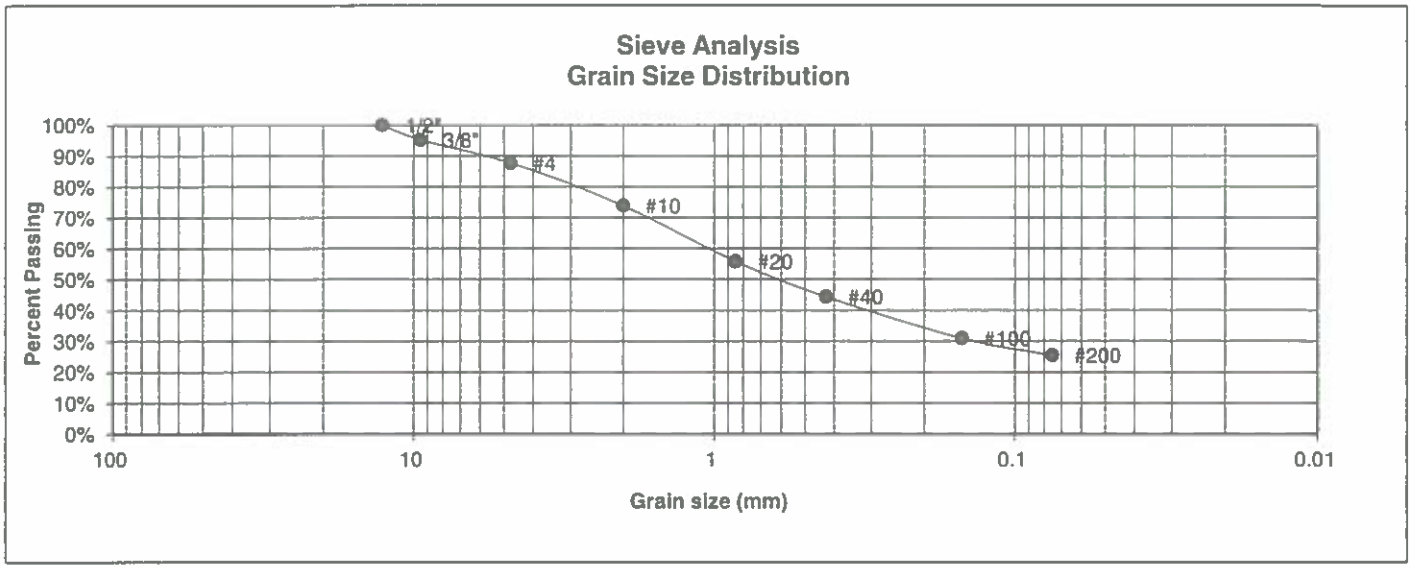
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	10/22/21

JOB NO.: 212446
FIG NO.: B-1

UNIFIED CLASSIFICATION	SM-SC	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	1	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	3	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	95.1%
4	87.7%
10	73.9%
20	55.9%
40	44.4%
100	30.9%
200	25.4%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	21
Plastic Index	7

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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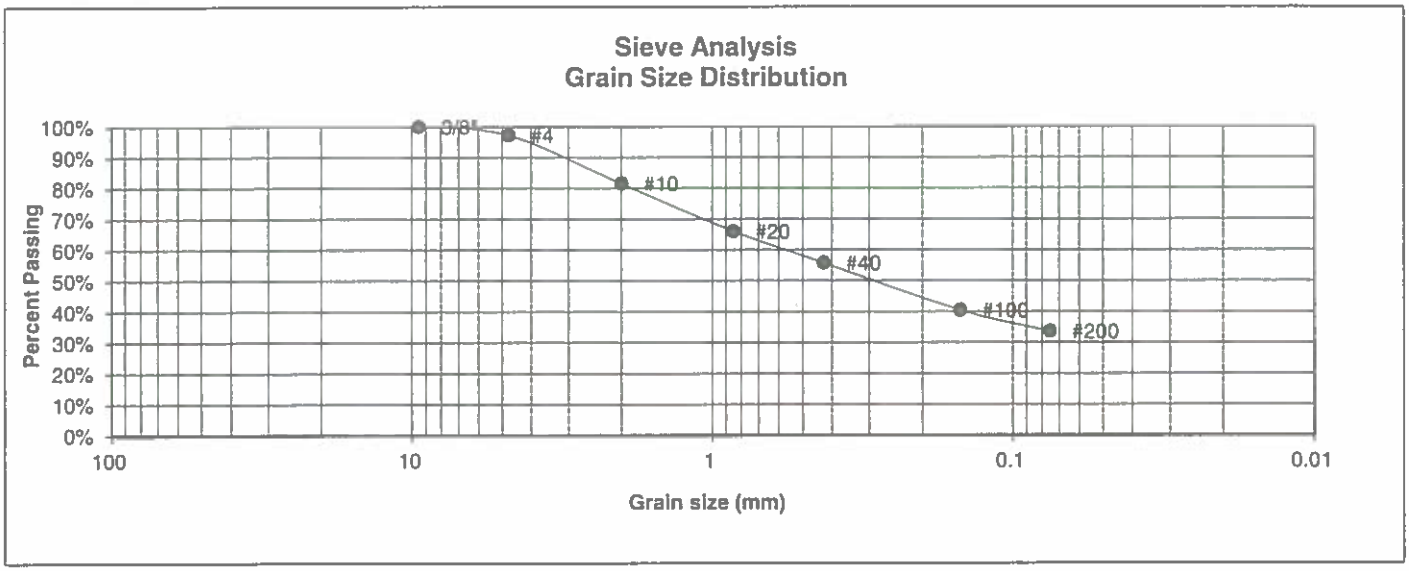
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	1/22/21

JOB NO.: 212446
FIG NO.: B-2

UNIFIED CLASSIFICATION	SC	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	1	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	4	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.2%
10	81.5%
20	66.0%
40	55.8%
100	40.4%
200	33.6%

Atterberg Limits	
Plastic Limit	16
Liquid Limit	28
Plastic Index	12

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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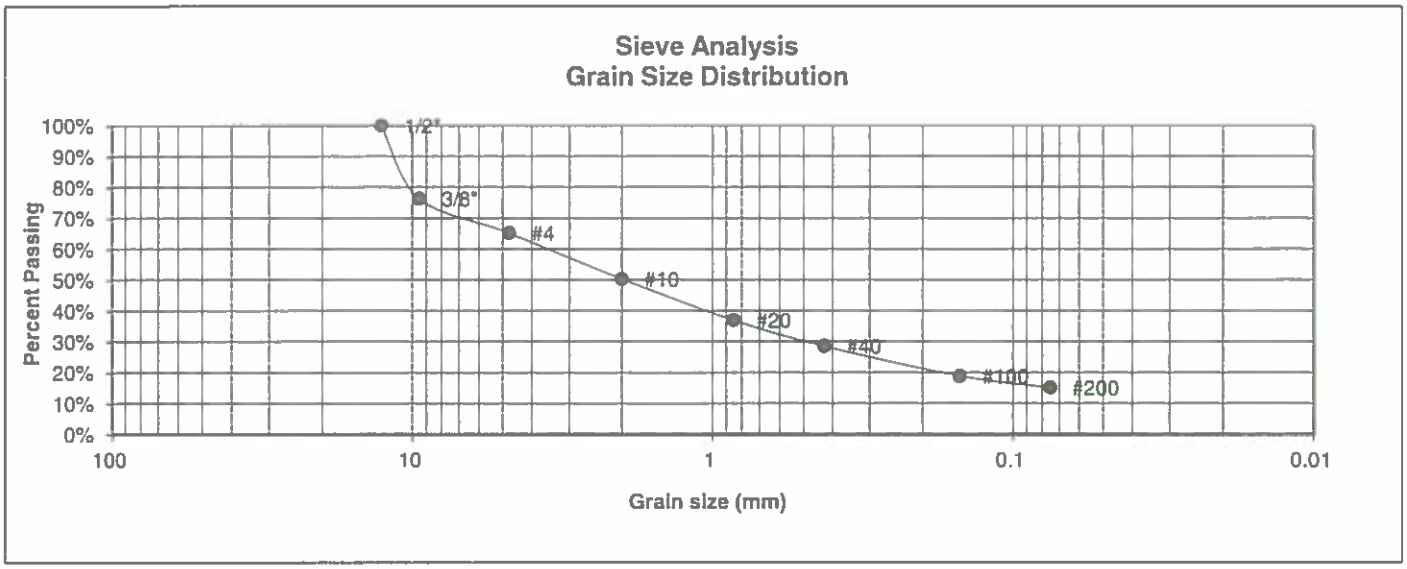
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	12/20/24

JOB NO.: 212446
FIG NO.: B-3

UNIFIED CLASSIFICATION	SM	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	1	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	6	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	76.3%
4	65.1%
10	50.2%
20	36.9%
40	28.5%
100	18.8%
200	15.0%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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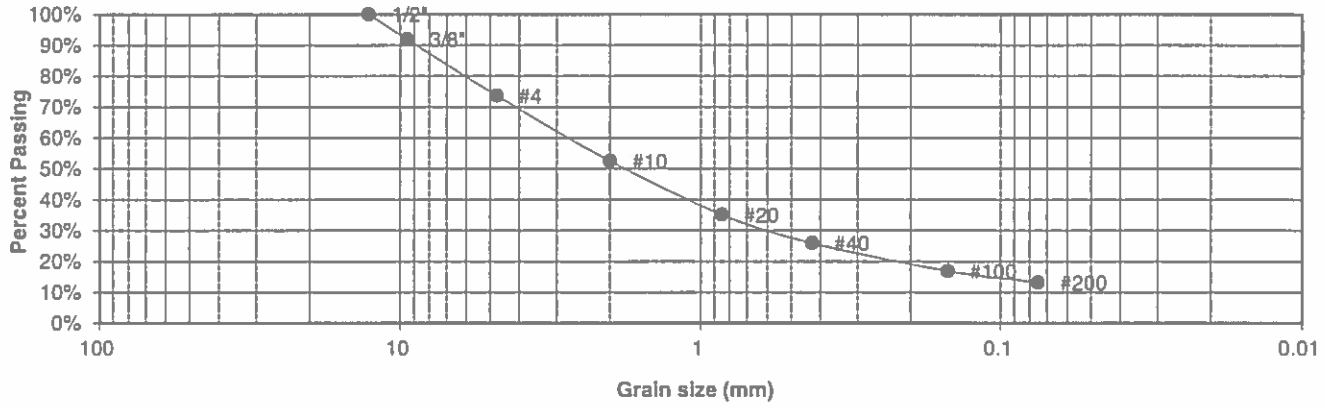
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	11/29/21

JOB NO.: 212446
FIG NO.: B-4

UNIFIED CLASSIFICATION	SM	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	2, CBR	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	1	JOB NO.	212446
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	91.9%
4	73.7%
10	52.5%
20	35.1%
40	25.9%
100	16.9%
200	13.2%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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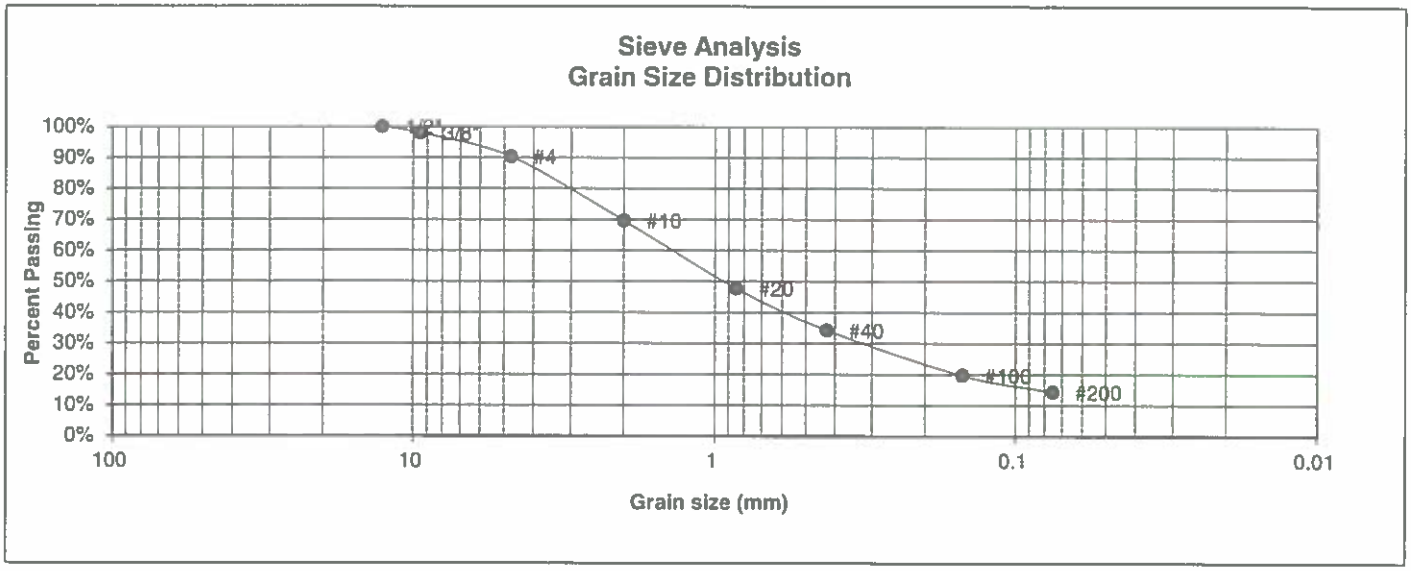
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	12/29/21

JOB NO.: 212446
FIG NO.: B-5

UNIFIED CLASSIFICATION	SM	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	2	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	1	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	97.9%
4	90.3%
10	69.6%
20	47.7%
40	34.3%
100	19.7%
200	14.3%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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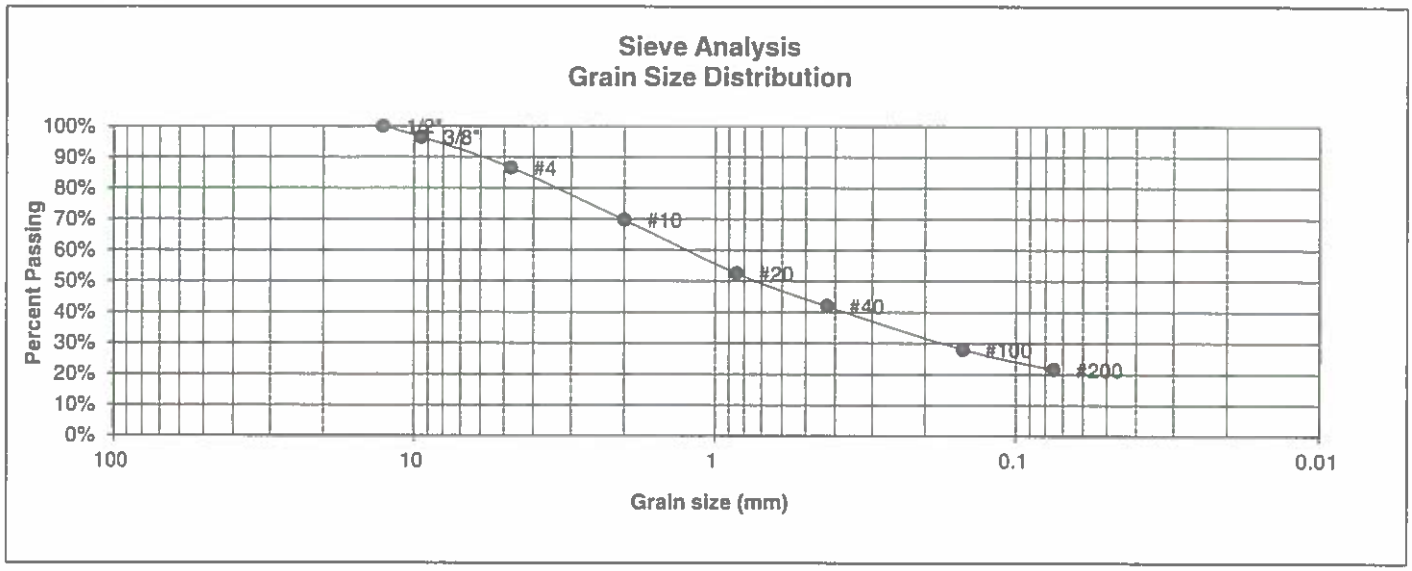
LABORATORY TEST RESULTS

DRAWN	DATE	CHECKED:	DATE
		DS	12/29/21

JOB NO. 212446
FIG NO. B-6

UNIFIED CLASSIFICATION	SC	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	2	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	5	JOB NO.	212446
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	96.4%
4	86.6%
10	69.7%
20	52.5%
40	42.0%
100	28.0%
200	21.5%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	26
Plastic Index	11

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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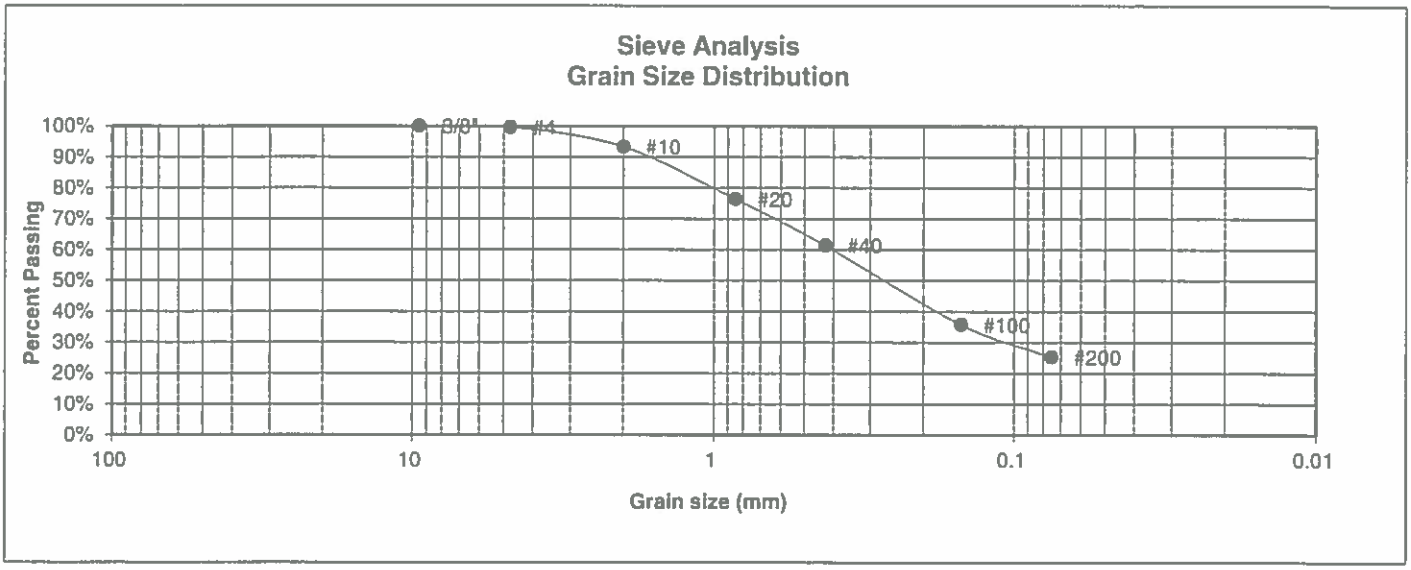
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DJ	12/29/21

JOB NO.: 212446
FIG NO.: B-7

UNIFIED CLASSIFICATION	SC	CLIENT	FOREST LAKES RESIDENTIAL
SOIL TYPE #	2	PROJECT	MESA TOP & TIMBER TREK
TEST BORING #	6	JOB NO.	212446
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.6%
10	93.3%
20	76.4%
40	61.4%
100	35.7%
200	25.3%

Atterberg Limits	
Plastic Limit	16
Liquid Limit	23
Plastic Index	7

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	

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LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: DS	DATE: 10/29/21

JOB NO.: 212446
FIG NO.: B-8

CLIENT	FOREST LAKES RESIDENTIAL	JOB NO.	212446
PROJECT	MESA TOP & TIMBER TREK	DATE	9/22/2021
LOCATION	MESA TOP & TIMBER TREK	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-2	1-2	1	SM	0.00
TB-5	1-2	1	SM	0.00
TB-6	10	2	SC	<0.01

QC BLANK PASS

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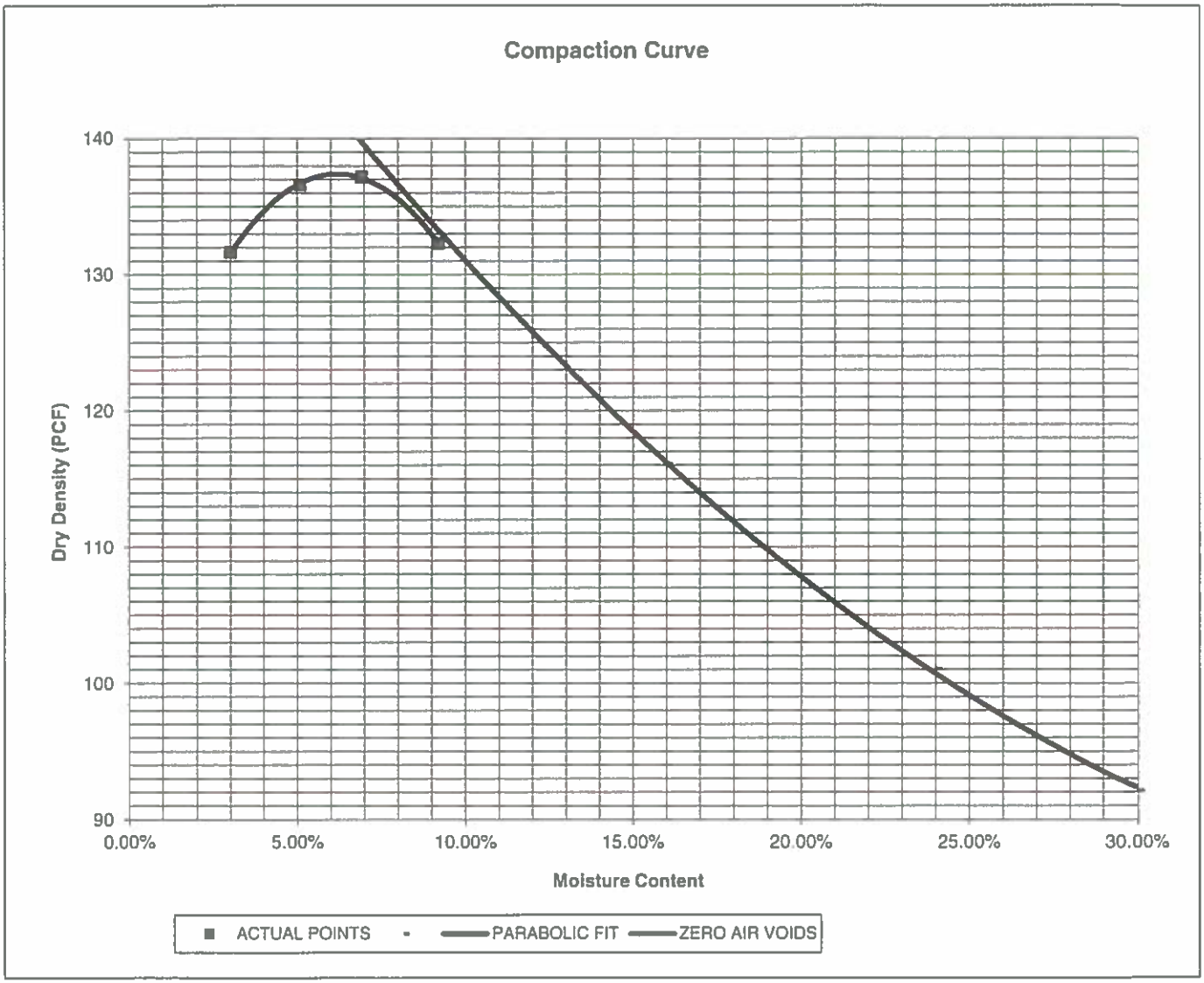
LABORATORY TEST
SULFATE RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	10/29/21

JOB NO.: 212446
FIG NO.: B-9

PROJECT	MESA TOP & TIMBER TREK	CLIENT	FOREST LAKES RESIDENTIAL
SAMPLE LOCATION	TB-1 @ 0-3'	JOB NO.	212446
SOIL DESCRIPTION	SAND, SILTY, RED BROWN	DATE	09/22/21

IDENTIFICATION	SM	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-B	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	137.5	OPTIMUM MOISTURE	6.2%



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MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		DJ	10/29/21

JOB NO.: 212446

FIG NO.: B-10

CBR TEST LOAD DATA

JOB NO: 212446
CLIENT: FOREST LAKES RESIDENTIAL
PROJECT: MESA TOP & TIMBER TREK
SOIL TYPE: 2

PISTON DIAMETER (cm)	PISTON AREA (in^2)
4.958	2.993

PENETRATION DEPTH (INCHES)	*10 BLOWS* MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	*25 BLOWS* MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	*56 BLOWS* MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	120	40.10	339	113.28	557	186.13
0.050	165	55.14	597	199.50	1049	350.54
0.075	194	64.83	779	260.32	1515	506.26
0.100	236	78.86	1012	338.18	2261	755.55
0.125	269	89.89	1215	406.01	2897	968.08
0.150	296	98.91	1409	470.84	3393	1133.83
0.175	339	113.28	1568	523.97	3713	1240.76
0.200	362	120.97	1708	570.76	4110	1373.43
0.300	482	161.07	2264	756.56	5521	1844.94
0.400	598	199.83	2633	879.86	6000	2005.01
0.500	715	238.93	2987	998.16		

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	354	353	99
WT. CAN	6.69	6.82	6.97
WT. CAN+WET	182.73	197.54	153.76
WT. CAN+DRY	162.59	178.37	140.21
WT. H20	20.14	19.17	13.55
WT. DRY SOIL	155.9	171.55	133.24
MOISTURE CONTENT	12.92%	11.17%	10.17%
WET DENSITY (PCF)	121.4	128.9	135.3
DRY DENSITY (PCF)	114.3	121.4	127.4
BEARING RATIO	7.89	33.82	75.56

90% OF DRY DENSITY	123.8
95% OF DRY DENSITY	130.6

BEARING RATIO AT 90% OF MAX	50.29	~ R VALUE	76
BEARING RATIO AT 95% OF MAX	97.85	~ R VALUE	84

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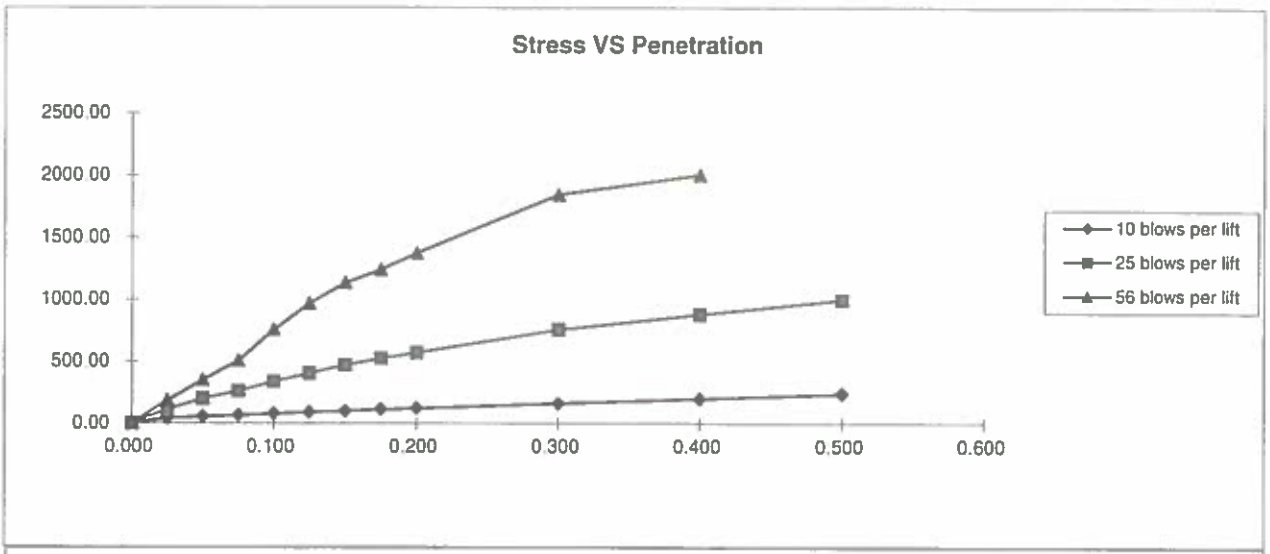
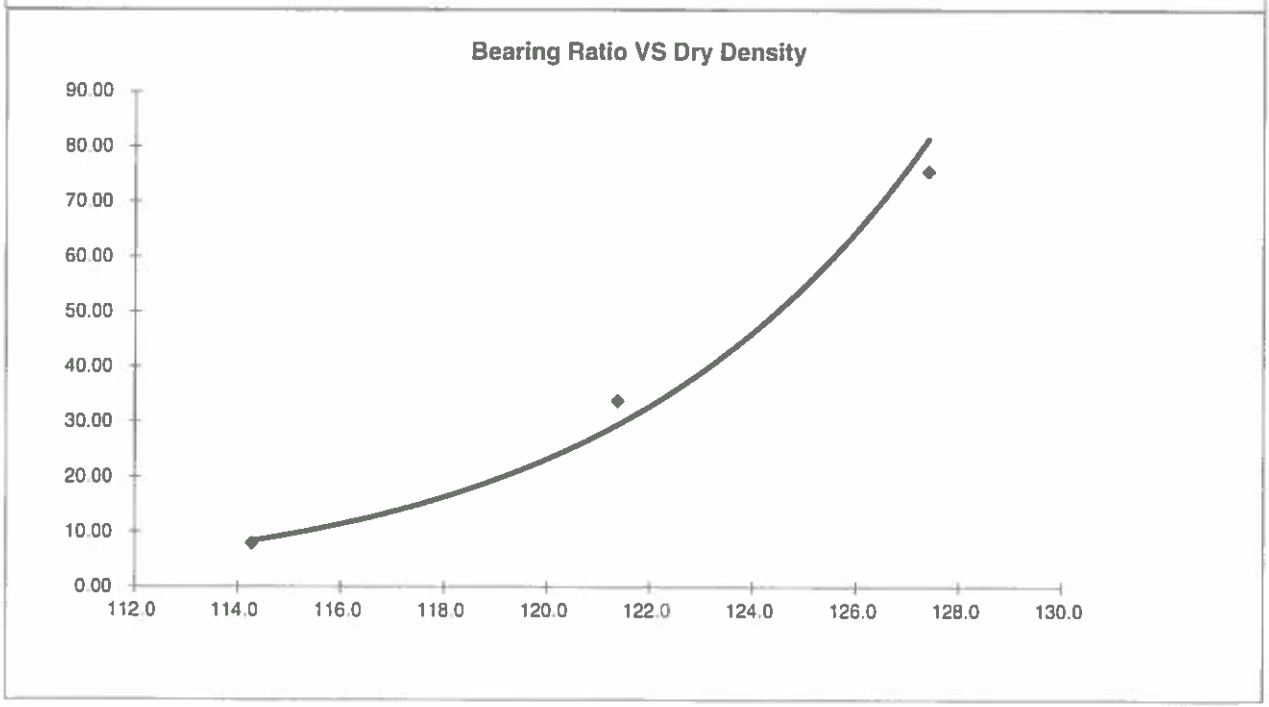
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		DS	10/22/21

JOB NO.: 212446
FIG NO.: B-15





BEARING RATIO AT 90% OF MAX	50.29	- R VALUE	76.00
BEARING RATIO AT 95% OF MAX	97.85	- R VALUE	84.00

JOB NO: 212446
SOIL TYPE: 2

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CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		DJ	10/22/01

JOB NO.: 212446
FIG NO.: B-12

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL - LOW VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.84
Soil Resilient Modulus	M_R =	13168

Weighted Structural Number (WSN): → WSN = 1.46

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

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

Left	Right	Difference
4.56	4.56	0.0

Job No. 212446
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL - LOW VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.46

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Basecourse

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Basecourse (inches)

FOR FULL DEPTH ASPHALT SECTION

$D_1 = (WSN)/C_1$ = 3.3 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASECOURSE SECTION

Asphalt Thickness (t) = [3] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 1.3 inches of Aggregate
Basecourse, use 4.0 inches

RECOMMENDED ALTERNATIVES

1. 3.0 inches of Asphalt + 4.0 inches of Aggregate Basecourse, or
2. 5.0 inches of Asphalt

Job No. 212446
Fig. No. C-2

DESIGN CALCULATIONS

CEMENT SECTIONS

DESIGN DATA FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL - LOW VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.46

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Cement Stabilized Subgrade

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Stabilized Subgrade (inches)

FOR ASPHALT + CEMENT STABILIZED SUBGRADE SECTION

Asphalt Thickness (t) = [4] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -2.7 inches of Cement Stabilized Subgrade
Cement Stabilized Subgrade, Use 10.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10.0 inches of Cement Stabilized Subgrade

Job No. 212446
Fig. No. C-3

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	292,000
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	13168

Weighted Structural Number (WSN): → WSN = 2.16

DESIGN TABLES AND EQUATIONS

$S_1 = [(R - 5) / 11.29] + 3$

$M_R = 10^{[(S_1 + 18.72) / 6.24]}$

$k = M_R / 19.4$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

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

Left	Right	Difference
5.47	5.47	0.0

Job No. 212446
Fig. No. C-4

DESIGN CALCULATIONS

DESIGN DATA FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	292,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	2.16

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Aggregate Basecourse

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Basecourse (inches)

FOR FULL DEPTH ASPHALT SECTION (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 4.9 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASECOURSE SECTION

Asphalt Thickness (t) = [4] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 3.6 inches of Aggregate
Basecourse, use 8.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 8.0 inches of Aggregate Basecourse, or
2. 5.0 inches of Asphalt

Job No. 212446
Fig. No. C-5

DESIGN CALCULATIONS

CEMENT SECTIONS

DESIGN DATA FOREST LAKES RESIDENTIAL DEVELOPMENT
FOREST LAKES, FILING NO. 6 - URBAN LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	292,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	2.16

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.11 Strength Coefficient - Cement Stabilized Subgrade

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Stabilized Subgrade (inches)

FOR ASPHALT + CEMENT STABILIZED SUBGRADE SECTION

Asphalt Thickness (t) = [4] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 3.6 inches of Cement Stabilized Subgrade
Cement Stabilized Subgrade, Use 10.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10.0 inches of Cement Stabilized Subgrade

Job No. 212446
Fig. No. C-6