



# ENTECH ENGINEERING, INC.

505 ELKTON DRIVE  
COLORADO SPRINGS, CO 80907  
PHONE (719) 531-5599  
FAX (719) 531-5238

November 30, 2021

Homes by Michael Turner  
12265 Oracle Boulevard, Suite 105  
Colorado Springs, Colorado 80921

Attn: Michael Turner

Re: Pavement Recommendations  
Abert Ranch Subdivision  
El Paso County, Colorado

**APPROVED**  
**Engineering Department**

12/13/2021 1:29:29 PM  
dsdnijkamp

EPC Planning & Community  
Development Department

Dear Mr. Turner:

As requested, Entech Engineering, Inc. obtained samples of the pavement subgrade soil from the proposed roadways within the above referenced subdivision. Laboratory testing was performed in order to determine the pavement support characteristics of the soil at proposed subgrade. This letter presents the results of the laboratory testing and pavement recommendations for the local residential roadways within the filing.

### **Project Description**

The project will consist of the paving of sections of Abert Ranch Drive and Silver Nell Drive in the Abert Ranch Subdivision. Subsurface Soil Investigation and laboratory testing was performed to determine the pavement support characteristics on the soil. The general layout of the site is presented in the Test Boring Location Map, Figure 1.

### **Subgrade Conditions**

Six test borings were drilled in the roadways in this filing, not exceeding 500 feet between each test boring. The test boring locations are shown in Figure No. 1. The Test Boring Logs are presented in Appendix A. A representative bulk sample of the subgrade soils was obtained from Test Boring No. 1 at the anticipated subgrade elevation. Soils encountered in the test borings consisted of very sandy to sandy clay overlying clayey sandstone. The sandstone was encountered at depth beneath the subgrade influence zone. The surficial soils were classified into one soil type (Soil Type 1).

Sieve Analyses were performed on the subgrade soils for the purpose of classification. The Sieve Analyses on the Type 1 soils indicated that approximately 51 to 67 percent of the soil particles passed the No. 200 sieve. The Type 1 soils classify as A-4 and A-6 soils, using the AASHTO classification system. The Type 1 soils typically provide poor pavement support characteristics. Water soluble sulfate tests indicated that the soils exhibited a negligible potential for below grade sulfate attack. Groundwater was not encountered in the test borings during or subsequent to drilling. The results of laboratory testing are presented Appendix B.

Swell/Consolidation testing on the site soils was required due to their plastic indexes. The testing resulted in swells ranging from 0.1 to 3.9 percent. Mitigation in the higher swell areas may be required. **Specific mitigation recommendations are discussed in the Mitigation section on Page 3.**

California Bearing Ratio (CBR) testing was performed on a sample of the Type 1 subgrade soils. The results of the CBR and classification testing are summarized in Table 1 and presented in the following tables, and in Appendix B, attached.

Soil Type 1 – Very Sandy Clay

R @ 90% = 1.0  
 R @ 95% = 12.0  
 Use R = 12.0 for design

Classification Testing

Liquid Limit	30
Plasticity Index	15
Percent Passing 200	51.4
AASHTO Classification	A-6
Group Index	4
Unified Soils Classification	CL

**Pavement Design**

The CBR testing was used to determine pavement sections for this site. The pavement sections were determined utilizing the El Paso County "Pavement Design Criteria and Report". Abert Ranch Drive from Silver Nell Drive to the cul-de-sac classifies as a rural local (cul-de-sac) roadway, which used an 18k ESAL value of 36,500 for design. Abert Ranch Drive from Settlers Ranch Road to the intersection of Silver Nell Drive and the west section of Silver Nell Drive classify as Rural Local Roads, which used and 18k ESAL value of 109,500 for design. Pavement alternatives for asphalt over aggregate basecourse and cement stabilized subgrade sections are provided. Design parameters used in the pavement analysis are as follows:

Reliability Local (Rural Local (cul-de-sac))	80%
Serviceability Index Rural Local	2.0
"R" Value Subgrade - Soil Type 1	12.0
Resilient Modulus - Soil Type 1	3,803 psi
Structural Coefficients:	
Hot Bituminous Pavement	0.44
Aggregate Basecourse	0.11

Pavement calculations are attached in Appendix C. Pavement sections recommended for the site are summarized as follows:

**Pavement Sections – Soil Type 1**

Local (Rural (cul-de-sac)) – ESAL = 36,500 Abert Ranch Drive from Silver Nell Drive to the cul-de-sac

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>
1. Asphalt Over Basecourse	4.0	6.0

**Pavement Sections – Soil Type 1**

Rural Local – ESAL = 109,000 Abert Ranch Drive from Settlers Ranch Road to the intersection of Silver Nell Drive and the west section of Silver Nell Drive

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>
1. Asphalt Over Basecourse	4.0	10.0

### Mitigation

El Paso County criteria requires mitigation of expansive soils for roadway subgrade that have a swell of 2 percent or greater with a 150 pound per square foot surcharge. Two samples resulted in volume changes of 3.9 and 4.7 percent. The roadway subgrade soils were initially moisture conditioned and processed during site grading. Prior to paving, the subgrade should be evaluated for proper moisture conditions. In areas that need additional moisture-conditioning, we recommend that the top 12-inches of the subgrade be scarified and moisture-conditioned to 0 to 4 percent over optimum moisture content and be recompacted. The overexcavated areas should be compacted and tested prior to placing the conditioned soils. Specific areas requiring mitigation should be field determined. The subgrade soils should be observed and tested by Entech personnel prior to paving.

### 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 its maximum Standard Proctor Dry Density, ASTM D-698 at 0 to 4 percent over optimum moisture content. Any loose or soft 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  $\pm 2$  percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

If significant grading is performed, the soils at subgrade may change. Modification to the pavement sections should be evaluated after site grading is completed.

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

We trust that this has provided you with the information you required. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.



Daniel P. Stegman

DPS/bs

Encl.

Entech Job No. 212882  
AAprojects/2021/212882 pr



Reviewed by:



Mark H. Hauschild, P.E.  
Senior Engineer

## TABLE

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

CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION  
 JOB NO. 212882

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, CBR	6	0-3	12.5	109.5	51.4	30	15		A-6	0.7	CL	CLAY, VERY SANDY
1	1	1-2	7.8	114.7	59.4	34	19	<0.01	A-6	3.9	CL	CLAY, VERY SANDY
1	2	1-2			59.6	27	10	0.01	A-4		CL	CLAY, VERY SANDY
1	3	1-2	6.7	124.6	64.4	30	9		A-4	0.5	CL	CLAY, SANDY
1	4	1-2	7.0	117.8	66.5	32	16		A-6	4.7	CL	CLAY, SANDY
1	5	1-2	4.1	119.1	63.1				A-4	0.1	CL	CLAY, SANDY
1	6	1-2	5.2	125.2	59.1	31	14		A-6	1.0	CL	CLAY, VERY SANDY
2	6	10	4.5	121.3	28.4	29	15	<0.01	A-2-6	0.9	SC	SAND, CLAYEY
3	1	10	6.8	119.6	28.5	26	11	0.01	A-2-6	0.2	SC	SANDSTONE, CLAYEY

**FIGURE**

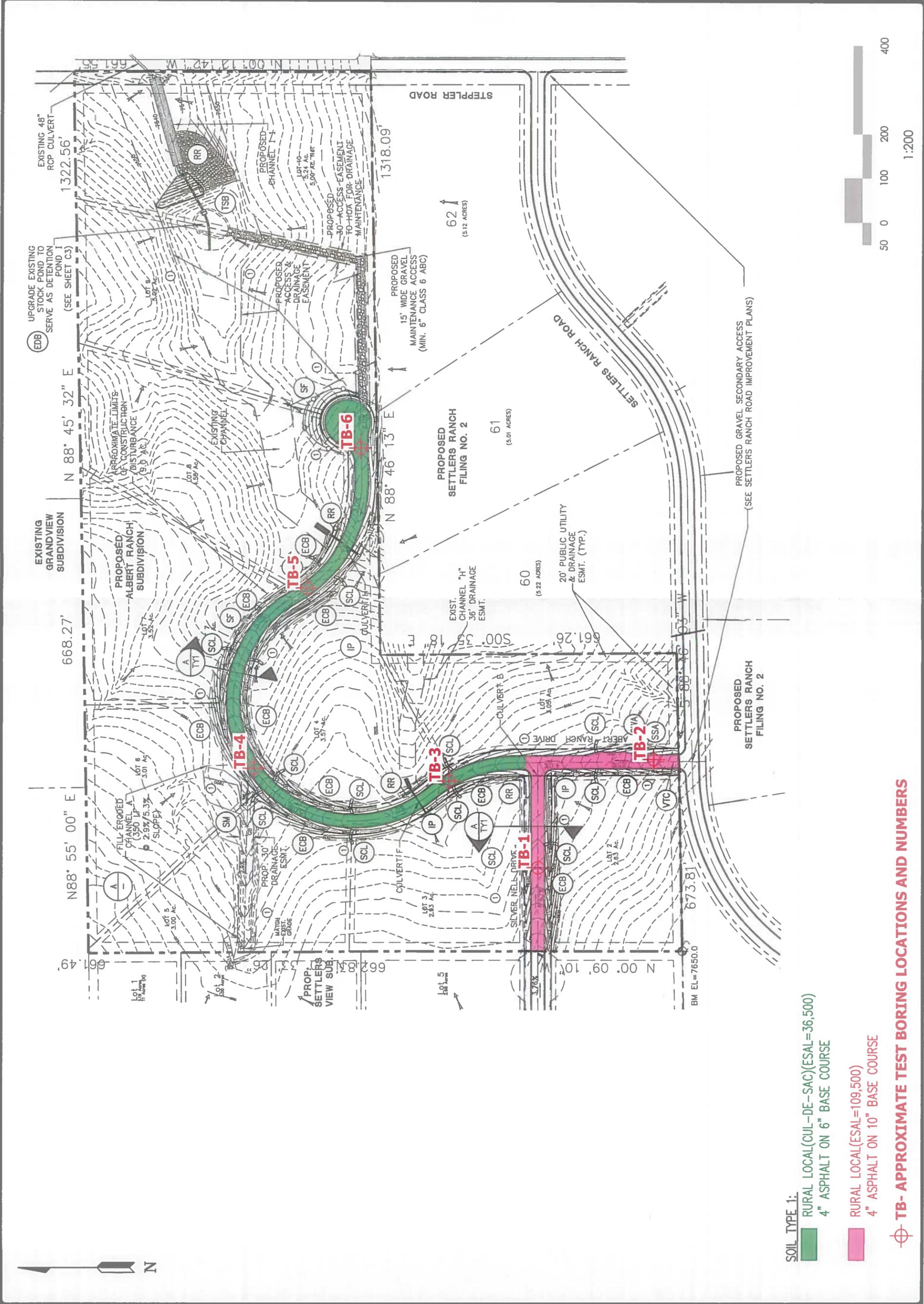
REVISION BY	DATE	DESCRIPTION

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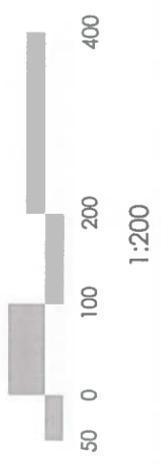
**TEST BORING LOCATION MAP**  
ABERT RANCH  
COLORADO SPRINGS, CO  
FOR: HOMES BY TURNER

DATE	11/25/21
DRAWN	JAC
CHECKED	DB
SCALE	1"=200'
JOB NO.	212062
FIGURE NO.	1



- SOIL TYPE 1:**
- RURAL LOCAL(CUL-DE-SAC)(ESAL=36,500)  
4" ASPHALT ON 6" BASE COURSE
  - RURAL LOCAL(ESAL=109,500)  
4" ASPHALT ON 10" BASE COURSE

**TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS**



## **APPENDIX A: Test Boring Logs**

TEST BORING NO. 1  
 DATE DRILLED 11/8/2021  
 Job # 212882

TEST BORING NO. 2  
 DATE DRILLED 11/8/2021  
 CLIENT HOMES BY MICHAEL TURNER  
 LOCATION ABERT RANCH SUBDIVISION

REMARKS

DRY TO 10', 11/8/21

CLAY, VERY SANDY, BROWN,  
 STIFF, MOIST

SANDSTONE, CLAYEY, FINE TO  
 MEDIUM GRAINED, BROWN,  
 VERY DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0 - 5	[Diagonal Hatching]	1	25	6.0	1
5 - 10	[Dotted]	1	50	6.2	2
10 - 20	[Dotted]	1	50	4.0	2

REMARKS

DRY TO 5', 11/8/21

CLAY, VERY SANDY, BROWN,  
 VERY STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0 - 5	[Diagonal Hatching]	1	33	7.8	1
5 - 10	[Diagonal Hatching]	1	45	4.0	1



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TEST BORING LOG

DRAWN:

DATE:

CHECKED:

DATE:

DS

11/24/21

JOB NO.:  
 212882

FIG NO.:  
 A- 1

TEST BORING NO. 3  
 DATE DRILLED 11/8/2021  
 Job # 212882

TEST BORING NO. 4  
 DATE DRILLED 11/8/2021  
 CLIENT HOMES BY MICHAEL TURNER  
 LOCATION ABERT RANCH SUBDIVISION

REMARKS

REMARKS

DRY TO 5', 11/8/21

CLAY, SANDY, BROWN, VERY STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			33	4.5	1
5			34	7.7	1

DRY TO 5', 11/8/21

CLAY, SANDY, BROWN, VERY STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			38	6.4	1
5			46	6.5	1



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TEST BORING LOG

DRAWN:

DATE:

CHECKED:

DATE:

*DS* 11/24/21

JOB NO:  
 212882

FIG NO:  
 A- 2

TEST BORING NO. 5  
 DATE DRILLED 11/8/2021  
 Job # 212882

TEST BORING NO. 6  
 DATE DRILLED 11/8/2021  
 CLIENT HOMES BY MICHAEL TURNER  
 LOCATION ABERT RANCH SUBDIVISION

REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type	REMARKS	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
DRY TO 5', 11/8/21 CLAY, SANDY, BROWN, STIFF, MOIST				19	14.5	1	DRY TO 10', 11/8/21 CLAY, SANDY, BROWN, STIFF, MOIST				24	7.7	1
SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST	5			20	6.2	2		5			15	8.5	1
	10						SAND, CLAYEY, FINE TO MEDIUM GRAINED, TAN, DENSE, MOIST	10			39	20.5	2
	15							15					
	20							20					



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**TEST BORING LOG**

DRAWN:

DATE:

CHECKED:

DATE:

*DJ* 11/24/21

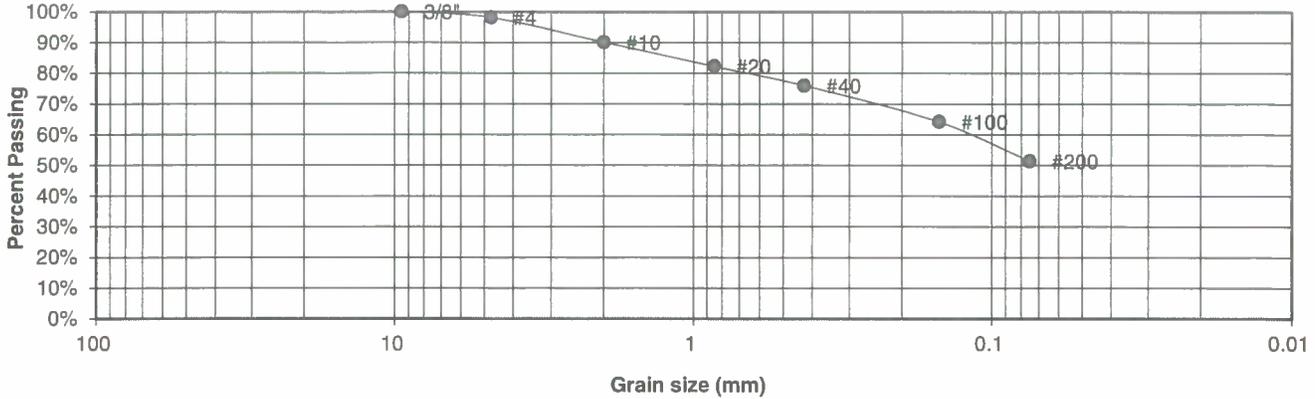
JOB NO.:  
212882

FIG NO.:  
A- 3

## **APPENDIX B: Laboratory Test Results**

UNIFIED CLASSIFICATION	CL	CLIENT	HOMES BY MICHAEL TURNER
SOIL TYPE #	1, CBR	PROJECT	ABERT RANCH SUBDIVISION
TEST BORING #	6	JOB NO.	212882
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	4

**Sieve Analysis  
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.2%
10	90.0%
20	82.2%
40	76.0%
100	64.2%
200	51.4%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	30
Plastic Index	15

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:
		ps	11/24/21

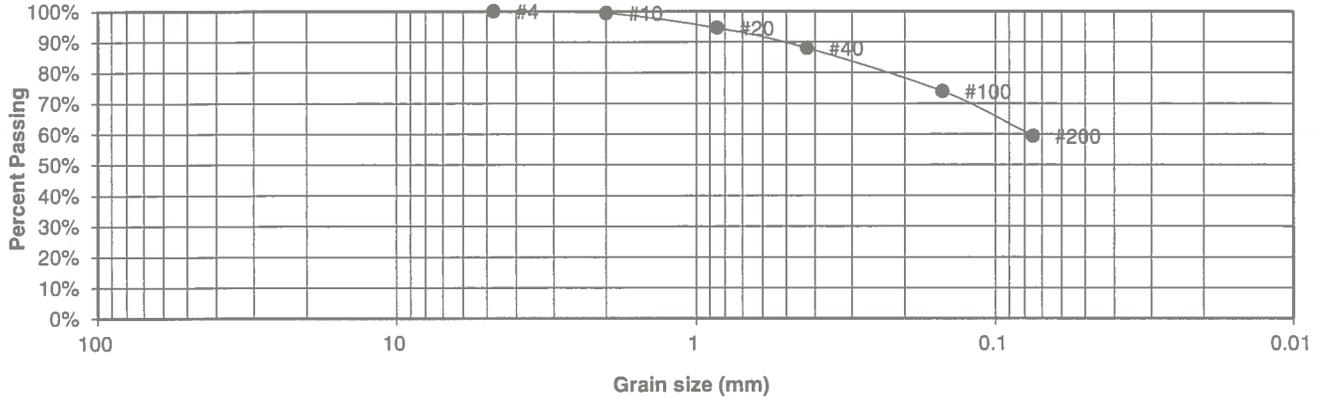
JOB NO.:

212882  
FIG NO.:

B-1

UNIFIED CLASSIFICATION	CL	CLIENT	HOMES BY MICHAEL TURNER
SOIL TYPE #	1	PROJECT	ABERT RANCH SUBDIVISION
TEST BORING #	1	JOB NO.	212882
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	8

**Sieve Analysis  
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.4%
20	94.6%
40	88.0%
100	73.9%
200	59.4%

Atterberg Limits	
Plastic Limit	15
Liquid Limit	34
Plastic Index	19

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



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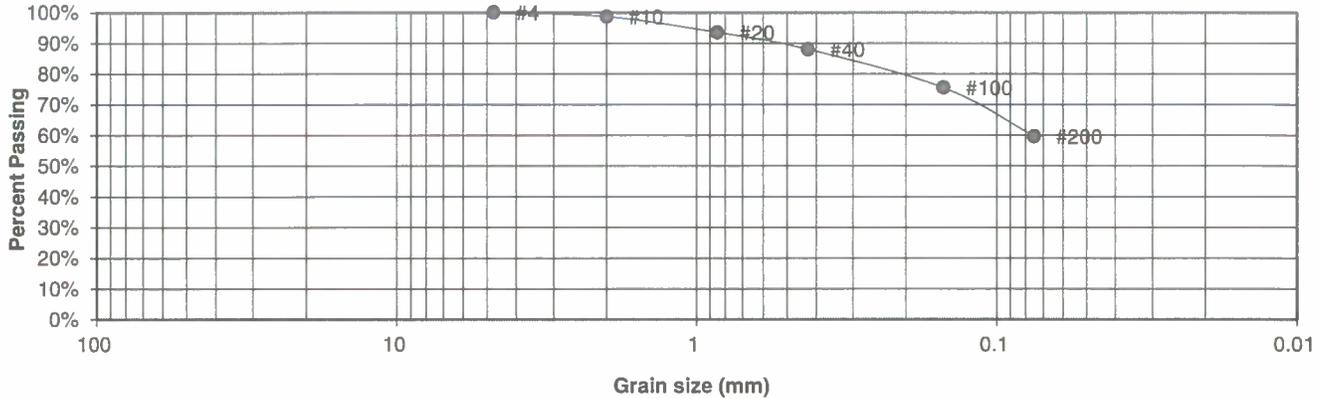
**LABORATORY TEST  
RESULTS**

DRAWN:	DATE:	CHECKED: <i>DB</i>	DATE: <i>11/24/21</i>
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JOB NO.:  
212882  
FIG NO.:  
*B-2*

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ABERT RANCH SUBDIVISION
<u>TEST BORING #</u>	2	<u>JOB NO.</u>	212882
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-4	<u>GROUP INDEX</u>	3

**Sieve Analysis  
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	98.7%
20	93.5%
40	88.0%
100	75.5%
200	59.6%

<u>Atterberg Limits</u>	
Plastic Limit	17
Liquid Limit	27
Plastic Index	10

<u>Swell</u>	
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	11/22/21

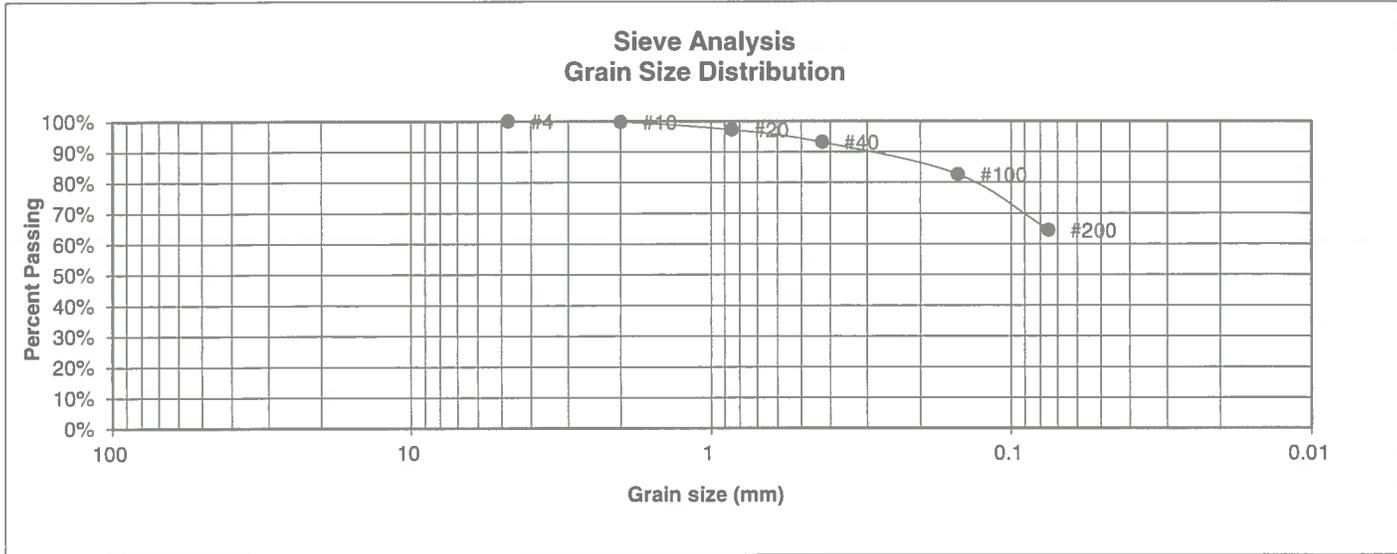
JOB NO.:

212882

FIG NO.:

B-3

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ABERT RANCH SUBDIVISION
<u>TEST BORING #</u>	3	<u>JOB NO.</u>	212882
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-4	<u>GROUP INDEX</u>	4



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.7%
20	97.2%
40	93.1%
100	82.6%
200	64.4%

<u>Atterberg Limits</u>	
Plastic Limit	21
Liquid Limit	30
Plastic Index	9
<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



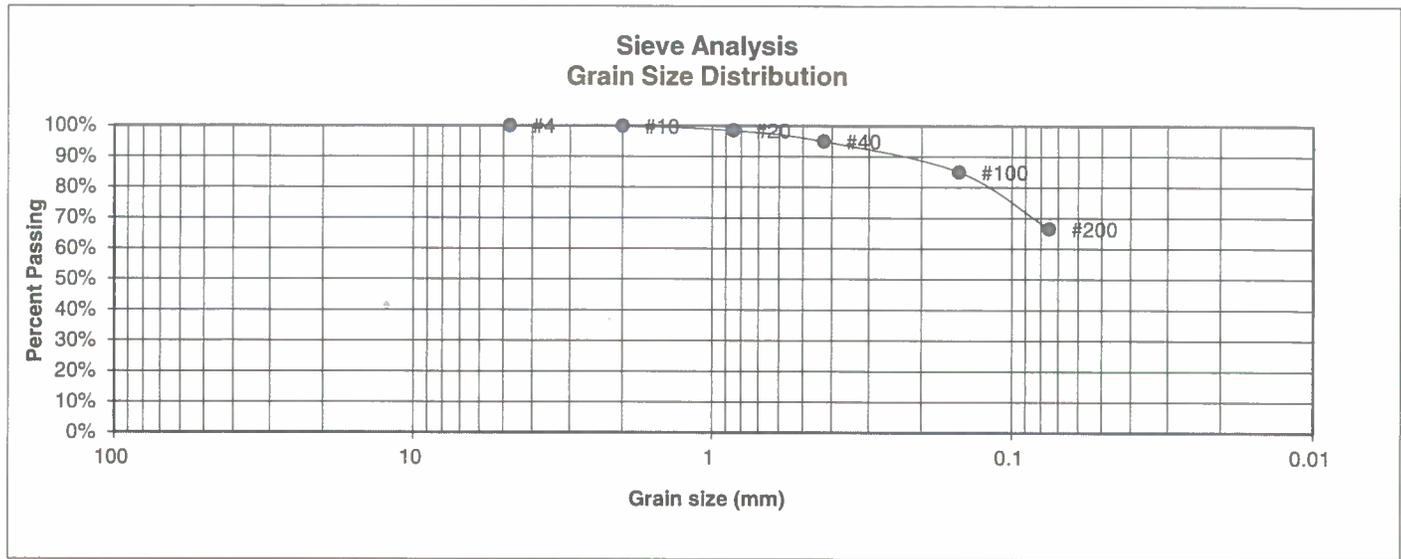
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**LABORATORY TEST  
RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		TDS	11/22/21

JOB NO.:  
212882  
FIG NO.:  
6-4

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ABERT RANCH SUBDIVISION
<u>TEST BORING #</u>	4	<u>JOB NO.</u>	212882
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	8



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.9%
20	98.4%
40	94.9%
100	85.0%
200	66.5%

<u>Atterberg Limits</u>	
Plastic Limit	16
Liquid Limit	32
Plastic Index	16

<u>Swell</u>	
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	11/22/21

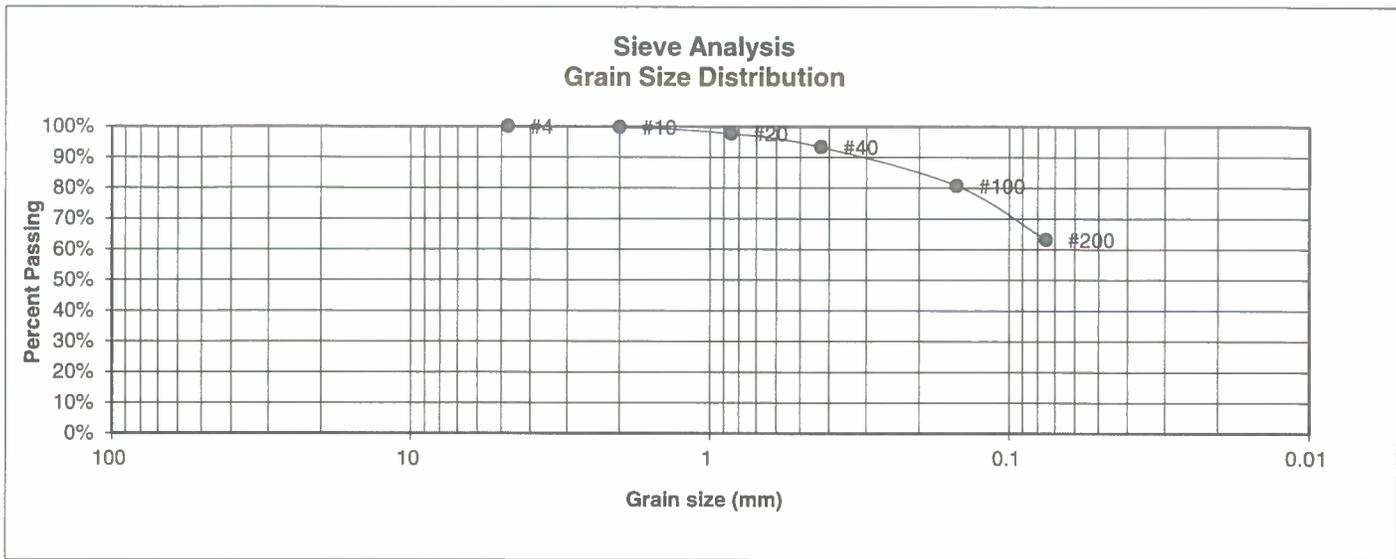
JOB NO.:

212882

FIG NO.:

B5

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ABERT RANCH SUBDIVISION
<u>TEST BORING #</u>	5	<u>JOB NO.</u>	212882
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-4	<u>GROUP INDEX</u>	0



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.8%
20	97.7%
40	93.4%
100	80.7%
200	63.1%

- Atterberg Limits  
 Plastic Limit  
 Liquid Limit  
 Plastic Index
- 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

11/22/21

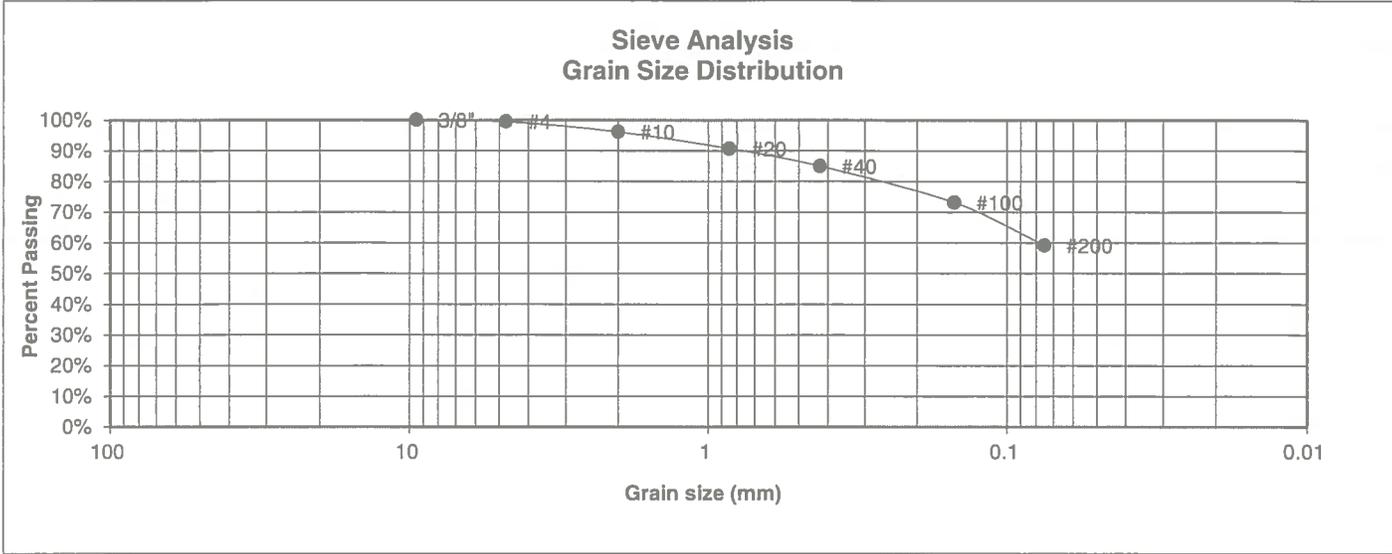
JOB NO.:

212882

FIG NO.:

B-6

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	ABERT RANCH SUBDIVISION
<u>TEST BORING #</u>	6	<u>JOB NO.</u>	212882
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	6



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.5%
10	96.2%
20	90.7%
40	85.0%
100	73.2%
200	59.1%

<u>Atterberg Limits</u>	
Plastic Limit	17
Liquid Limit	31
Plastic Index	14

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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COLORADO SPRINGS, COLORADO 80907

**LABORATORY TEST  
RESULTS**

DRAWN:	DATE:	CHECKED: <i>TDS</i>	DATE: <i>11/20/21</i>
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JOB NO.:

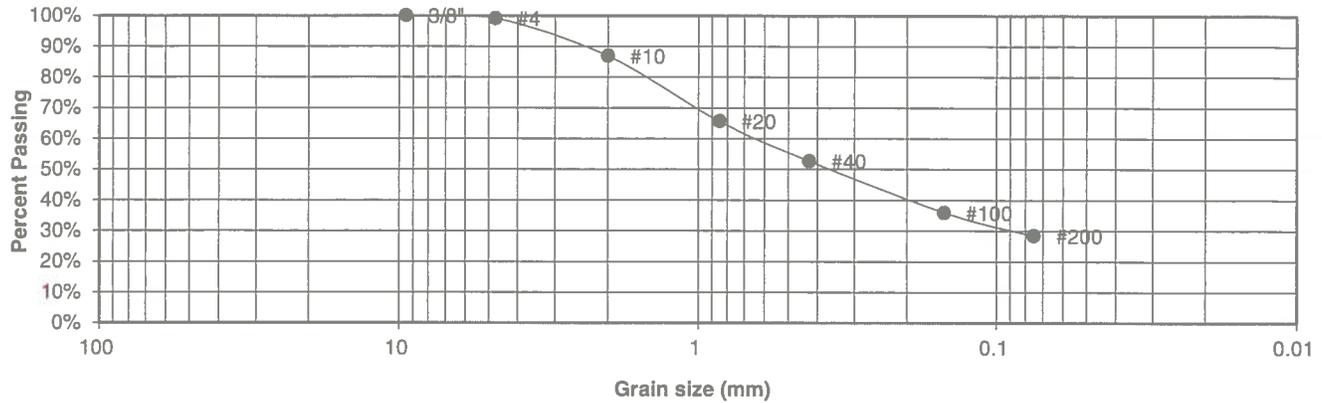
212882

FIG NO.:

*B-7*

UNIFIED CLASSIFICATION	SC	CLIENT	HOMES BY MICHAEL TURNER
SOIL TYPE #	2	PROJECT	ABERT RANCH SUBDIVISION
TEST BORING #	6	JOB NO.	212882
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	1

**Sieve Analysis  
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.1%
10	86.9%
20	65.6%
40	52.7%
100	35.9%
200	28.4%

Atterberg Limits	
Plastic Limit	14
Liquid Limit	29
Plastic Index	15

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	11/22/21

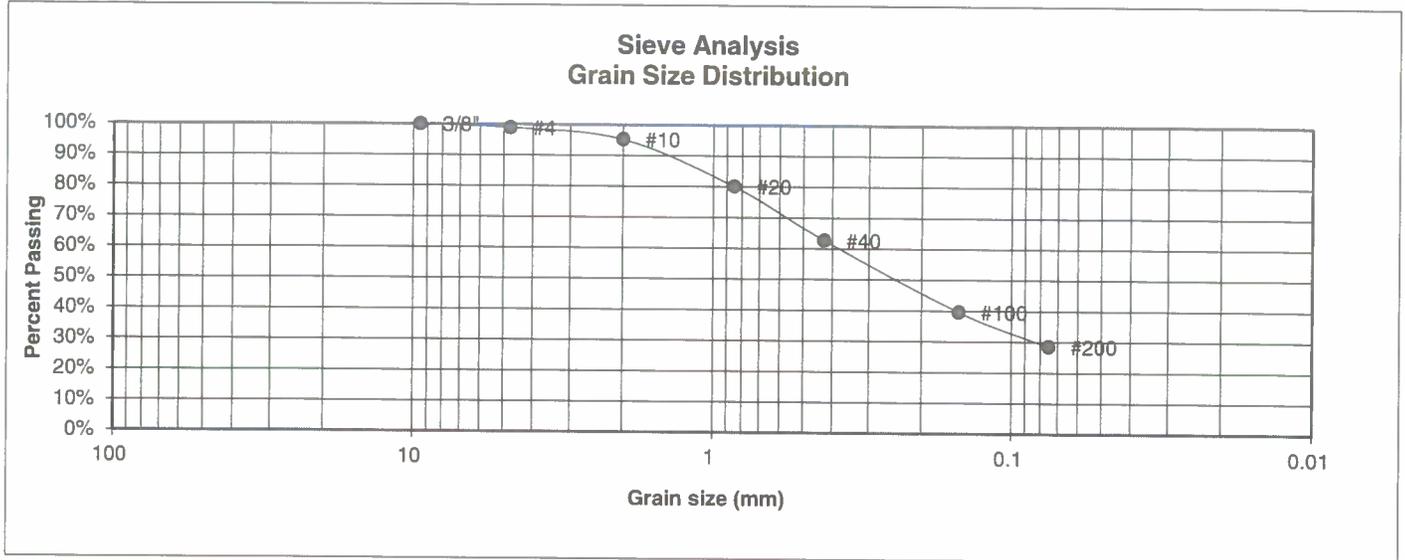
JOB NO.:

212882  
FIG NO.:

B-8

**UNIFIED CLASSIFICATION** SC  
**SOIL TYPE #** 3  
**TEST BORING #** 1  
**DEPTH (FT)** 10  
**AASHTO CLASSIFICATION** A-2-6

**CLIENT** HOMES BY MICHAEL TURNER  
**PROJECT** ABERT RANCH SUBDIVISION  
**JOB NO.** 212882  
**TEST BY** BL  
**GROUP INDEX** 0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.9%
10	95.2%
20	80.1%
40	62.7%
100	39.6%
200	28.5%

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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 505 ELKTON DRIVE  
 COLORADO SPRINGS, COLORADO 80907

**LABORATORY TEST RESULTS**

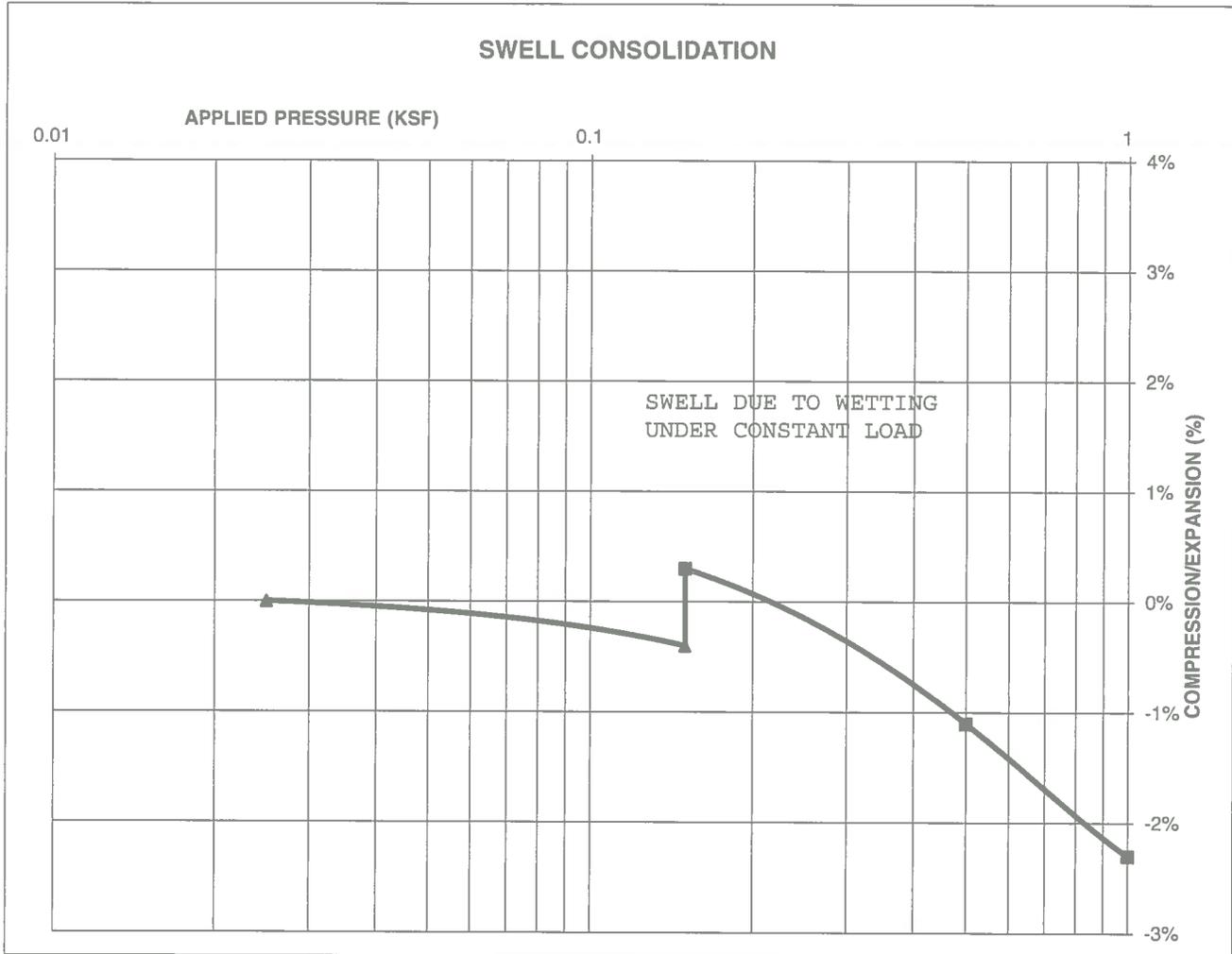
DRAWN:	DATE:	CHECKED: <i>DS</i>	DATE: <i>11/2/11</i>
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JOB NO.:  
 212882  
 FIG NO.:  
**B-9**

**CONSOLIDATION TEST RESULTS**

TEST BORING #	1	DEPTH(ft)	0-3
DESCRIPTION	CL	SOIL TYPE	1, CBR
NATURAL UNIT DRY WEIGHT (PCF)			110
NATURAL MOISTURE CONTENT			12.5%
SWELL/CONSOLIDATION (%)			0.7%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		DJ	11/24/21

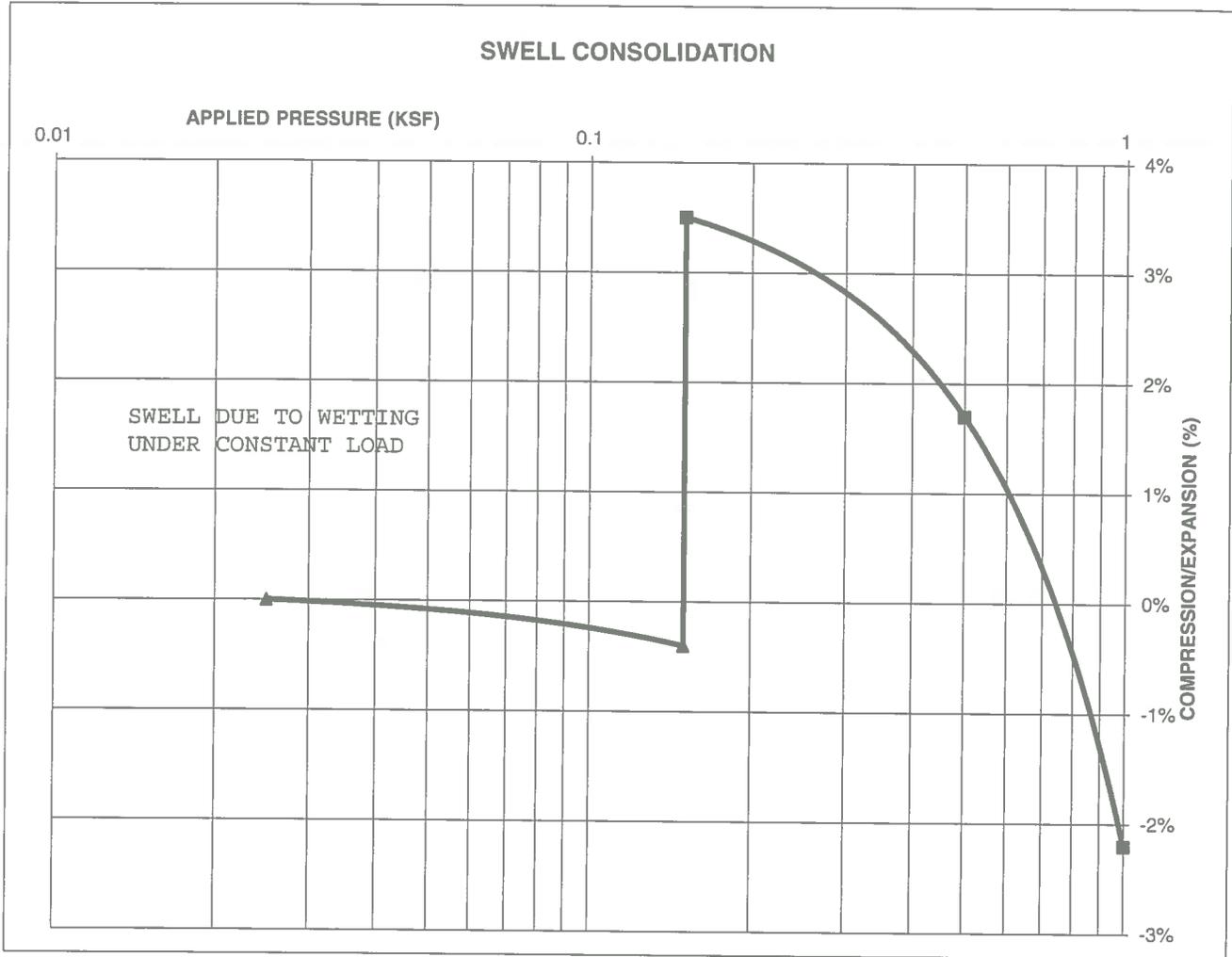
JOB NO.: 212882

FIG NO.: B-10

**CONSOLIDATION TEST RESULTS**

TEST BORING #	1	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			115
NATURAL MOISTURE CONTENT			7.8%
SWELL/CONSOLIDATION (%)			3.9%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

DS

11/21/21

JOB NO.:

212882

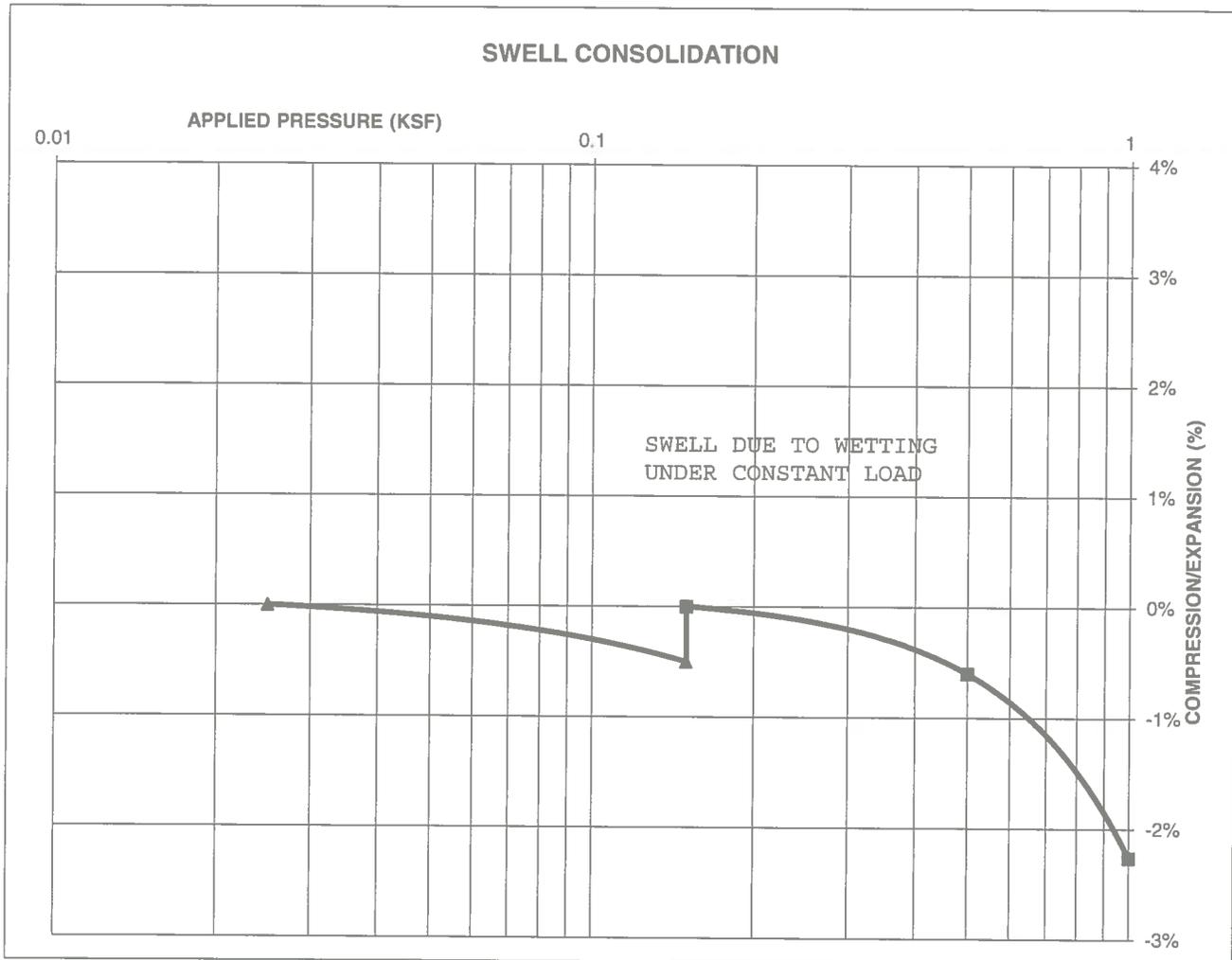
FIG NO.:

B-11

**CONSOLIDATION TEST RESULTS**

TEST BORING #	3	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			125
NATURAL MOISTURE CONTENT			6.7%
SWELL/CONSOLIDATION (%)			0.5%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

DS

11/24/21

JOB NO.:

212882

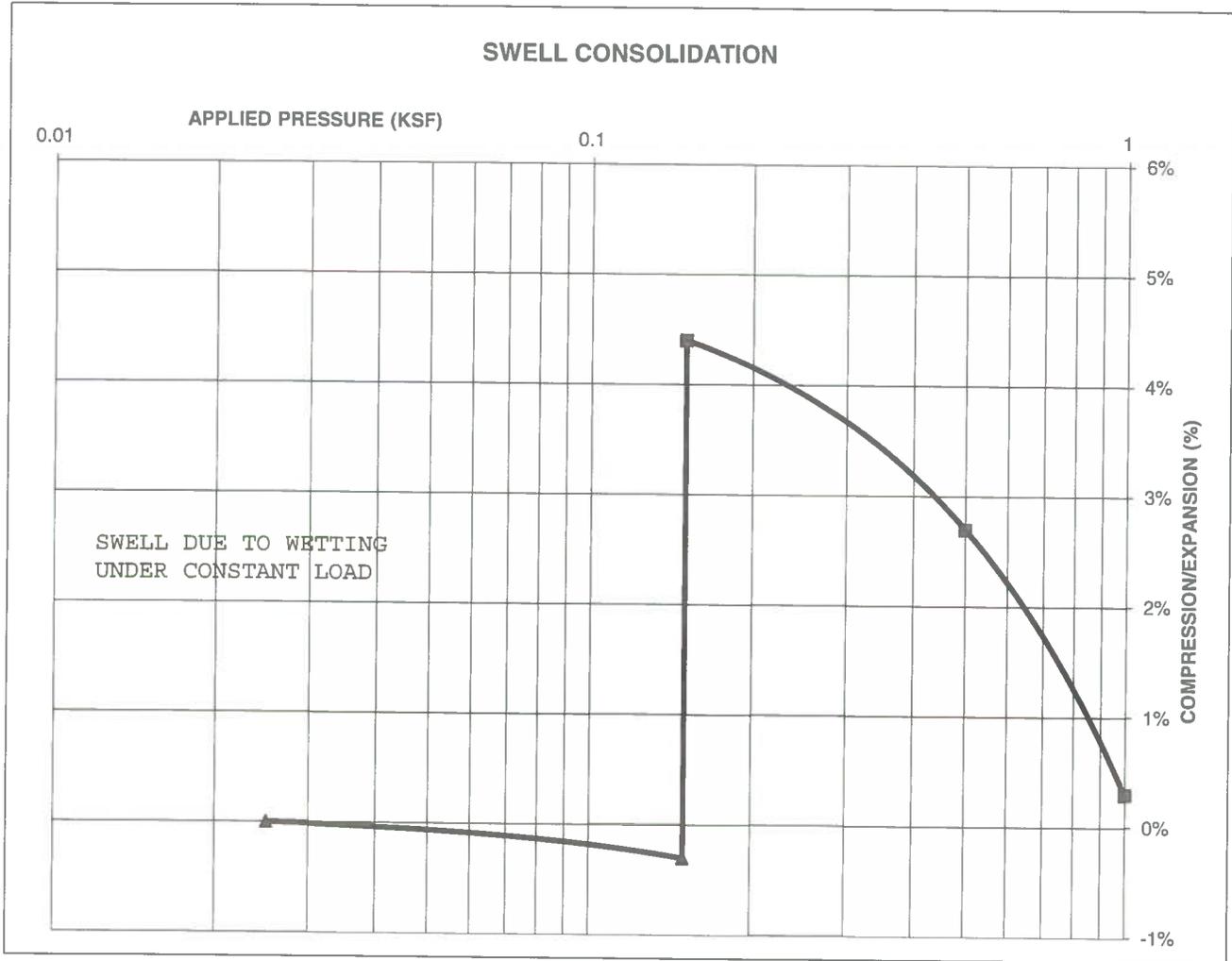
FIG NO.:

B-12

**CONSOLIDATION TEST RESULTS**

TEST BORING #	4	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			118
NATURAL MOISTURE CONTENT			7.0%
SWELL/CONSOLIDATION (%)			4.7%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

BS

11/20/01

JOB NO.:

212882

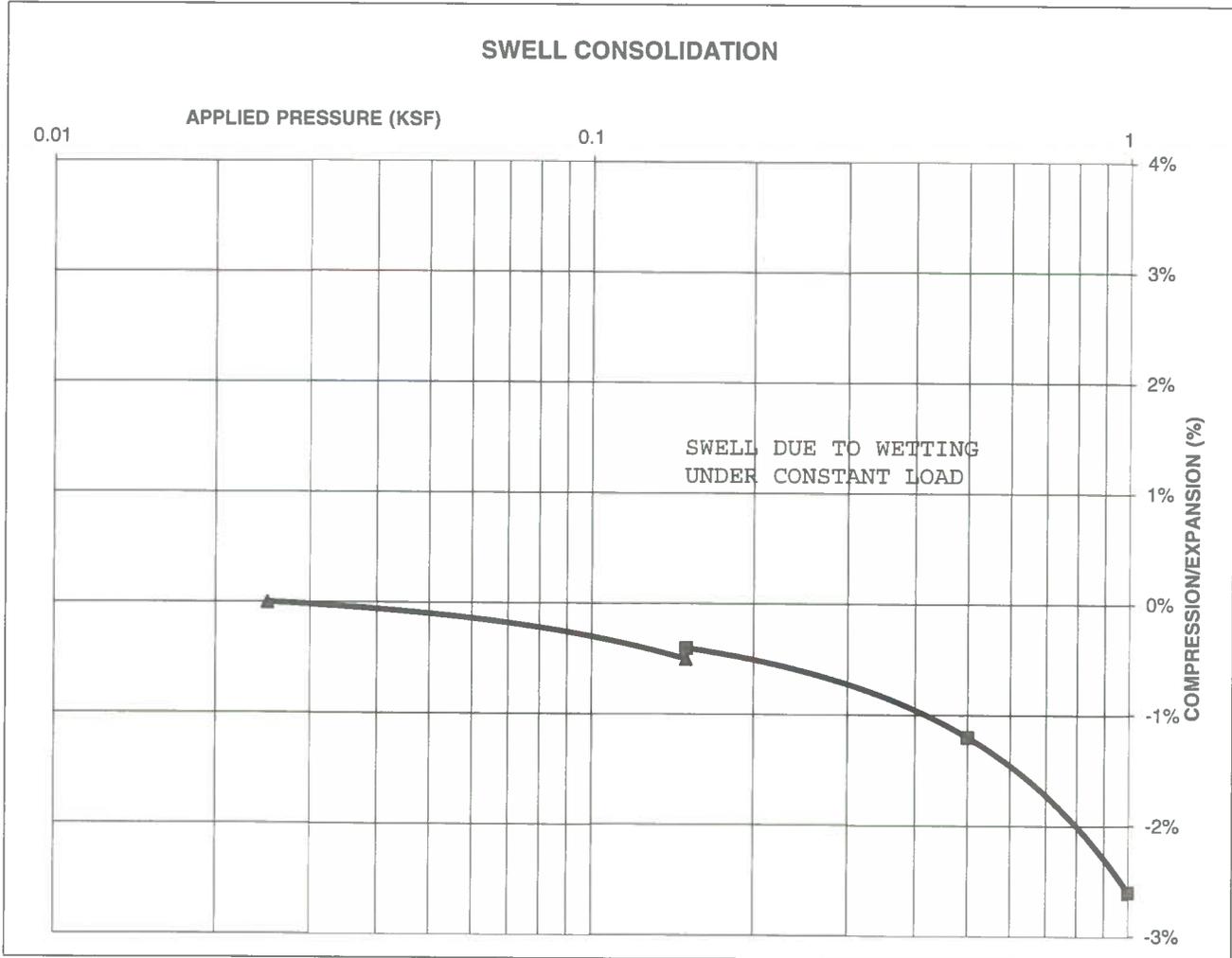
FIG NO.:

B-13

**CONSOLIDATION TEST RESULTS**

TEST BORING #	5	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			119
NATURAL MOISTURE CONTENT			4.1%
SWELL/CONSOLIDATION (%)			0.1%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

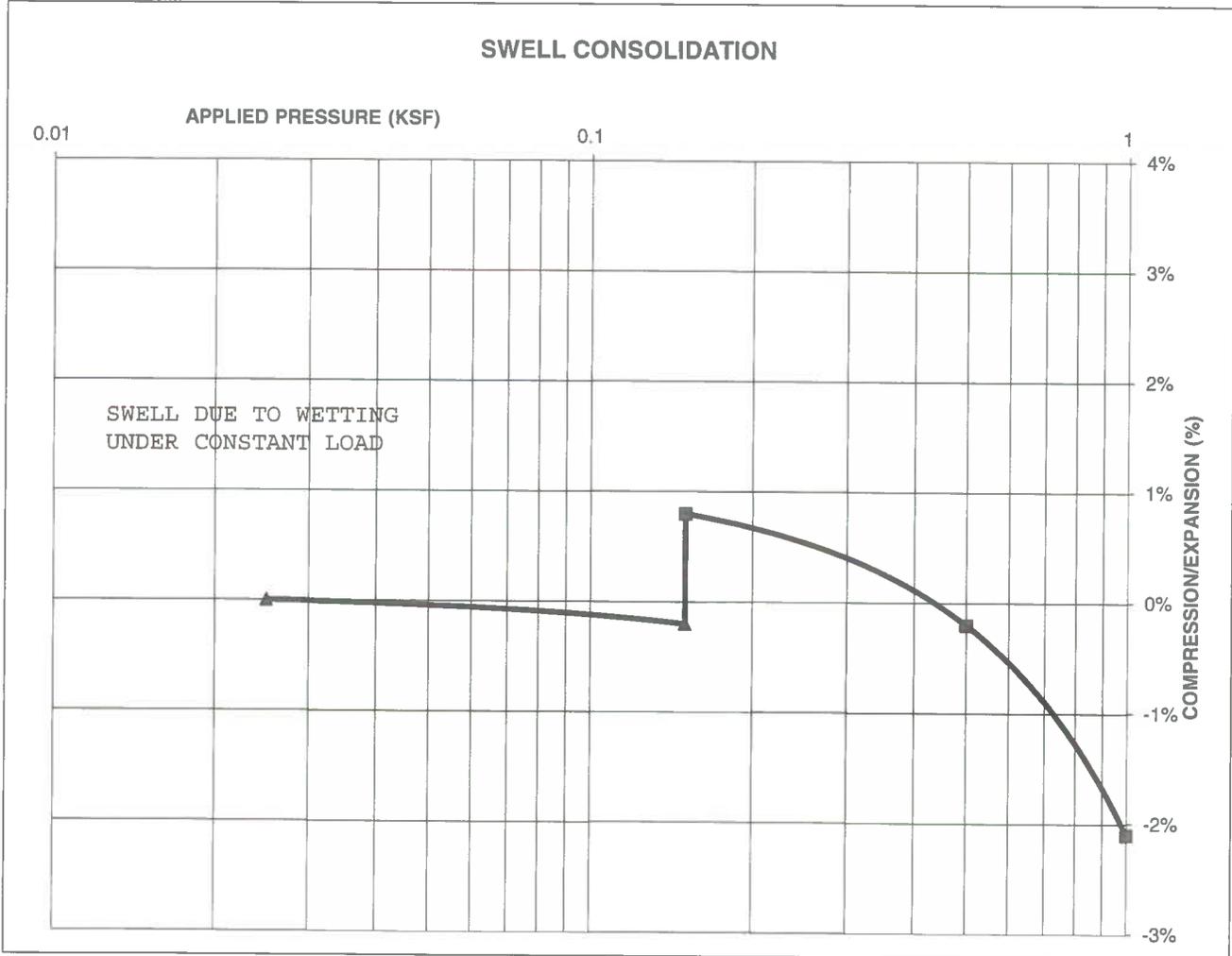
DRAWN:	DATE:	CHECKED:	DATE:
		BS	11/24/21

JOB NO.:  
 212882  
 FIG NO.:  
 B-14

**CONSOLIDATION TEST RESULTS**

TEST BORING #	6	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)			125
NATURAL MOISTURE CONTENT			5.2%
SWELL/CONSOLIDATION (%)			1.0%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

DJ

11/22/21

JOB NO.:

212882

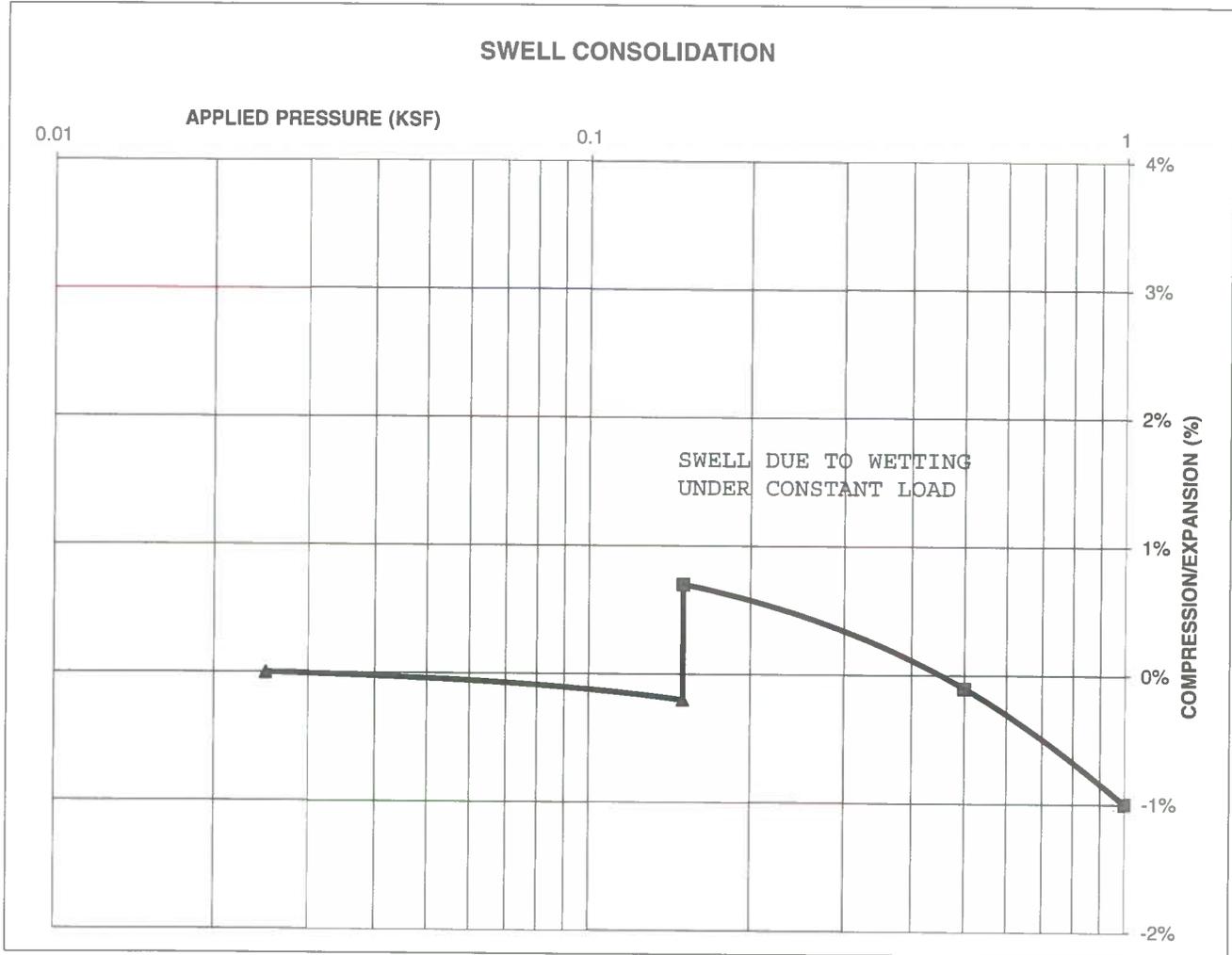
FIG NO.:

B-15

**CONSOLIDATION TEST RESULTS**

TEST BORING #	6	DEPTH(ft)	10
DESCRIPTION	SC	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			121
NATURAL MOISTURE CONTENT			4.5%
SWELL/CONSOLIDATION (%)			0.9%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

*DS*

*11/24/21*

JOB NO.:

212882

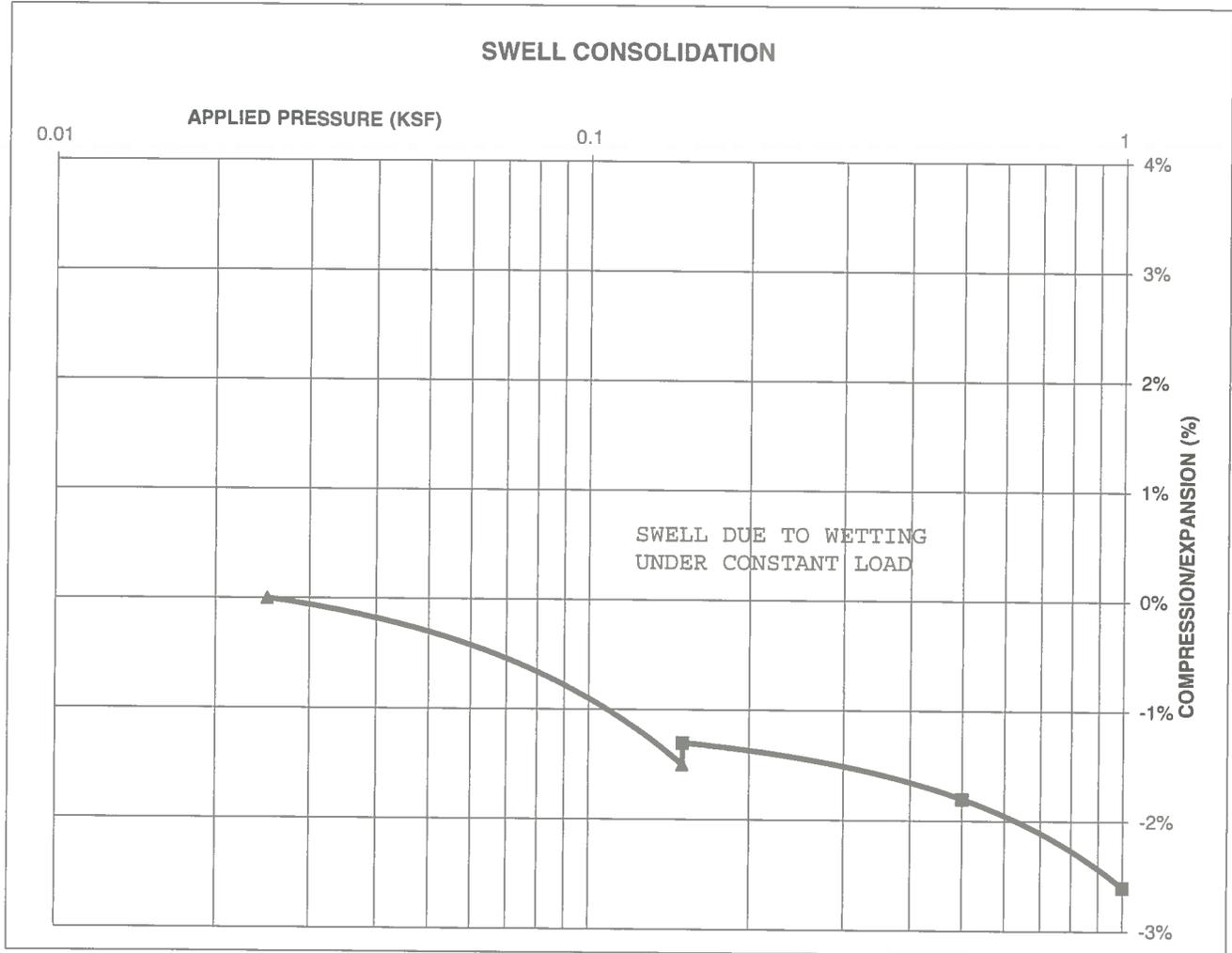
FIG NO.:

*B-16*

**CONSOLIDATION TEST RESULTS**

TEST BORING #	1	DEPTH(ft)	10
DESCRIPTION	SC	SOIL TYPE	3
NATURAL UNIT DRY WEIGHT (PCF)			120
NATURAL MOISTURE CONTENT			6.8%
SWELL/CONSOLIDATION (%)			0.2%

JOB NO. 212882  
 CLIENT HOMES BY MICHAEL TURNER  
 PROJECT ABERT RANCH SUBDIVISION



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**SWELL CONSOLIDATION  
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

DS

11/24/21

JOB NO.:

212882

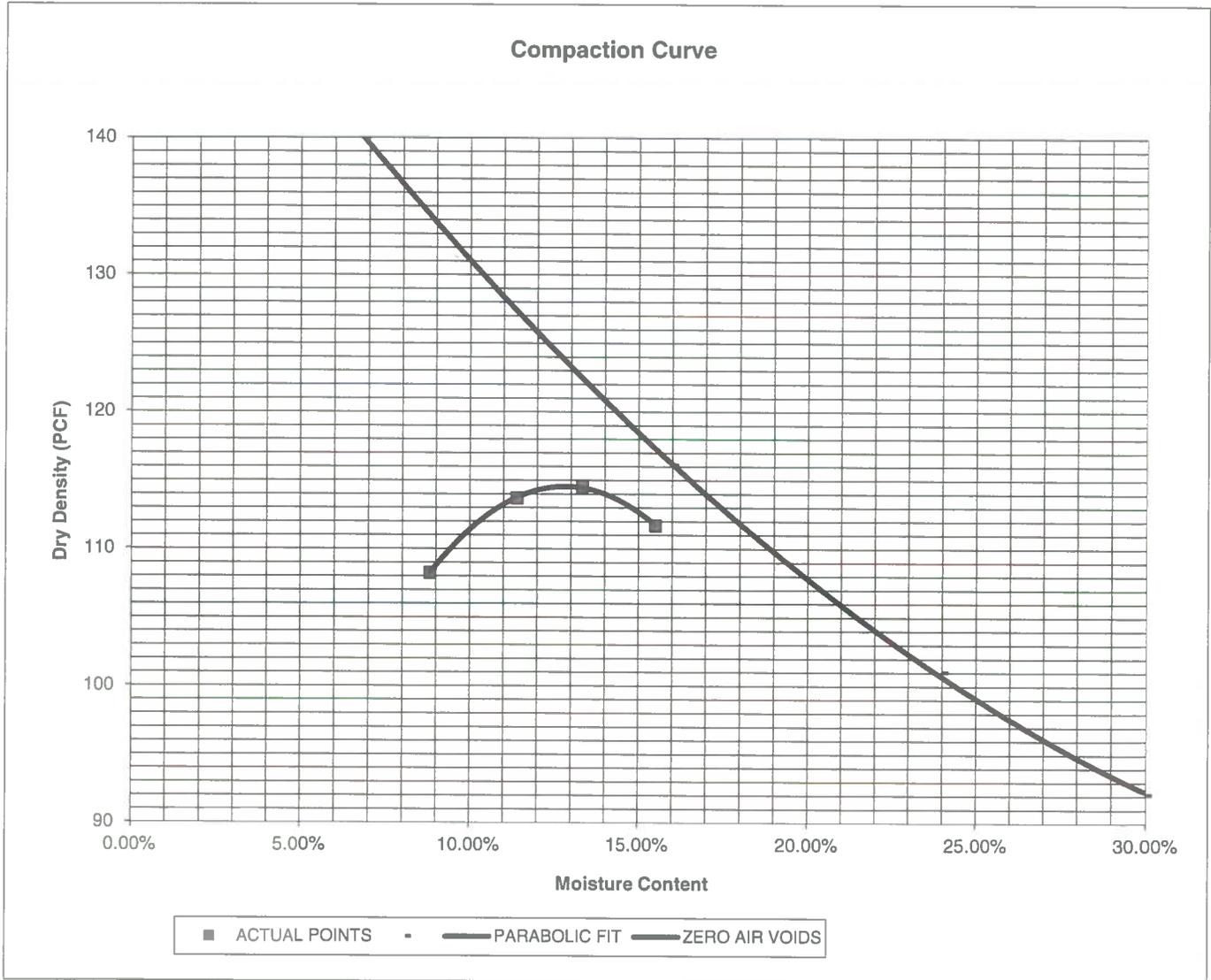
FIG NO.:

B-17



<u>PROJECT</u>	ABERT RANCH SUBDIVISION	<u>CLIENT</u>	HOMES BY MICHAEL TURNER
<u>SAMPLE LOCATION</u>	TB-6 @ 0-3'	<u>JOB NO.</u>	212882
<u>SOIL DESCRIPTION</u>	CLAY, VERY SANDY, BROWN	<u>DATE</u>	11/22/21

<u>IDENTIFICATION</u>	CL	<u>COMPACTION TEST #</u>	1
<u>TEST DESIGNATION / METHOD</u>	ASTM D-698-A	<u>TEST BY</u>	BC
<u>MAXIMUM DRY DENSITY (PCF)</u>	114.5	<u>OPTIMUM MOISTURE</u>	12.9%



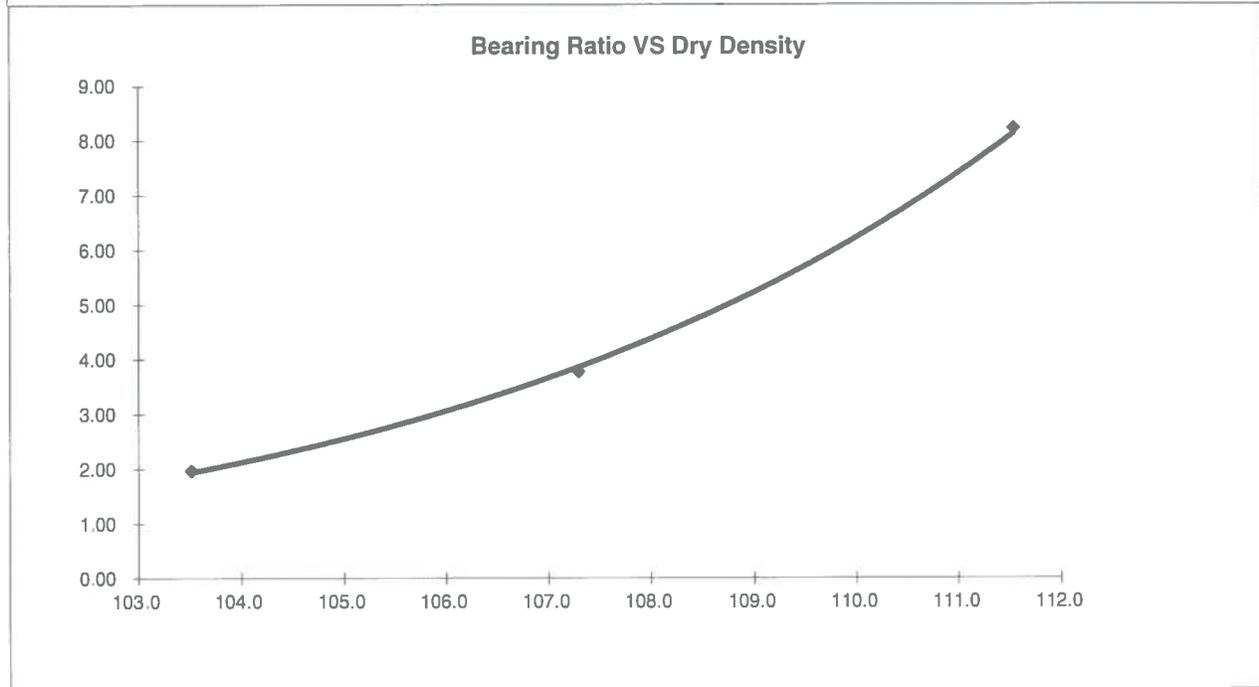
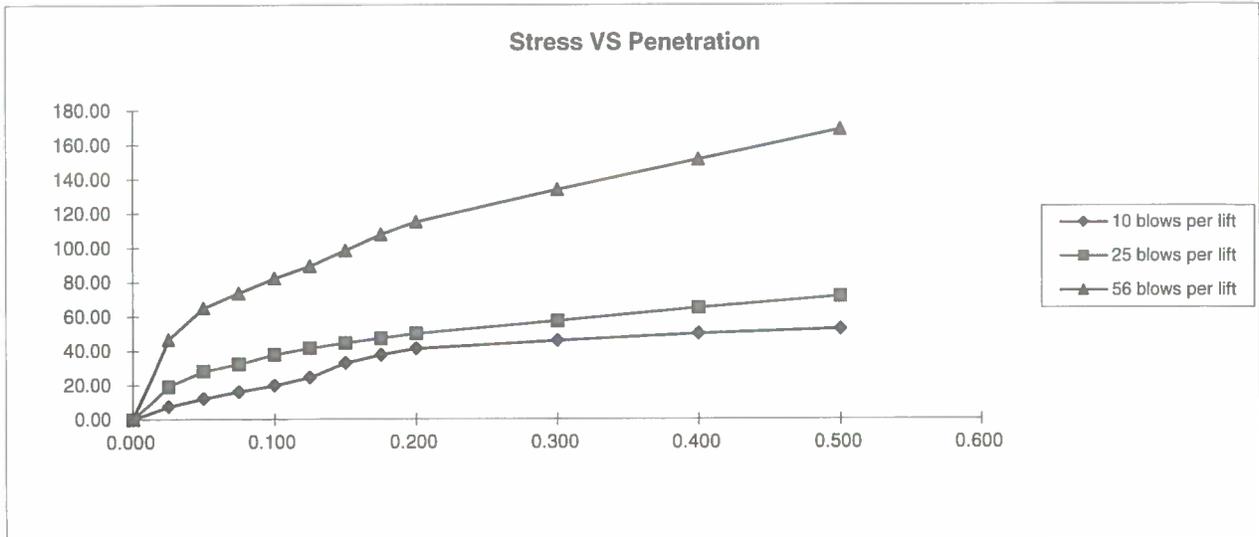

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**MOISTURE DENSITY RELATION**

DRAWN:	DATE:	CHECKED: <i>DS</i>	DATE: <i>11/22/21</i>
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JOB NO.:  
212882  
FIG NO.:  
*B-19*





BEARING RATIO AT 90% OF MAX	1.75 ~ R VALUE	1.00
BEARING RATIO AT 95% OF MAX	5.33 ~ R VALUE	12.00

JOB NO: 212882  
SOIL TYPE: 1



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**CALIFORNIA BEARING RATIO**

DRAWN:	DATE:	CHECKED: <i>DJ</i>	DATE: <i>1/12/24</i>
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JOB NO: 212882  
FIG NO: *B-21*

## **APPENDIX C: Pavement Design Calculations**

## FLEXIBLE PAVEMENT DESIGN

### DESIGN DATA

HOME S BY MICHAEL TURNER - ABERT RANCH SUBDIVISION  
SOIL TYPE 1 - RURAL LOCAL (CUL-DE-SAC)

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL ( $W_{18}$ ) =	36,500
Hveem Stabilometer (R Value) Results:	R =	12
Standard Deviation	$S_o$ =	0.45
Loss in Serviceability	$\Delta\psi$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	$Z_R$ =	-0.84
Soil Resilient Modulus	$M_R$ =	3803

Weighted Structural Number (WSN): ➔ WSN = 2.39

### 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

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

Left	Right	Difference
4.56	4.56	0.0

Job No. 212882

Fig. No. C-1

## DESIGN CALCULATIONS

### DESIGN DATA

HOME S BY MICHAEL TURNER - ABERT RANCH SUBDIVISION  
SOIL TYPE 1 - RURAL LOCAL (CUL-DE-SAC)  
Equivalent (18 kip) Single Axle Load Applications (ESAL): ESAL = 36,500  
Hveem Stabilometer (R Value) Results: R = 12  
Weighted Structural Number (WSN): WSN = 2.39

### 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 Base Course

$D_1 =$  Depth of Asphalt (inches)

$D_2 =$  Depth of Base Course (inches)

### FOR FULL DEPTH ASPHALT SECTION (CURRENTLY NOT ALLOWED)

$$D_1 = (WSN)/C_1 = 5.4 \text{ inches of Full Depth Asphalt}$$

Use 5.5 inches Full Depth

### FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) =  inches

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 5.7 \text{ inches of Aggregate}$$

Base Course, use 6.0 inches

### RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 6.0 inches of Aggregate Base Course, or
2. 5.5 inches of Full Depth Asphalt

Job No. 212882

Fig. No. C-2

# FLEXIBLE PAVEMENT DESIGN

## DESIGN DATA

HOME S BY MICHAEL TURNER - ABERT RANCH SUBDIVISION  
SOIL TYPE 1 - RURAL LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL ( $W_{18}$ ) =	109,500
Hveem Stabilometer (R Value) Results:	R =	12
Standard Deviation	$S_o$ =	0.45
Loss in Serviceability	$\Delta psi$ =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	$Z_R$ =	-0.84
Soil Resilient Modulus	$M_R$ =	3803

Weighted Structural Number (WSN): ➔ WSN = 2.84

## 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
5.04	5.04	0.0

Job No. 212882

Fig. No. C-3

## DESIGN CALCULATIONS

### DESIGN DATA

HOME S BY MICHAEL TURNER - ABERT RANCH SUBDIVISION

SOIL TYPE 1 - RURAL LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 109,500
Hveem Stabilometer (R Value) Results:	R = 12
Weighted Structural Number (WSN):	WSN = 2.84

### 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 Base Course

$D_1 =$  Depth of Asphalt (inches)

$D_2 =$  Depth of Base Course (inches)

### FOR FULL DEPTH ASPHALT SECTION (CURRENTLY NOT ALLOWED)

$$D_1 = (WSN)/C_1 = 6.5 \text{ inches of Full Depth Asphalt}$$

Use 6.5 inches Full Depth

### FOR ASPHALT + AGGREGATE BASE COURSE SECTION

$$\text{Asphalt Thickness (t)} = \boxed{4} \text{ inches}$$

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 9.9 \text{ inches of Aggregate}$$

Base Course, use 10.0 inches

### RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10.0 inches of Aggregate Base Course, or
2. 6.5 inches of Full Depth Asphalt

Job No. 212882

Fig. No. C-4