Geotechnical Data Report
I-94 Painted Canyon Landslide
Project No. SER-5-094(107)030, PCN 20549
Billings County, North Dakota

December 29, 2014

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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Submitted To:
North Dakota Department of Transportation
608 East Boulevard Avenue
Bismarck, North Dakota 58505

By:
Shannon & Wilson, Inc.
1321 Bannock Street,Suite 200
Denver, CO 80204

23-1-01447-500

Project No. SER-5-094(107)030, PCN 20549

I-94 Painted Canyon Landslide
Geotechnical Data Report

CERTIFICATION

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered professional engineer under the laws of the State of North Dakota. This document was originally issued and sealed by Gregory R. Fischer, Registration number PE-4324 on December 29, 2014 and the original document is stored at the North Dakota Department of Transportation.

Gregory R. Fischer, Ph.D., P.E.

12/29/14
Date

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GEOTECHNICAL DATA REPORT
I-94 PAINTED CANYON LANDSLIDE
PROJECT NO. SER-5-094(107)030, PCN 20549
BILLINGS COUNTY, NORTH DAKOTA

1.0 INTRODUCTION

This Geotechnical Data Report (GDR) presents subsurface explorations and laboratory test results completed for the Painted Canyon Landslide. This GDR also describes geotechnical instrumentation installed at the site and presents data obtained from the instrumentation. This report does not provide geotechnical design recommendations or construction considerations.

2.0 PROJECT DESCRIPTION

The Painted Canyon Landslide (the Project) is an approximately 500-foot wide landslide (based on site observations by the North Dakota Department of Transportation [NDDOT] and Shannon & Wilson, Inc. [SWI]) currently affecting the westbound (WB) lanes of I-94 near RP 31.8 (Figure 1). Two previous landslides have occurred in the vicinity of the Project, one in 1970 and the other in 1979. The former landslide resulted in a major regrading effort that extended into Theodore Roosevelt National Park. The latter landslide was not mitigated. Instead, a pull-off road overlooking the Park was abandoned and fencing was placed around the headscarp.

We understand movement of the current landslide began in 2001. Since then, movement has continued at varying rates, requiring a number of pavement overlays in the WB lanes of I-94 to maintain operation of the highway. In 2012, NDDOT installed horizontal drains at the site as a relatively inexpensive mitigation measure that could be accomplished entirely within the NDDOT right-of-way. However, since installing the drains, the landslide has continued to move. As a result, NDDOT has elected to mitigate the landslide with a structural system consisting of a single row of 4-foot diameter drilled shafts connected by a cap beam. Permanent prestressed ground anchors will be installed through cap beam.

3.0 FIELD EXPLORATIONS AND LABORATORY TESTING

The NDDOT completed 16 borings at the site between 2001 and 2013. SWI completed two borings in conjunction with NDDOT in 2014. A summary of the field explorations completed at the site, including boring location and depth, is provided in Table 2. The locations of the borings are shown in the Site and Exploration Plan included as Figure 1. Boring logs prepared by SWI are provided in Appendix A. Boring logs prepared by NDDOT are provided in Appendix B.

3.1 Drilling and Sampling Methods

Two Shannon & Wilson borings were drilled by the NDDOT using a Diedrich D-50 truck-mounted drill rig. The borings were advanced using hollow-stem augers. Sampling was completed in selected borings. Several borings were completed for the installation of geotechnical instrumentation. Soil/rock samples were not retrieved from these borings and boring logs were not prepared (see Table 1).

Disturbed soil/rock samples were obtained in selected borings in general accordance with the Standard Penetration Test (SPT) (ASTM Designation: D 1586). The SPT consists of driving a 2-inch outside diameter (O.D.), 1.375-inch inside diameter (I.D.) split-spoon sampler a distance of 18 inches with a 140-pound hammer free-falling a distance of 30 inches. An automatic hammer system was used to advance the sampler.

Relatively undisturbed soil/rock samples were obtained using 3-inch (nominal) diameter thin-walled tube sampler (Shelby tubes). These samples were collected by using the hydraulic system of the drill rig to push the thin walled tube sample into the soil at the bottom of the borehole. The thin-walled tube is connected to the drill rods via a rigid sampling head. After pushing, the drill rods are retracted and the tube is detached from the sampling head. Tube samples were extruded in the NDDOT Materials and Research Laboratory for testing and classification.

3.2 Laboratory Testing

NDDOT completed laboratory testing of selected soil/rock samples in the NDDOT Materials and Research Laboratory. Testing consisted of both index and engineering property tests. Index testing included natural moisture content, unit weight, grain-size analysis (mechanical and hydrometer) and Atterberg limits. Engineering property testing included unconfined compressive strength and triaxial compression testing. Laboratory test results are presented in Appendices A and B.

3.3 Inclinometer Casing Groundwater Readings

Shannon & Wilson was provided groundwater level measurements taken from inside the inclinometer casings, refer to Figures 3 and 4. We understand the bottom of the inclinometer casing was installed uncapped and covered with a geosynthetic. The annulus between the casing and the borehole was backfilled with pea-gravel. The inclinometer casing was installed without slots. Unless the inclinometer casings are slotted and a specific monitoring zone is established, responsiveness of the water levels within the casing will tend to be slower than a typical well and may not reflect actual groundwater conditions at the time of measurements.

4.0 GEOTECHNICAL INSTRUMENTATION

Geotechnical instrumentation installed at the site consisted of inclinometers to measure slope movement and vibrating wire piezometers (VWPs) to measure pore water pressures. The instruments were installed in the borings specified in Table 1. The instrumentation program is described in Appendix C, including a discussion of instrumentation installation procedures and data obtained from the instrumentation.

5.0 LIMITATIONS

This data report was prepared for the exclusive use of NDDOT for specific application to this project. The information and data contained within this report is a representation of factual data only and not a warranty of subsurface conditions. The boring logs represent opinions of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are necessarily interpretive and actual changes may be gradual or abrupt.

Within the limitations of scope, schedule and budget, the information presented in this report was obtained in accordance with generally accepted professional geotechnical engineering principles and practice at the time this report was prepared. We make no warranty, either express or implied.

SHANNON & WILSON, INC.

12/29/14

Gregory R. Fischer, Ph.D., P.E.
Senior Vice President

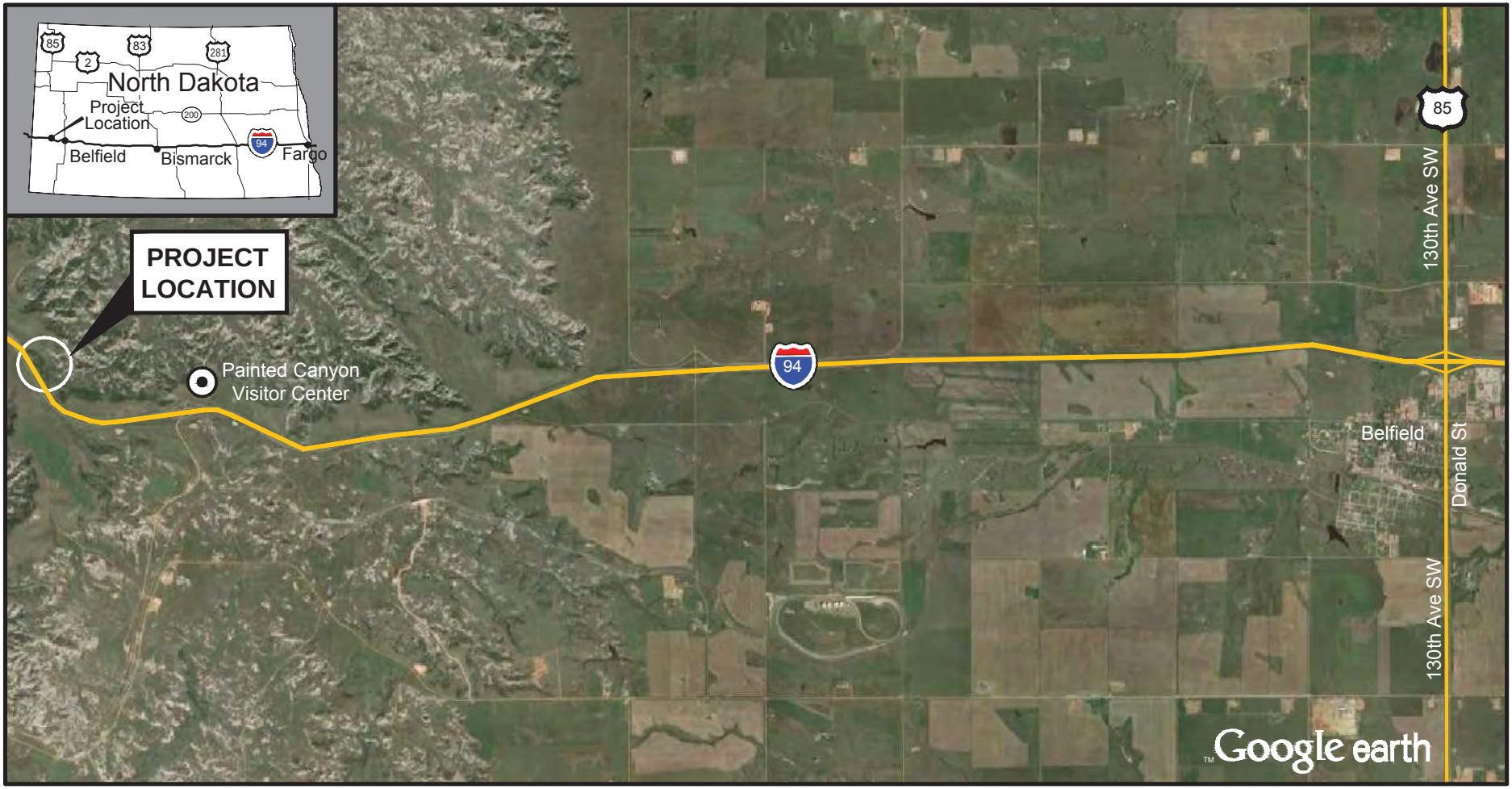
DAV:GRF/dav

TABLE 1
SUMMARY OF FIELD EXPLORATIONS

Boring/ Inclinometer Casing Designation	Boring Completed By[1]	LOCATION[2]			Date Completed[3]	Total Depth (ft)	Boring Log Available[4]	INSTRUMENTATION[4]		Comment
		Station	Offset (ft)	Ground Elev. (ft)				Inclinometer Installed	Vibrating Wire Piezometer(s) Installed	
1	NDDOT	433+04	142 LT	2,775	11/5/2001 (Date Inclinometer Initialized)	64		X		
1A	NDDOT	-	-	-	8/21/2013 (Date Inclinometer Initialized)	50		X		Installed to replace adjacent Casing 1
2	NDDOT	432+89	142 LT	2,776	7/29/2008	73	X	X		
3	NDDOT	435+09	195 LT	2,774	7/10/2010	72	X	X		
3A	NDDOT	-	-	-	8/21/2013 (Date Inclinometer Initialized)	50		X		Installed to replace adjacent Casings 3
4	NDDOT	432+02	134 LT	2,777	9/21/2011 (Date Inclinometer Initialized)	50		X		
5	NDDOT	436+91	220 LT	2,777	9/7/2011	43	X	X		
5A	NDDOT	-	-	-	8/21/2013 (Date Inclinometer Initialized)	40		X		Installed to replace adjacent Casing 5
6	NDDOT	432+97	71 LT	2,797	9/7/2011	52	X	X		
7	NDDOT	434+64	68 LT	2,797	9/21/2011 (Date Inclinometer Initialized)	51		X		
8	NDDOT	435+82	21 RT	2,799	9/8/2011	62	X	X		
9	NDDOT	433+89	149 RT	2,813	9/21/2011 (Date Inclinometer Initialized)	51		X		
10	NDDOT	434+79	391 LT	2,737	7/29/2013	65	X	X		
11	NDDOT	434+34	530 LT	2,713	7/30/2013	55	X	X		
12	NDDOT	433+86	710 LT	2,685	7/30/2013	45	X	X		
13	NDDOT	433+57	388 LT	2,737	7/31/2013	65	X	X		
SW-01	NDDOT/SWI	433+86	73 LT	2,797	3/14/2014	110	X	X	X	
SW-02	NDDOT/SWI	433+94	253 LT	2,752	3/14/2014	99.6	X	X	X	

NOTES: 1) See report text for a discussion of drilling and sampling procedures.
2) Stationing and offset reference I-94 median stationing.
3) The completion dates are unknown for some borings/inclinometers. Where the drilling date was not indicated, the date of the inclinometer initialization was indicated above.
4) Boring logs only available for explorations that were sampled.
5) See Appendix C for a discussion of instrumentation installed at the site.

Filename: J:\231\01447-500\23-1-01447-500 Vic map.dwg Date: 12-19-2014 Login: bac



0 6,000 12,000

Approximate Scale in Feet

N

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

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VICINITY MAP

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FIG. 1

FIG. 1

LEGEND

- NDDOT Inclinometer/Boring Designation and Approximate Location
- SW-01 — Shannon & Wilson Inclinometer/Boring Designation and Approximate Location
- Scarp Mapped by NDDOT and Confirmed by Shannon & Wilson

0 100 200

Approximate Scale in Feet

I-94 Painted Canyon Landslide
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Billings County, North Dakota

SITE AND EXPLORATION PLAN

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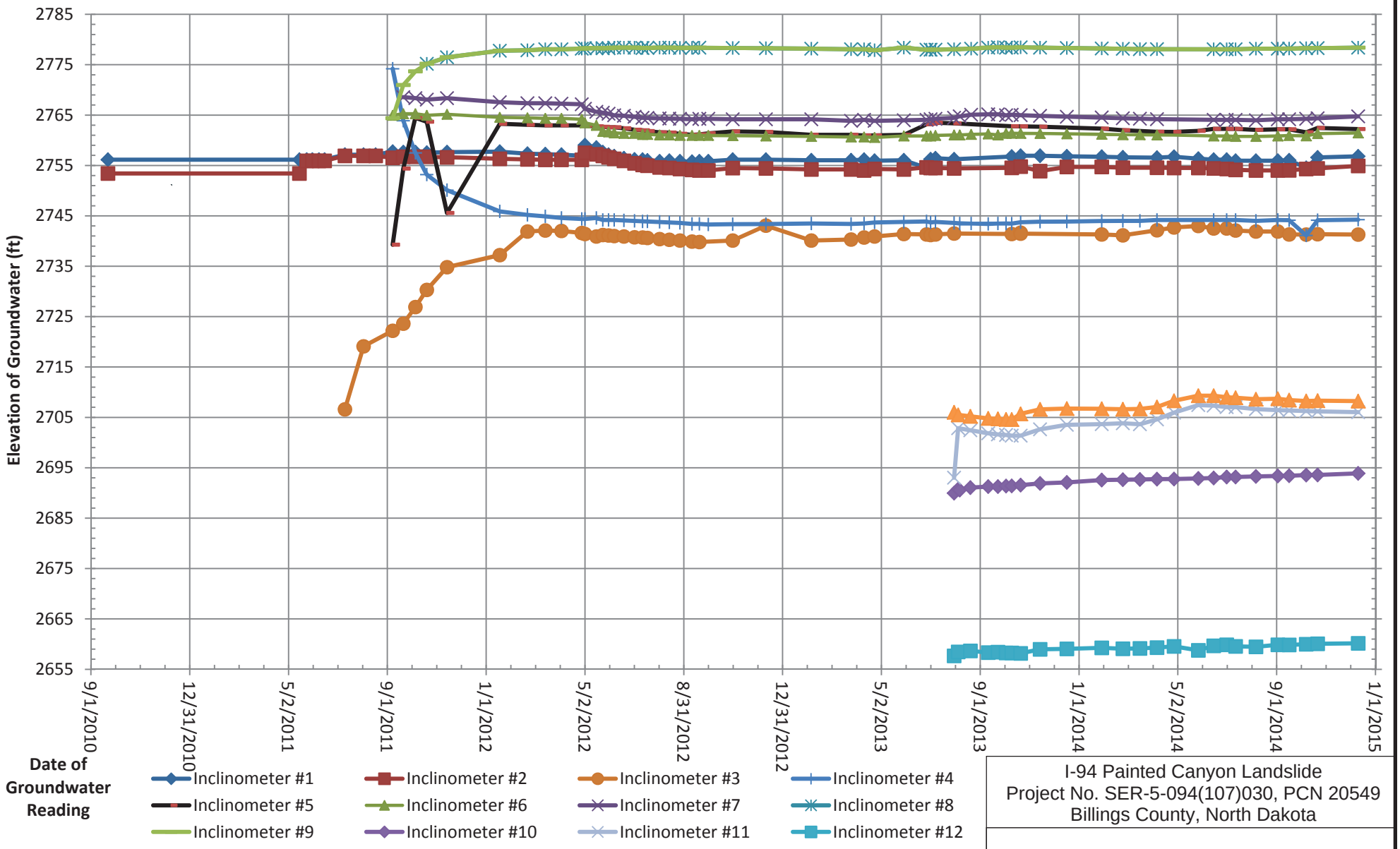
FIG. 2

Filename: J:\23\01447-500\23-1-01447-500 Figure 2.dwg Layout: site Date: 12-19-2014 Login: bac



Notes: 1. All groundwater readings were collected by NDDOT and provided to Shannon & Wilson on December 18, 2014.
2. The bottom of the inclinometer casing was uncapped and covered with a geosynthetic. The annulus between the casing and the borehole was backfilled with pea-gravel. The inclinometer casing was installed without slots. The above groundwater readings likely have slow responses to changes in water levels and may not reflect actual groundwater levels.

FIG. 3

I-94 Painted Canyon Landslide
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NDDOT INCLINOMETER CASING GROUNDWATER ELEVATIONS

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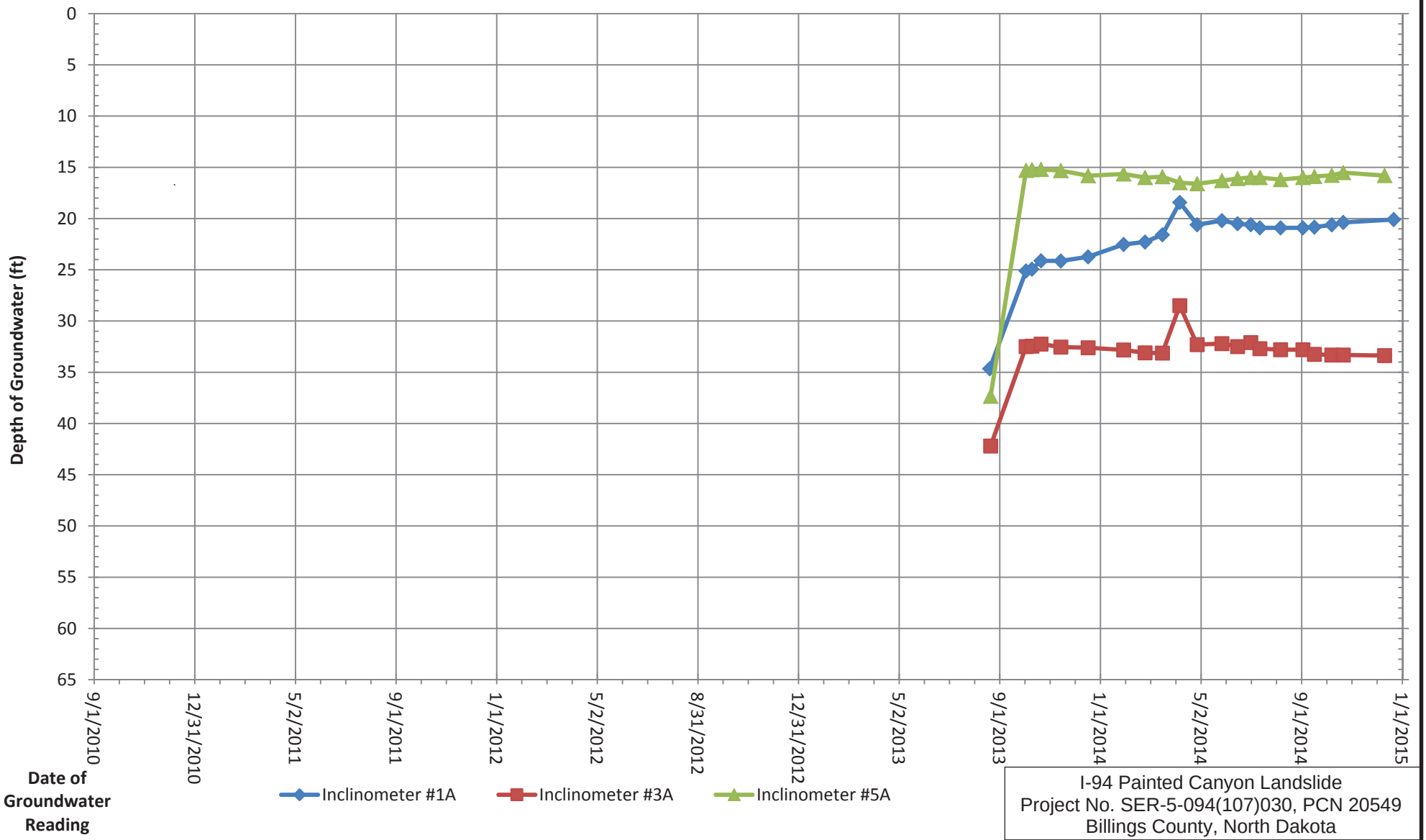
FIG. 3



Notes: 1. All groundwater readings were collected by NDDOT and provided to Shannon & Wilson on December 18, 2014.
2. The bottom of the inclinometer casing was uncapped and covered with a geosynthetic. The annulus between the casing and the borehole was backfilled with pea-gravel. The inclinometer casing was installed without slots. The above groundwater readings likely have slow responses to changes in water levels and may not reflect actual groundwater levels.

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NDDOT INCLINOMETER CASING GROUNDWATER DEPTHS

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FIG. 4

FIG. 4

APPENDIX A

NDDOT/SWI FIELD EXPLORATIONS AND LABORATORY TEST RESULTS

APPENDIX A

NDDOT/SWI FIELD EXPLORATIONS AND LABORATORY TEST RESULTS

TABLE

FIGURES

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REFERENCE

Shannon & Wilson, Inc., (Shannon & Wilson), 2014, Mitigation Alternatives and Supplementary Data Report, Rev.1, I-94 Painted Canyon Landslide, Project No. SER-5-094(107)030, PCN 20549, Billings County, North Dakota prepared by Shannon & Wilson, Inc., Denver, CO, 23-1-01400-001, for North Dakota Department of Transportation, June 20.

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	Natural Water Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]				ATTERBERG LIMITS			UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION (UU)		Unconfined Compressive Strength
									Fines							
Boring	Sample	Depth (feet)					Gravel	Sand	0.074 mm to 0.005 mm	<0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Cell Pressure	Peak Principal Stress Difference	
		Top	Bottom		(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(psi)	(psi)	(psi)
SW-01	S-1	2.0	4.0	SM			1	62	24	13	Non-Plastic					
	S-2	4.0	6.0	SM	12.7		0	64	21	15	Non-Plastic					
	S-4	8.0	10.0	SM	14.8		0	62	23	15	Non-Plastic					
	S-6	12.0	14.0	SM	10.3		0	65	23	12	Non-Plastic					
	S-7	14.0	16.0	SM			0	65	22	13	Non-Plastic					
	S-8	16.0	18.0	SM	7.5		0	73	16	11	Non-Plastic					
	S-10	20.0	22.0	SM	5.3		0	80	12	8	Non-Plastic					
	S-11	22.0	22.3		7.0											
	S-12	24.0	24.2	SM	3.4		0	55	29	16	Non-Plastic					
	S-13	26.0	28.0	SM	7.7		0	77	18	5	Non-Plastic					
	S-15A	30.0	30.8	SM	13.8		5	72	12	11	Non-Plastic					
	S-15B	30.8	32.0	CH	24.9		0	6	24	70	65	24	41			
	S-16A	33.0	33.2	CH			0	3	9	88	73	29	44			
	S-16B	33.6	33.8	CH	28.4		0	6	8	86	74	33	41			
	S-16C	34.0	34.2	CH			0	8	8	84	78	28	50			
	S-17	34.0	36.0	CH	28.4		0	1	8	91	70	31	39			
	S-18A	36.3	36.6	CH	30.9		0	2	21	77	56	27	29			19.7
	S-18B	36.8	37.0	CH	30.9	123.5	0	0	13	87	67	27	40			
	S-18C	37.3	37.4	CH			0	1	11	88	67	28	39			
	S-19	38.0	40.0	CH	28.9		0	1	13	86	57	25	32			
	S-20A	41.1	41.6	CH	20.8	129.8	0	1	11	88	53	22	31			28.3
	S-20B	40.4	40.5	CH	25.0	129.8	0	3	11	86	72	32	40			
	S-20	40.0	42.0	CL			0	1	18	81	46	21	25			
	S-21	42.4	42.8	CH	30.3	118.6	0	2	12	86	68	32	36			34.3
	S-22A	44.5	45.0	CH	22.2	132.3	0	5	16	79	73	23	50	20.5	52.0	
	S-22B	45.0	45.5		24.0	131.5								41.0	59.4	
	S-23	46.0	46.5	CH			0	2	6	92	53	26	27			
	S-24	46.5	48.0	CL	16.1		0	7	39	54	41	20	21			

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	Natural Water Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]				ATTERBERG LIMITS			UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION (UU)		Unconfined Compressive Strength
									Fines							
Boring	Sample	Depth (feet)					Gravel	Sand	0.074 mm to 0.005 mm	<0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Cell Pressure	Peak Principal Stress Difference	
		Top	Bottom		(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(psi)	(psi)	(psi)
SW-01	S-25	48.0	48.8	CH			0	0	1	99	63	25	38			
	S-26	48.8	50.0	CH	24.2		0	2	19	79	53	25	28			
	S-27	50.0	52.0	CL	16.2		0	1	42	57	44	22	22			N/R
	S-28	52.0	54.0	CH	20.0		0	2	23	75	53	20	33			
	S-30	55.5	56.0	CL	12.6						30	19	11			
	S-32A	56.5	56.8	CL	15.7		0	35	37	28	45	19	26			
	S-32B	56.8	57.3	ML	26.1		0	35	46	19	31	23	8			
	S-33	58.0	59.0	CL	21.6	126.6	0	1	80	19	40	23	17			36.6
	S-34	59.5	60.0	CL	19.7		0	1	64	35	45	19	26			
	S-35	60.0	62.0	CL	18.3		0	2	44	54	43	18	25			
	S-36	62.0	63.2	CH			0	1	26	73	56	22	34			
	S-37	63.2	65.2	CH	21.1		0	1	20	79	62	21	41			
	S-38	65.2	65.9	CH			0	0	54	46	55	19	36			
	S-39A	66.0	68.0	CH	21.6		0	3	18	79	64	24	40			
	S-39B	66.0	68.0	MH							56	34	22			
	S-41	70.0	72.0	CH	26.7		0	1	32	67	95	31	64			
	S-42	72.0	73.0	CH			0	3	47	50	99	35	64			
	S-43	73.0	74.0	CH	26.4		0	10	53	37	83	31	52			
	S-44	74.0	76.0	CH	19.5		0	8	58	34	61	24	37			
	S-45	76.0	78.0	CH	23.9		0	3	59	38	70	19	51			
	S-46A	78.0	80.0	CH	13.0		0	21	51	28	79	22	57			
	S-46B	78.0	80.0	CH	22.7		0	13	55	32	86	23	63			
	S-47	80.0	81.2	CH			0	1	52	47	85	22	63			
	S-48	81.2	82.0	CH	22.5		0	1	57	42	83	24	59			
	S-49	82.0	84.0	CH	23.5		0	0	47	53	87	24	63			
	S-50	84.0	86.0	CH	23.6		0	1	45	54	82	25	57			
	S-51	86.0	88.0	CH	21.4		0	0	41	59	85	22	63			
	S-53	89.0	90.0	CH	23.4		0	0	31	69	85	26	59			

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	Natural Water Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]				ATTERBERG LIMITS			UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION (UU)		Unconfined Compressive Strength
									Fines							
Boring	Sample	Depth (feet)					Gravel	Sand	0.074 mm to 0.005 mm	<0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Cell Pressure	Peak Principal Stress Difference	
		Top	Bottom		(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(psi)	(psi)	(psi)
SW-01	S-54	90.0	92.0	CH	24.2		0	1	18	81	87	24	63			
	S-60	100.0	102.0	CH	24.7		0	0	14	86	92	33	59			
	S-61	102.0	103.0	CH			0	3	70	27	91	23	68			
	S-62	103.0	105.0	CH	21.4		0	9	61	30	92	22	70			
	S-64	105.4	107.4	CH	21.2		0	0	49	51	88	19	69			
	S-65	107.4	108.0	CH			0	0	13	87	93	27	66			
	S-66	108.0	110.0	CH	25.6		0	1	8	91	90	25	65			
SW-02	S-1	2.0	4.0	SM			0	76	11	13	Non-Plastic					
	S-2	4.0	6.0	SM	28.4		0	81	4	15	Non-Plastic					
	S-3	7.0	9.0	SM			0	81	2	17	Non-Plastic					
	S-4	9.0	11.0	CH	28.2		0	13	10	77	56	25	31			
	S-5A	11.0	13.0	CH			0	2	11	87	52	26	26			
	S-5B	11.0	13.0	MH			0	3	20	77	54	30	24			
	S-6	13.0	15.0	CH	26.4		0	2	14	84	65	23	42			
	S-7	15.0	17.0	CH	18.0	131.1	0	2	1	97	61	19	42			17.4
	S-8	17.0	17.2	CL			0	18	41	41	33	17	16			
	S-9	17.2	19.0	CL	20.2		0	8	51	41	36	17	19			
	S-10	19.0	20.8	CL			0	10	57	33	37	20	17			
	S-11A	21.9	22.4	CL	22.6	128.7	0	0	33	67	47	20	27			94.0
	S-11B	22.4	22.9		22.0	128.7										82.8
	S-12	23.0	25.0	CL	24.5	127.5	1	1	29	69	48	20	28	22.1	110.1	
	S-13A	25.4	25.9	MH	20.3	129.8	0	0	16	84	67	38	29	11.9	45.9	
	S-13B	25.9	26.4		21.2	129.1								23.8	78.6	
	S-14A	27.3	27.9	CH	19.5	133.2	0	2	38	60	57	20	37	12.9	150.4	
	S-14B	28.4	28.9		19.1	133.2								25.9	151.2	
	S-17	31.0	33.0	CH	23.8	124.7	0	2	33	65	69	23	46			25.3
	S-18	33.0	35.0	CH			0	1	40	59	99	29	70			
	S-19	35.0	37.0	CH	23.2		0	7	48	45	79	22	57			

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SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	Natural Water Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]				ATTERBERG LIMITS			UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION (UU)		Unconfined Compressive Strength
									Fines							
Boring	Sample	Depth (feet)					Gravel	Sand	0.074 mm to 0.005 mm	<0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Cell Pressure	Peak Principal Stress Difference	
		Top	Bottom		(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(psi)	(psi)	(psi)
SW-02	S-20	37.0	39.0	CH			7	28	40	25	53	23	30			
	S-21A	39.0	41.0	CH	23.4		0	13	50	37	93	23	70			
	S-21B	39.0	41.0	CH	25.1		0	3	47	50	86	18	68			
	S-22	41.0	43.0		24.6											
	S-23	43.0	45.0	CH	24.3		0	0	41	59	82	24	58			
	S-24A	45.2	45.4	CH			0	0	37	63	84	25	59			
	S-24B	46.2	46.4	CH			0	0	42	58	85	25	60			
	S-25	47.0	49.0	CH	25.3		0	0	49	51	85	26	59			
	S-26A	49.4	49.6	CH			0	0	32	68	86	28	58			
	S-26B	50.2	50.4	CH			0	3	22	75	87	31	56			
	S-32	60.0	62.0	CH	20.3		0	0	42	58	77	30	47			
	S-33	62.0	62.7		19.4											
	S-34	62.7	64.7	CH	20.1		0	3	63	34	96	22	74			
	S-35	65.0	65.5		16.9											
	S-36	65.5	67.5	CH	21.8		0	0	33	67	97	27	70			
	S-37	67.5	68.4	CH			0	0	7	93	86	20	66			
	S-38	68.4	70.4	CH	23.0		0	0	23	77	87	21	66			
	S-39	70.5	71.1	CH			0	0	7	93	96	29	67			
	S-40	71.1	73.1	CH	23.4		0	0	9	91	98	23	75			
	S-41	73.1	73.7	CH			0	0	42	58	85	24	61			
	S-42	73.7	75.7	CH	20.6		0	0	50	50	85	19	66			
	S-43	76.0	76.8	CH			0	0	61	39	88	22	66			
	S-44	76.8	78.8	CH	21.9		0	2	56	42	88	19	69			
	S-45	79.0	79.7	CH			0	0	46	54	87	25	62			
	S-46	79.7	81.7	CH	24.6		0	0	12	88	104	26	78			
	S-47	82.0	82.7	CH			0	0	4	96	104	25	79			
	S-48	82.7	84.7	CH	24.4		0	1	15	84	111	33	78			
	S-49	85.0	85.5		19.9											

TABLE A-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	Natural Water Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]				ATTERBERG LIMITS			UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION (UU)		Unconfined Compressive Strength
									Fines							
Boring	Sample	Depth (feet)					Gravel	Sand	0.074 mm to 0.005 mm	<0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Cell Pressure	Peak Principal Stress Difference	
		Top	Bottom		(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(psi)	(psi)	(psi)
SW-02	S-50	85.5	86.7	CH	18.2		3	1	52	44	74	18	56			
	S-51	87.0	87.2	CH	11.3						52	20	32			
	S-52	89.0	91.0	CH	22.0		0	4	66	30	65	19	46			
	S-53	91.0	91.6	CH			0	1	68	31	74	23	51			
	S-54	91.6	93.6	CH	21.2		0	9	59	32	63	17	46			
	S-56	95.0	97.0	CH	23.3		3	4	61	32	63	19	44			
	S-57	97.0	97.6	CH			4	1	70	25	62	23	39			
	S-58	97.6	99.6	CH	24.4		0	2	68	30	66	21	45			

NOTES: 1) Refer to Figure A-1 for definitions.
2) Gravel defined as particles larger than the No. 4 sieve size and sand as particles between the No. 4 and No. 200 sieve size.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor*.
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

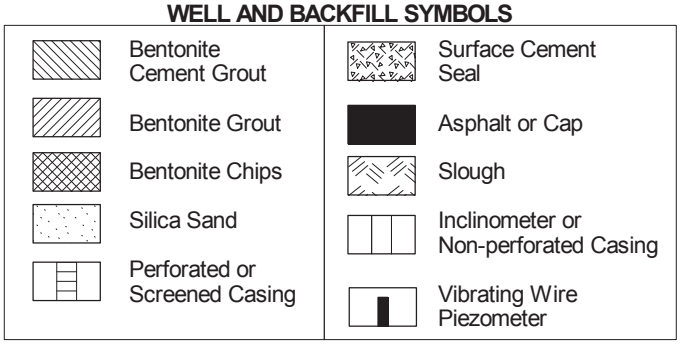
PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND Fine Medium Coarse	 #200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.) #40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.) #10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL Fine Coarse	 #4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.) 3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS



PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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SOIL DESCRIPTION AND LOG KEY

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW		Well-Graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW		Well-Graded Sand; Well-Graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

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FIG. A-1
Sheet 2 of 3

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

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[2]Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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SOIL DESCRIPTION AND LOG KEY

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FIG. A-1
Sheet 3 of 3

2013_BORING_CLASS3_23-01400.GPJ_SWNEW.GDT 6/18/14

WEATHERING OR ALTERATION

TERM	DESCRIPTION
Fresh	No evidence of alteration
Slightly	Slight discoloration on surface
Moderately	Discoloring evident; Alteration penetrating well below rock surface
Highly	Entire rock mass discolored
Completely	Rock reduced to a soil with relict rock texture

STRENGTH

TERM	APPROX. UCS (psi x 1000)
Very Low	<0.7
Low	0.7 to 4
Moderate	4 to 7
Medium High	7 to 15
High	15 to 36
Very High	>36

JOINT ROUGHNESS COEFFICIENT (JRC)

COEFFICIENT	DESCRIPTION
14 to 20	VERY ROUGH: Near vertical edges evident
10 to 14	ROUGH: Smooth ridges, surface abrasion
6 to 10	SLIGHTLY ROUGH: Asperities on surface can be felt
2 to 6	SMOOTH: Appears and feels smooth
0 to 2	SLICKENSIDED: Visible polishing, striated surface

DISCONTINUITY DATA

SPACING	
TERM	SPACING
Very Wide	>10 ft.
Wide	3 to 10 ft.
Moderately Close	1 to 3 ft.
Close	2 in. to 1 ft.
Very Close	<2 in.

APERTURE WIDTH	
TERM	SPACING
Very Tight	<0.1mm
Tight	0.1 to 0.25mm
Partly Open	0.25 to 0.5mm
Open	0.5 to 2.5mm
Moderately Wide	2.5 to 10mm
Wide	10mm to 1cm
Very Wide	1 to 10cm
Extremely Wide	10 to 100cm
Cavernous	>1m

DISCONTINUITY TERMS

FRACTURE - Collective term for any natural break excluding shears, shear zones, and faults

JOINT (JT) - Planar break with little or no displacement

FOLIATION JOINT (FJ) or BEDDING JOINT (BJ) - Joint along foliation or bedding

INCIPIENT JOINT (IJ) or INCIPIENT FRACTURE (IF) - Joint or fracture not evident until wetted and dried; breaks along existing surface

RANDOM FRACTURE (RF) - Natural, very irregular fracture that does not belong to a set

BEDDING PLANE SEPARATION or PARTING - A separation along bedding after extraction from stress relief or slaking

FRACTURE ZONE (FZ) - Planar zone of broken rock without gouge

MECHANICAL BREAK (MB) - Breaks due to drilling or handling; drilling break (DB), hammer break (HB)

SHEAR (SH) - Surface of differential movement evident by presence of slickensides, striations, or polishing

SHEAR ZONE (SZ) - Zone of gouge and rock fragments bounded by planar shear surfaces

FAULT (FT) - Shear zone of significant extent; differentiation from shear zone may be site-specific

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ROCK CLASSIFICATION AND LOG KEY

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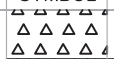
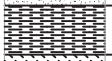
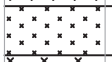
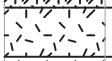
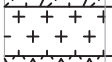
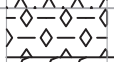
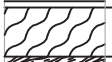
FIG. A-2
Sheet 1 of 2

ROCK CLASSIFICATION SYMBOLS

BEDROCK TYPE	GRAPHIC SYMBOL	ROCK NAME
Clastic Sedimentary Rocks		Breccia
		Conglomerate
		Sandstone
		Siltstone
		Claystone / Interbedded claystone and siltstone
		Shale
		Coal
Carbonate Sedimentary Rocks		Limestone
		Dolomite
		Coral
Evaporite Rocks		Gypsum
		Halite
		Calcite
Extrusive Igneous Rocks		Tuff
		Rhyolite
		Dacite
		Andesite
		Basalt
Intrusive Igneous Rocks		Granite
		Grano-diorite
		Diorite
		Gabbro
Metamorphic Rocks		Marble
		Quartzite
		Slate
		Phyllite
		Schist
		Gneiss

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ROCK CLASSIFICATION AND LOG KEY

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FIG. A-2
Sheet 2 of 2

Total Depth:	110 ft.	Northing:	50 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2797.0 ft.	Easting:	100 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+85.80	Drill Rig Equipment:	D-50	Hammer Type:	Automatic
Horiz. Datum:		Offset:	72.88' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very loose to loose, brown, *Silty Sand (SM)*; moist; trace of gravel from 2' to 4'.
Fill

16.0

Loose to medium dense, brown, *Silty Sand (SM)*; moist.

22.0

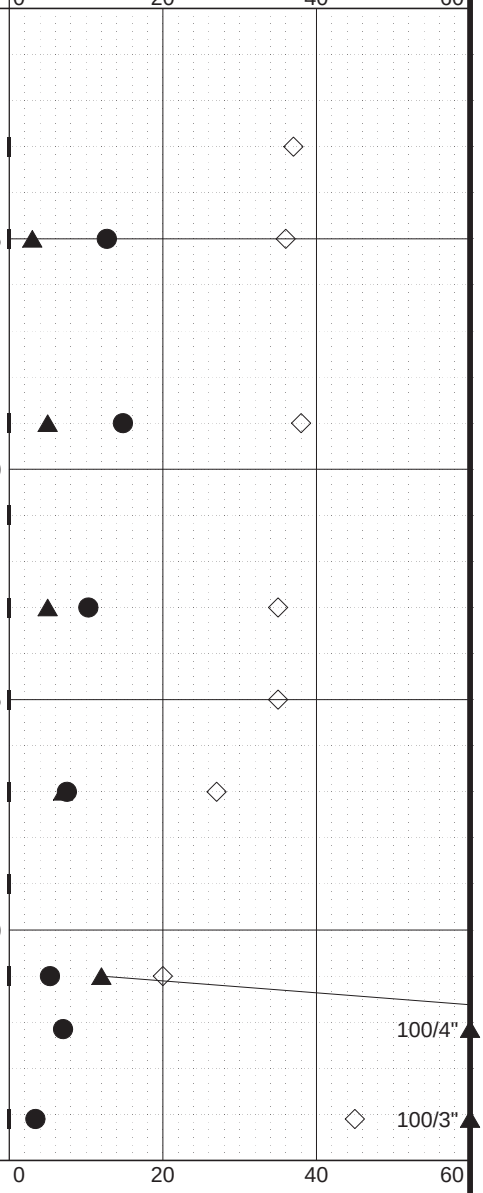
Very dense, brown, *Silty Sand (SM)*; moist; iron-oxide-stained below 28.9 feet.

CONTINUED NEXT SHEET

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit — Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered	Piezometer Screen and Sand Filter
E Environmental Sample Obtained	Bentonite-Cement Grout
Thin Wall Sample	Bentonite Chips/Pellets
Standard Penetration Test	Surface Concrete Seal
	Ground Water Level ATD
	Ground Water Level in VWP

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-01

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FIG. A-3
Sheet 1 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	110 ft.	Northing:	50 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2797.0 ft.	Easting:	100 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+85.80	Drill Rig Equipment:	D-50	Hammer Type:	Automatic
Horiz. Datum:		Offset:	72.88' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, *Silty Sand (SM)* (Cont'd).

30.0 — Medium dense, red-brown, *Silty Sand (SM)*; moist; iron-oxide-stained; stratified.

30.8 — Stiff, gray, *Fat Clay (CH)*; moist; trace to few sand; scattered carbonaceous fragments; broken, hackly, blocky, many short slickensides; iron-oxide-stained joints.

34.2 — Distorted Zone

Stiff to hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; high-angle slickensides 40 to 65 degrees, disturbed texture at 39.5 feet.

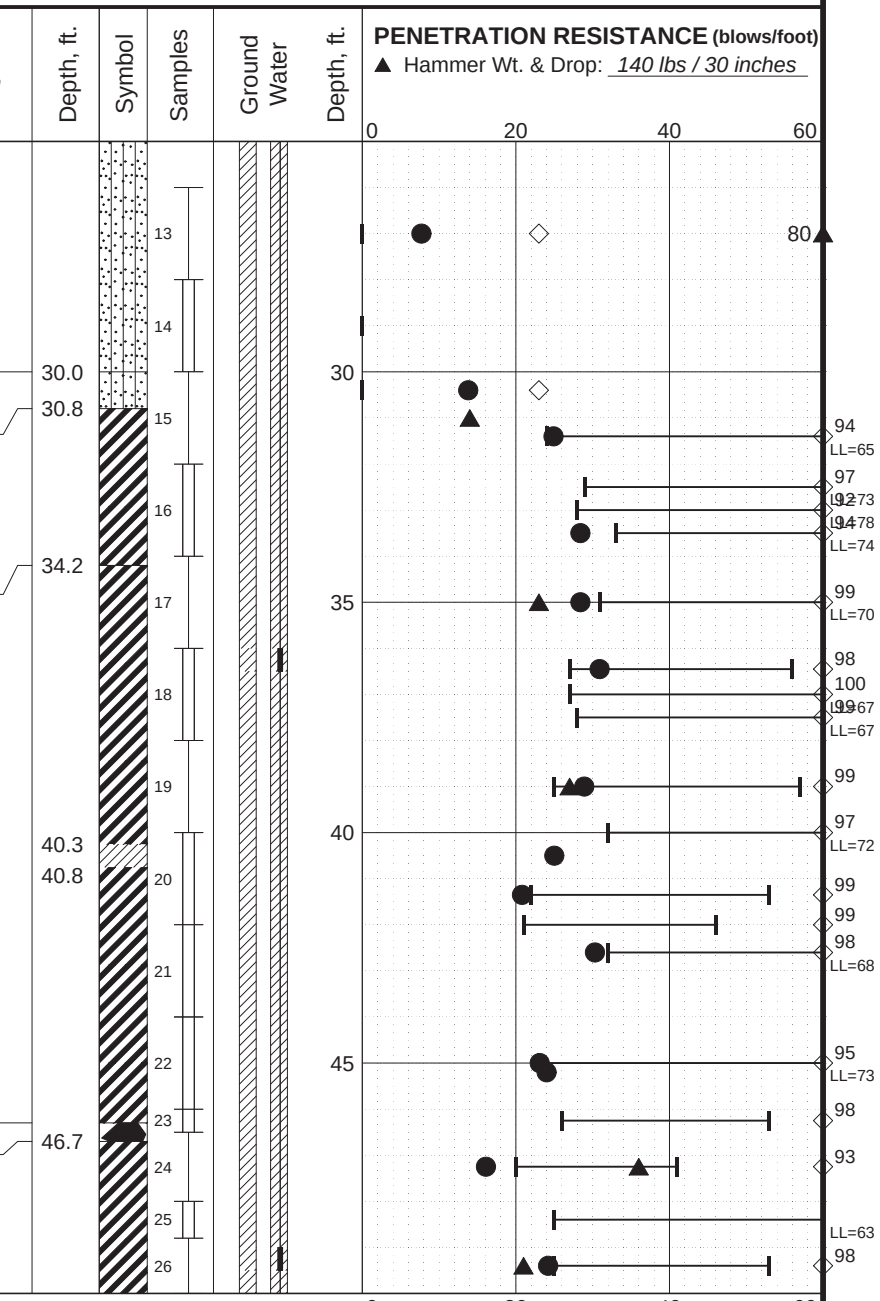
40.3 — *-Lean Clay (CL)*

40.8

46.7 — Black *Coal*; moist.

Very stiff to hard, gray, *Fat to Lean Clay (CH, CL)*; moist; trace of fine sand; uniform; light gray silt modules; scattered carbonaceous fragments.

CONTINUED NEXT SHEET



LEGEND

*	Sample Not Recovered		Piezometer Screen and Sand Filter
E	Environmental Sample Obtained		Bentonite-Cement Grout
	Thin Wall Sample		Bentonite Chips/Pellets
	Standard Penetration Test		Surface Concrete Seal
			Ground Water Level ATD
			Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

LOG OF BORING SW-01

June 2014 — 23-1-01400-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 2 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	110 ft.	Northing:	50 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2797.0 ft.	Easting:	100 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+85.80	Drill Rig Equipment:	D-50	Hammer Type:	Automatic
Horiz. Datum:		Offset:	72.88' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very stiff to hard, *Fat to Lean Clay (CH, CL)* (Cont'd).

55.5

Very stiff to hard, gray *Sandy Lean Clay to Lean Clay, and Sandy Silt (CL, ML)*; moist; scattered carbonaceous fragments.

62.0

Hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; scattered carbonaceous fragments.

67.5

Coal; moist.

67.9

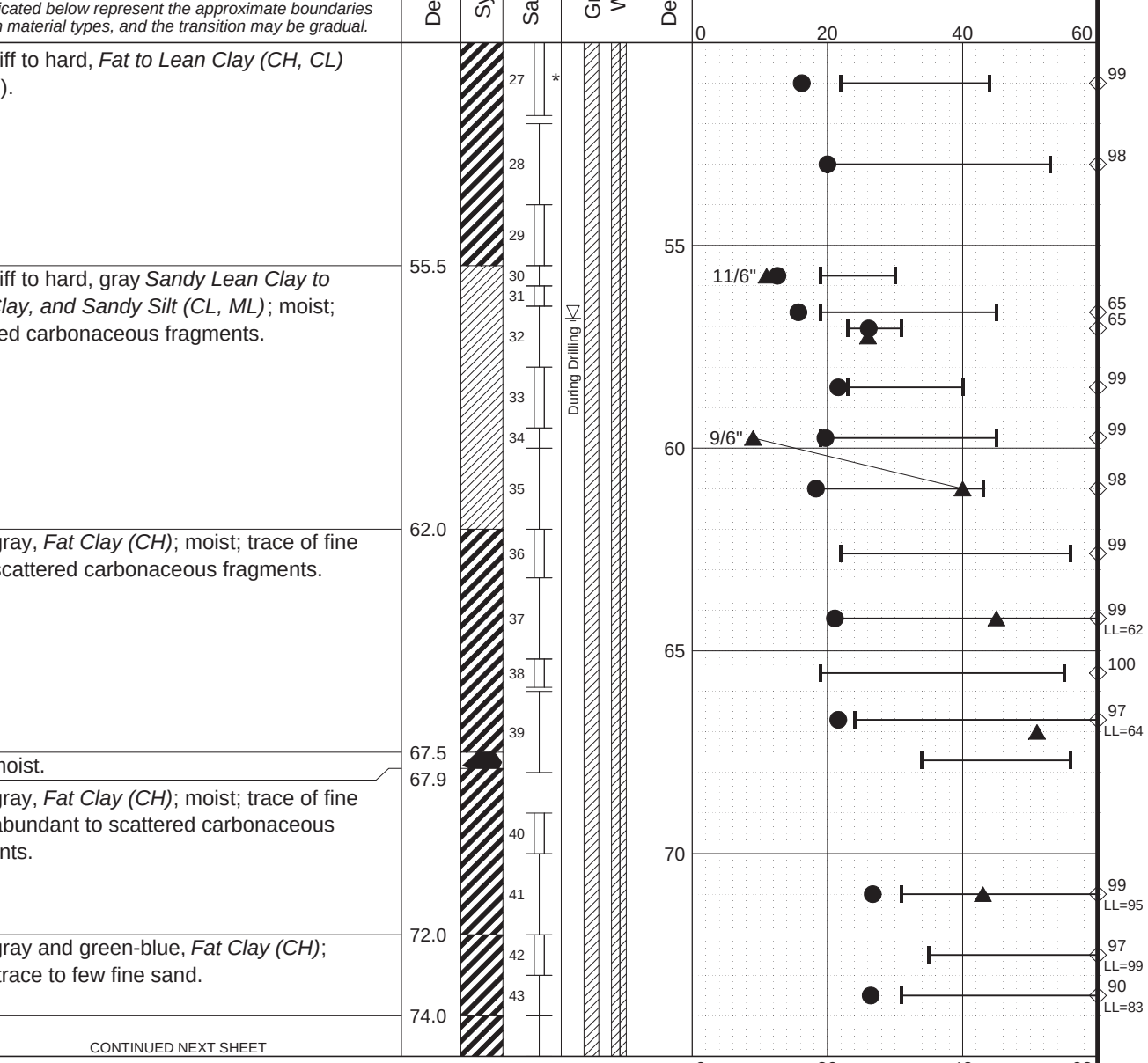
Hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; abundant to scattered carbonaceous fragments.

72.0

Hard, gray and green-blue, *Fat Clay (CH)*; moist; trace to few fine sand.

74.0

CONTINUED NEXT SHEET



LEGEND

*	Sample Not Recovered		Piezometer Screen and Sand Filter
E	Environmental Sample Obtained		Bentonite-Cement Grout
	Thin Wall Sample		Bentonite Chips/Pellets
	Standard Penetration Test		Surface Concrete Seal
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

LOG OF BORING SW-01

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 3 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	110 ft.	Northing:	50 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2797.0 ft.	Easting:	100 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+85.80	Drill Rig Equipment:	D-50	Hammer Type:	Automatic
Horiz. Datum:		Offset:	72.88' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Hard, gray, *Fat Clay (CH)*; moist; trace iron-oxide stains; blebs of disturbed clay.

78.0

Hard, gray, *Sandy Fat Clay to Fat Clay (CH)*; moist; trace to few fine sand; trace carbonaceous fragments.

81.2

Very stiff grading to hard, gray, *Fat Clay (CH)*; moist; trace of sand; locally laminated; scattered carbonaceous fragments; slickensided and disturbed from 92 to 94 feet.

94.0

Very dense, black to medium brown *Coal*; moist.

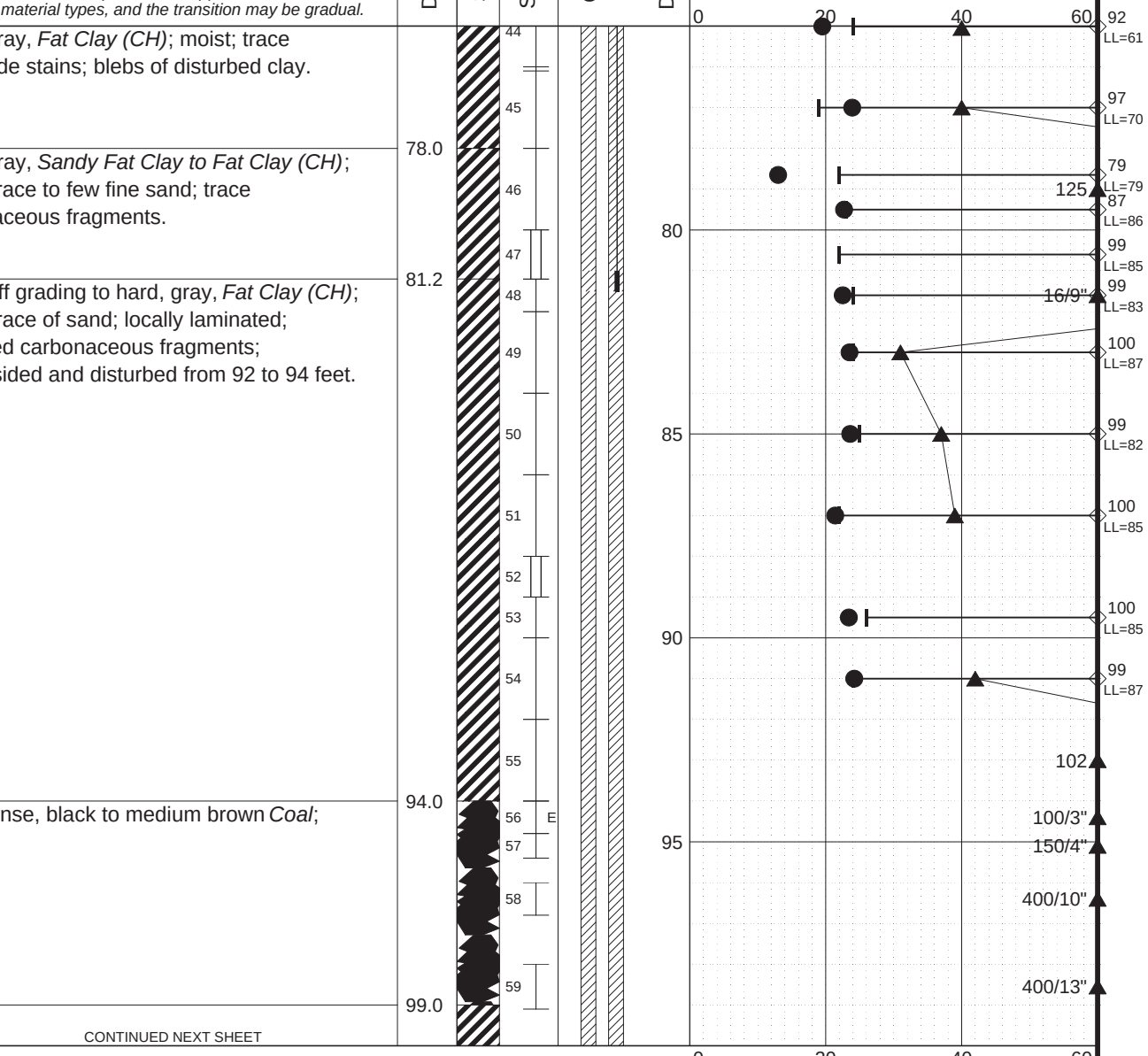
99.0

CONTINUED NEXT SHEET

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

LEGEND

*	Sample Not Recovered		Piezometer Screen and Sand Filter
E	Environmental Sample Obtained		Bentonite-Cement Grout
	Thin Wall Sample		Bentonite Chips/Pellets
	Standard Penetration Test		Surface Concrete Seal
		▽	Ground Water Level ATD
		▼	Ground Water Level in VWP

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
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Billings County, North Dakota

LOG OF BORING SW-01

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 4 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	110 ft.	Northing:	50 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2797.0 ft.	Easting:	100 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+85.80	Drill Rig Equipment:	D-50	Hammer Type:	Automatic
Horiz. Datum:		Offset:	72.88' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; trace carbonaceous fragments.

103.0

Hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; 20-degree bedding angle.

105.0

Hard, gray, *Fat Clay (CH)*; moist; trace of fine sand; locally laminated; 1/2-inch coal layer at 109 feet.

110.0

BOTTOM OF BORING
COMPLETED 3/14/2014

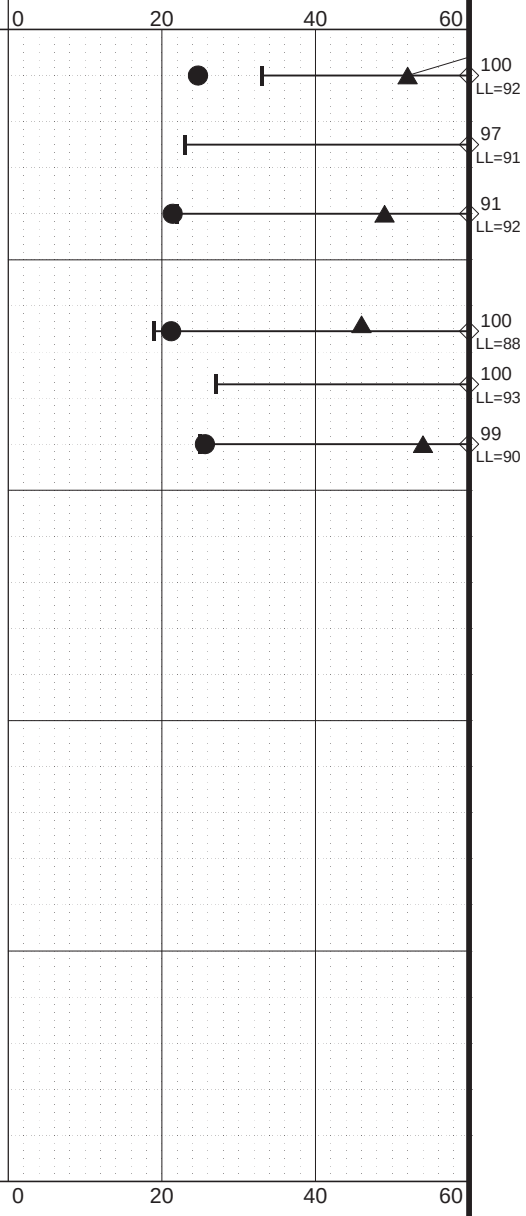
Inclinometer casing installed to bottom of boring. VWPs taped to outside of casing.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

Samples: 60, 61, 62, 63, 64, 65, 66

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered	Piezometer Screen and Sand Filter
E Environmental Sample Obtained	Bentonite-Cement Grout
Thin Wall Sample	Bentonite Chips/Pellets
Standard Penetration Test	Surface Concrete Seal
	Ground Water Level ATD
	Ground Water Level in VWP

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
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LOG OF BORING SW-01

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3
Sheet 5 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	99.6 ft.	Northing:	100 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2752.2 ft.	Easting:	50 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+93.60	Drill Rig Equipment:	D-90	Hammer Type:	Automatic
Horiz. Datum:		Offset:	252.78' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very loose, brown, *Silty Sand (SM)*; moist.

4.0

Very loose, brown, *Silty Sand (SM)*; wet.

9.0

Medium stiff to stiff, gray, *Fat Clay and Elastic Silt (CH, MH)*; moist to wet; trace of fine sand; scattered to abundant carbonaceous fragments.

17.0

Hard, gray, *Lean Clay with Sand to Lean Clay (CL)*; moist; trace of gravel; laminated; fine sand partings and lenses.

23.0

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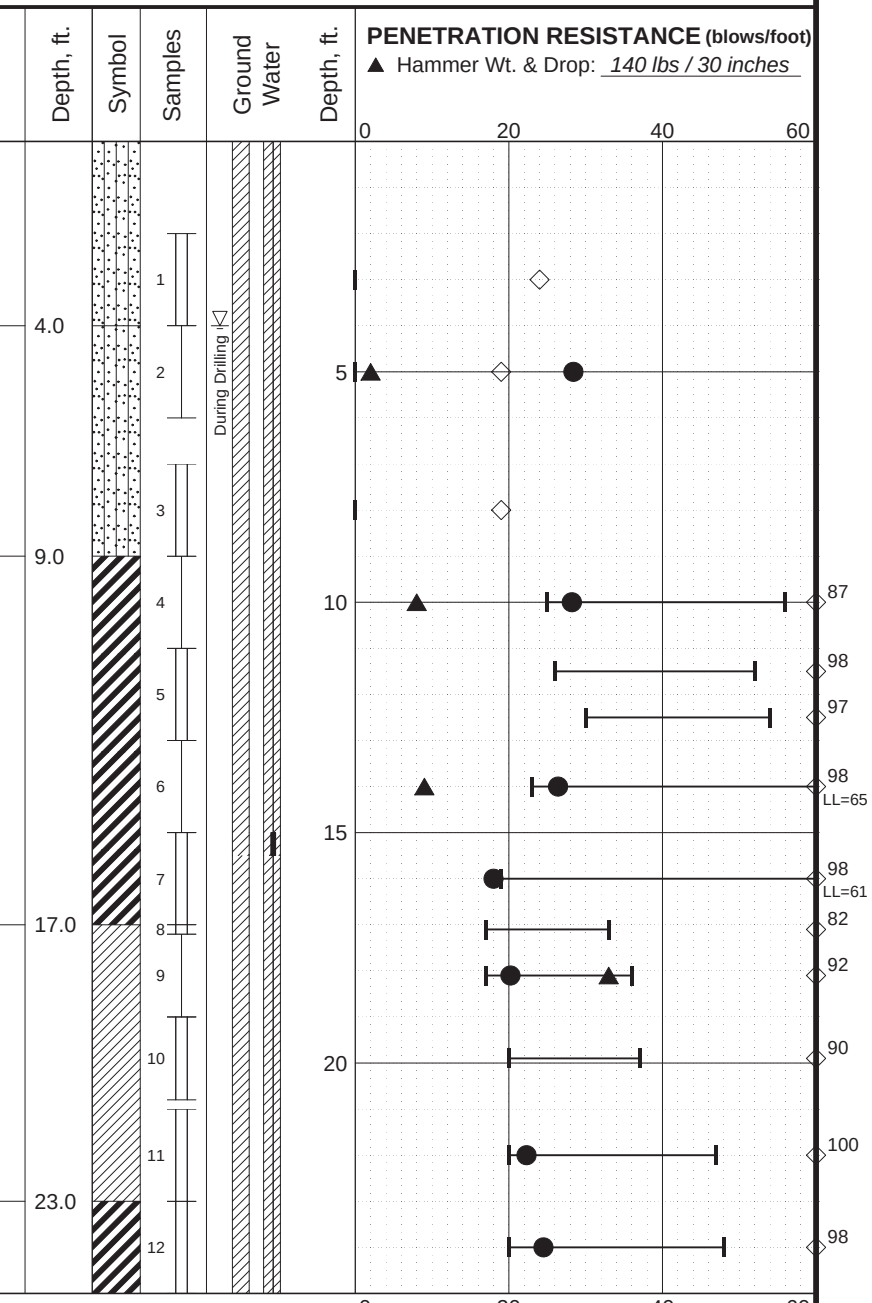

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

LEGEND

* Sample Not Recovered

Thin Wall Sample

Standard Penetration Test

Piezometer Screen and Sand Filter

Bentonite-Cement Grout

Bentonite Chips/Pellets

Surface Concrete Seal

Ground Water Level ATD

Ground Water Level in VWP

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
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LOG OF BORING SW-02

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SHANNON & WILSON, INC.
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FIG. A-4
Sheet 1 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	99.6 ft.	Northing:	100 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2752.2 ft.	Easting:	50 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+93.60	Drill Rig Equipment:	D-90	Hammer Type:	Automatic
Horiz. Datum:		Offset:	252.78' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very stiff to hard, gray, *Lean to Fat Clay and Elastic Silt (CL, CH, MH)*; moist; trace of fine sand; scattered carbonaceous fragments; several hard iron pyrite clusters; scattered silt blebs.

29.6 — Dark gray and brown, *organic Silt (OH)* with organic fragments and decayed wood; moist.

29.9 — Very dense, black *Coal*; moist.

31.0 — Stiff, brown, organic(?); *Fat Clay (CH)*; moist; trace of fine sand; coal lenses; large carbonaceous fragments.

32.5 — Very stiff to hard, green-gray, *Fat Clay (CH)*; moist; trace to few fine sand; large carbonaceous fragments; high-angle (60 to 65 degrees) slickensides.

39.0 — Very stiff, gray, *Sandy Fat Clay to Fat Clay (CH)*; moist; trace to few gravel; 1-inch lense of iron pyrite crystals; two slickensides.

41.0 — Very stiff to hard, gray, Fat Clay (CH); moist; trace of fine sand; scattered carbonaceous fragments; high (45 to 80 degrees) angle and low (20 to 25 degrees) angle slickensides.

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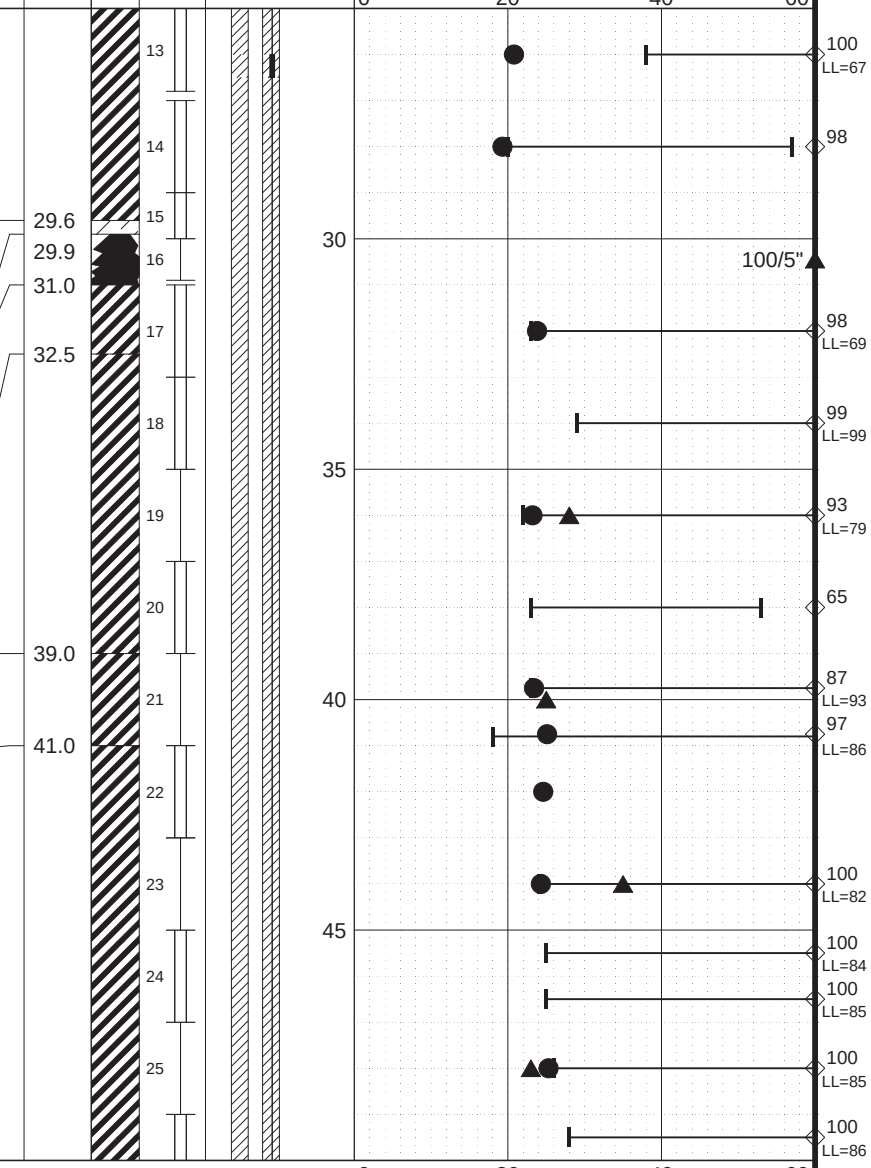

LEGEND

* Sample Not Recovered	Piezometer Screen and Sand Filter
Thin Wall Sample	Bentonite-Cement Grout
Standard Penetration Test	Bentonite Chips/Pellets
	Surface Concrete Seal
	Ground Water Level ATD
	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

LOG OF BORING SW-02

June 2014 — 23-1-01400-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	99.6 ft.	Northing:	100 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2752.2 ft.	Easting:	50 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+93.60	Drill Rig Equipment:	D-90	Hammer Type:	Automatic
Horiz. Datum:		Offset:	252.78' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
50.5	Very dense, black *Coal*; wet; trace clayey at 57 feet; trace slickensides, clay lenses.
58.0	Very dense, black *Coal*; moist; peaty; laminated.
60.0	Hard, gray, *Fat Clay (CH)*; moist; abundant carbonaceous fragments.
62.0	Hard, gray, *Fat Clay (CH)*; moist; trace of sand; laminated with fine sand; trace carbonaceous fragments.
65.5	Hard, gray, *Fat Clay (CH)*; moist; locally laminated; 1-inch coal layer at 67.5 feet.
67.7	Hard, gray, *Fat Clay (CH)*; moist to wet; trace of sand, trace of gravel; blocky; slickensides on short soil fragments; small harder chunks in softer matrix; locally sheared; hard clay between two disturbed zones.
70.9	Hard, gray, *Fat Clay (CH)*; moist; laminated (1/8- to 1/4-inch) silt blebs and silt lenses; trace coal at 82 feet; 45-degree slickenside at 83 feet.

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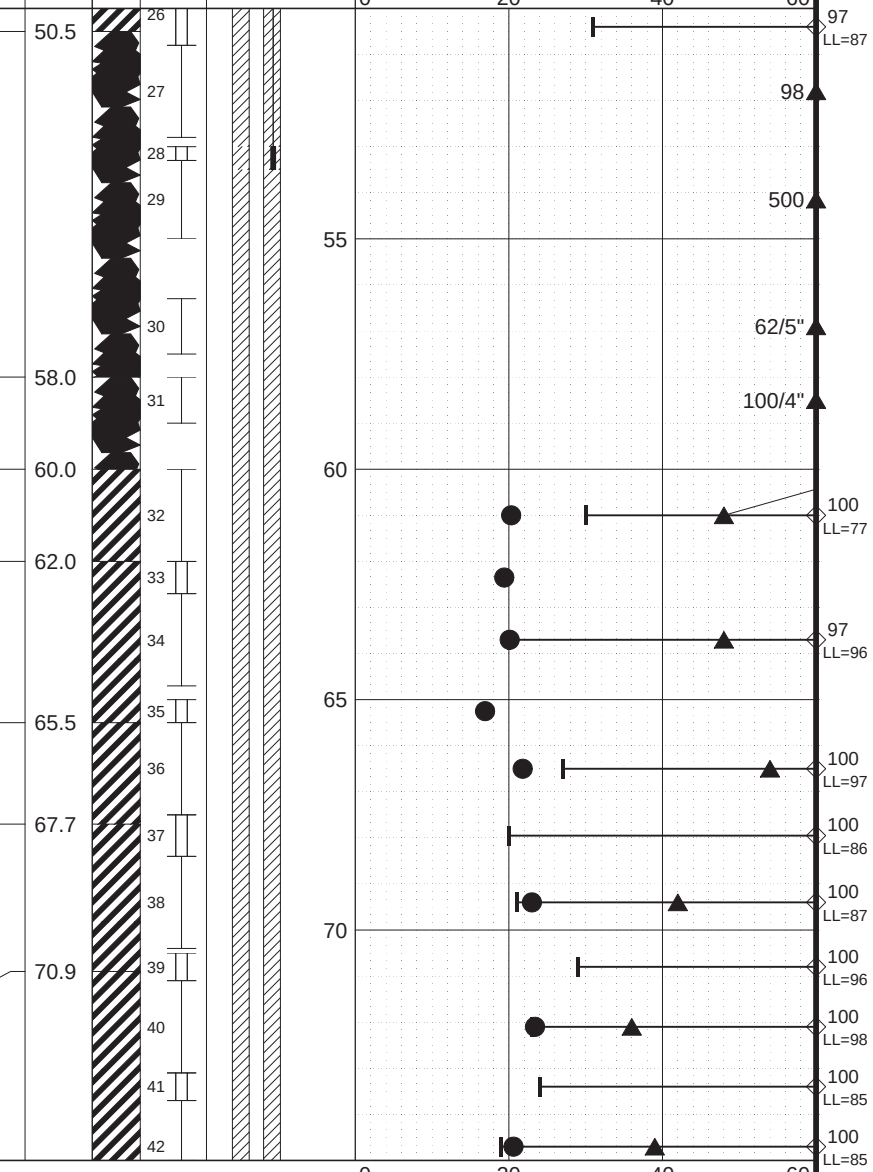

LEGEND

* Sample Not Recovered	Piezometer Screen and Sand Filter
Thin Wall Sample	Bentonite-Cement Grout
Standard Penetration Test	Bentonite Chips/Pellets
	Surface Concrete Seal
	Ground Water Level ATD
	Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

LOG OF BORING SW-02

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 5

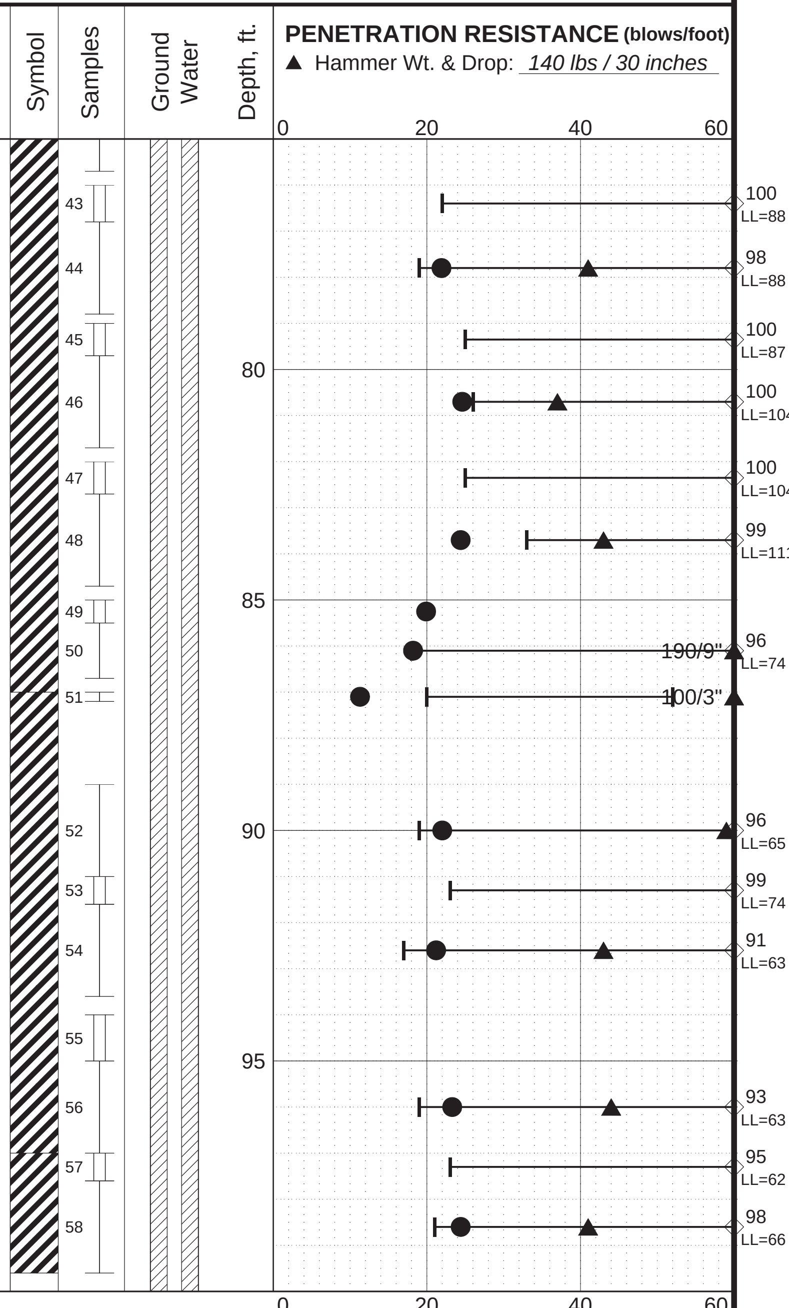
MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14

Total Depth:	99.6 ft.	Northing:	100 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2752.2 ft.	Easting:	50 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+93.60	Drill Rig Equipment:	D-90	Hammer Type:	Automatic
Horiz. Datum:		Offset:	252.78' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
Hard, *Fat Clay (CH)* (Cont'd).	
Hard, gray, *Fat Clay (CH)*; moist; trace to few sand, trace of gravel; laminated.	87.0
Hard, gray, *Fat Clay (CH)*; moist; carbonaceous fragments.	97.0
CONTINUED NEXT SHEET	99.6



LEGEND

- * Sample Not Recovered
- Thin Wall Sample
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Surface Concrete Seal
- Ground Water Level ATD
- Ground Water Level in VWP

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
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4. Groundwater level, if indicated above, is for the date specified and may vary.
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I-94 Painted Canyon Landslide
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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

Total Depth:	99.6 ft.	Northing:	100 ft.	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	2752.2 ft.	Easting:	50 ft.	Drilling Company:	NDDOT	Rod Type.:	AW
Vert. Datum:		Station:	433+93.60	Drill Rig Equipment:	D-90	Hammer Type:	Automatic
Horiz. Datum:		Offset:	252.78' L	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches

0 20 40 60

BOTTOM OF BORING
COMPLETED 3/14/2014

Inclinometer casing installed to bottom of boring. VWPs taped to outside of casing.

105
110
115
120

0 20 40 60

LEGEND

* Sample Not Recovered
Thin Wall Sample
Standard Penetration Test
Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Surface Concrete Seal
Ground Water Level ATD
Ground Water Level in VWP

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit — Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
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5. USCS designation is based on visual-manual classification and selected lab testing.

I-94 Painted Canyon Landslide
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LOG OF BORING SW-02

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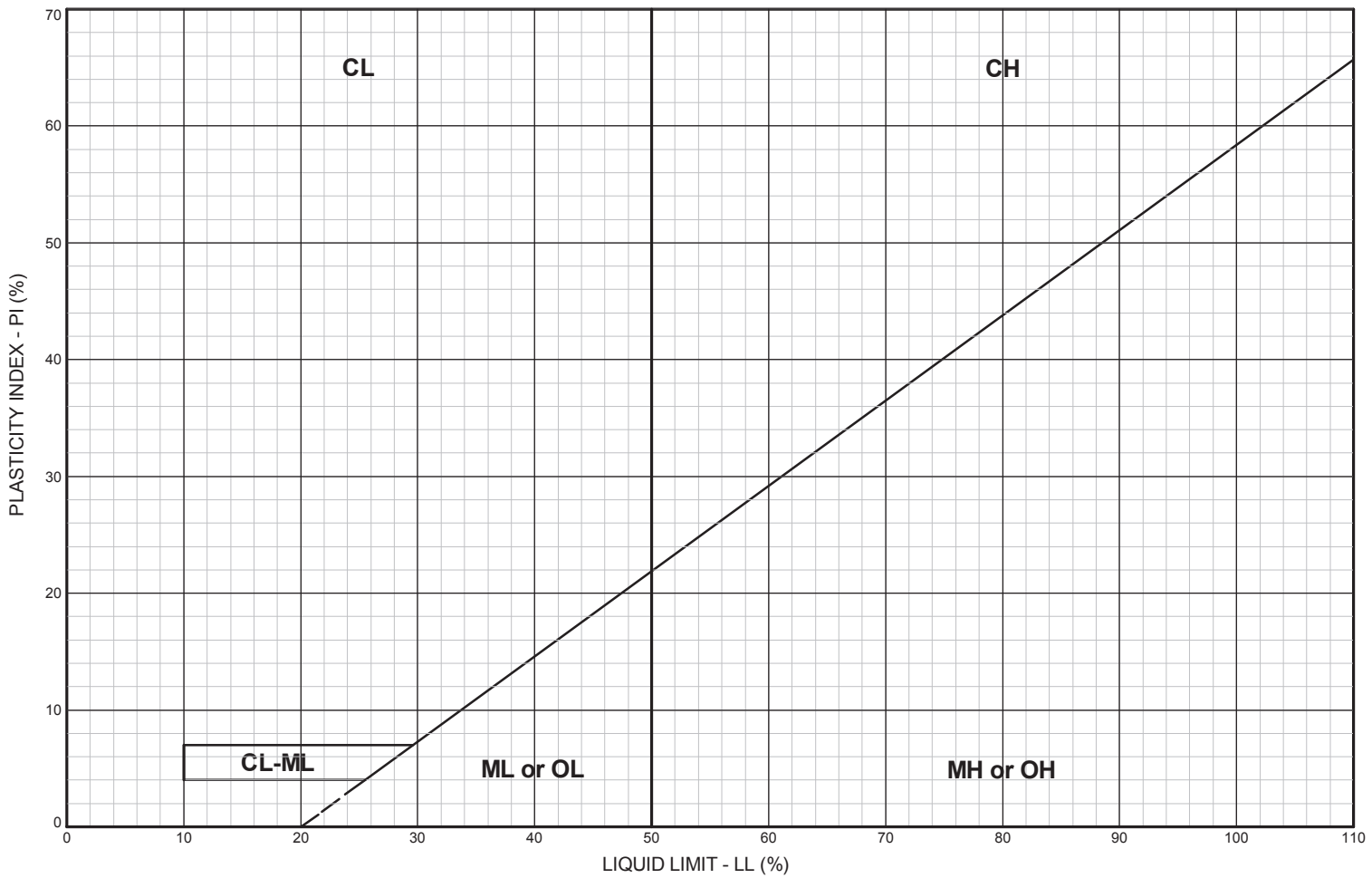
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 5 of 5

MASTER LOG E 23-01400.GPJ SHAN WIL.GDT 4/10/14



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
SW-01, S-1	3.0	SM	Silty Sand	NP	NP	NP		37.0
SW-01, S-2	5.0	SM	Silty Sand	NP	NP	NP	12.7	36.0
SW-01, S-4	9.0	SM	Silty Sand	NP	NP	NP	14.8	38.0
SW-01, S-5	11.0			NP	NP	NP		
SW-01, S-6	13.0	SM	Silty Sand	NP	NP	NP	10.3	35.0
SW-01, S-7	15.0	SM	Silty Sand	NP	NP	NP		35.0
SW-01, S-8	17.0	SM	Silty Sand	NP	NP	NP	7.5	27.0

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PLASTICITY CHART
BORING SW-01

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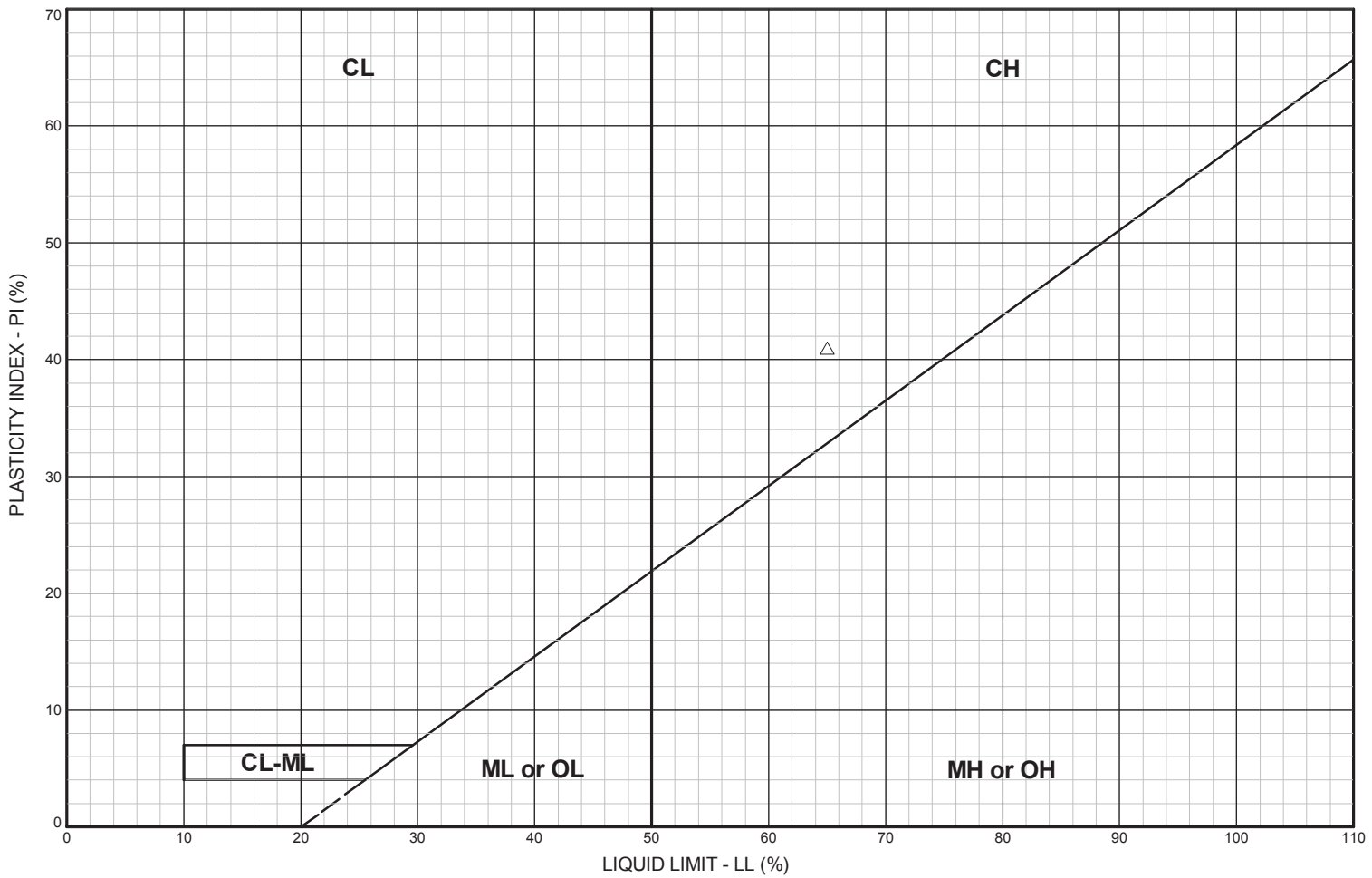
FIG. A-5
Sheet 1 of 10

FIG. A-5



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
SW-01, S-9	19.0			NP	NP	NP		
SW-01, S-10	21.0	SM	Silty Sand	NP	NP	NP	5.3	20.0
SW-01, S-12	24.1	SM	Silty Sand	NP	NP	NP	3.4	45.0
SW-01, S-13	27.0	SM	Silty Sand	NP	NP	NP	7.7	23.0
SW-01, S-14	29.0			NP	NP	NP		
SW-01, S-15	30.4	SM	Silty Sand	NP	NP	NP	13.8	23.0
△ SW-01, S-15	31.4	CH	Fat Clay	65	24	41	24.9	94.0

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

PLASTICITY CHART
BORING SW-01

June 2014 23-1-01400-001

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FIG. A-5
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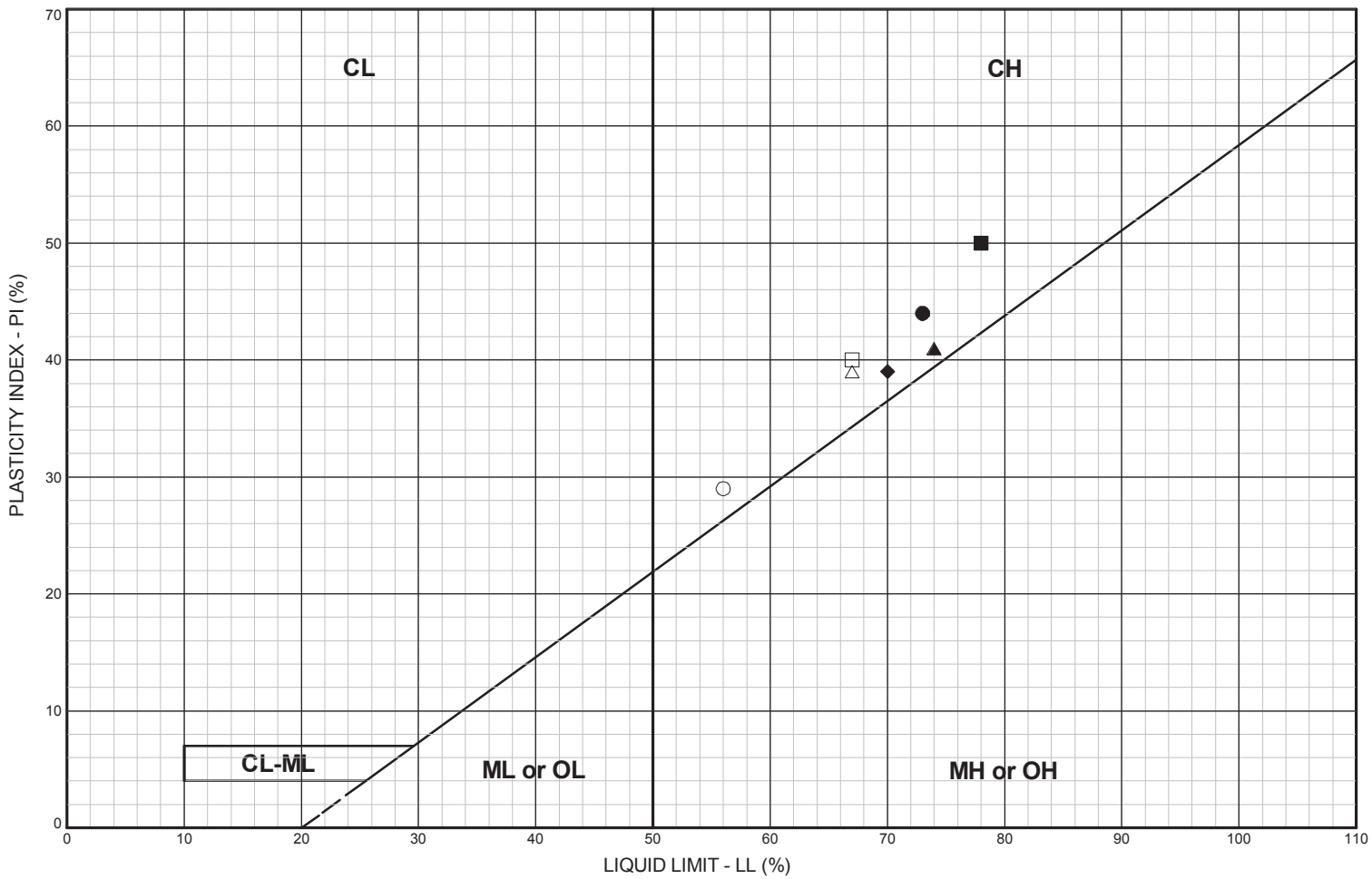
FIG. A-5



LEGEND

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-16	32.5	CH	Fat Clay	73	29	44		97.0
■ SW-01, S-16	33.0	CH	Fat Clay	78	28	50		92.0
▲ SW-01, S-16	33.5	CH	Fat Clay	74	33	41	28.4	94.0
◆ SW-01, S-17	35.0	CH	Fat Clay	70	31	39	28.4	99.0
○ SW-01, S-18	36.5	CH	Fat Clay	56	27	29	30.9	98.0
□ SW-01, S-18	37.0	CH	Fat Clay	67	27	40		100.0
△ SW-01, S-18	37.5	CH	Fat Clay	67	28	39		99.0

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PLASTICITY CHART
BORING SW-01

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FIG. A-5
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FIG. A-5

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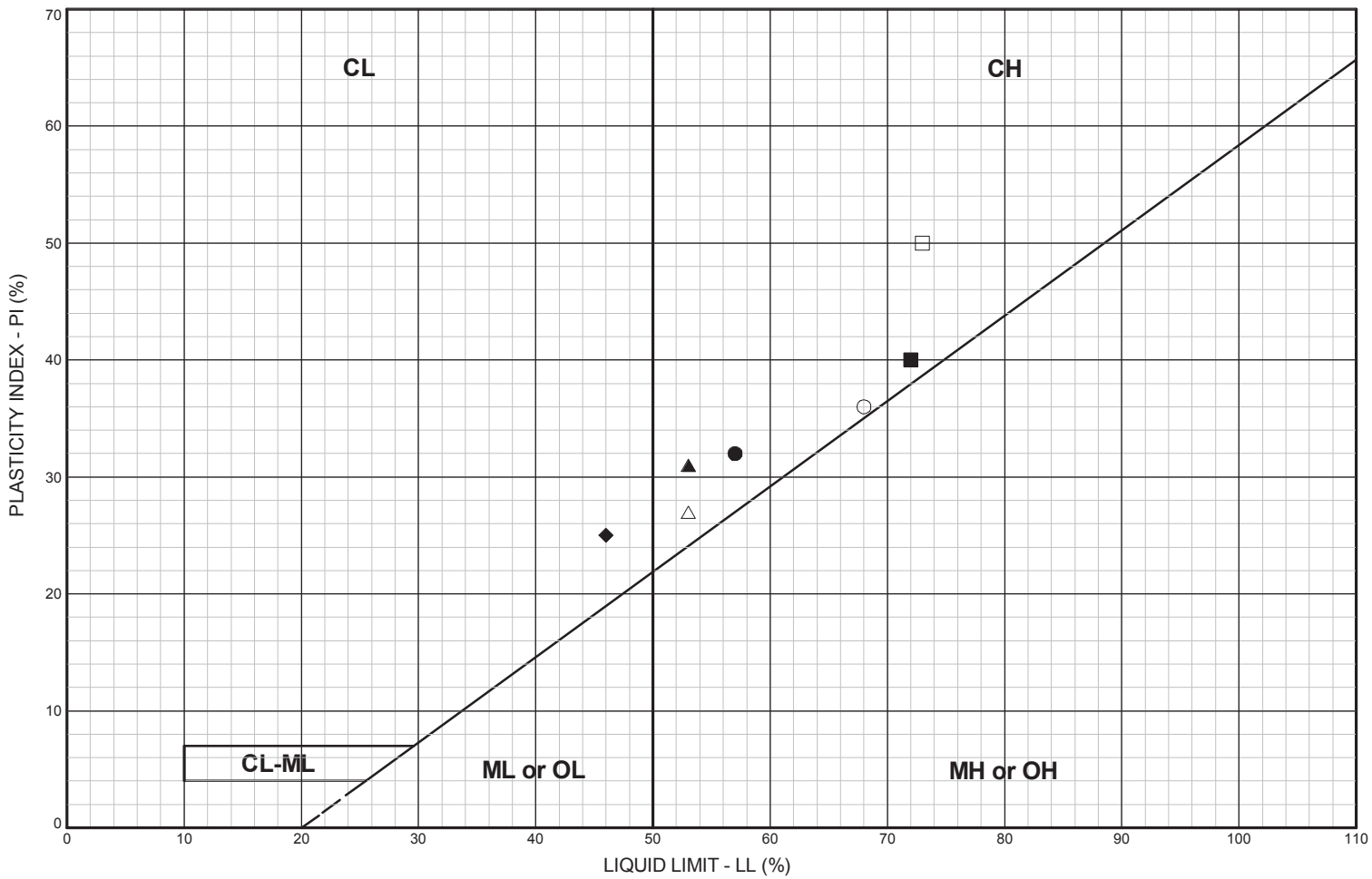

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-19	39.0	CH	Fat Clay	57	25	32	28.9	99.0
■ SW-01, S-20	40.0	CH	Fat Clay	72	32	40		97.0
▲ SW-01, S-20	41.4	CH	Fat Clay	53	22	31	20.8	99.0
◆ SW-01, S-21	42.0	CL	Lean Clay	46	21	25		99.0
○ SW-01, S-21	42.6	CH	Fat Clay	68	32	36	30.3	98.0
□ SW-01, S-22	45.0	CH	Fat Clay	73	23	50	23.1	95.0
△ SW-01, S-23	46.3	CH	Fat Clay	53	26	27		98.0

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BORING SW-01

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FIG. A-5
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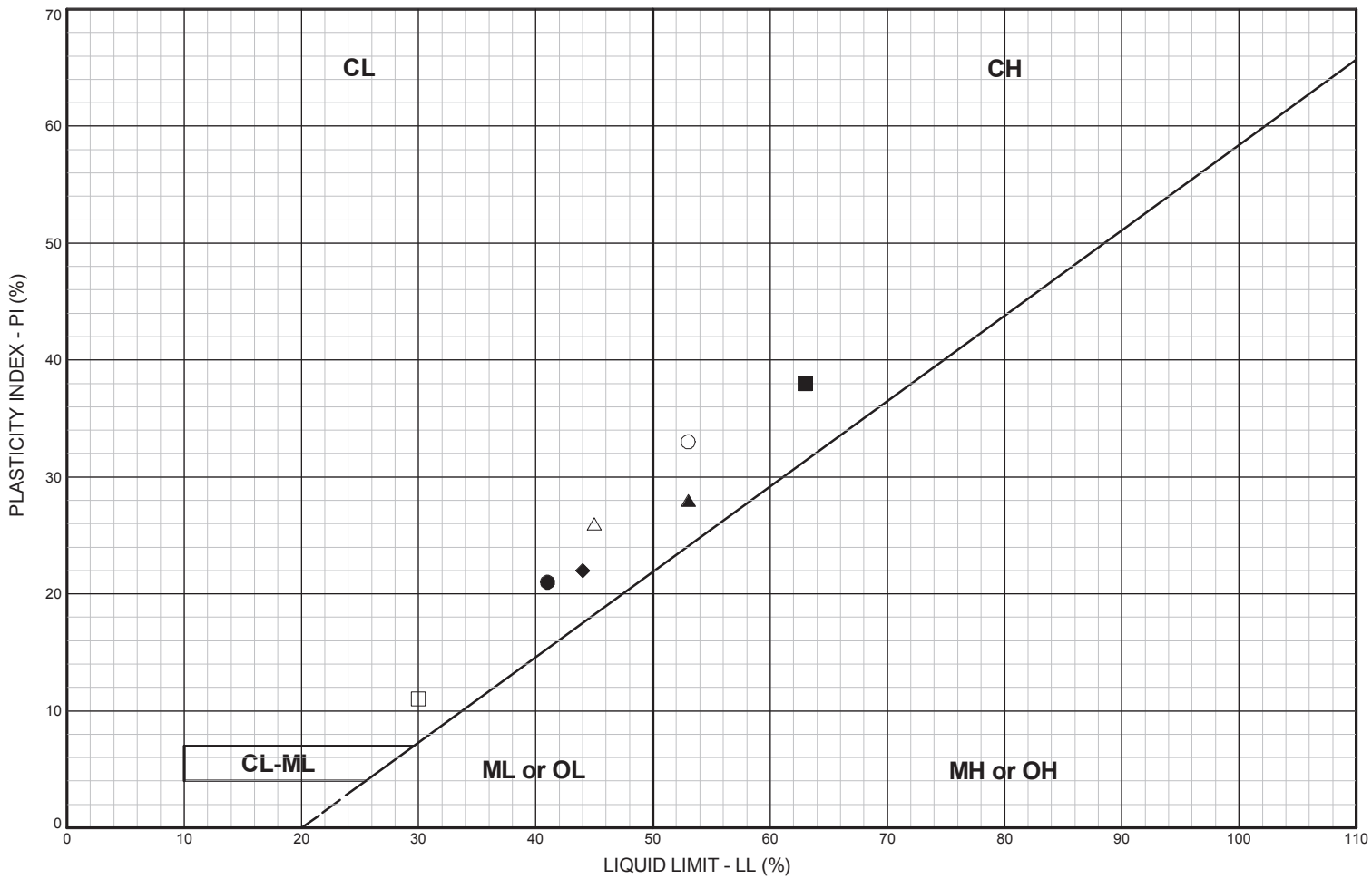
FIG. A-5



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● SW-01, S-24	47.3	CL	Lean Clay	41	20	21	16.1	93.0
■ SW-01, S-25	48.4	CH	Fat Clay	63	25	38		
▲ SW-01, S-26	49.4	CH	Fat Clay	53	25	28	24.2	98.0
◆ SW-01, S-27	51.0	CL	Lean Clay	44	22	22	16.2	99.0
○ SW-01, S-28	53.0	CH	Fat Clay	53	20	33	20.0	98.0
□ SW-01, S-30	55.8	CL	Lean Clay	30	19	11	12.6	
△ SW-01, S-32	56.7	CL	Sandy Lean Clay	45	19	26	15.7	65.0

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FIG. A-5
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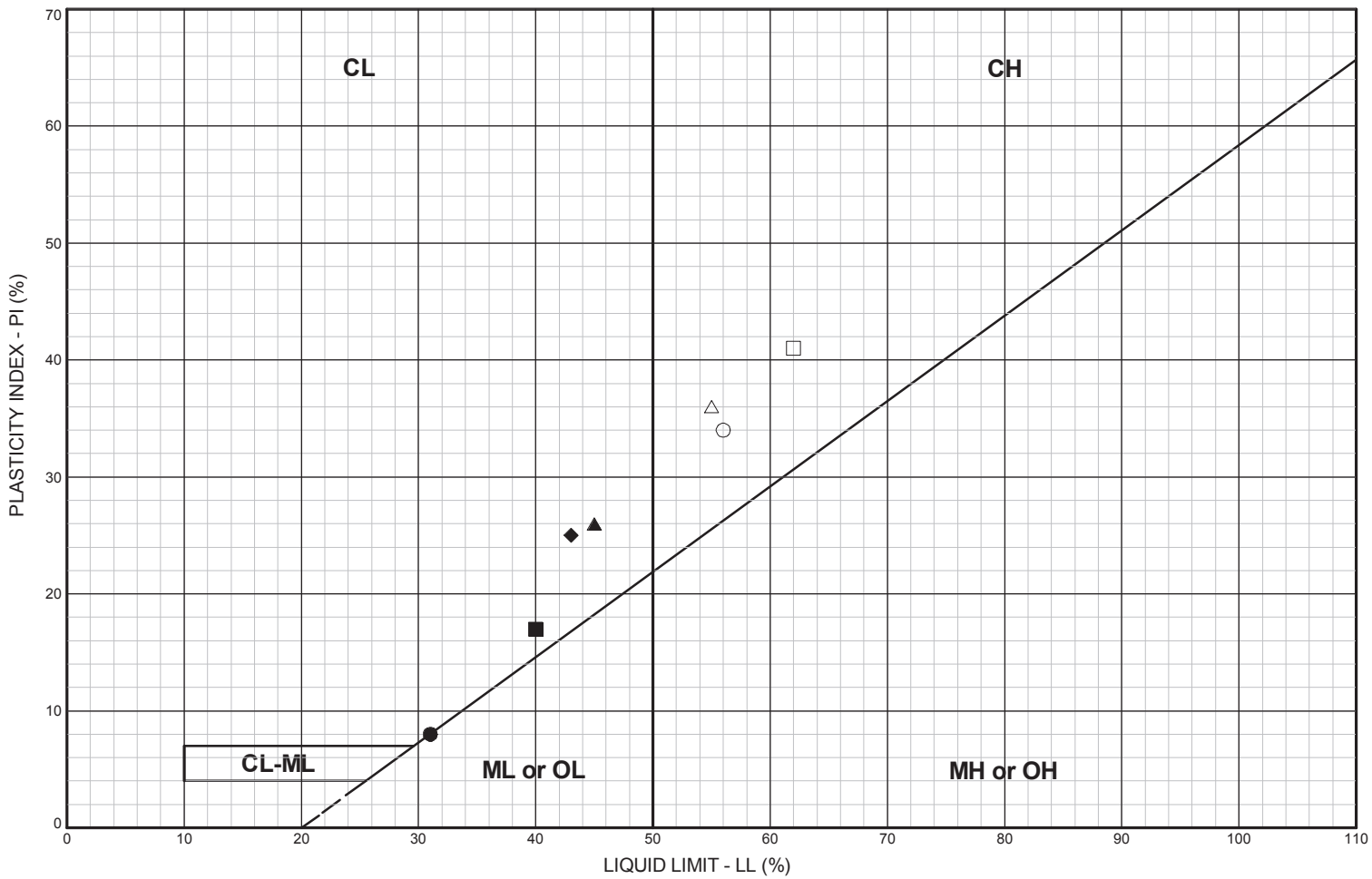
FIG. A-5



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-32	57.1	ML	Sandy Silt	31	23	8	26.1	65.0
■ SW-01, S-33	58.5	CL	Lean Clay	40	23	17	21.6	99.0
▲ SW-01, S-34	59.8	CL	Lean Clay	45	19	26	19.7	99.0
◆ SW-01, S-35	61.0	CL	Lean Clay	43	18	25	18.3	98.0
○ SW-01, S-36	62.6	CH	Fat Clay	56	22	34		99.0
□ SW-01, S-37	64.2	CH	Fat Clay	62	21	41	21.1	99.0
△ SW-01, S-38	65.6	CH	Fat Clay	55	19	36		100.0

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BORING SW-01

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FIG. A-5
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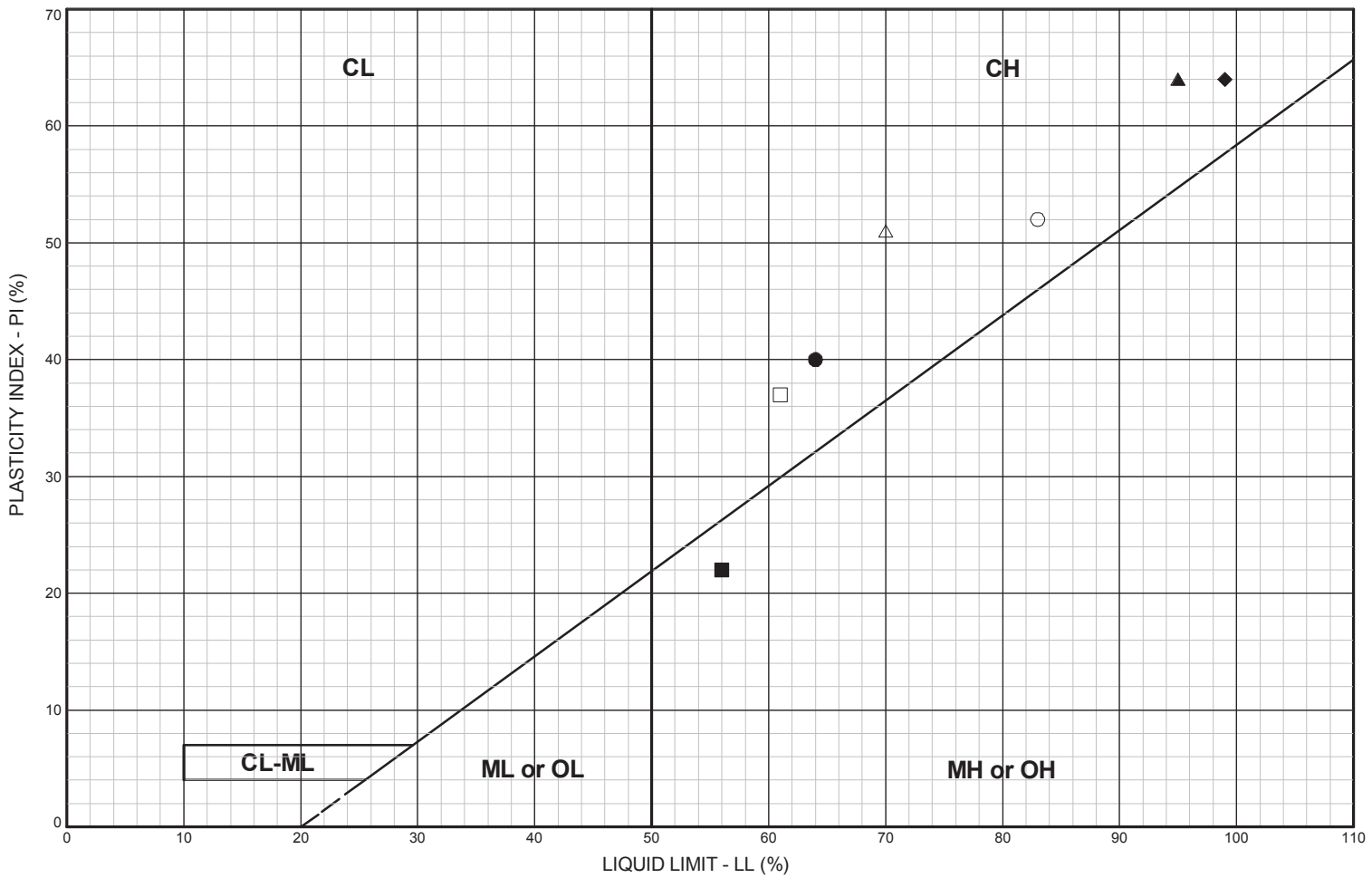
FIG. A-5



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-39	66.7	CH	Fat Clay	64	24	40	21.6	97.0
■ SW-01, S-39	67.7	MH	Elastic Silt [Coal]	56	34	22		
▲ SW-01, S-41	71.0	CH	Fat Clay	95	31	64	26.7	99.0
◆ SW-01, S-42	72.5	CH	Fat Clay	99	35	64		97.0
○ SW-01, S-43	73.5	CH	Fat Clay	83	31	52	26.4	90.0
□ SW-01, S-44	75.0	CH	Fat Clay	61	24	37	19.5	92.0
△ SW-01, S-45	77.0	CH	Fat Clay	70	19	51	23.9	97.0

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BORING SW-01

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FIG. A-5
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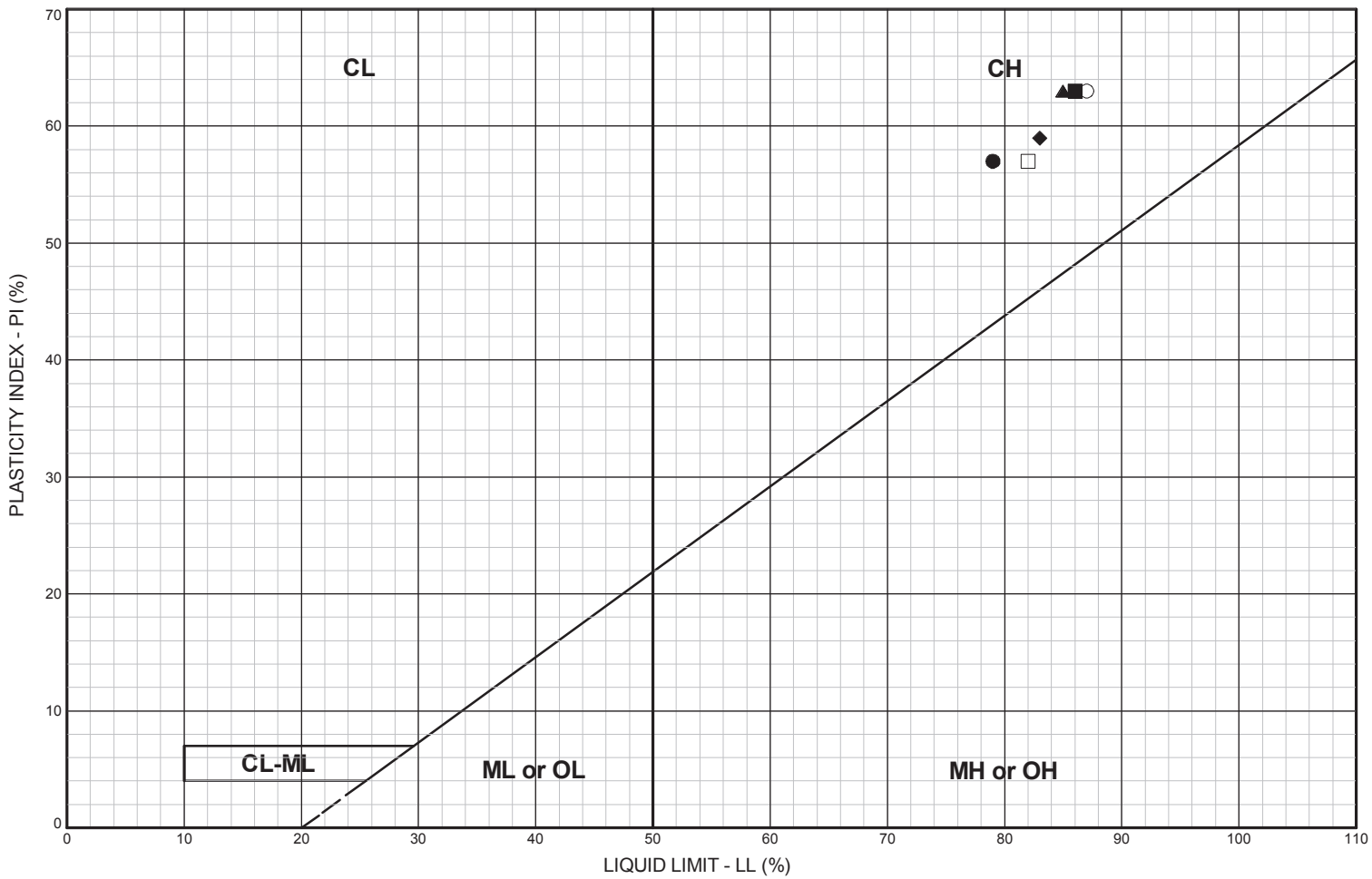
FIG. A-5



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-46	78.7	CH	Fat Clay with Sand	79	22	57	13.0	79.0
■ SW-01, S-46	79.5	CH	Fat Clay	86	23	63	22.7	87.0
▲ SW-01, S-47	80.6	CH	Fat Clay	85	22	63		99.0
◆ SW-01, S-48	81.6	CH	Fat Clay	83	24	59	22.5	99.0
○ SW-01, S-49	83.0	CH	Fat Clay	87	24	63	23.5	100.0
□ SW-01, S-50	85.0	CH	Fat Clay	82	25	57	23.6	99.0
△ SW-01, S-51	87.0	CH	Fat Clay	85	22	63	21.4	100.0

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PLASTICITY CHART
BORING SW-01

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FIG. A-5
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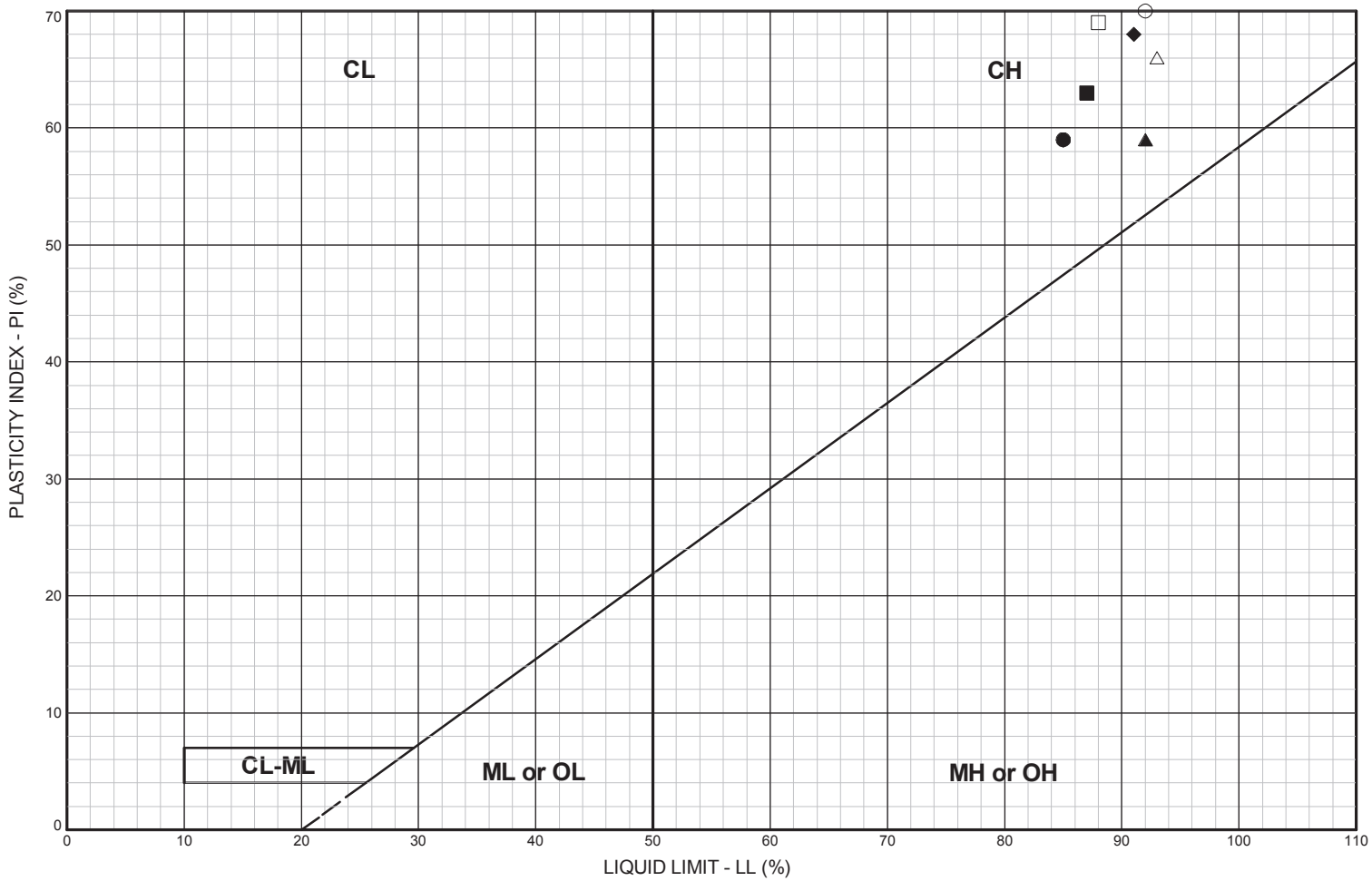
FIG. A-5



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-53	89.5	CH	Fat Clay	85	26	59	23.4	100.0
■ SW-01, S-54	91.0	CH	Fat Clay	87	24	63	24.2	99.0
▲ SW-01, S-60	101.0	CH	Fat Clay	92	33	59	24.7	100.0
◆ SW-01, S-61	102.5	CH	Fat Clay	91	23	68		97.0
○ SW-01, S-62	104.0	CH	Fat Clay	92	22	70	21.4	91.0
□ SW-01, S-64	106.6	CH	Fat Clay	88	19	69	21.2	100.0
△ SW-01, S-65	107.7	CH	Fat Clay	93	27	66		100.0

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BORING SW-01

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FIG. A-5
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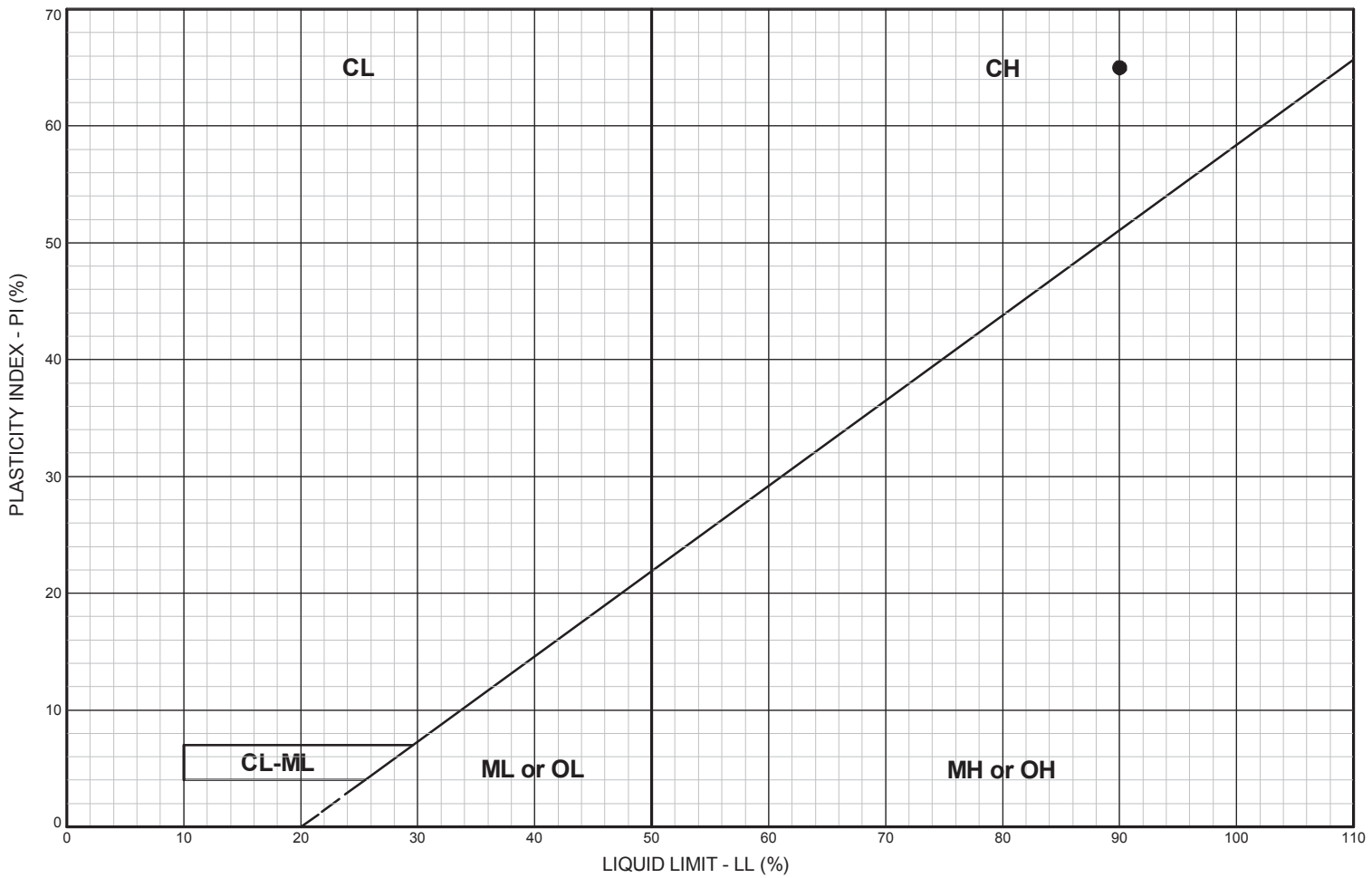
FIG. A-5



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-66	109.0	CH	Fat Clay	90	25	65	25.6	99.0

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PLASTICITY CHART
BORING SW-01

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FIG. A-5
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FIG. A-5

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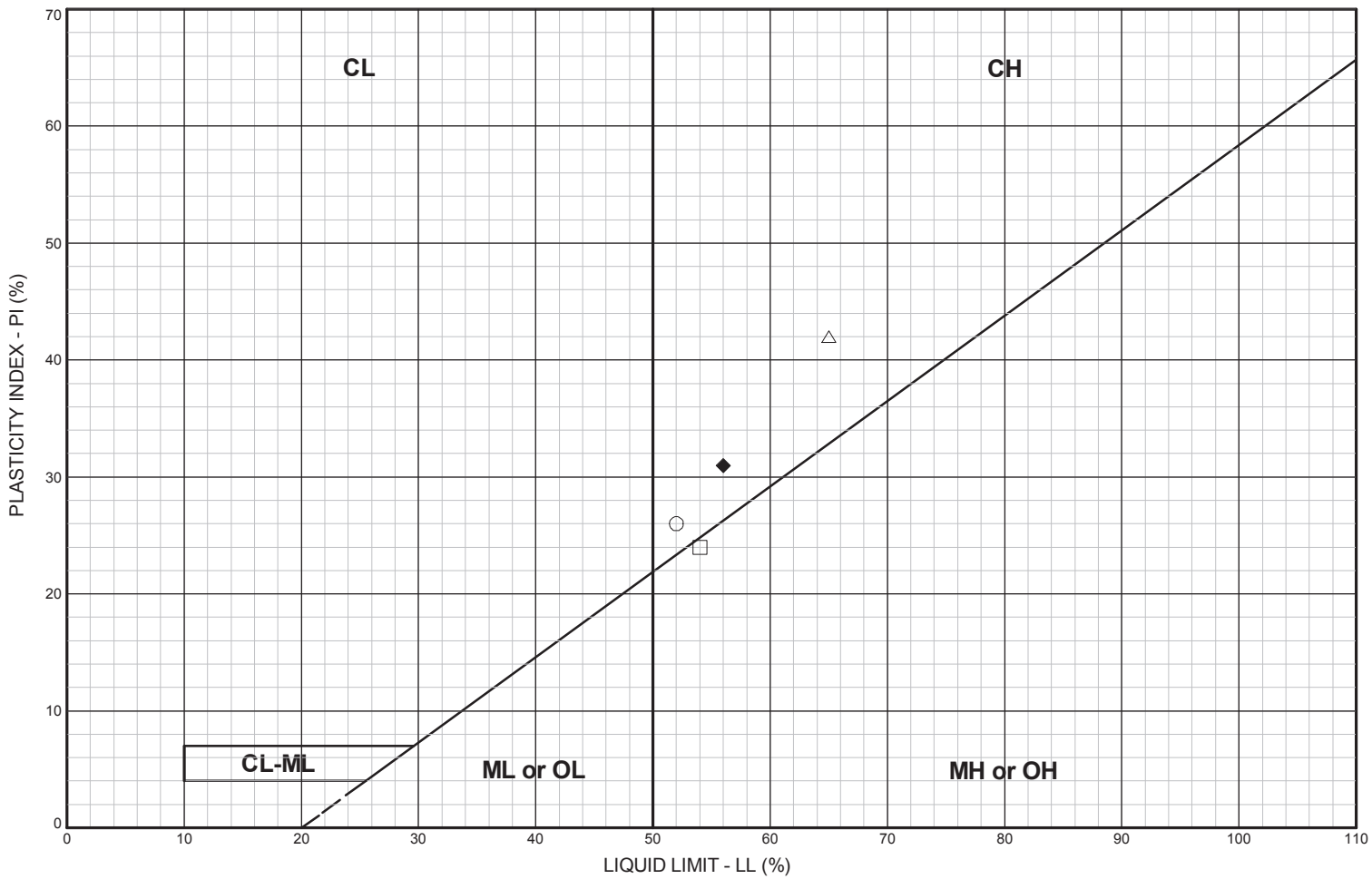

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
SW-02, S-1	3.0	SM	Silty Sand	NP	NP	NP		24.0
SW-02, S-2	5.0	SM	Silty Sand	NP	NP	NP	28.4	19.0
SW-02, S-3	8.0	SM	Silty Sand	NP	NP	NP		19.0
◆ SW-02, S-4	10.0	CH	Fat Clay	56	25	31	28.2	87.0
○ SW-02, S-5	11.5	CH	Fat Clay	52	26	26		98.0
□ SW-02, S-5	12.5	MH	Elastic Silt	54	30	24		97.0
△ SW-02, S-6	14.0	CH	Fat Clay	65	23	42	26.4	98.0

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PLASTICITY CHART BORING SW-02

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FIG. A-6
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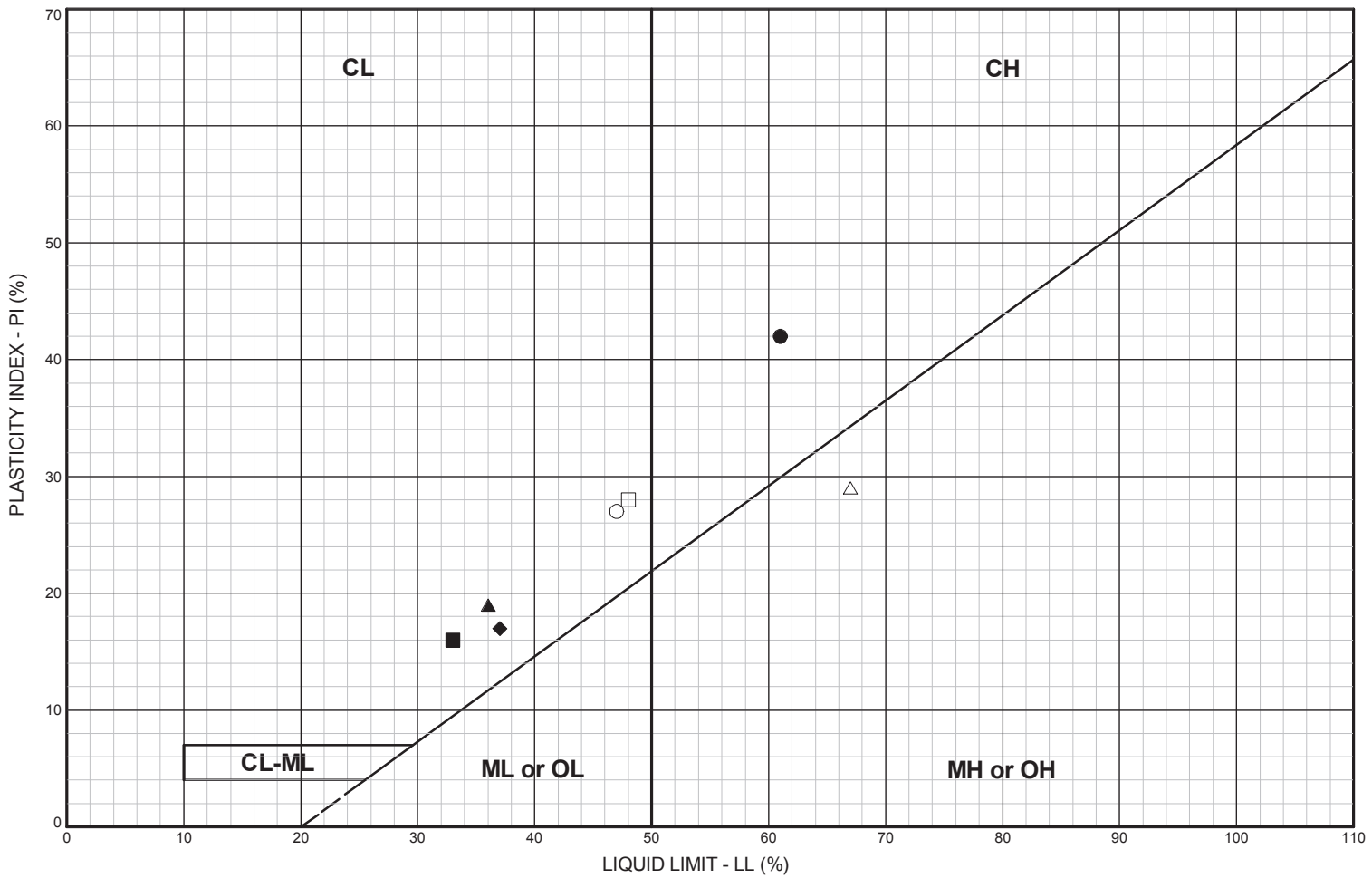
FIG. A-6



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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-02, S-7	16.0	CH	Fat Clay	61	19	42	18.0	98.0
■ SW-02, S-8	17.1	CL	Lean Clay with Sand	33	17	16		82.0
▲ SW-02, S-9	18.1	CL	Lean Clay	36	17	19	20.2	92.0
◆ SW-02, S-10	19.9	CL	Lean Clay	37	20	17		90.0
○ SW-02, S-11	22.0	CL	Lean Clay	47	20	27	22.3	100.0
□ SW-02, S-12	24.0	CL	Lean Clay	48	20	28	24.5	98.0
△ SW-02, S-13	26.0	MH	Elastic Silt	67	38	29	20.8	100.0

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PLASTICITY CHART
BORING SW-02

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FIG. A-6
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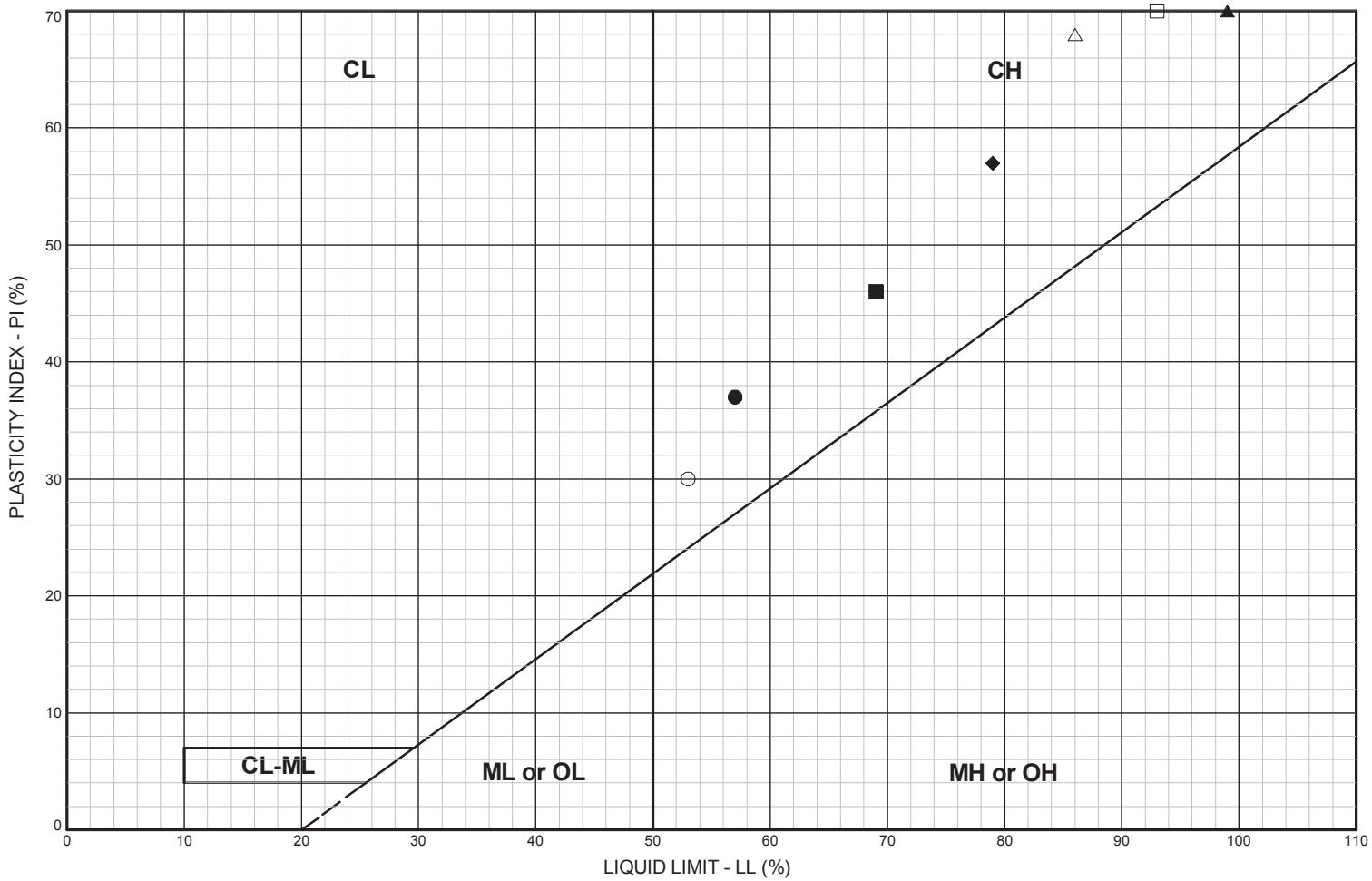
FIG. A-6



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● SW-02, S-14	28.0	CH	Fat Clay	57	20	37	19.3	98.0
■ SW-02, S-17	32.0	CH	Fat Clay	69	23	46	23.8	98.0
▲ SW-02, S-18	34.0	CH	Fat Clay	99	29	70		99.0
◆ SW-02, S-19	36.0	CH	Fat Clay	79	22	57	23.2	93.0
○ SW-02, S-20	38.0	CH	Sandy Fat Clay	53	23	30		65.0
□ SW-02, S-21	39.8	CH	Fat Clay	93	23	70	23.4	87.0
△ SW-02, S-21	40.8	CH	Fat Clay	86	18	68		

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FIG. A-6
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FIG. A-6

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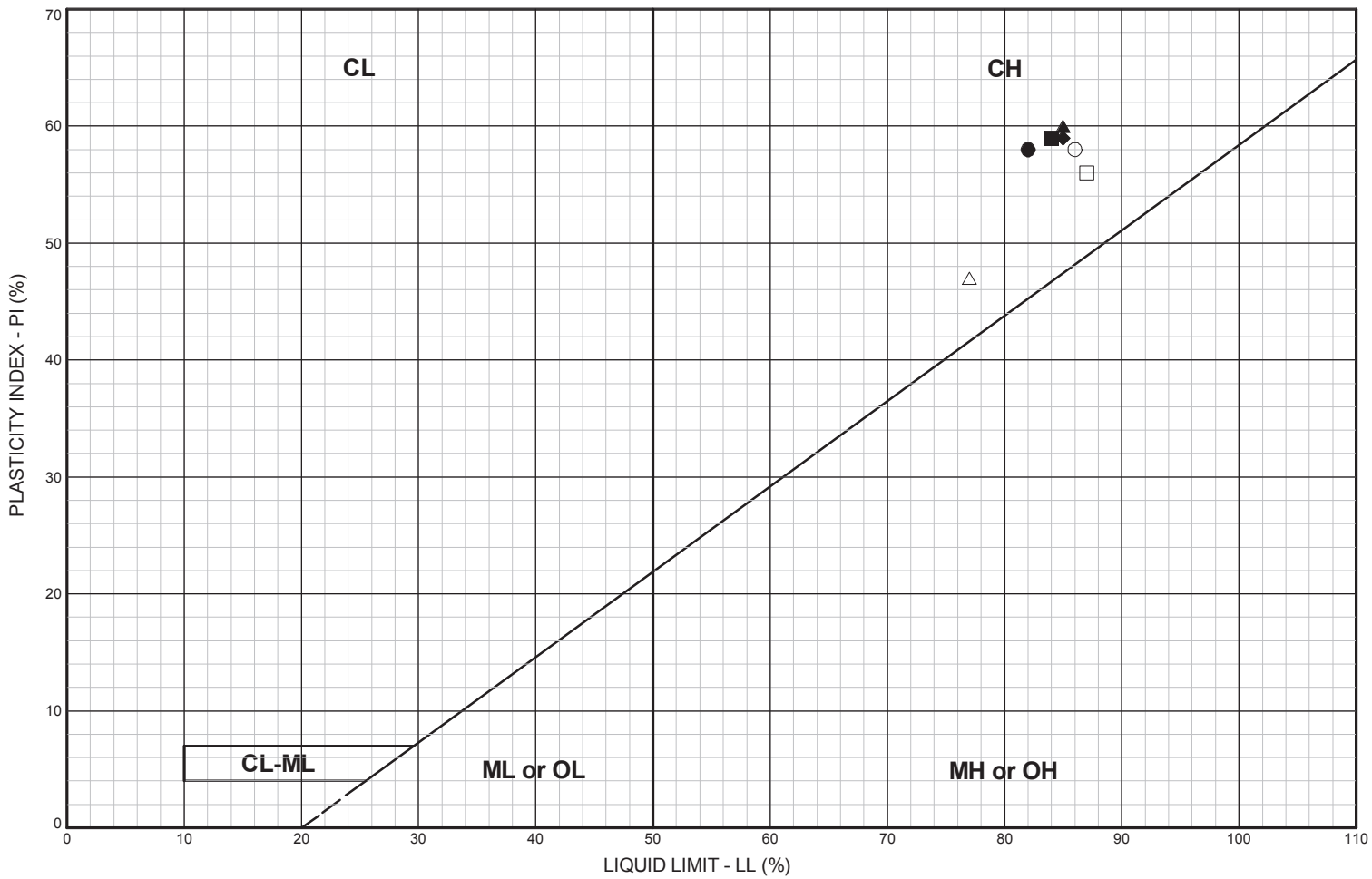

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● SW-02, S-23	44.0	CH	Fat Clay	82	24	58	24.3	100.0
■ SW-02, S-24	45.5	CH	Fat Clay	84	25	59		100.0
▲ SW-02, S-24	46.5	CH	Fat Clay	85	25	60		100.0
◆ SW-02, S-25	48.0	CH	Fat Clay	85	26	59	25.3	100.0
○ SW-02, S-26	49.5	CH	Fat Clay	86	28	58		100.0
□ SW-02, S-26	50.4	CH	Fat Clay	87	31	56		97.0
△ SW-02, S-32	61.0	CH	Fat Clay	77	30	47	20.3	100.0

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FIG. A-6
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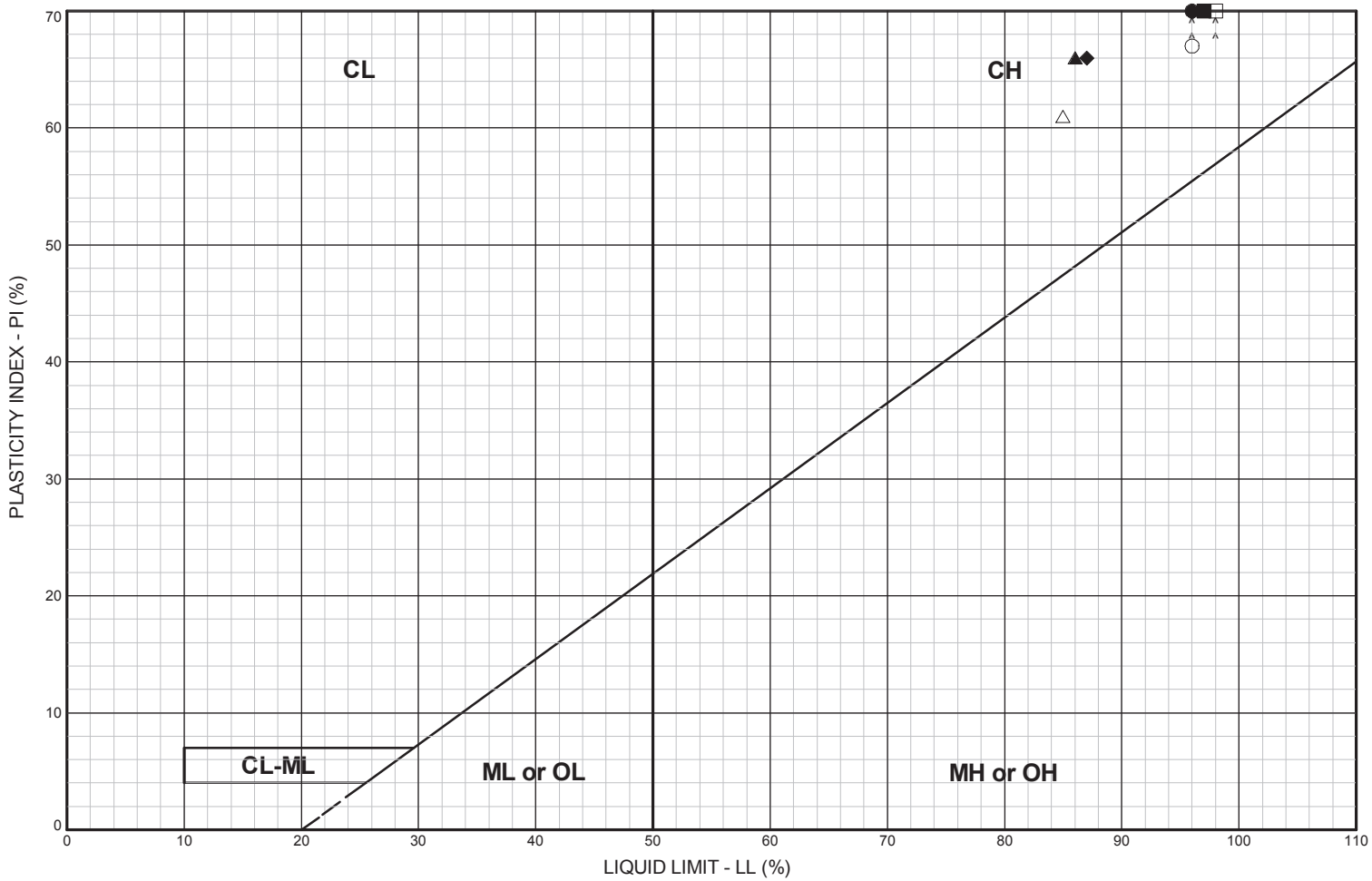
FIG. A-6



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● SW-02, S-34	63.7	CH	Fat Clay	96	20	76	20.1	97.0
■ SW-02, S-36	66.5	CH	Fat Clay	97	27	70	21.8	100.0
▲ SW-02, S-37	68.0	CH	Fat Clay	86	20	66		100.0
◆ SW-02, S-38	69.4	CH	Fat Clay	87	21	66	23.0	100.0
○ SW-02, S-39	70.8	CH	Fat Clay	96	29	67		100.0
□ SW-02, S-40	72.1	CH	Fat Clay	98	23	75	23.4	100.0
△ SW-02, S-41	73.4	CH	Fat Clay	85	24	61		100.0

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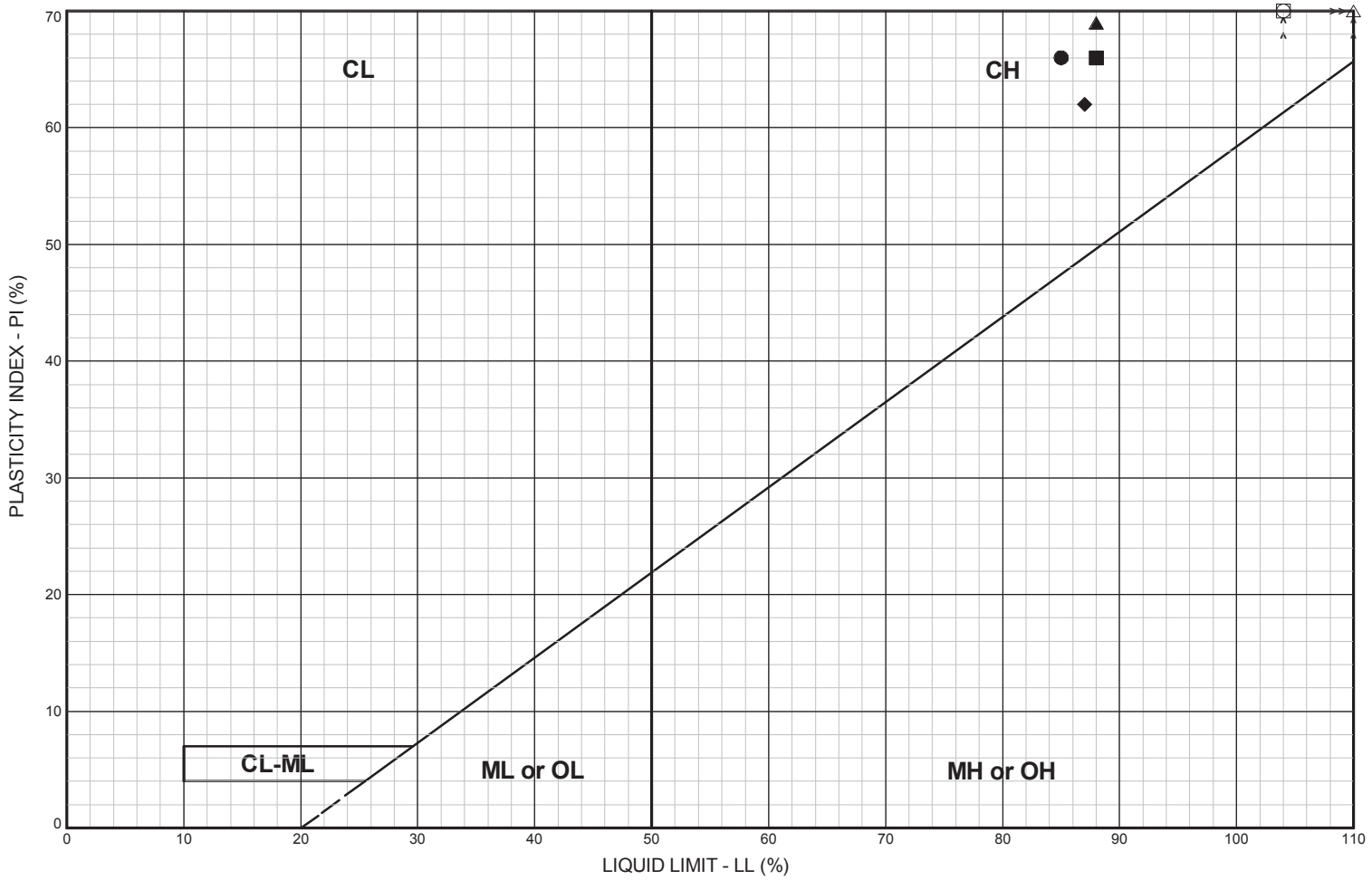
FIG. A-6



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-02, S-42	74.7	CH	Fat Clay	85	19	66	20.6	100.0
■ SW-02, S-43	76.4	CH	Fat Clay	88	22	66		100.0
▲ SW-02, S-44	77.8	CH	Fat Clay	88	19	69	21.9	98.0
◆ SW-02, S-45	79.4	CH	Fat Clay	87	25	62		100.0
○ SW-02, S-46	80.7	CH	Fat Clay	104	26	78	24.6	100.0
□ SW-02, S-47	82.4	CH	Fat Clay	104	25	79		100.0
△ SW-02, S-48	83.7	CH	Fat Clay	111	33	78	24.4	99.0

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

PLASTICITY CHART
BORING SW-02

June 2014 23-1-01400-001

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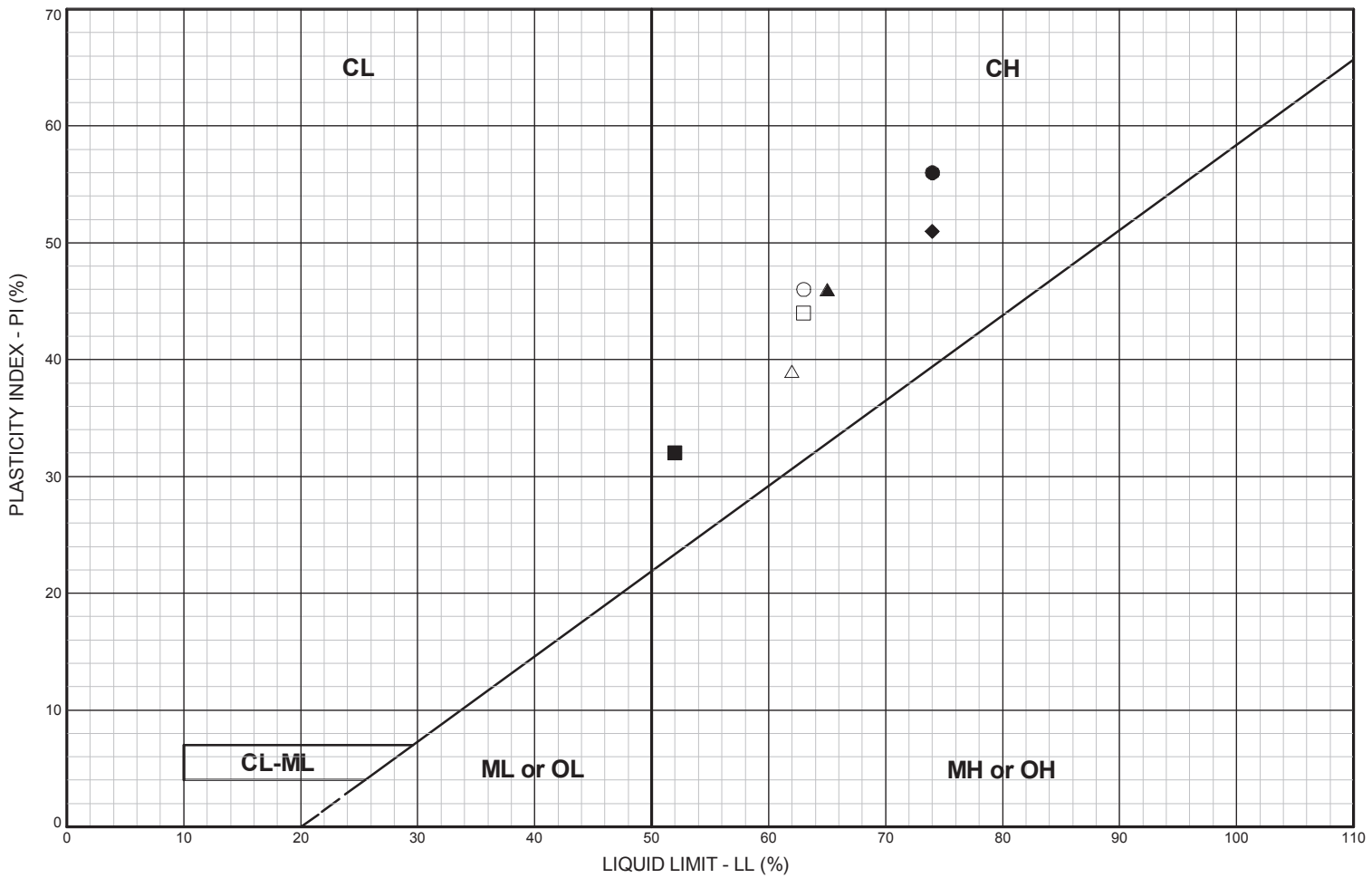
FIG. A-6
Sheet 6 of 8

FIG. A-6



LEGEND

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CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-02, S-50	86.1	CH	Fat Clay	74	18	56	18.2	96.0
■ SW-02, S-51	87.1	CH	Fat Clay	52	20	32	11.3	
▲ SW-02, S-52	90.0	CH	Fat Clay	65	19	46	22.0	96.0
◆ SW-02, S-53	91.3	CH	Fat Clay	74	23	51		99.0
○ SW-02, S-54	92.6	CH	Fat Clay	63	17	46	21.2	91.0
□ SW-02, S-56	96.0	CH	Fat Clay	63	19	44	23.3	93.0
△ SW-02, S-57	97.3	CH	Fat Clay	62	23	39		95.0

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PLASTICITY CHART BORING SW-02

June 2014 23-1-01400-001

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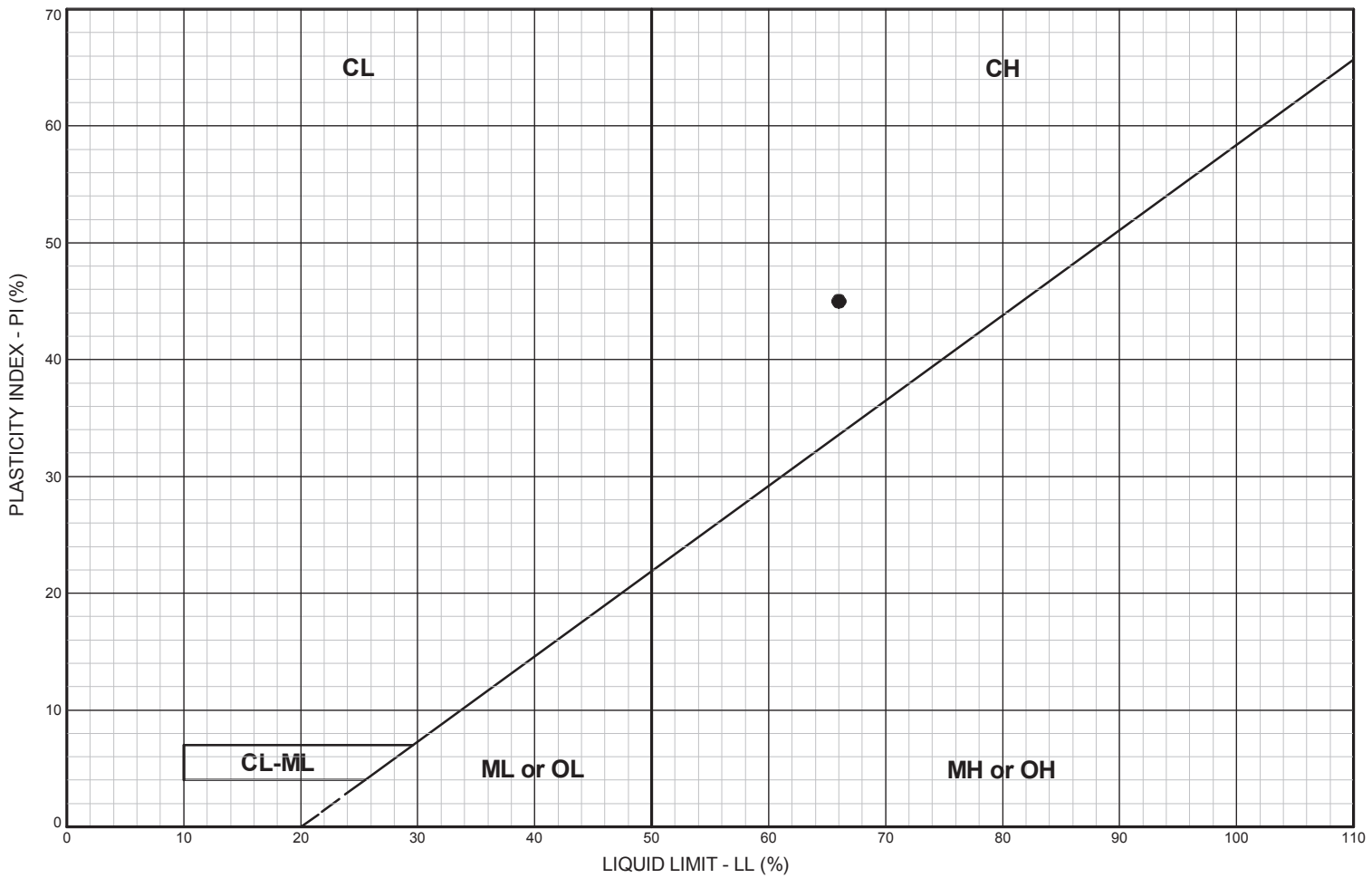
FIG. A-6
Sheet 7 of 8

FIG. A-6



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

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CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-02, S-58	98.6	CH	Fat Clay	66	21	45	24.4	98.0

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PLASTICITY CHART
BORING SW-02

June 2014 23-1-01400-001

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FIG. A-6
Sheet 8 of 8

FIG. A-6

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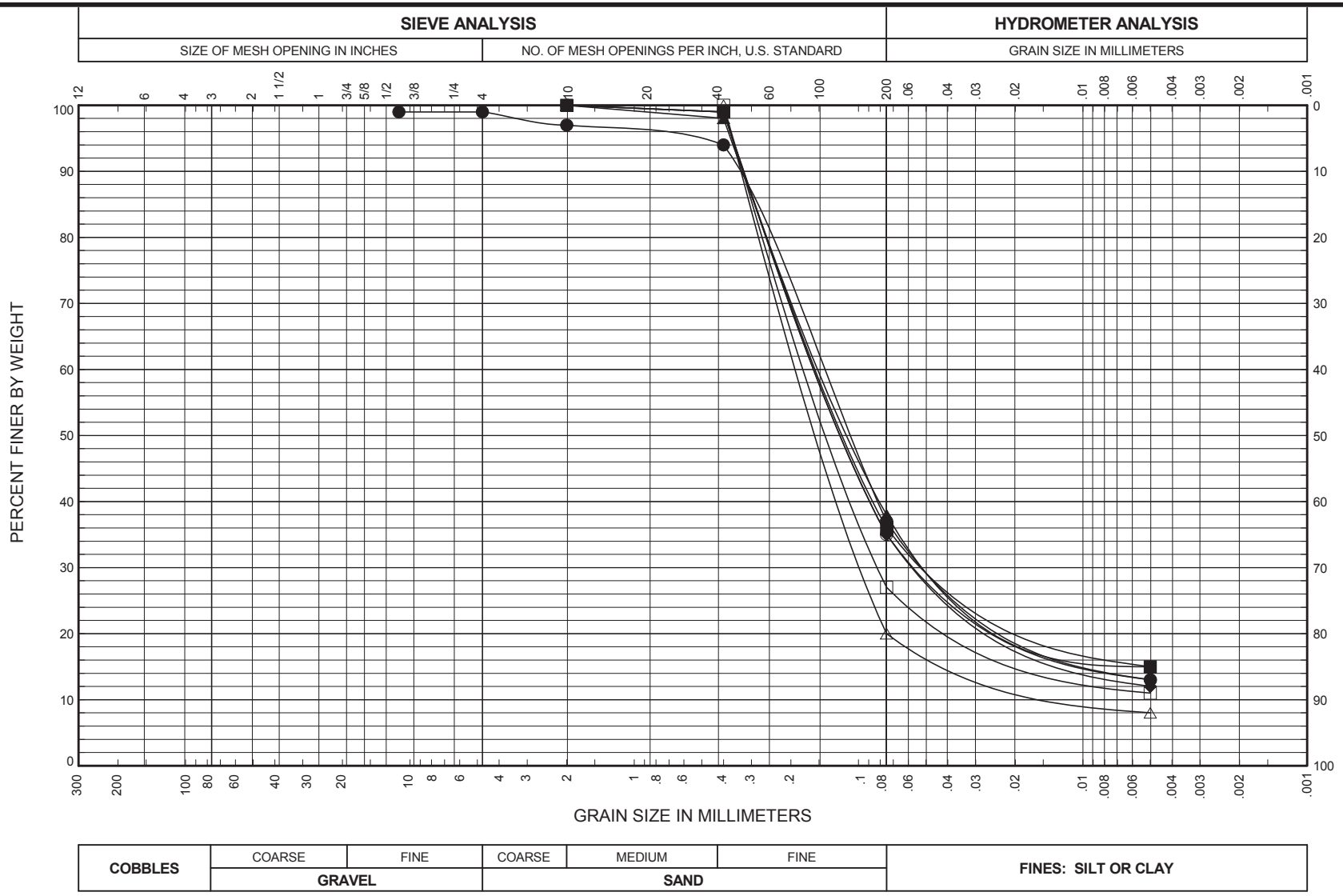

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-1	3.0	SM	Silty Sand	37.0		NP	NP	NP
■ SW-01, S-2	5.0	SM	Silty Sand	36.0	12.7	NP	NP	NP
▲ SW-01, S-4	9.0	SM	Silty Sand	38.0	14.8	NP	NP	NP
◆ SW-01, S-6	13.0	SM	Silty Sand	35.0	10.3	NP	NP	NP
○ SW-01, S-7	15.0	SM	Silty Sand	35.0		NP	NP	NP
□ SW-01, S-8	17.0	SM	Silty Sand	27.0	7.5	NP	NP	NP
△ SW-01, S-10	21.0	SM	Silty Sand	20.0	5.3	NP	NP	NP

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GRAIN SIZE DISTRIBUTION
BORING SW-01

June 2014 23-1-01400-001

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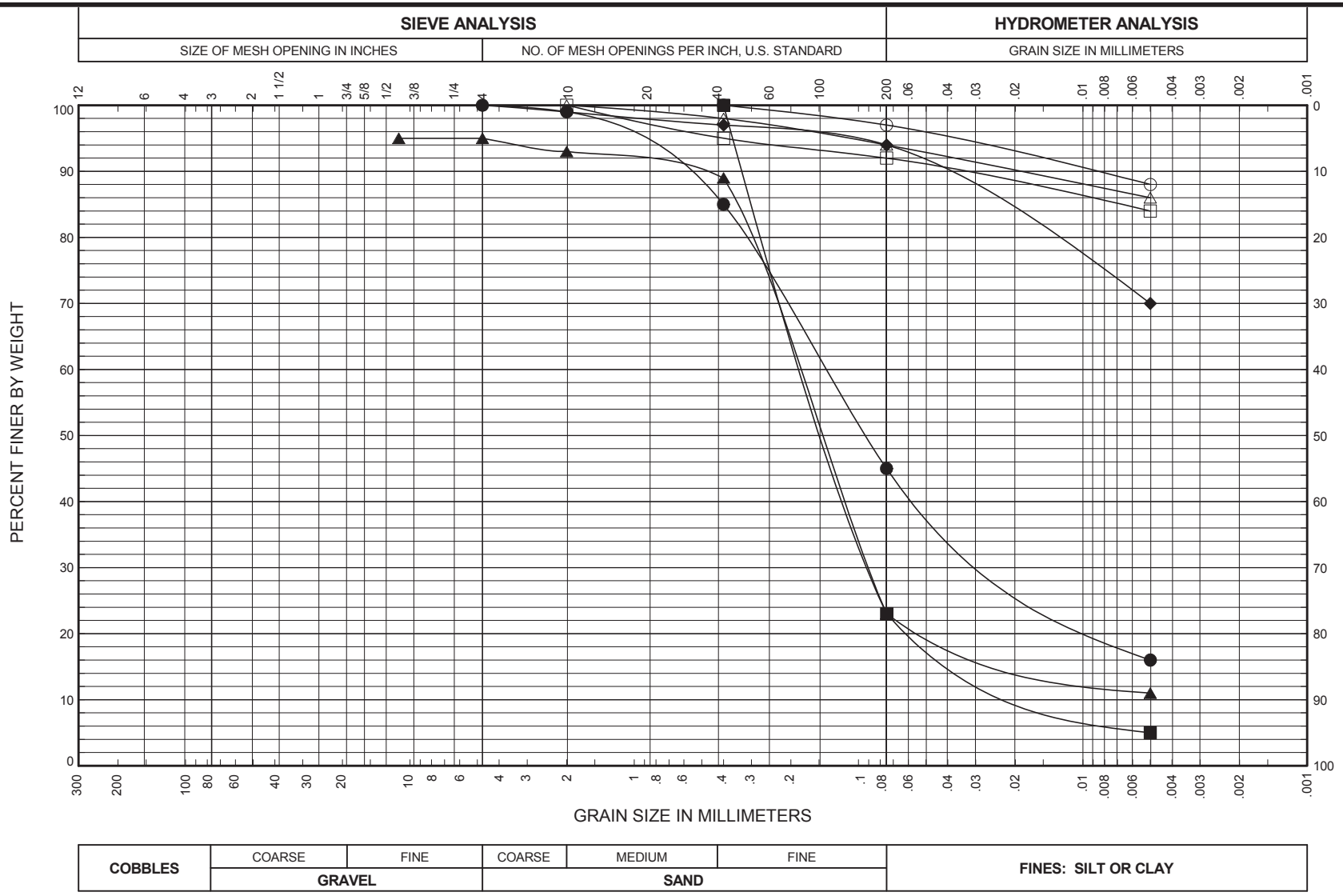
FIG. A-7
Sheet 1 of 9

FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-12	24.1	SM	Silty Sand	45.0	3.4	NP	NP	NP
■ SW-01, S-13	27.0	SM	Silty Sand	23.0	7.7	NP	NP	NP
▲ SW-01, S-15	30.4	SM	Silty Sand	23.0	13.8	NP	NP	NP
◆ SW-01, S-15	31.4	CH	Fat Clay	94.0	24.9	65	24	41
○ SW-01, S-16	32.5	CH	Fat Clay	97.0		73	29	44
□ SW-01, S-16	33.0	CH	Fat Clay	92.0		78	28	50
△ SW-01, S-16	33.5	CH	Fat Clay	94.0	28.4	74	33	41

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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FIG. A-7
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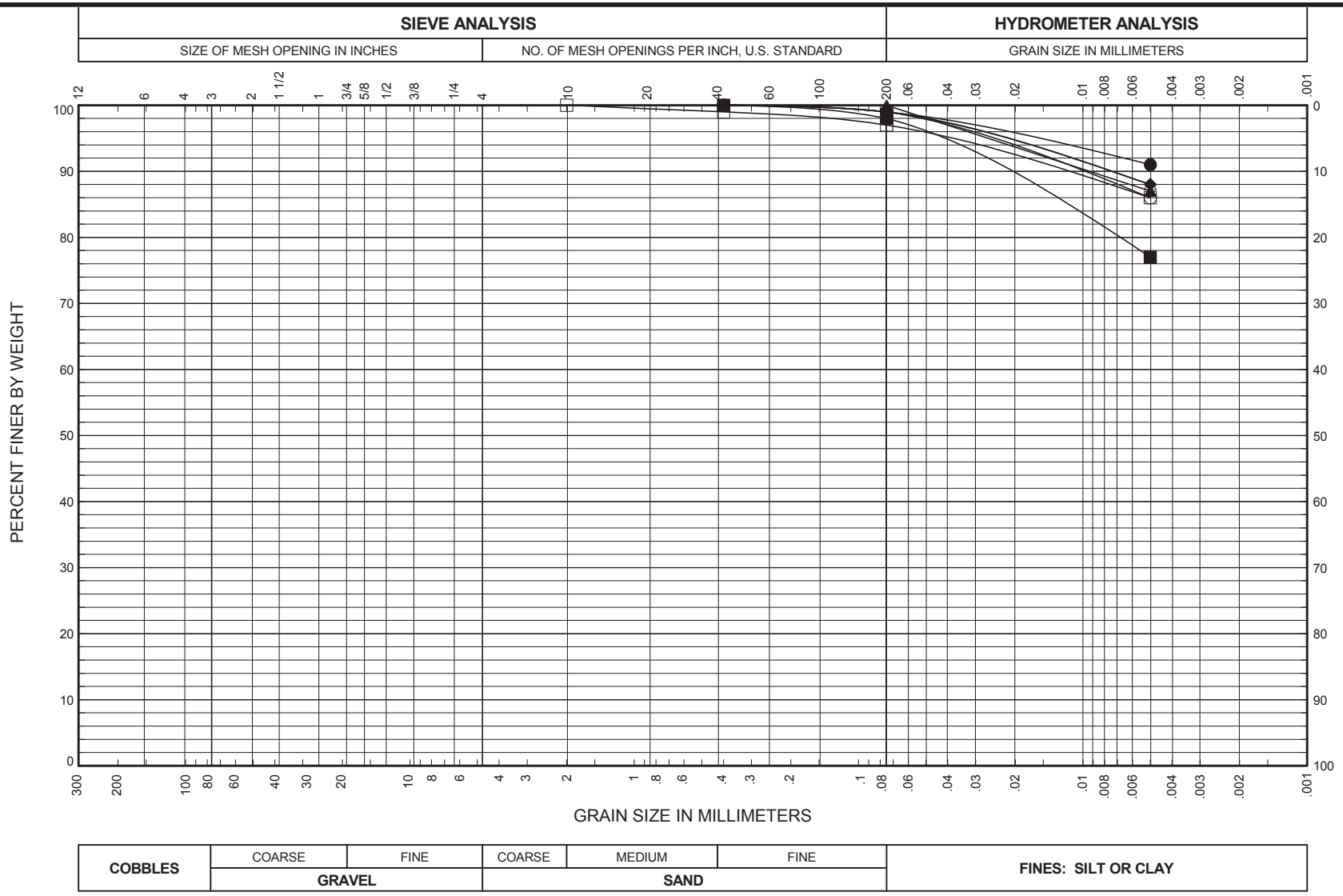
FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-17	35.0	CH	Fat Clay	99.0	28.4	70	31	39
■ SW-01, S-18	36.5	CH	Fat Clay	98.0	30.9	56	27	29
▲ SW-01, S-18	37.0	CH	Fat Clay	100.0		67	27	40
◆ SW-01, S-18	37.5	CH	Fat Clay	99.0		67	28	39
○ SW-01, S-19	39.0	CH	Fat Clay	99.0	28.9	57	25	32
□ SW-01, S-20	40.0	CH	Fat Clay	97.0		72	32	40
△ SW-01, S-20	41.4	CH	Fat Clay	99.0	20.8	53	22	31

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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FIG. A-7
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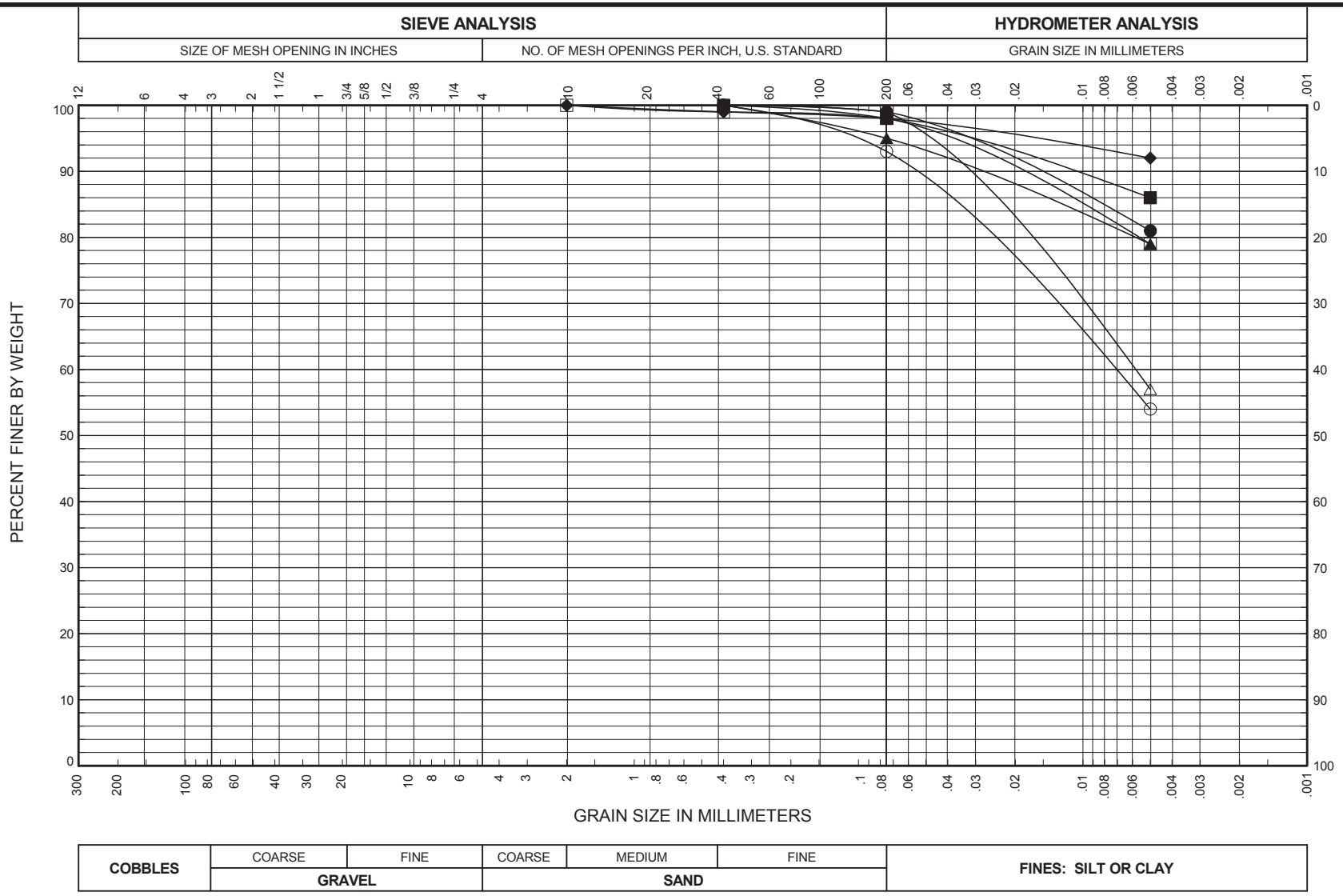
FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-21	42.0	CL	Lean Clay	99.0		46	21	25
■ SW-01, S-21	42.6	CH	Fat Clay	98.0	30.3	68	32	36
▲ SW-01, S-22	45.0	CH	Fat Clay	95.0	23.1	73	23	50
◆ SW-01, S-23	46.3	CH	Fat Clay	98.0		53	26	27
○ SW-01, S-24	47.3	CL	Lean Clay	93.0	16.1	41	20	21
□ SW-01, S-26	49.4	CH	Fat Clay	98.0	24.2	53	25	28
△ SW-01, S-27	51.0	CL	Lean Clay	99.0	16.2	44	22	22

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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FIG. A-7
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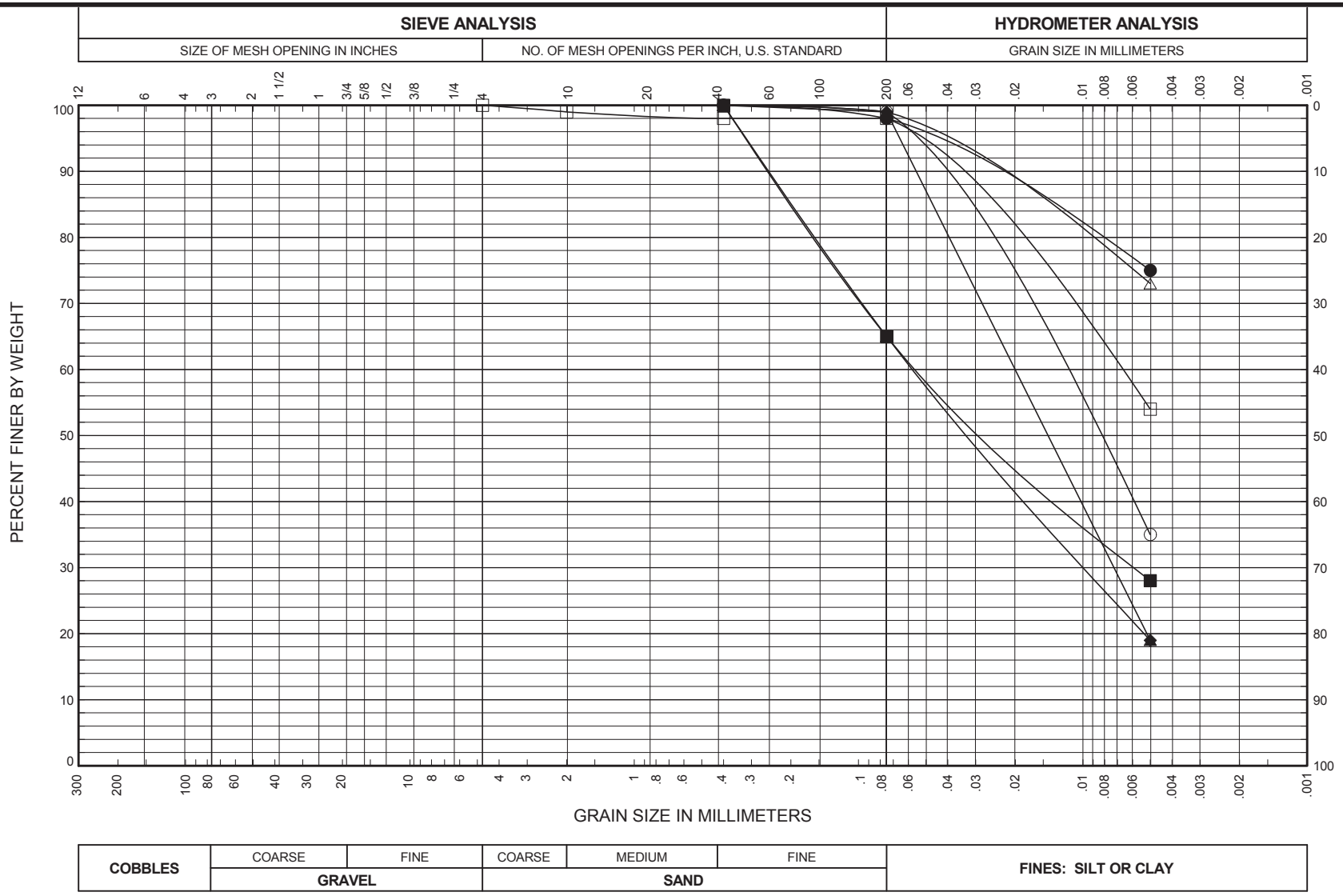
FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-28	53.0	CH	Fat Clay	98.0	20.0	53	20	33
■ SW-01, S-32	56.7	CL	Sandy Lean Clay	65.0	15.7	45	19	26
▲ SW-01, S-32	57.1	ML	Sandy Silt	65.0	26.1	31	23	8
◆ SW-01, S-33	58.5	CL	Lean Clay	99.0	21.6	40	23	17
○ SW-01, S-34	59.8	CL	Lean Clay	99.0	19.7	45	19	26
□ SW-01, S-35	61.0	CL	Lean Clay	98.0	18.3	43	18	25
△ SW-01, S-36	62.6	CH	Fat Clay	99.0		56	22	34

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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FIG. A-7
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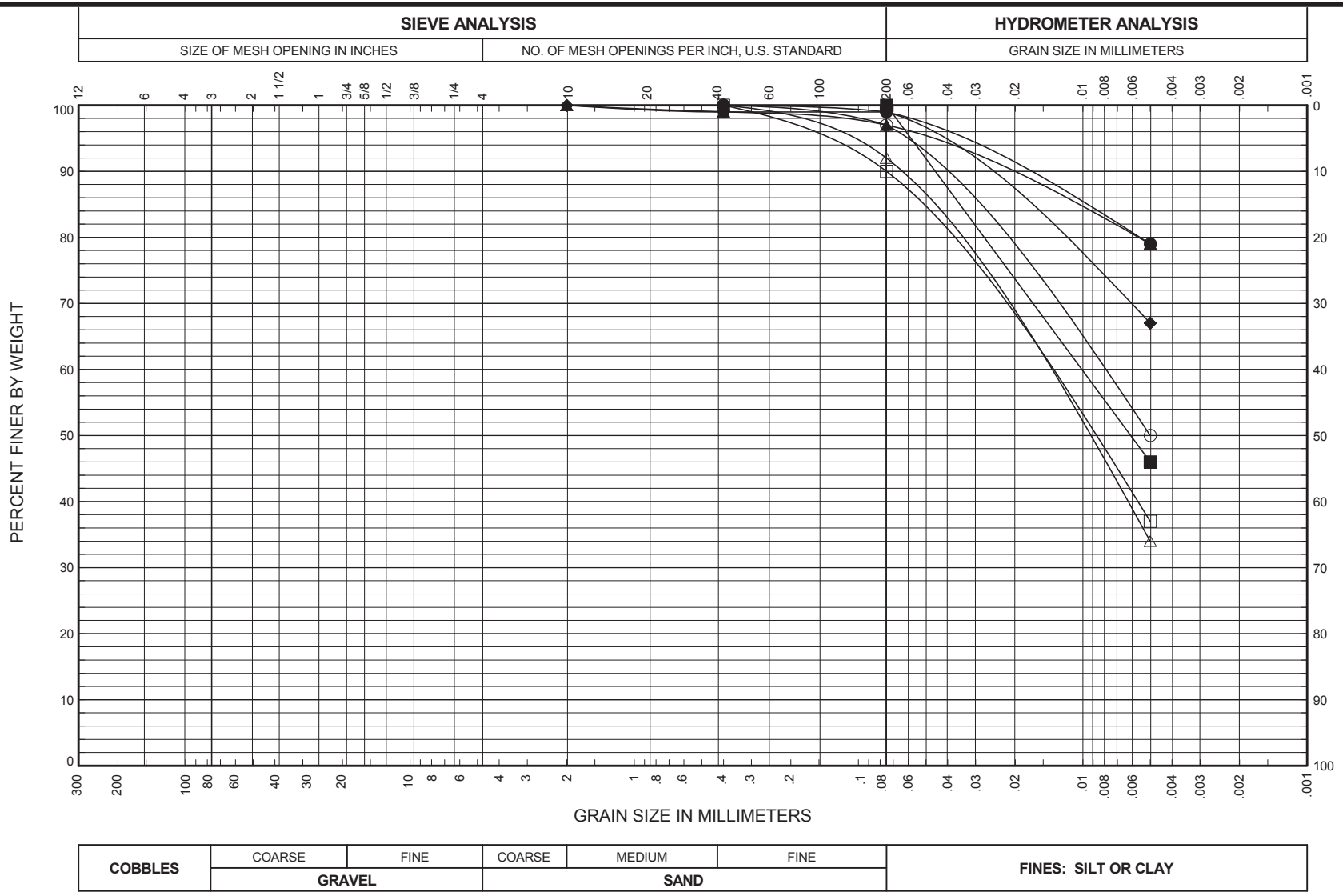
FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-37	64.2	CH	Fat Clay	99.0	21.1	62	21	41
■ SW-01, S-38	65.6	CH	Fat Clay	100.0		55	19	36
▲ SW-01, S-39	66.7	CH	Fat Clay	97.0	21.6	64	24	40
◆ SW-01, S-41	71.0	CH	Fat Clay	99.0	26.7	95	31	64
○ SW-01, S-42	72.5	CH	Fat Clay	97.0		99	35	64
□ SW-01, S-43	73.5	CH	Fat Clay	90.0	26.4	83	31	52
△ SW-01, S-44	75.0	CH	Fat Clay	92.0	19.5	61	24	37

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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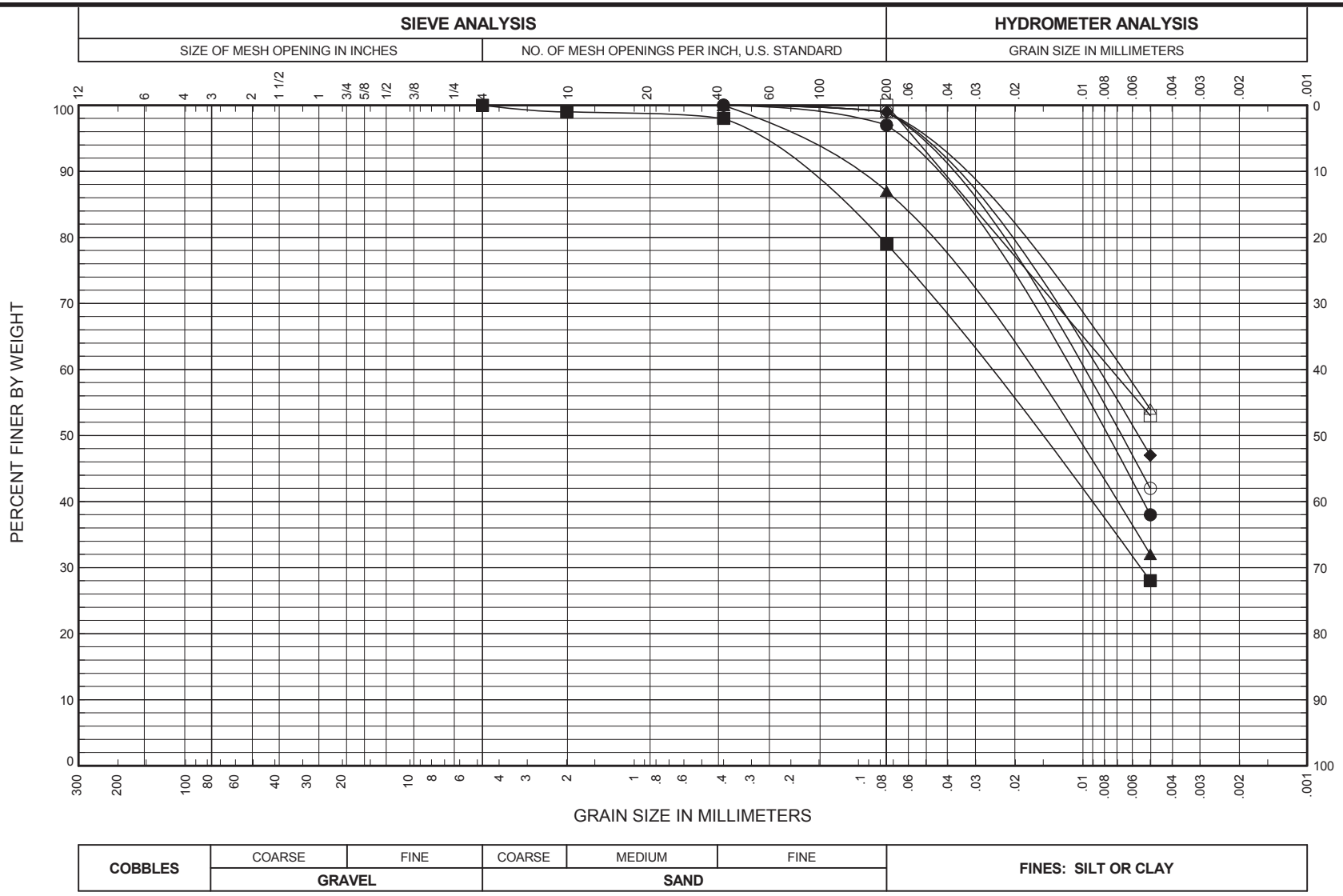
FIG. A-7
Sheet 6 of 9

FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-45	77.0	CH	Fat Clay	97.0	23.9	70	19	51
■ SW-01, S-46	78.7	CH	Fat Clay with Sand	79.0	13.0	79	22	57
▲ SW-01, S-46	79.5	CH	Fat Clay	87.0	22.7	86	23	63
◆ SW-01, S-47	80.6	CH	Fat Clay	99.0		85	22	63
○ SW-01, S-48	81.6	CH	Fat Clay	99.0	22.5	83	24	59
□ SW-01, S-49	83.0	CH	Fat Clay	100.0	23.5	87	24	63
△ SW-01, S-50	85.0	CH	Fat Clay	99.0	23.6	82	25	57

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

June 2014 23-1-01400-001

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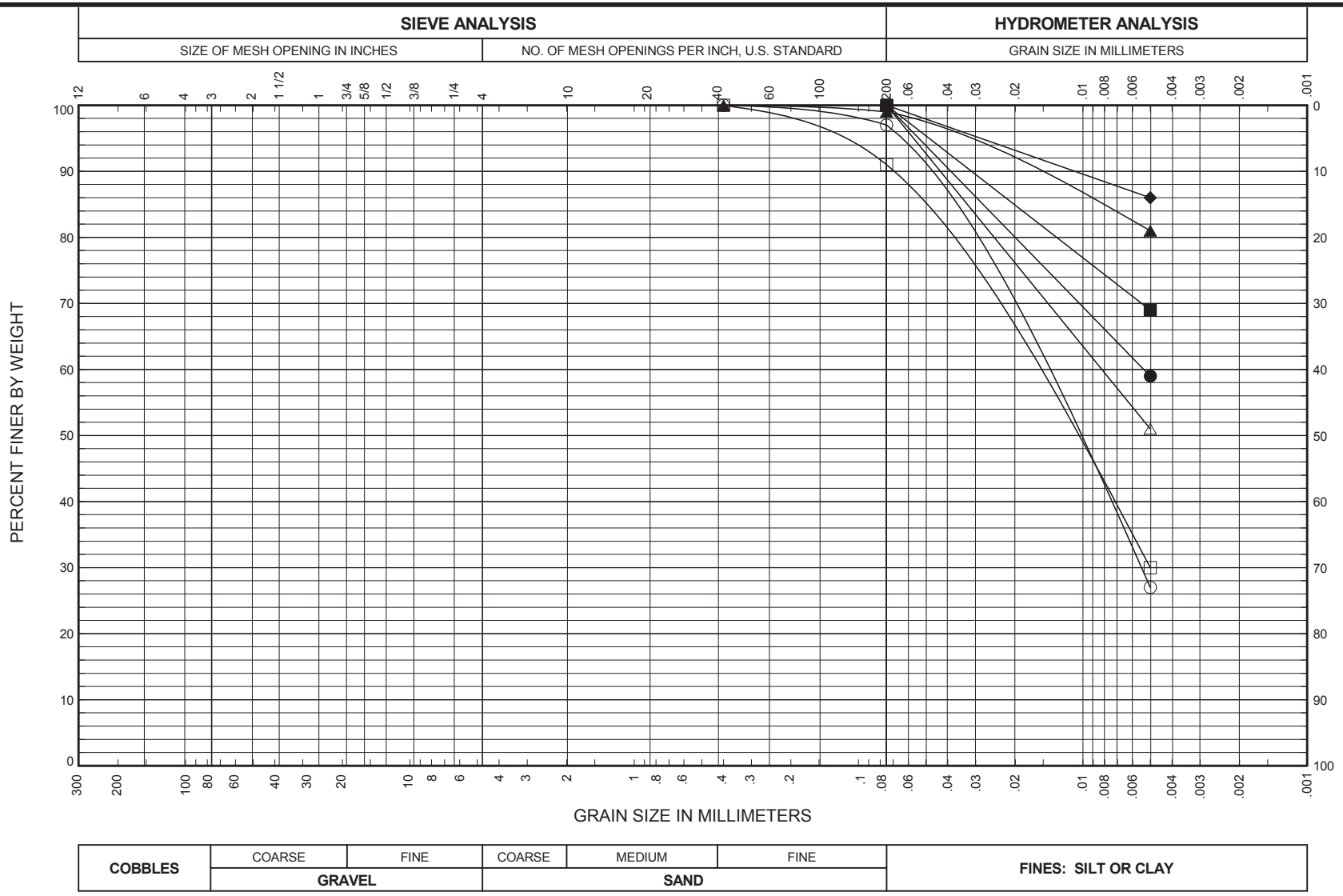
FIG. A-7
Sheet 7 of 9

FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-51	87.0	CH	Fat Clay	100.0	21.4	85	22	63
■ SW-01, S-53	89.5	CH	Fat Clay	100.0	23.4	85	26	59
▲ SW-01, S-54	91.0	CH	Fat Clay	99.0	24.2	87	24	63
◆ SW-01, S-60	101.0	CH	Fat Clay	100.0	24.7	92	33	59
○ SW-01, S-61	102.5	CH	Fat Clay	97.0		91	23	68
□ SW-01, S-62	104.0	CH	Fat Clay	91.0	21.4	92	22	70
△ SW-01, S-64	106.6	CH	Fat Clay	100.0	21.2	88	19	69

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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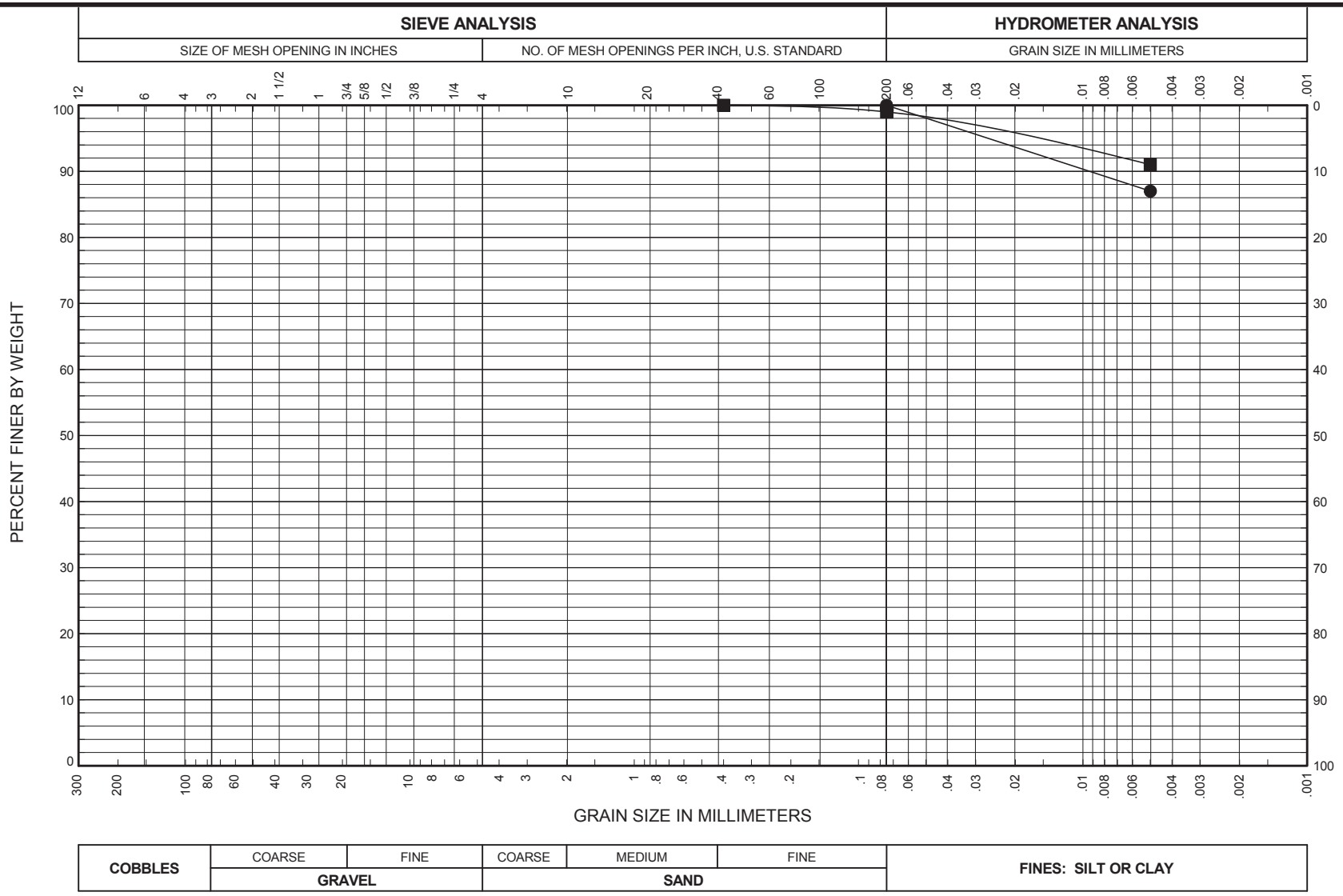
FIG. A-7
Sheet 8 of 9

FIG. A-7



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-65	107.7	CH	Fat Clay	100.0		93	27	66
■ SW-01, S-66	109.0	CH	Fat Clay	99.0	25.6	90	25	65

I-94 Painted Canyon Landslide
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GRAIN SIZE DISTRIBUTION
BORING SW-01

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FIG. A-7
Sheet 9 of 9

FIG. A-7

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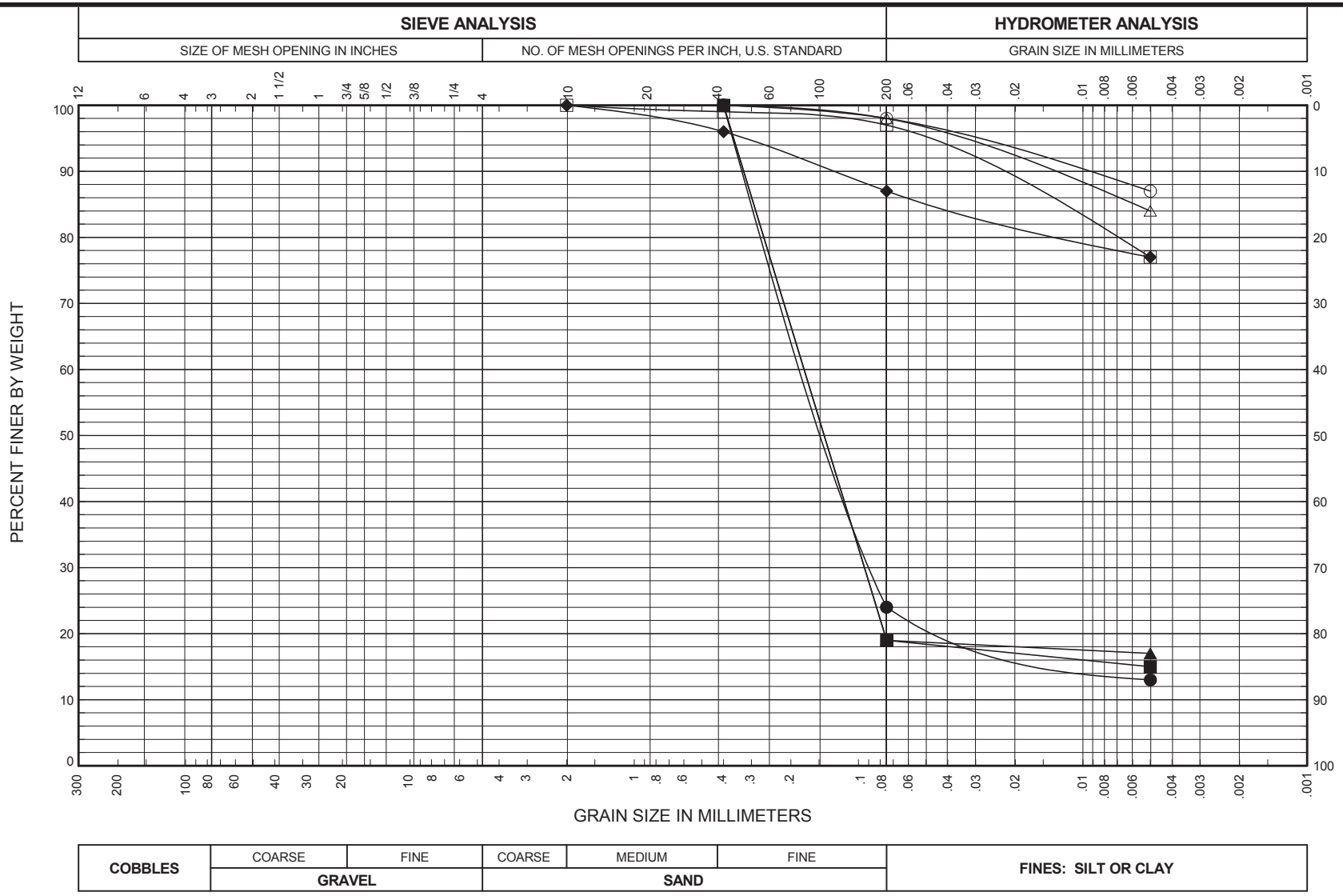

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-1	3.0	SM	Silty Sand	24.0		NP	NP	NP
■ SW-02, S-2	5.0	SM	Silty Sand	19.0	28.4	NP	NP	NP
▲ SW-02, S-3	8.0	SM	Silty Sand	19.0		NP	NP	NP
◆ SW-02, S-4	10.0	CH	Fat Clay	87.0	28.2	56	25	31
○ SW-02, S-5	11.5	CH	Fat Clay	98.0		52	26	26
□ SW-02, S-5	12.5	MH	Elastic Silt	97.0		54	30	24
△ SW-02, S-6	14.0	CH	Fat Clay	98.0	26.4	65	23	42

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GRAIN SIZE DISTRIBUTION
BORING SW-02

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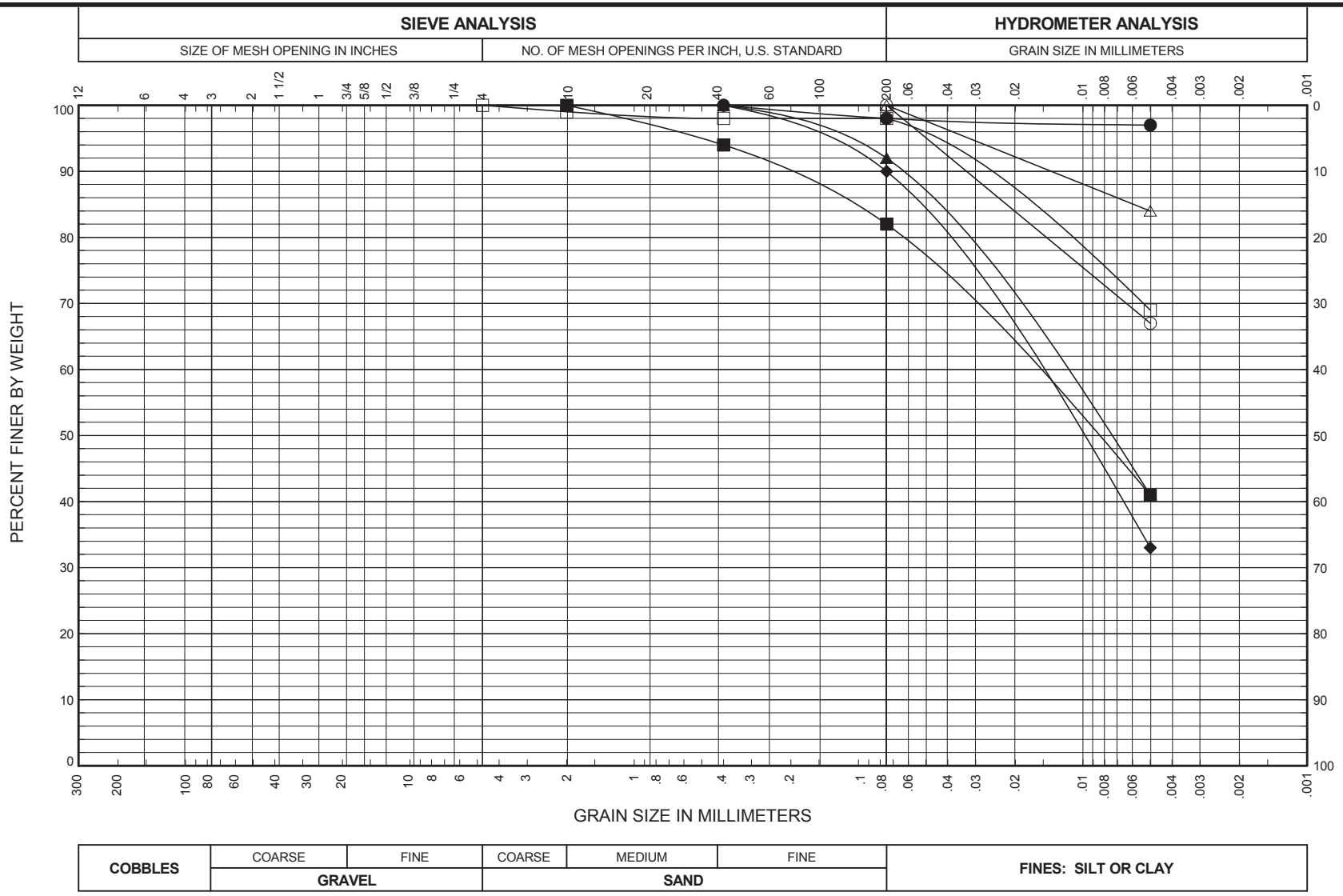
FIG. A-8
Sheet 1 of 7

FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-7	16.0	CH	Fat Clay	98.0	18.0	61	19	42
■ SW-02, S-8	17.1	CL	Lean Clay with Sand	82.0		33	17	16
▲ SW-02, S-9	18.1	CL	Lean Clay	92.0	20.2	36	17	19
◆ SW-02, S-10	19.9	CL	Lean Clay	90.0		37	20	17
○ SW-02, S-11	22.0	CL	Lean Clay	100.0	22.3	47	20	27
□ SW-02, S-12	24.0	CL	Lean Clay	98.0	24.5	48	20	28
△ SW-02, S-13	26.0	MH	Elastic Silt	100.0	20.8	67	38	29

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GRAIN SIZE DISTRIBUTION
BORING SW-02

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FIG. A-8
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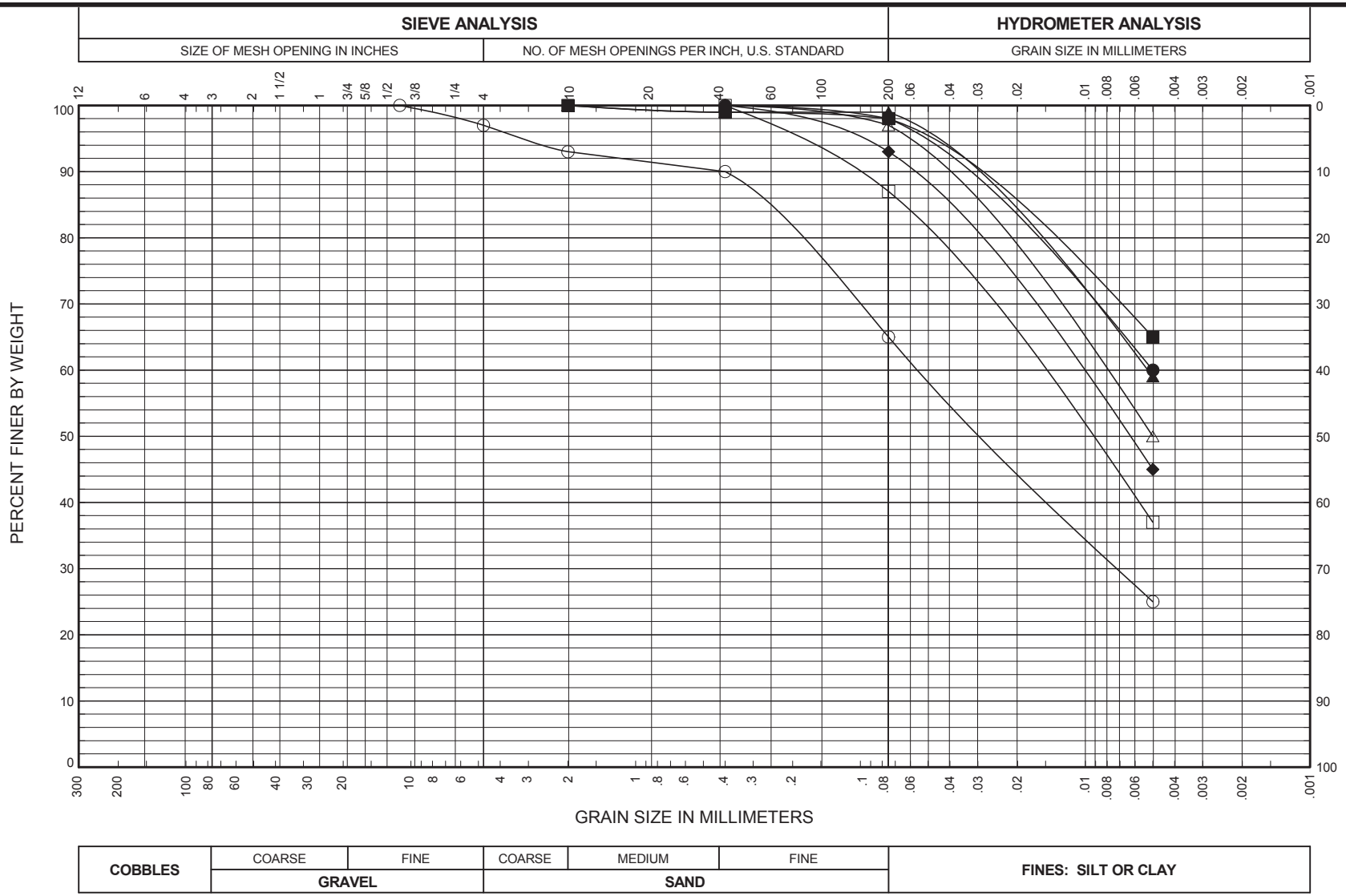
FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-14	28.0	CH	Fat Clay	98.0	19.3	57	20	37
■ SW-02, S-17	32.0	CH	Fat Clay	98.0	23.8	69	23	46
▲ SW-02, S-18	34.0	CH	Fat Clay	99.0		99	29	70
◆ SW-02, S-19	36.0	CH	Fat Clay	93.0	23.2	79	22	57
○ SW-02, S-20	38.0	CH	Sandy Fat Clay	65.0		53	23	30
□ SW-02, S-21	39.8	CH	Fat Clay	87.0	23.4	93	23	70
△ SW-02, S-21	40.8	CH	Fat Clay	97.0	25.1			

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GRAIN SIZE DISTRIBUTION
BORING SW-02

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FIG. A-8
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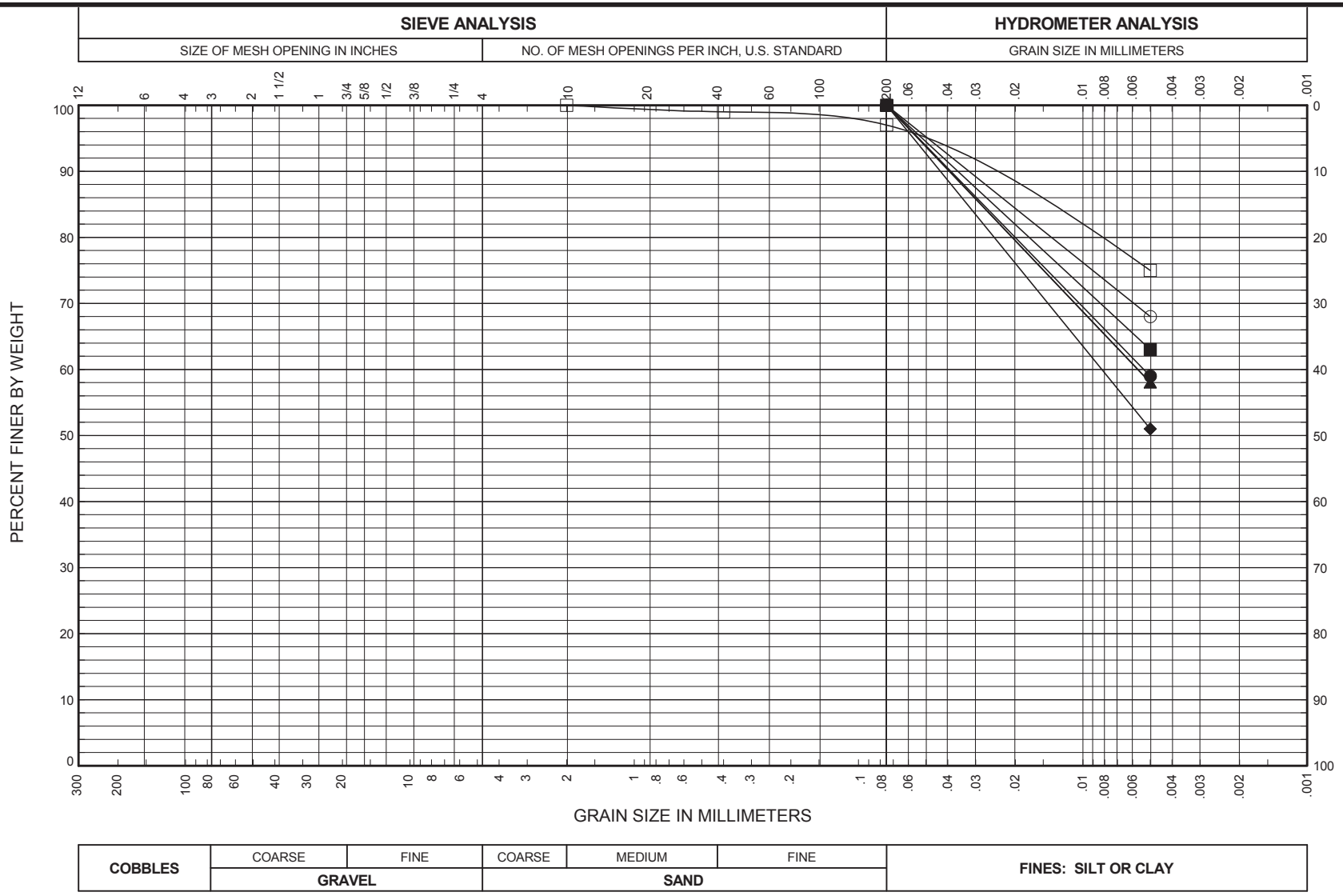
FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-23	44.0	CH	Fat Clay	100.0	24.3	82	24	58
■ SW-02, S-24	45.5	CH	Fat Clay	100.0		84	25	59
▲ SW-02, S-24	46.5	CH	Fat Clay	100.0		85	25	60
◆ SW-02, S-25	48.0	CH	Fat Clay	100.0	25.3	85	26	59
○ SW-02, S-26	49.5	CH	Fat Clay	100.0		86	28	58
□ SW-02, S-26	50.4	CH	Fat Clay	97.0		87	31	56
△ SW-02, S-32	61.0	CH	Fat Clay	100.0	20.3	77	30	47

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

GRAIN SIZE DISTRIBUTION
BORING SW-02

June 2014 23-1-01400-001

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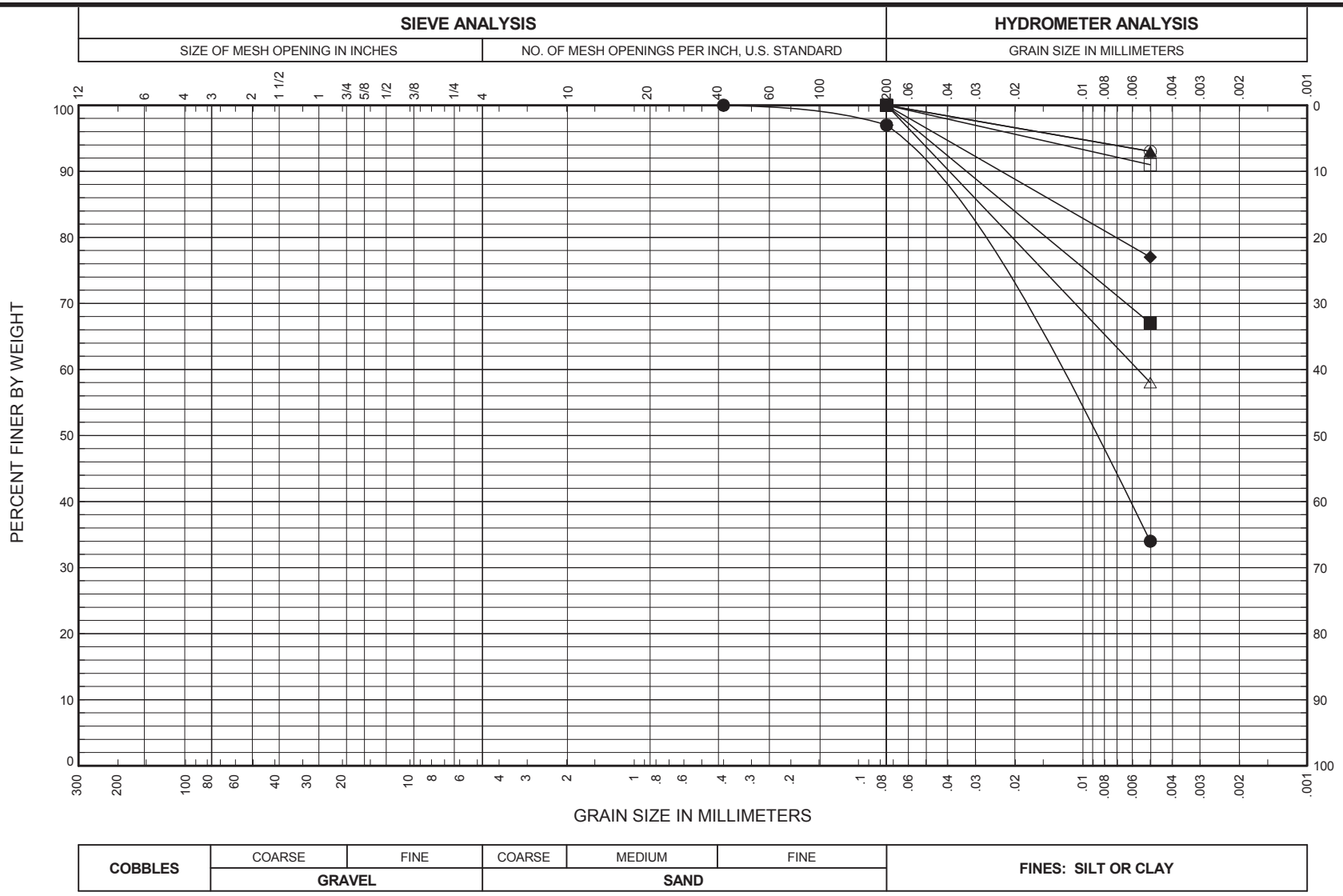
FIG. A-8
Sheet 4 of 7

FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-34	63.7	CH	Fat Clay	97.0	20.1	96	20	76
■ SW-02, S-36	66.5	CH	Fat Clay	100.0	21.8	97	27	70
▲ SW-02, S-37	68.0	CH	Fat Clay	100.0		86	20	66
◆ SW-02, S-38	69.4	CH	Fat Clay	100.0	23.0	87	21	66
○ SW-02, S-39	70.8	CH	Fat Clay	100.0		96	29	67
□ SW-02, S-40	72.1	CH	Fat Clay	100.0	23.4	98	23	75
△ SW-02, S-41	73.4	CH	Fat Clay	100.0		85	24	61

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

GRAIN SIZE DISTRIBUTION
BORING SW-02

June 2014 23-1-01400-001

SHANNON & WILSON, INC.
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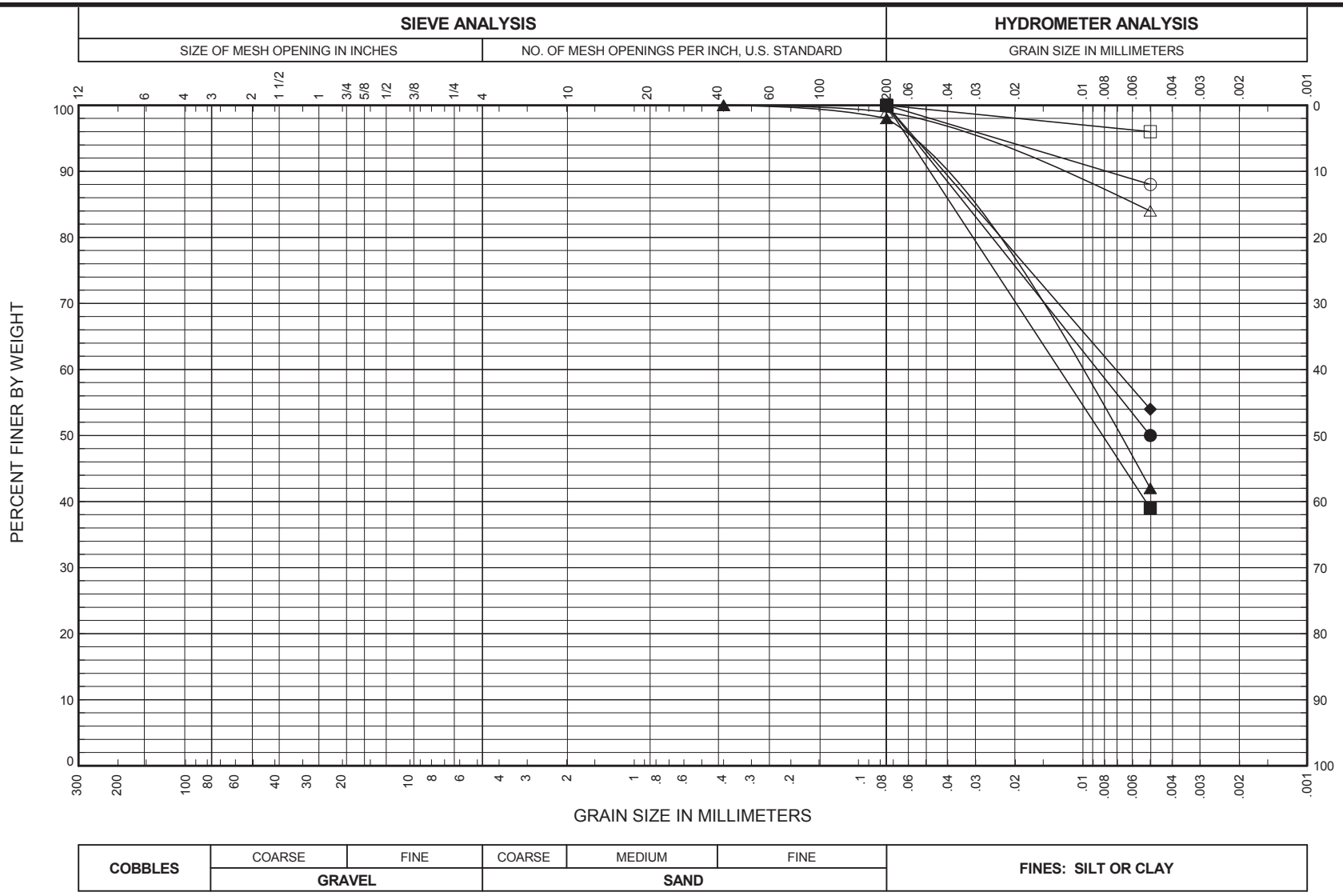
FIG. A-8
Sheet 5 of 7

FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-42	74.7	CH	Fat Clay	100.0	20.6	85	19	66
■ SW-02, S-43	76.4	CH	Fat Clay	100.0		88	22	66
▲ SW-02, S-44	77.8	CH	Fat Clay	98.0	21.9	88	19	69
◆ SW-02, S-45	79.4	CH	Fat Clay	100.0		87	25	62
○ SW-02, S-46	80.7	CH	Fat Clay	100.0	24.6	104	26	78
□ SW-02, S-47	82.4	CH	Fat Clay	100.0		104	25	79
△ SW-02, S-48	83.7	CH	Fat Clay	99.0	24.4	111	33	78

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

GRAIN SIZE DISTRIBUTION
BORING SW-02

June 2014 23-1-01400-001

SHANNON & WILSON, INC.
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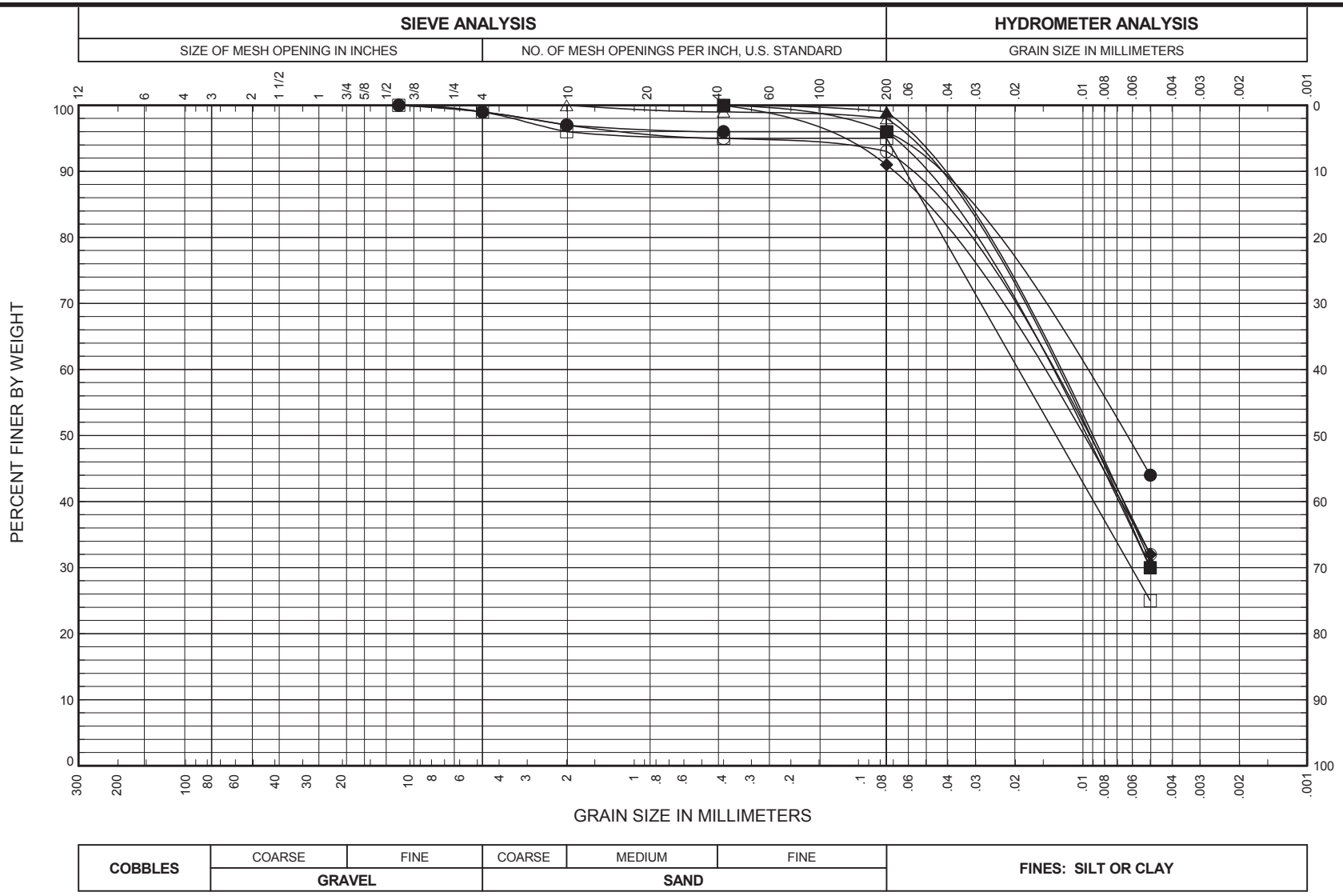
FIG. A-8
Sheet 6 of 7

FIG. A-8



SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-02, S-50	86.1	CH	Fat Clay	96.0	18.2	74	18	56
■ SW-02, S-52	90.0	CH	Fat Clay	96.0	22.0	65	19	46
▲ SW-02, S-53	91.3	CH	Fat Clay	99.0		74	23	51
◆ SW-02, S-54	92.6	CH	Fat Clay	91.0	21.2	63	17	46
○ SW-02, S-56	96.0	CH	Fat Clay	93.0	23.3	63	19	44
□ SW-02, S-57	97.3	CH	Fat Clay	95.0		62	23	39
△ SW-02, S-58	98.6	CH	Fat Clay	98.0	24.4	66	21	45

I-94 Painted Canyon Landslide
Project No. SER-5-094 (107), 030, PCN 20549
Billings County, North Dakota

GRAIN SIZE DISTRIBUTION
BORING SW-02

June 2014 23-1-01400-001

SHANNON & WILSON, INC.
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FIG. A-8
Sheet 7 of 7

FIG. A-8

APPENDIX B

NDDOT FIELD EXPLORATIONS AND LABORATORY TEST RESULTS

APPENDIX B

NDDOT FIELD EXPLORATIONS AND LABORATORY TEST RESULTS

FIGURES

FIGURES CONTINUED

REFERENCES

NDDOT, 2013, Geotechnical Boring Logs and Supplemental Geotechnical Laboratory Data, Borings 10, 11, 12, & 13, provided to Shannon & Wilson on November 20, 2011.

NDDOT, 2012, Job# 1, North Dakota Department of Transportation, SIM-SER-5-094(093)031, FHWA Full Involvement, Billings County, RP 31 Permanent Slide Repair, Pipe Installation, Mill & Overlay, and Guardrail, PCN 19467, Section 175, Sheets 2 through 4 (logs of Borings 2, 3, 5, 6, & 8), dated March 23.

NDDOT, 2011, Supplemental Geotechnical Laboratory Data, Borings 2, 3, 5, 6, & 8, provided to Shannon & Wilson on November 14, 2011.

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	SIM-SER-5-094(093)031	175	2

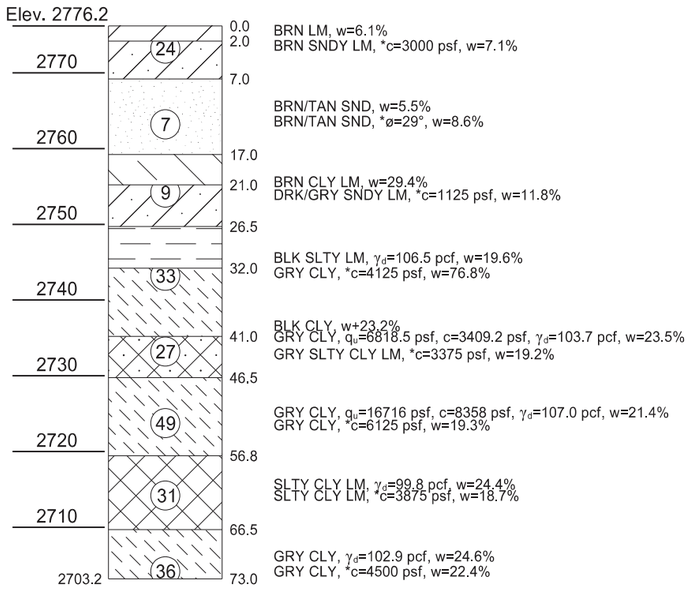
Notes:

THE ENCIRCLED NUMBERS INDICATE THE NUMBER OF BLOWS DELIVERED BY A 140 POUND AUTOMATIC HAMMER FROM A HEIGHT OF 30 INCHES TO DRIVE A 2 INCH O.D. SPLIT-BARREL SAMPLER 1 FOOT.

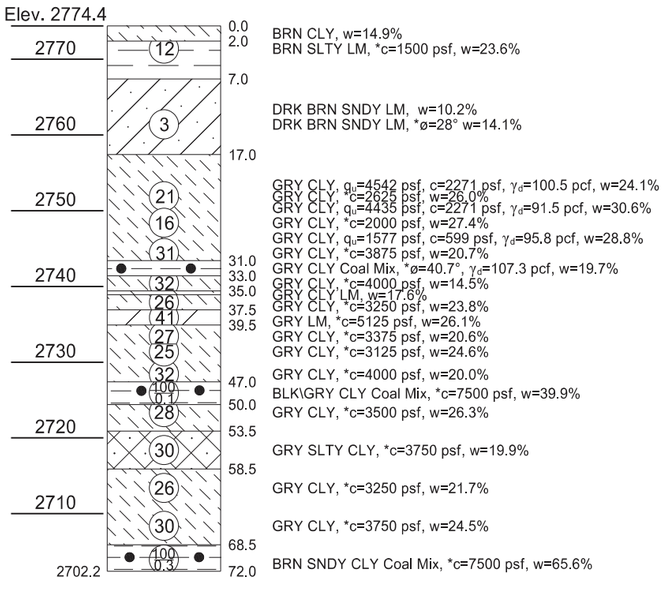
THE BORING DATA SHOWN IS FOR NORTH DAKOTA DEPARTMENT OF TRANSPORTATION'S (NDDOT) DESIGN AND ESTIMATING PURPOSES ONLY. THE BORING LOGS ARE ONLY REPRESENTATIVE OF THE EXACT LOCATION FROM WHICH THE SAMPLES WERE TAKEN AND INTERPRETATION BETWEEN THE SAMPLE LOCATIONS IS DISCOURAGED. THE NDDOT ASSUMES NO RESPONSIBILITY IF THE SOIL CONDITIONS ENCOUNTERED DURING CONSTRUCTION DIFFER FROM THOSE SHOWN. FURTHER SOIL INFORMATION MAY BE AVAILABLE AT:

NDDOT
MATERIALS & RESEARCH DIVISION
300 AIRPORT ROAD
BISMARCK, NORTH DAKOTA 58504-6005
PHONE (701)328-6900

q_u=Unconfined Compressive Strength (psf)
w=Moisture Content (%)
ø=Friction Angle (deg)
c=Cohesion (psf)
γ_d=Dry Density (pcf)
*=These cohesive values and friction angles are estimated from blow counts



Painted Canyon Boring #2 Station 432+89 - 142' LT
Drilled on 7/28/2008 to 7/29/2008



Painted Canyon Boring #3 Station 435+09- 195' LT
Drilled on 7/10/2010

This document was originally issued and sealed by Jeff Jirava, Registration Number PE- 5950, on 3/23/2012 and the original document is stored at the North Dakota Department of Transportation

Painted Canyon

Boring Logs

FIG. B-1

Boring #2 STA 432+89 (Median Centerline) 142’ Lt Elev = 2776.15 ft

Depth (ft.)	Textural Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (psf)	Blowcount (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	Brn Lm	3TW	M					6.1	
2.0-4.0	Brn Sndy Lm	SS	SPT			3000*	24	7.1	
10.0-12.0	Brn/Tan Snd	3TW	M					5.5	
12.0-14.0	Brn/Tan Snd	SS	SPT			29*	7	8.6	
20.0-21.0	Brn Cly Lm	3TW	M					29.4	
21.0-23.0	DrkGry Snd Lm	SS	SPT			1125*	9	11.8	
30.0-32.0	Blk Slty Lm	3TW	D					19.6	110.7
32.0-34.0	Gry Cly	SS	SPT			4125*	33	76.8	
40.0	Blk Cly	-	M					23.2	
40.0-41.0	Gry Cly	3TW	UC	6818.5		3409.2		23.5	103.7
41.0-43.0	Gry Slty Cly Lm	SS	SPT			3375*	27	19.2	
50.0-51.5	Gry Cly	3TW	UC	16716		8358		21.4	107.0
51.5-53.5	Gry Cly	SS	SPT			6125*	49	19.3	
60.0-61.0	Slty Cly Lm	3TW	D					24.4	99.8
61.0-63.0	Slty Cly Lm	SS	SPT			3875*	31	18.7	
70.0-71.0	Gry Cly	3TW	D					24.6	102.9
71.0-73.0	Gry Cly	SS	SPT			4500*	36	22.4	

SS - Split Spoon
3TW - 3" Thin Wall (Shelby tube)
M - Moisture Test
D - Density Test
UC - Unconfined Compression Test
UU - Unconsolidated Undrained Test
SPT- Standard Penetration Test

*Friction and Cohesive values are estimated from the blowcounts. These values are used in absence of triaxial strength testing information.
**Cores have been divided into samples < 2 feet in length due to different textural classes.

FIG. B-2

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-36-2008	**Date Reported**	10/14/2008	**Boring Number**	2
County	Billings	**Submitted By**	Naumann	**Project Number**	Painted Canyon
District	Dickinson	**Structure Location**		**PCN**	

Comments

Lab Number	520	521	522	523
Reference Point + Ft	31+3628	31+3628	31+3628	31+3628
Distance From CenterLine (Ft.)	104' Lt WB	104' Lt WB	104' Lt WB	104' Lt WB
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	10.0 - 12.0	12.0 - 14.0
Field Sample No.	520	521	522	523
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	1	1	0	0
% Fine Sand (-No. 40 + No. 200)	46	61	83	83
% Silt (0.074 - 0.005 mm)	38	25	14	13
% Clay (-0.005 mm)	14	13	3	4
Liquid Limit (-No. 40)	23	0	0	0
Plasticity Index (-No. 40)	3	0	0	0
Plastic Limit	20	0	0	0
Soil Color	BRN	BRN	BRN/TAN	BRN/TAN
Textural Class	LM	SNDY LM	SND	SND
Soil Class (AASHTO M-145)	A-4(0)	A-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F4	F3	F2	F2
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	6.1	7.1	5.5	8.6

FIG. B-3
Sheet 1 of 5

FIG. B-3
Sheet 1 of 5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-36-2008	**Date Reported**	10/14/2008	**Boring Number**	2
County	Billings	**Submitted By**	Naumann	**Project Number**	Painted Canyon
District	Dickinson	**Structure Location**		**PCN**	

Comments

Lab Number	524	525	526	527
Reference Point + Ft	31+3628	31+3628	31+3628	31+3628
Distance From CenterLine (Ft.)	104' Lt WB	104' Lt WB	104' Lt WB	104' Lt WB
Depth, Ft.	20.0 - 21.0	21.0 - 23.0	30.0 - 32.0	32.0 - 34.0
Field Sample No.	524	525	526	527
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	88	100	100
% Pass. No. 10 Sieve	100	81	100	100
% Coarse Sand (-No. 10 + No.40)	0	8	0	2
% Fine Sand (-No. 40 + No. 200)	41	52	5	11
% Silt (0.074 - 0.005 mm)	37	16	76	37
% Clay (-0.005 mm)	21	6	19	50
Liquid Limit (-No. 40)	27	0	33	47
Plasticity Index (-No. 40)	5	0	10	22
Plastic Limit	22	0	23	25
Soil Color	BRN	DRK/GRY	BLK	GRAY
Textural Class	CLY LM	SNDY LM	SLTY LM	CLY
Soil Class (AASHTO M-145)	A-4(1)	A-2-4(0)	A-4(10)	A-7-6(21)
Frost Class	F4	F2	F4	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	29.4	11.8	19.6	76.8

FIG. B-3
Sheet 2 of 5

FIG. B-3
Sheet 2 of 5

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Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-36-2008	**Date Reported**	10/14/2008	**Boring Number**	2
County	Billings	**Submitted By**	Naumann	**Project Number**	Painted Canyon
District	Dickinson	**Structure Location**		**PCN**	

Comments

Lab Number	528	529	530	531
Reference Point + Ft	31+3628	31+3628	31+3628	31+3628
Distance From CenterLine (Ft.)	104' Lt WB	104' Lt WB	104' Lt WB	104' Lt WB
Depth, Ft.	-	40.0 - 41.0	41.0 - 43.0	50.0 - 51.5
Field Sample No.	528	529	530	531
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	1	1	0
% Fine Sand (-No. 40 + No. 200)	1	1	26	1
% Silt (0.074 - 0.005 mm)	13	18	51	18
% Clay (-0.005 mm)	86	80	23	82
Liquid Limit (-No. 40)	66	77	32	74
Plasticity Index (-No. 40)	43	50	12	50
Plastic Limit	23	26	20	24
Soil Color	BLK	GRAY	GRAY	GRAY
Textural Class	CLY	CLY	SLTY CLY LM	CLY
Soil Class (AASHTO M-145)	A-7-6(49)	A-7-6(58)	A-6(8)	A-7-6(58)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	23.2	23.5	19.2	21.4

FIG. B-3
Sheet 3 of 5

FIG. B-3
Sheet 3 of 5

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-36-2008	**Date Reported**	10/14/2008	**Boring Number**	2
County	Billings	**Submitted By**	Naumann	**Project Number**	Painted Canyon
District	Dickinson	**Structure Location**		**PCN**	

Comments

Lab Number	532	533	534	535
Reference Point + Ft	31+3628	31+3628	31+3628	31+3628
Distance From CenterLine (Ft.)	104' Lt WB	104' Lt WB	104' Lt WB	104' Lt WB
Depth, Ft.	51.5 - 53.5	60.0 - 61.0	61.0 - 63.0	70.0 - 71.0
Field Sample No.	532	533	534	535
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	1	16	10	10
% Silt (0.074 - 0.005 mm)	26	56	62	38
% Clay (-0.005 mm)	73	28	28	52
Liquid Limit (-No. 40)	59	61	55	48
Plasticity Index (-No. 40)	37	35	34	31
Plastic Limit	22	26	20	17
Soil Color	GRAY	GRY	GRY	GRY
Textural Class	CLY	SLTY CLY LM	SLTY CLY LM	CLY
Soil Class (AASHTO M-145)	A-7-6(42)	A-7-6(32)	A-7-6(33)	A-7-6(29)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	19.3	24.4	18.7	24.6

FIG. B-3
Sheet 4 of 5

FIG. B-3
Sheet 4 of 5

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Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-36-2008	**Date Reported**	10/14/2008	**Boring Number**	2
County	Billings	**Submitted By**	Naumann	**Project Number**	Painted Canyon
District	Dickinson	**Structure Location**		**PCN**	

Comments

Lab Number	535.1	536
Reference Point + Ft	31+3628	31+3628
Distance From CenterLine (Ft.)	104' Lt WB	104' Lt WB
Depth, Ft.	70.0 - 71.0	71.0 - 73.0
Field Sample No.	535.1	536
% Pass. 3/8" Sieve	100	100
% Pass. No. 4 Sieve	100	100
% Pass. No. 10 Sieve	100	100
% Coarse Sand (-No. 10 + No.40)	0	2
% Fine Sand (-No. 40 + No. 200)	0	1
% Silt (0.074 - 0.005 mm)	40	41
% Clay (-0.005 mm)	60	57
Liquid Limit (-No. 40)	86	78
Plasticity Index (-No. 40)	61	55
Plastic Limit	25	23
Soil Color	GRY	GRY
Textural Class	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(71)	A-7-6(62)
Frost Class	F3	F3
Optimum Moisture (%)		
Maximum Dry Density (pcf)		
Ph of Soil		
% Organic Content		
Pocket Pentrometer		
Depth (Ft.) | Moisture (%)		
Avg. Moisture (%)	24.6	22.4

FIG. B-3
Sheet 5 of 5

FIG. B-3
Sheet 5 of 5

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Testing Lab. Supervisor
Date Printed: 10/24/2011

Torvane Shear Strengths

Boring No. #2 Station 3173628 Offset WB Lt. 104'

Project No. 9100 Date 7-28-09 County Billings

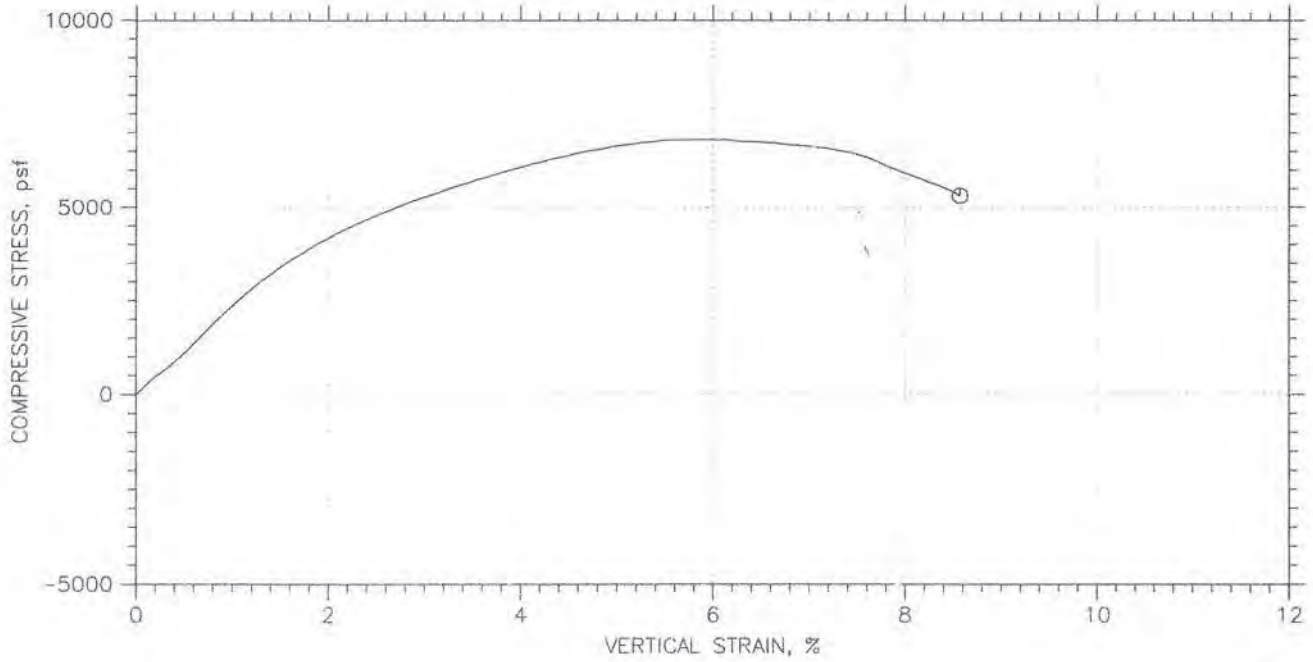
Depth (ft.)	Stress Reading	Factor	Shear Strength (kg/cm^2)	Shear Strength *(lbs/ft^2)
0.0-2.0	Bent Tube			
10.0-12.0	.675	Large		
20.0-22.0	Bent Tube			Bent Tube
30.0-32.0	.40	Sm		
40.0-42.0	Bent Tube			
50.0-52.0	Bent Tube			
60.0-62.0	Bent Tube			
70.0-72.0	Bent Tube			

* kg/cm^2 x 2048 = lbs/ft^2

FIG. B-4

57-9C9-08

UNCONFINED COMPRESSION TEST REPORT



Symbol		⏲			
Test No.		UC-18-08			
Initial	Diameter, in	2.86			
	Height, in	5.18			
	Water Content, %	23.48			
	Dry Density, pcf	103.65			
	Saturation, %	104.38			
	Void Ratio	0.59606			
Unconfined Compressive Strength, psf		6818.5			
Undrained Shear Strength, psf		3409.2			
Time to Failure, min		5.9147			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

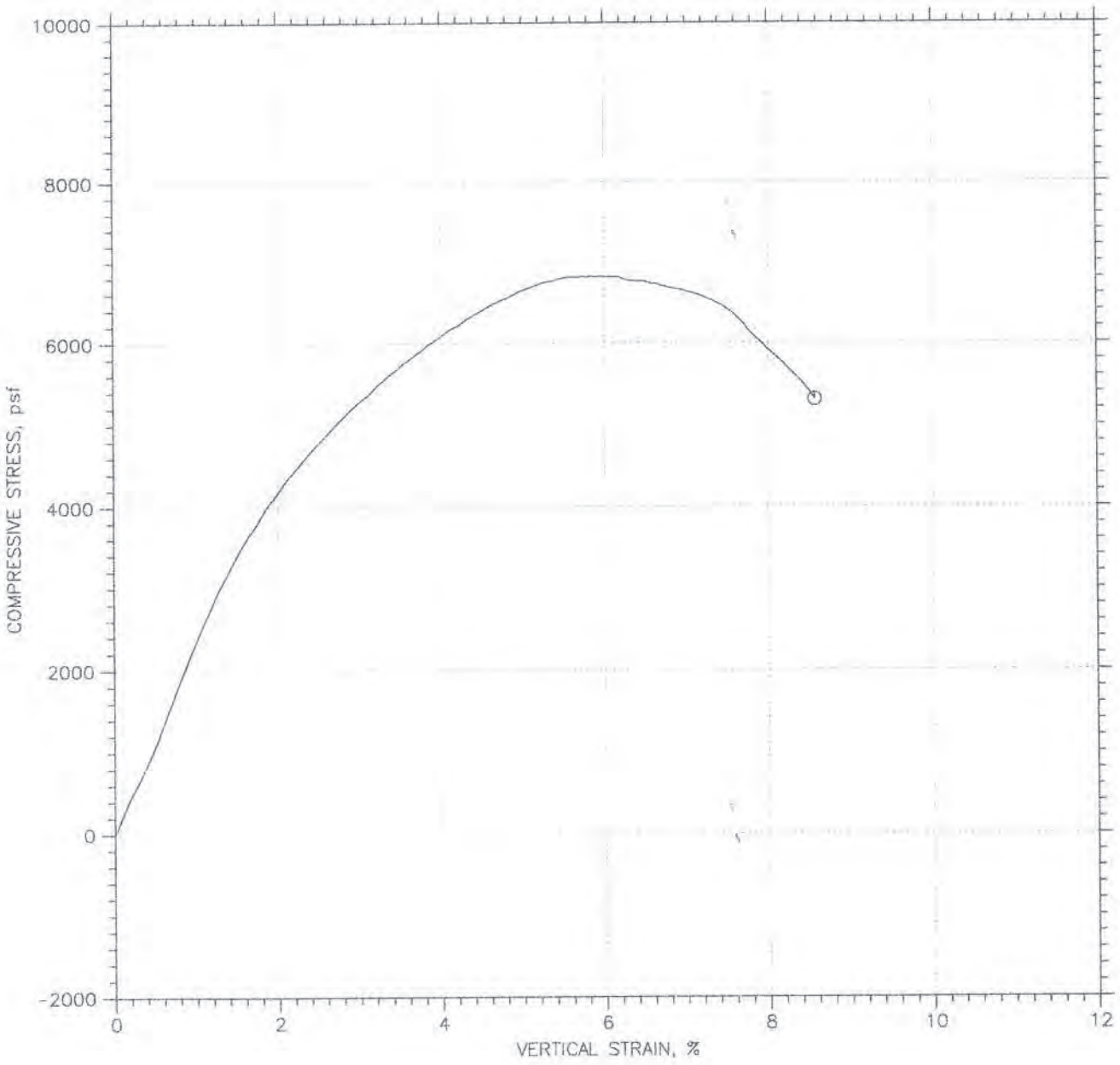
Project: Painted Canyon
Location: 31+3628
Project No.:
Boring No.: 2
Sample Type: Shelby Tube
Description: Total Length 11.5" GRY Clay. Specimen short on length
Remarks:

Tue, 07-OCT-2008 07:41:43

FIG. B-5

SS-529-08

UNCONFINED COMPRESSION TEST REPORT



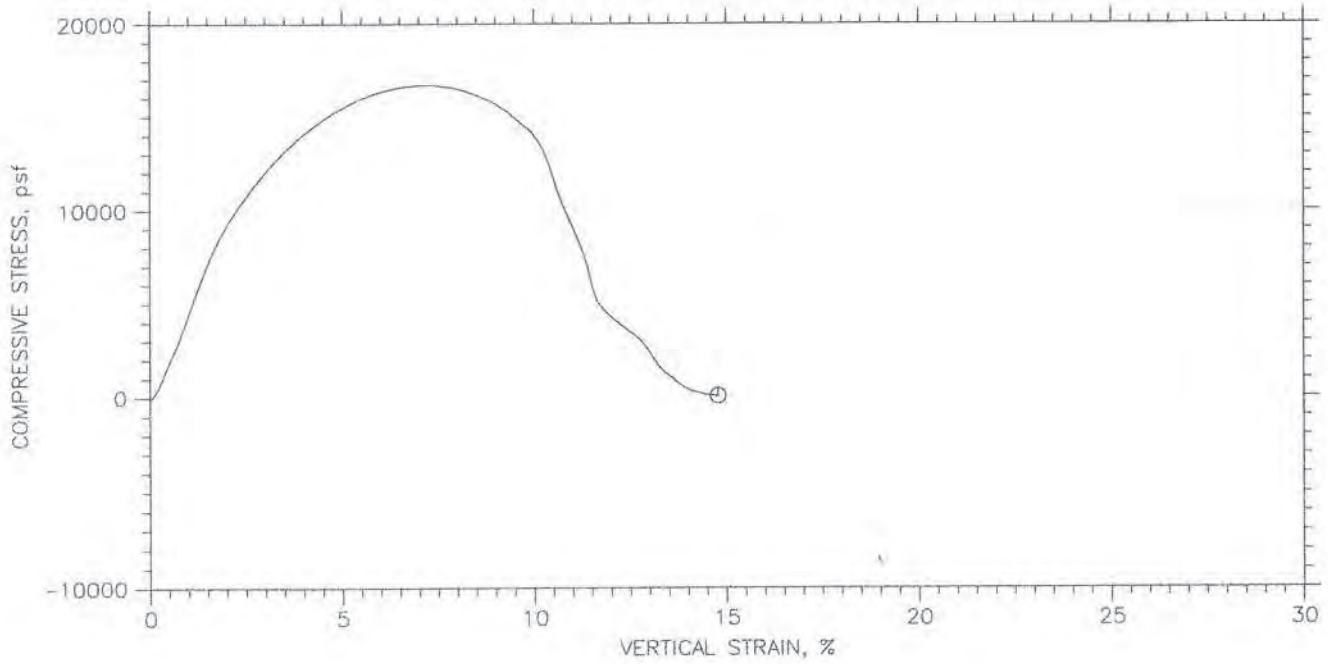
Project: Painted Canyon	Location: 31+3628	Project No.:
Boring No.: 2	Tested By: ---WH	Checked By: ---
Sample No.: ss-529-08	Test Date: 10/6/2008	Depth: 40.0-41.0
Test No.: UC-18-08	Sample Type: Shelby Tube	Elevation: -----
Description: Total Length 11.5" GRY Clay. Specimen short on length		
Remarks:		

Tue, 07-OCT-2008 07:41:43

FIG. B-5
Sheet 2 of 2

531-08

UNCONFINED COMPRESSION TEST REPORT



Symbol		⊙			
Test No.		UC-19-08			
Initial	Diameter, in	2.86			
	Height, in	5.1			
	Water Content, %	21.43			
	Dry Density, pcf	106.96			
	Saturation, %	103.88			
	Void Ratio	0.54674			
Unconfined Compressive Strength, psf		16716			
Undrained Shear Strength, psf		8358			
Time to Failure, min		5.0868			
Strain Rate, %/min		1			
Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

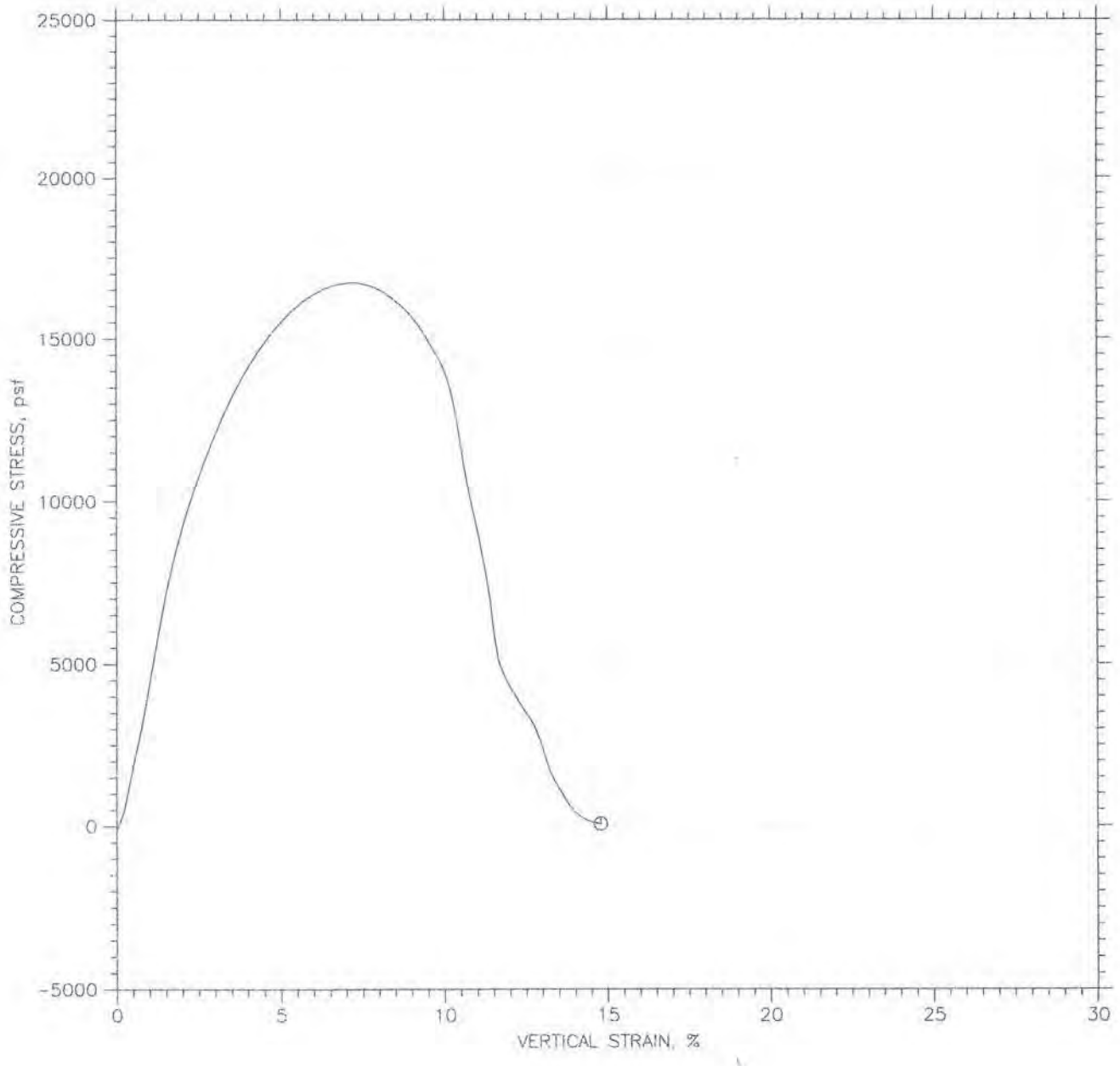
Project: Painted Canyon
Location: 31+3628
Project No.:
Boring No.: 2
Sample Type: Shelby Tube
Description: Total Length 13" GRY Slicken sided clay. Tube crimped had to cut. Tube distorted along the whole length. Specimen
Remarks: Specimen not full length, but tested anyway.

Tue, 14-OCT-2008 08:09:50

FIG. B-6
Sheet 1 of 2

531-08

UNCONFINED COMPRESSION TEST REPORT



Project: Painted Canyon	Location: 31+3628	Project No.:
Boring No.: 2	Tested By: ---WH	Checked By: ---
Sample No.: ss-531-08	Test Date: 10/7/08	Depth: 50.0-51.5
Test No.: UC-19-08	Sample Type: Shelby Tube	Elevation: -----
Description: Total Length 13" GRY Slicken sided clay. Tube crimped had to cut. Tube distorted along the whole length. Specimen		
Remarks: Specimen not full length, but tested anyway.		

Tue, 14-OCT-2008 08:09:50

FIG. B-6
Sheet 2 of 2

Boring #3 STA 435+09 (Median Centerline) 195' LT Elev = 2774.42 ft

Depth (ft.)	Textural Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (psf)	Blowcount (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	Brn Cly	3TW	M					14.9	
2.0-4.0	Brn Slty Lm	SS	SPT			1500*	12	23.6	
10.0-12.0	Drk Brn Sndy Lm	3TW	M					10.2	
12.0-14.0	Drk Brn Sndy Lm	SS	SPT		28*		3	14.1	
20.0-22.0	Gry Cly	3TW	UC	4542		2271		24.1	100.5
22.0-23.0	Gry Cly	SS	SPT			2625*	21	26.0	
23.0-25.0	Gry Cly	3TW	UU	4435		2218		30.6	91.5
25.0-27.0	Gry Cly	SS	SPT			2000*	16	27.4	
27.0-29.0	Gry Cly	3TW	UC	1577		599		28.8	95.8
29.0-31.0	Gry Cly	SS	SPT			3875*	31	20.7	
31.0-33.0	Gry Cly Coal mix	3TW	UU		40.7			19.7	107.3
33.0-35.0	Gry Cly	SS	SPT			4000*	32	14.5	
35.0-35.5	Lt Gry Cly Lm	3TW	M					17.6	
35.5-37.5	Lt Gry Cly	SS	SPT			3250*	26	23.8	
37.5-39.5	Gry Lm	SS	SPT			5125*	41	26.1	
40.0-42.0	Gry Cly	SS	SPT			3375*	27	20.6	
42.0-44.0	Gry Cly	SS	SPT			3125*	25	24.6	
45.0-47.0	Gry Cly	SS	SPT			4000*	32	20.0	
47.0-48.5	Blk\Gry Cly Coal Mix	SS	SPT			7500*	100/0.1	39.9	
50.0-52.0	Gry Cly	SS	SPT			3500*	28	26.3	
55.0-57.0	Gry Slty Cly	SS	SPT			3750*	30	19.9	
60.0-62.0	Gry Cly	SS	SPT			3250*	26	21.7	
65.0-67.0	Gry Cly	SS	SPT			3750*	30	24.5	
70.0-72.0	Brn Sndy Cly Coal Mix	SS	SPT			7500*	100/0.3	65.6	

SS - Split Spoon
3TW - 3" Thin Wall (Shelby tube)
M - Moisture Test
D - Density Test
UC - Unconfined Compression Test
UU - Unconsolidated Undrained Test
SPT- Standard Penetration Test

*Friction and Cohesive values are estimated from the blowcounts. These values are used in absence of triaxial strength testing information.
**Cores have been divided into samples < 2 feet in length due to different textural classes.

FIG. B-7

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	496	497	498	499
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	10.0 - 12.0	12.0 - 14.0
Field Sample No.	496	497	498	499
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	5	3	0	1
% Fine Sand (-No. 40 + No. 200)	29	3	69	68
% Silt (0.074 - 0.005 mm)	35	78	18	15
% Clay (-0.005 mm)	31	17	13	17
Liquid Limit (-No. 40)	36	0	0	0
Plasticity Index (-No. 40)	13	0	0	0
Plastic Limit	23	0	0	0
Soil Color	Brn	Brn	Drk Brn	Drk Brn
Textural Class	CLY	SLTY LM	SNDY LM	SNDY LM
Soil Class (AASHTO M-145)	A-6(7)	A-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F3	F4	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	14.9	23.6	10.2	14.1

FIG. B-8
Sheet 1 of 6

FIG. B-8
Sheet 1 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	500	501	502	503
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	20.0 - 22.0	22.0 - 24.0	23.0 - 25.0	25.0 - 27.0
Field Sample No.	500	501	502	503
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	0	1	0
% Silt (0.074 - 0.005 mm)	30	21	6	9
% Clay (-0.005 mm)	70	79	93	91
Liquid Limit (-No. 40)	58	60	67	69
Plasticity Index (-No. 40)	32	8	38	41
Plastic Limit	26	53	29	28
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(37)	A-5(17)	A-7-6(45)	A-7-6(48)
Frost Class	F3	F4	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	24.1	26.0	30.6	27.4

FIG. B-8
Sheet 2 of 6

FIG. B-8
Sheet 2 of 6

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Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	504	505	506	507
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	27.0 - 29.0	29.0 - 31.0	31.0 - 33.0	33.0 - 35.0
Field Sample No.	504	505	506	507
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	1	3	3	0
% Silt (0.074 - 0.005 mm)	15	11	34	36
% Clay (-0.005 mm)	84	86	63	64
Liquid Limit (-No. 40)	54	64	45	58
Plasticity Index (-No. 40)	29	37	28	36
Plastic Limit	25	27	17	22
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(33)	A-7-6(42)	A-7-6(29)	A-7-6(41)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	28.8	20.7	19.7	14.5

FIG. B-8
Sheet 3 of 6

FIG. B-8
Sheet 3 of 6

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	508	509	510	511
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	35.0 - 37.0	37.0 - 39.0	37.5 - 39.5	40.0 - 42.0
Field Sample No.	508	509	510	511
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	27	19	38	0
% Silt (0.074 - 0.005 mm)	49	47	45	32
% Clay (-0.005 mm)	23	34	18	67
Liquid Limit (-No. 40)	37	38	29	45
Plasticity Index (-No. 40)	15	20	5	26
Plastic Limit	22	18	23	19
Soil Color	Lt Gry	Lt Gry	Gry	Gry
Textural Class	CLY LM	CLY	LM	CLY
Soil Class (AASHTO M-145)	A-6(10)	A-6(15)	A-4(2)	A-7-6(28)
Frost Class	F3	F3	F4	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	17.6	23.8	26.1	20.6

FIG. B-8
Sheet 4 of 6

FIG. B-8 Sheet 4 of 6

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	512	513	514	515
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	42.0 - 44.0	45.0 - 47.0	47.0 - 49.0	50.0 - 52.0
Field Sample No.	512	513	514	515
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	100	100	100
% Coarse Sand (-No. 10 + No.40)	1	0	21	1
% Fine Sand (-No. 40 + No. 200)	1	1	23	2
% Silt (0.074 - 0.005 mm)	23	13	24	29
% Clay (-0.005 mm)	75	86	32	68
Liquid Limit (-No. 40)	52	59	52	80
Plasticity Index (-No. 40)	31	37	18	50
Plastic Limit	21	22	35	30
Soil Color	Gry	Gry	Blk\Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(33)	A-7-6(41)	A-7-5(8)	A-7-5(57)
Frost Class	F3	F3	F4	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	24.6	20.0	39.9	26.3

FIG. B-8
Sheet 5 of 6

FIG. B-8
Sheet 5 of 6

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Testing Lab. Supervisor
Date Printed: 10/24/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-16-2011	**Date Reported**	7/28/2011	**Boring Number**	1
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District	Dickinson	**Structure Location**		**PCN**	19467

Comments

Lab Number	516	517	518	519
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	55.0 - 57.0	60.0 - 62.0	65.0 - 67.0	70.0 - 72.0
Field Sample No.	516	517	518	519
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	
% Fine Sand (-No. 40 + No. 200)	2	0	1	
% Silt (0.074 - 0.005 mm)	63	47	32	
% Clay (-0.005 mm)	35	52	67	
Liquid Limit (-No. 40)	59	75	76	
Plasticity Index (-No. 40)	37	50	51	
Plastic Limit	22	25	25	
Soil Color	Gry	Gry	Gry	Brn
Textural Class	SLTY CLY	CLY	CLY	
Soil Class (AASHTO M-145)	A-7-6(41)	A-7-6(58)	A-7-6(59)	
Frost Class	F3	F3	F3	
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	19.9	21.7	24.5	65.6

FIG. B-8
Sheet 6 of 6

FIG. B-8
Sheet 6 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/24/2011

Torvane Shear Strengths

Boring No. 3 Station 31+3544 Offset 159' LT

Project No. SER-5-094(093)031 Date 7-11-11 County Billings

Depth (ft.)	Stress Reading	Factor	Shear Strength (kg/cm^2)	Shear Strength *(lbs/ft^2)
0.0-2.0	.4	2.5	1.0	2048.0
10.0-12.0	.350	.2	.007	143.36
20.0-22.0	.40	2.5	1.0	2048.0
27.0-29.0	.50	2.5	1.25	2560.0
31.0-33.0	.50	2.5	1.25	2560.0

Need to check torvane for accuracy.

* kg/cm^2 x 2048 = lbs/ft^2

FIG. B-9

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	SIM-SER-5-094(093)031	175	3

Notes:

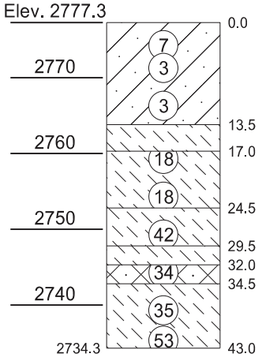
THE ENCIRCLED NUMBERS INDICATE THE NUMBER OF BLOWS DELIVERED BY A 140 POUND AUTOMATIC HAMMER FROM A HEIGHT OF 30 INCHES TO DRIVE A 2 INCH O.D. SPLIT-BARREL SAMPLER 1 FOOT.

THE BORING DATA SHOWN IS FOR NORTH DAKOTA DEPARTMENT OF TRANSPORTATION'S (NDDOT) DESIGN AND ESTIMATING PURPOSES ONLY. THE BORING LOGS ARE ONLY REPRESENTATIVE OF THE EXACT LOCATION FROM WHICH THE SAMPLES WERE TAKEN AND INTERPRETATION BETWEEN THE SAMPLE LOCATIONS IS DISCOURAGED. THE NDDOT ASSUMES NO RESPONSIBILITY IF THE SOIL CONDITIONS ENCOUNTERED DURING CONSTRUCTION DIFFER FROM THOSE SHOWN. FURTHER SOIL INFORMATION MAY BE AVAILABLE AT:

NDDOT
MATERIALS & RESEARCH DIVISION
300 AIRPORT ROAD
BISMARCK, NORTH DAKOTA 58504-6005
PHONE (701)328-6900

q_u=Unconfined Compressive Strength (psf)
w=Moisture Content (%)
ø=Friction Angle (deg)
c=Cohesion (psf)
γ_d=Dry Density (pcf)
*=These cohesive values and friction angles are estimated from blow counts

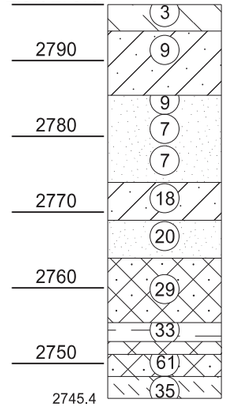
Elev. 2777.3



0.0 BRN SNDY LM, w=6.4%
BRN SNDY LM, *c=875 psf, w=7.4%
BRN SNDY LM, *c=375 psf, w=7.7%
BRN SNDY LM, *ø=28°, w=23.4%
13.5 BRN BLK CLY, c=2347 psf, γ_d=90.5 pcf, w=33.4%
17.0 BRN GRY CLY, *c=2250 psf, w=26.8%
BRN GRY CLY, c=8136 psf, γ_d=95.8 pcf, w=28.8%
24.5 BRN GRY CLY, *c=2250 psf, w=27.7%
GRY CLY, c=3290 psf, γ_d=108.6 pcf, w=22.3%
29.5 GRY CLY, *c=5250 psf, w=24.8%
32.0 BLK GRY CLY, c=4766 psf, γ_d=100.9 pcf, w=31.3%
34.5 GRY SLTY CLY, *c=4250 psf, w=19.8%
GRY CLY, c=2275 psf, γ_d=111.6 pcf, w=18.9%
GRY CLY, *c=4375 psf, w=19.6%
GRY CLY, q_u=16675 psf, c=8335 psf, γ_d=118.2 pcf, w=15.1%
43.0 GRY CLY, *c=6625 psf, w=16.0%

Painted Canyon Boring #5 Station 436+91 - 220' LT
Drilled on 9/7/2011

Elev. 2797.4



0.0 BRN CLY LM, *c=375 psf, w=15.2%
3.5 BRN TAN SNDY LM, *c=1125 psf, w=16.1%
8.5 BRN SNDY LM, w=11.2%
12.0 BRN SND, *ø=30°, w=6.3%
14.5 BRN SND, *ø=29°, w=7.2%
18.5 BRN TAN SND, *ø=29°, w=9.0%
23.5 BRN TAN SNDY LM, *c=2250 psf, w=8.4%
28.5 BRN SND, *c=2500 psf, w=25.6%
33.5 GRY SLTY CLY, q_u=6972.5 psf, c=3486.2 psf, γ_d=103.8 pcf, w=23.9%
37.0 DRK GRY SLTY CLY, *c=3625 psf, w=23.4%
39.5 GRY SLTY CLY, q_u=2521.1 psf, c=1260.7 psf, γ_d=102.4 pcf, w=24.6%
42.0 GRY SLTY LM, *c=4125 psf, w=23.1%
44.5 GRY SLTY CLY LM, w=44.5%
46.2 GRY SLTY CLY, *c=7625 psf, w=24.9%
49.1
52.0 GRY CLY, *c=4375 psf, w=21.7%

Painted Canyon Boring #6 Station 432+97 - 71' LT
Drilled on 9/7/2011

This document was originally issued and sealed by Jeff Jirava, Registration Number PE- 5950, on 3/23/2012 and the original document is stored at the North Dakota Department of Transportation

Painted Canyon

Boring Logs

FIG. B-10

Boring #5 STA 436+91 (Median Centerline) 220’ LT Elev = 2777.3 ft

Depth (ft.)	Textural Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (psf)	Blowcount (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	Brn Sndy Lm	3TW	M					6.4	
2.0-4.0	Brn Sndy Lm	SS	SPT			875*	7	7.4	
5.0-7.0	Brn Sndy Lm	SS	SPT			375*	3	7.7	
10.0-12.0	Brn Sndy Lm	SS	SPT		28*		3	23.4	
15.0-17.0	Brn Blk Cly	3TW	UU			2347		33.4	90.5
17.0-19.0	Brn Gry Cly	SS	SPT			2250*	18	26.8	
20.0-22.0	Brn Gry Cly	3TW	UU			8136		28.8	95.8
22.0-24.0	Brn Gry Cly	SS	SPT			2250*	18	27.7	
25.0-27.0	Gry Cly	3TW	UU			3290		22.3	108.6
27.0-29.0	Gry Cly	SS	SPT			5250*	42	24.8	
30.0-32.0	Blk Gry Cly	3TW	UU			4766		31.3	100.9
32.0-34.0	Gry Slty Cly	SS	SPT			4250*	34	19.8	
35.0-37.0	Gry Cly	3TW	UU			2275		18.9	111.6
37.0-39.0	Gry Cly	SS	SPT			4375*	35	19.6	
40.0-41.0	Gry Cly	3TW	UC	16675		8335		15.1	118.2
41.0-43.0	Gry Cly	SS	SPT			6625*	53	16.0	

SS - Split Spoon
3TW - 3" Thin Wall (Shelby tube)
M - Moisture Test
D - Density Test
UC - Unconfined Compression Test
UU - Unconsolidated Undrained Test
SPT- Standard Penetration Test

*Friction and Cohesive values are estimated from the blowcounts. These values are used in absence of triaxial strength testing information.
**Cores have been divided into samples < 2 feet in length due to different textural classes.

FIG. B-11

Boring #6 Sta 432+97 (Median Centerline) 71' LT Elev = 2797.4 ft

Depth (ft.)	Textural Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (psf)	Blowcount (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	Brn Cly Lm	SS	SPT			375*	3	15.2	
5.0-7.0	Brn Tan Sndy Lm	SS	SPT			1125*	9	16.1	
10.0-12.0	Brn Sndy Lm	3TW	M					11.2	
12.0-14.0	Brn Snd	SS	SPT		30*		9	6.3	
15.0-17.0	Brn Snd	SS	SPT		29*		7	7.2	
20.0-22.0	Brn Tan Snd	SS	SPT		29*		7	9.0	
25.0-27.0	Brn Tan Sndy Lm	SS	SPT			2250*	18	8.4	
30.0-32.0	Brn Snd	SS	SPT			2500*	20	25.6	
35.0-37.0	Gry Slty Cly	3TW	UC	6972.5		3486.2		23.9	103.8
37.0-39.0	Drk Gry Slty Cly	SS	SPT			3625*	29	23.4	
40.0-42.0	Gry Slty Cly	3TW	UC	2521.1		1260.7		24.6	102.4
42.0-44.0	Gry Slty Lm	SS	SPT			4125*	33	23.1	
45.0-46.2	Gry Slty Cly Lm	3TW	M					44.5	
46.2-48.2	Gry Slty Cly	SS	SPT			7625*	61	24.9	
50.0-52.0	Gry Cly	SS	SPT			4375*	35	21.7	

SS - Split Spoon
3TW - 3" Thin Wall (Shelby tube)
M - Moisture Test
D - Density Test

UC - Unconfined Compression Test
UU - Unconsolidated Undrained Test
SPT- Standard Penetration Test

*Friction and Cohesive values are estimated from the blowcounts. These values are used in absence of triaxial strength testing information.
**Cores have been divided into samples < 2 feet in length due to different textural classes.

FIG. B-12

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-41-2011	**Date Reported**	10/3/2011	**Boring Number**	6
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	863	864	865	866
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	5.0 - 7.0	10.0 - 12.0	12.0 - 14.0
Field Sample No.	863	864	865	866
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	99	99	100	100
% Pass. No. 10 Sieve	97	99	100	100
% Coarse Sand (-No. 10 + No.40)	2	4	1	0
% Fine Sand (-No. 40 + No. 200)	44	52	73	85
% Silt (0.074 - 0.005 mm)	27	26	13	6
% Clay (-0.005 mm)	24	17	14	8
Liquid Limit (-No. 40)	0	0	0	0
Plasticity Index (-No. 40)	0	0	0	0
Plastic Limit	0	0	0	0
Soil Color	Brn	Brn Tan	Brn	Brn
Textural Class	CLY LM	SNDY LM	SNDY LM	SND
Soil Class (AASHTO M-145)	A-4(0)	A-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F4	F3	F3	F2
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	15.2	16.1	11.2	6.3

FIG. B-13
Sheet 1 of 4

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/9/2011

FIG. B-13
Sheet 1 of 4

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-41-2011	**Date Reported**	10/3/2011	**Boring Number**	6
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	867	868	869	870
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	15.0 - 17.0	20.0 - 22.0	25.0 - 27.0	30.0 - 32.0
Field Sample No.	867	868	869	870
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	4	0	0
% Fine Sand (-No. 40 + No. 200)	85	77	80	80
% Silt (0.074 - 0.005 mm)	0	4	6	6
% Clay (-0.005 mm)	15	15	14	14
Liquid Limit (-No. 40)	0	0	0	0
Plasticity Index (-No. 40)	0	0	0	0
Plastic Limit	0	0	0	0
Soil Color	brn	Brn Tan	Brn Tan	Brn
Textural Class	SND	SND	SNDY LM	SND
Soil Class (AASHTO M-145)	A-2-4(0)	A-2-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F2	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	7.2	9.0	8.4	25.6

FIG. B-13
Sheet 2 of 4

FIG. B-13
Sheet 2 of 4

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-41-2011	**Date Reported**	10/3/2011	**Boring Number**	6
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	871	872	873	874
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	35.0 - 37.0	37.0 - 39.0	40.0 - 42.0	42.0 - 44.0
Field Sample No.	871	872	873	874
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	4	0	6	23
% Silt (0.074 - 0.005 mm)	58	57	64	57
% Clay (-0.005 mm)	38	42	31	20
Liquid Limit (-No. 40)	38	45	33	27
Plasticity Index (-No. 40)	17	21	9	4
Plastic Limit	21	24	24	24
Soil Color	Gry	Drk Gry	Gry	Gry
Textural Class	SLTY CLY	SLTY CLY	SLTY CLY	SLTY LM
Soil Class (AASHTO M-145)	A-6(17)	A-7-6(24)	A-4(9)	A-4(2)
Frost Class	F3	F3	F4	F4
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	23.9	23.4	24.6	23.1

FIG. B-13
Sheet 3 of 4

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Testing Lab. Supervisor
Date Printed: 11/9/2011

FIG. B-13
Sheet 3 of 4

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-41-2011	**Date Reported**	10/3/2011	**Boring Number**	6
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	875	876	877
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft
Depth, Ft.	45.0 - 47.0	47.0 - 49.0	50.0 - 52.0
Field Sample No.	875	876	877
% Pass. 3/8" Sieve	100	100	100
% Pass. No. 4 Sieve	100	100	100
% Pass. No. 10 Sieve	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0
% Fine Sand (-No. 40 + No. 200)	4	4	0
% Silt (0.074 - 0.005 mm)	71	61	9
% Clay (-0.005 mm)	25	35	90
Liquid Limit (-No. 40)	33	34	60
Plasticity Index (-No. 40)	7	12	33
Plastic Limit	25	22	28
Soil Color	Gry	Gry	Gry
Textural Class	SLTY CLY LM	SLTY CLY	CLY
Soil Class (AASHTO M-145)	A-4(8)	A-6(12)	A-7-6(38)
Frost Class	F4	F3	F3
Optimum Moisture (%)			
Maximum Dry Density (pcf)			
Ph of Soil			
% Organic Content			
Pocket Pentrometer			
Depth (Ft.) | Moisture (%)			
Avg. Moisture (%)	44.5	24.9	21.7

FIG. B-13
Sheet 4 of 4

FIG. B-13
Sheet 4 of 4

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Testing Lab. Supervisor

Date Printed: 11/9/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2011	**Date Reported**	10/3/2011	**Boring Number**	7
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	878	879	880	881
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	5.0 - 7.0	10.0 - 12.0	15.0 - 17.0
Field Sample No.	878	879	880	881
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	27	1	0	1
% Fine Sand (-No. 40 + No. 200)	34	60	84	84
% Silt (0.074 - 0.005 mm)	27	27	10	9
% Clay (-0.005 mm)	11	13	5	7
Liquid Limit (-No. 40)	0	0	0	0
Plasticity Index (-No. 40)	0	0	0	0
Plastic Limit	0	0	0	0
Soil Color	Brn Tan	Brn	Brn	Brn
Textural Class	SNDY LM	SNDY LM	SND	SND
Soil Class (AASHTO M-145)	A-4(0)	A-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F3	F3	F2	F2
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	5.6	12.1	5.6	13.2

FIG. B-14
Sheet 1 of 5

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Testing Lab. Supervisor
Date Printed: 11/9/2011

FIG. B-14
Sheet 1 of 5

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2011	**Date Reported**	10/3/2011	**Boring Number**	7
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	882	883	884	885
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	20.0 - 22.0	25.0 - 27.0	30.0 - 32.0	35.0 - 37.0
Field Sample No.	882	883	884	885
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	1
% Fine Sand (-No. 40 + No. 200)	80	81	81	3
% Silt (0.074 - 0.005 mm)	13	13	12	33
% Clay (-0.005 mm)	6	6	7	62
Liquid Limit (-No. 40)	0	0	0	54
Plasticity Index (-No. 40)	0	0	0	24
Plastic Limit	0	0	0	30
Soil Color	Brn	Brn	Brn	Gry
Textural Class	SND	SND	SND	CLY
Soil Class (AASHTO M-145)	A-2-4(0)	A-2-4(0)	A-2-4(0)	A-7-5(28)
Frost Class	F2	F2	F2	F4
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	7.9	8.8	26.1	22.6

FIG. B-14
Sheet 2 of 5

FIG. B-14 Sheet 2 of 5

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Testing Lab. Supervisor
Date Printed: 11/9/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2011	**Date Reported**	10/3/2011	**Boring Number**	7
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	886	887	888	889
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	40.0 - 42.0	42.0 - 44.0	45.0 - 47.0	47.0 - 49.0
Field Sample No.	886	887	888	889
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	1	0	2
% Silt (0.074 - 0.005 mm)	5	8	9	10
% Clay (-0.005 mm)	95	91	90	88
Liquid Limit (-No. 40)	69	65	69	71
Plasticity Index (-No. 40)	37	37	43	42
Plastic Limit	32	28	26	28
Soil Color	Drk Gry	Drk Gry	Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-5(45)	A-7-5(33)	A-7-6(50)	A-7-6(49)
Frost Class	F3	F4	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	30.1	28.6	24.2	23.8

FIG. B-14
Sheet 3 of 5

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Testing Lab. Supervisor
Date Printed: 11/9/2011

FIG. B-14
Sheet 3 of 5

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2011	**Date Reported**	10/3/2011	**Boring Number**	7
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	890	891	892	893
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	50.0 - 52.0	52.0 - 54.0	55.0 - 56.5	56.5 - 58.5
Field Sample No.	890	891	892	893
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	2	0	3
% Silt (0.074 - 0.005 mm)	7	41	18	36
% Clay (-0.005 mm)	93	57	81	61
Liquid Limit (-No. 40)	60	43	56	43
Plasticity Index (-No. 40)	37	20	34	26
Plastic Limit	23	23	22	16
Soil Color	Gry	Drk Gry	Lt Gry	Lt Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(42)	A-7-6(21)	A-7-6(39)	A-7-6(27)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	23.5	17.6	17.0	11.2

FIG. B-14
Sheet 4 of 5

FIG. B-14
Sheet 4 of 5

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Testing Lab. Supervisor
Date Printed: 11/9/2011

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-42-2011	**Date Reported**	10/3/2011	**Boring Number**	7
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	894	895
Distance From CenterLine (Ft.)	0 ft	0 ft
Depth, Ft.	60.0 - 61.0	61.0 - 62.0
Field Sample No.	894	895
% Pass. 3/8" Sieve	100	100
% Pass. No. 4 Sieve	100	100
% Pass. No. 10 Sieve	100	100
% Coarse Sand (-No. 10 + No.40)	0	0
% Fine Sand (-No. 40 + No. 200)	3	45
% Silt (0.074 - 0.005 mm)	60	40
% Clay (-0.005 mm)	37	15
Liquid Limit (-No. 40)	52	29
Plasticity Index (-No. 40)	32	4
Plastic Limit	20	25
Soil Color	Lt Gry	Gry
Textural Class	SLTY CLY	LM
Soil Class (AASHTO M-145)	A-7-6(34)	A-4(1)
Frost Class	F3	F4
Optimum Moisture (%)		
Maximum Dry Density (pcf)		
Ph of Soil		
% Organic Content		
Pocket Pentrometer		
Depth (Ft.) | Moisture (%)		
Avg. Moisture (%)	18.1	27.6

FIG. B-14
Sheet 5 of 5

FIG. B-14
Sheet 5 of 5

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Testing Lab. Supervisor

Date Printed: 11/9/2011

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	SIM-SER-5-094(093)031	175	4

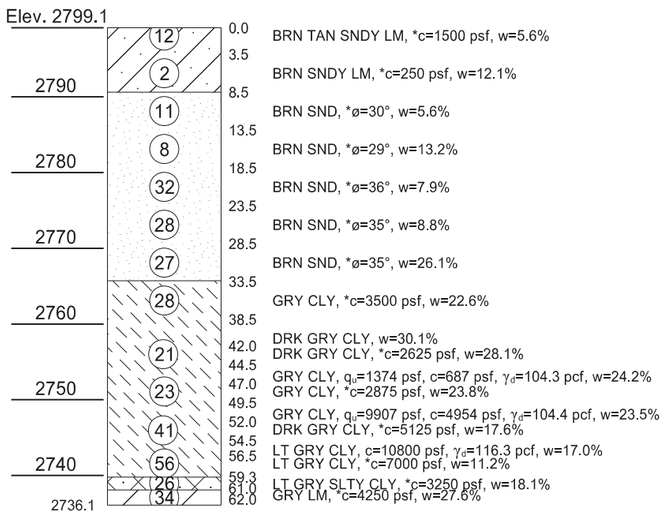
Notes:

THE ENCIRCLED NUMBERS INDICATE THE NUMBER OF BLOWS DELIVERED BY A 140 POUND AUTOMATIC HAMMER FROM A HEIGHT OF 30 INCHES TO DRIVE A 2 INCH O.D. SPLIT-BARREL SAMPLER 1 FOOT.

THE BORING DATA SHOWN IS FOR NORTH DAKOTA DEPARTMENT OF TRANSPORTATION'S (NDDOT) DESIGN AND ESTIMATING PURPOSES ONLY. THE BORING LOGS ARE ONLY REPRESENTATIVE OF THE EXACT LOCATION FROM WHICH THE SAMPLES WERE TAKEN AND INTERPRETATION BETWEEN THE SAMPLE LOCATIONS IS DISCOURAGED. THE NDDOT ASSUMES NO RESPONSIBILITY IF THE SOIL CONDITIONS ENCOUNTERED DURING CONSTRUCTION DIFFER FROM THOSE SHOWN. FURTHER SOIL INFORMATION MAY BE AVAILABLE AT:

NDDOT
MATERIALS & RESEARCH DIVISION
300 AIRPORT ROAD
BISMARCK, NORTH DAKOTA 58504-6005
PHONE (701)328-6900

q_u=Unconfined Compressive Strength (psf)
w=Moisture Content (%)
ø=Friction Angle (deg)
c=Cohesion (psf)
γ_d=Dry Density (pcf)
*=These cohesive values and friction angles are estimated from blow counts



Painted Canyon Boring #8 Station 435+82 - 21' RT
Drilled on 9/8/2011

This document was originally issued and sealed by Jeff Jirava, Registration Number PE- 5950, on 3/23/2012 and the original document is stored at the North Dakota Department of Transportation

Painted Canyon

Boring Logs

FIG. B-15

Boring #8 STA 433+85 (Median Centerline) 21' RT Elev = 2799.1 ft

Depth (ft.)	Textural Class	Sample Type	Test Type	Comp. Strength (psf)	Friction Angle (degr.)	Cohesion (psf)	Blowcount (bpf)	Field Moisture (%)	Dry Unit Weight (pcf)
0.0-2.0	Brn Tan Sndy Lm	SS	SPT			1500*	12	5.6	
5.0-7.0	Brn Sndy Lm	SS	SPT			250*	2	12.1	
10.0-12.0	Brn Snd	SS	SPT		30*		11	5.6	
15.0-17.0	Brn Snd	SS	SPT		29*		8	13.2	
20.0-22.0	Brn Snd	SS	SPT		36*		32	7.9	
25.0-27.0	Brn Snd	SS	SPT		35*		28	8.8	
30.0-32.0	Brn Snd	SS	SPT		35*		27	26.1	
35.0-37.0	Gry Cly	SS	SPT			3500*	28	22.6	
40.0-42.0	Drk Gry Cly	3TW	M					30.1	
42.0-44.0	Drk Gry Cly	SS	SPT			2625*	21	28.6	
45.0-47.0	Gry Cly	3TW	UU	1374		687		24.2	104.3
47.0-49.0	Gry Cly	SS	SPT			2875*	23	23.8	
50.0-52.0	Gry Cly	3TW	UU	9907		4954		23.5	104.4
52.0-54.0	Drk Gry Cly	SS	SPT			5125*	41	17.6	
55.0-56.5	Lt Gry Cly	3TW	UU			10800		17.0	116.3
56.5-58.5	Lt Gry Cly	SS	SPT			7000*	56	11.2	
60.0-61.0	Lt Gry Slty Cly	SS	SPT			3250*	26	18.1	
61.0-62.0	Gry Lm	SS	SPT			4250*	34	27.6	

SS - Split Spoon
3TW - 3" Thin Wall (Shelby tube)
M - Moisture Test
D - Density Test

UC - Unconfined Compression Test
UU - Unconsolidated Undrained Test
SPT- Standard Penetration Test

*Friction and Cohesive values are estimated from the blowcounts. These values are used in absence of triaxial strength testing information.
**Cores have been divided into samples < 2 feet in length due to different textural classes.

FIG. B-16

DEEP FOUNDATION BORING LOG F-430?
Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	10				SER-5-094(093)031

Project Location	County	Date Started	Date Finished
Slide area	Billings	7-29-13	7-29-13

SAMP. TYPE	CORE NO.	CORE DEPTH FROM	CORE DEPTH TO	SPT	SAMPLE RECOV.	JAR. NO.	SAMPLE NO.	HORIZON DEPTH FROM	HORIZON DEPTH TO	COLOR	TEXT. CLASS	CONSISTENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLASTICITY (Y/N)	REMARKS
SS #1	1	0.0	2.0	2 / 32	1.4 / 2.0	1	417	0.0	8.0	Brn	fine Snd	Very Loose	Y	N	N	Organics mix
Drill to 2.0																
SS #2	2	2.0	4.0	2 / 2	0.5 / 2.0	2	418			Brn	fine snd	Very Loose	Y	N	N	
Drill 4.0																
STW #1	[illegible]	4.0	6.0		0.0 / 2.0											no Recovery
SS #3	3	4.0	6.0	1 / 1	1.1 / 2.0	3	419			Brn	fn Snd	Very Loose	Y	Y	N	fn Snd, Disturbed
Drill to 6.0																
SS #4	4	6.0	8.0	2 / 2	1.7 / 2.0	4	420			Brn	fn Snd	Very Loose	Y	Y	Y	silty cly in Tip
Drill to 8.0																
SS #5	5	8.0	10.0	3 / 4	1.7 / 2.0	5	421	8.0	10.0	Brn	Sndy cly	Soft	Y	N	Y	Silty cly
Drill to 10																
STW #1	6	10.0	12.0		2.0 / 2.0		422	10.0	14.0	Blk	silty cly					coal mixed no Torvane
SS #6	7	12.0	14.0	4 / 6	1.3 / 2.0	6	423			Blk gry	silty cly	med Stiff	N	N	Y	Coal layer Throughout
Drill to 14.0																
STW #2	8	14.0	16.0		1.6 / 2.0		424	14.0	31.5	Gry	silty cly					coal Deps, Heavy Snd mix no Torvane

10
12

FIG. B-17
Sheet 1 of 4

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. Naumann	10				SER-5-094(093)031
Project Location	**County**	**Date Started**			**Date Finished**
Slide area	Billings	7-29-13			7-29-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	DEPTH	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
SS #7	9	16.0	18.0		10 12	2.0 2.0	7	425			Gry	Silty Clay	Stiff	N	N	Y	Heavy Soil mix, Coal Dep.
Drill to 18.0																	
3TW #3	10	18.0	20.0			2.0 2.0		426			Gry	Silty Clay					To Hard to Torque
SS #8	11	20.0	22.0		8 10	2.0 2.0	8	427			Gry	Silty Clay	Stiff	N	N	Y	Coal Dep. Soil mix
Drill to 22.0																	
3TW #4	12	22.0	24.0			2.0 2.0		428			Gry	Silty Clay					Very Hard no torque Retrieved Frozen Dist.
SS #9	13	24.0	26.0		8 11	2.0 2.0	9	429			Gry	Silty Clay	Stiff	N	N	Y	IO Dep.
Drill to 26.0																	
3TW #5	14	26.0	28.0			2.0 2.0		430			Gry	Silty Clay					Bent Tube no Torque
SS #10	15	28.0	30.0		14 15	2.0 2.0	10	431			Gry	Silty Clay	Stiff	N	N	Y	Coal lenses
Drill to 30.0																	
3TW #6	16	30.0	31.5			1.5 1.5		432	31.5	34.0	Blk Gry	Silty Clay					Coal to Bottom, pushed 1.5 Bent tube no Torque
SS #11	17	31.5	33.5		18 19	2.0 2.0	11	433			Blk Gry	Silty Clay	Very Stiff	Y	Y	Y	Coal layers avg 0.5'
Drill to 34.0'																	
SS #12	18	34.0	36.0		42 51	2.0 2.0	12	434	34.0	41.0	Blk	Coal	Very Dense	Y	Y	N	Coal

FIG. B-17
Sheet 2 of 4

FIG. B-17
Sheet 2 of 4

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	10				SER-5-094(093)031
Project Location	**County**	**Date Started**			**Date Finished**
Painted Canyon Slide		7-29-13			7-29-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	DEPTH TO	COLOR	TEXT. CLASS	CONSIS. TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS. TICITY (Y/N)	REMARKS
Dr	11 to	37.5														
SS #13	19	37.5	39.5	55/45	1.0/1.0	13	435			Blk	coal	Very Dense	Y	Y	N	100 blow 0.3" 2nd set Dry Impossible
Drill to		40.5														
SS #14	20	400	41.0	60/40	1.0/1.0	14	436			Blk	Coal	Very Dense	Y	N	N	0.4/2nd set 100 blow sliv. tip
Drill to		42.5														
SS #15	21	42.5	44.5	9/12	2.0/2.0	15	437	41.0	/	Gry	Sdy clay	Stiff	N	N	Y	
Dr	11 to	45.0														
SS #16	22	45.0	47.0	14/16	2.0/2.0	16	438			Gry	Sandy clay Lr	Stiff	N	N	Y	
Dr	11 to	49.5														
SS #17	23	49.5	49.5	11/13	2.0/2.0	17	439			Gry	Silty clay	Stiff	N	N	Y	
Dr	11 to	50.0														
Ca	24	53.0	53.0	8/12	2.0/2.0	18	440			Gry	Silty clay	Stiff	N	N	Y	Coal Dep.
Dr	11 to	52.5														

FIG. B-17
Sheet 3 of 4

FIG. B-17
Sheet 3 of 4

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division

SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	10				SER-S-094(093)031
Project Location	**County**	**Date Started**			**Date Finished**
Part of Canyon Side	Billings	7-29-13			7-29-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	DEPTH	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
SS #19	25	52.5	54.5		20 24	2.0 2.0	19	441			Gry	Silty Clay	Very Stiff	N	N	Y	coal Dep.
Drill to 55.0																	
SS 20	26	55.0	57.0		19 19	2.0 2.0	20	442			Gry	Silty Clay	Very Stiff	N	N	Y	Coal Dep
Drill to 57.5																	
SS 21	27	57.5	59.5		21 21	2.0 2.0	21	443			Gry	Silty Clay	Very Stiff	N	N	Y	Coal Dep
Drill to 65.0																	
Stop																	

FIG. B-17
Sheet 4 of 4

FIG. B-17
Sheet 4 of 4

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	417	418	419	420
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	4.0 - 6.0	6.0 - 8.0
Field Sample No.	417	418	419	420
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	99	100	100
% Pass. No. 10 Sieve	100	99	100	100
% Coarse Sand (-No. 10 + No.40)	0	2	1	0
% Fine Sand (-No. 40 + No. 200)	72	66	69	69
% Silt (0.074 - 0.005 mm)	19	19	18	22
% Clay (-0.005 mm)	8	13	13	9
Liquid Limit (-No. 40)	0	0	0	0
Plasticity Index (-No. 40)	0	0	0	0
Plastic Limit	0	0	0	0
Soil Color	Brn	Brn	Brn	Brn
Textural Class	SNDY LM	SNDY LM	SNDY LM	SNDY LM
Soil Class (AASHTO M-145)	A-2-4(0)	A-2-4(0)	A-2-4(0)	A-2-4(0)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	4.5	8.1	19.2	31.4

FIG. B-18
Sheet 1 of 7

FIG. B-18 Sheet 1 of 7

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/23/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	421	422	423	424
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	8.0 - 10.0	10.0 - 12.0	12.0 - 14.0	14.0 - 16.0
Field Sample No.	421	422	423	424
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	99	98
% Coarse Sand (-No. 10 + No.40)	0	0	1	1
% Fine Sand (-No. 40 + No. 200)	10	3	6	9
% Silt (0.074 - 0.005 mm)	73	83	44	43
% Clay (-0.005 mm)	17	15	48	46
Liquid Limit (-No. 40)	33	35	62	72
Plasticity Index (-No. 40)	8	7	33	41
Plastic Limit	25	28	29	31
Soil Color	Brn	Blk	Blk Gry	Gry
Textural Class	SLTY LM	SLTY LM	CLY	CLY
Soil Class (AASHTO M-145)	A-4(7)	A-4(8)	A-7-6(36)	A-7-5(42)
Frost Class	F4	F4	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	28.0	30.2	32.8	34.1

FIG. B-18
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Testing Lab. Supervisor
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FIG. B-18
Sheet 2 of 7

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	425	426	427	428
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	16.0 - 18.0	18.0 - 20.0	22.0 - 22.0	22.0 - 24.0
Field Sample No.	425	426	427	428
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	10	4	6	0
% Silt (0.074 - 0.005 mm)	54	59	49	49
% Clay (-0.005 mm)	36	37	45	50
Liquid Limit (-No. 40)	61	76	80	96
Plasticity Index (-No. 40)	36	52	56	73
Plastic Limit	25	24	24	22
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	SLTY CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(36)	A-7-6(57)	A-7-6(60)	A-7-6(85)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	19.9	26.2	21.6	28.4

FIG. B-18
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FIG. B-18
Sheet 3 of 7

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/23/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	429	430	431	432
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	24.0 - 26.0	26.0 - 28.0	28.0 - 30.0	30.0 - 31.5
Field Sample No.	429	430	431	432
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	0	0	2
% Silt (0.074 - 0.005 mm)	40	48	34	13
% Clay (-0.005 mm)	60	52	66	85
Liquid Limit (-No. 40)	113	102	110	102
Plasticity Index (-No. 40)	90	74	86	63
Plastic Limit	23	27	24	38
Soil Color	Gry	Gry	Gry	Blk Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(105)	A-7-6(87)	A-7-6(100)	A-7-5(76)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	24.7	25.0	25.4	27.6

FIG. B-18
Sheet 4 of 7

FIG. B-18
Sheet 4 of 7

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/23/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	433	434	435	436
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	31.5 - 33.5	34.0 - 36.0	37.5 - 39.5	40.0 - 41.0
Field Sample No.	433	434	435	436
% Pass. 3/8" Sieve	100			
% Pass. No. 4 Sieve	100			
% Pass. No. 10 Sieve	100			
% Coarse Sand (-No. 10 + No.40)	4			
% Fine Sand (-No. 40 + No. 200)	7			
% Silt (0.074 - 0.005 mm)	22			
% Clay (-0.005 mm)	67			
Liquid Limit (-No. 40)	77			
Plasticity Index (-No. 40)	47			
Plastic Limit	30			
Soil Color	Blk Gry	Blk	Blk	Blk
Textural Class	CLY			
Soil Class (AASHTO M-145)	A-7-5(48)			
Frost Class	F3			
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)				

FIG. B-18
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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	437	438	439	440
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	42.5 - 44.5	45.0 - 47.0	47.5 - 49.5	50.0 - 52.0
Field Sample No.	437	438	439	440
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	1
% Fine Sand (-No. 40 + No. 200)	0	3	0	2
% Silt (0.074 - 0.005 mm)	21	68	56	17
% Clay (-0.005 mm)	79	30	44	82
Liquid Limit (-No. 40)	95	85	86	86
Plasticity Index (-No. 40)	63	62	64	60
Plastic Limit	32	24	22	26
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	SLTY CLY LM	SLTY CLY	CLY
Soil Class (AASHTO M-145)	A-7-5(75)	A-7-6(69)	A-7-6(74)	A-7-6(69)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	26.2	23.5	23.5	25.9

FIG. B-18
Sheet 6 of 7

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/23/2013

FIG. B-18
Sheet 6 of 7

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-23-2013	**Date Reported**	8/28/2013	**Boring Number**	10
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments samples 434-436 were coal no tests run.

Lab Number	441	442	443
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft
Depth, Ft.	52.5 - 54.5	55.0 - 57.0	57.5 - 59.5
Field Sample No.	441	442	443
% Pass. 3/8" Sieve	100	100	100
% Pass. No. 4 Sieve	100	100	100
% Pass. No. 10 Sieve	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	1
% Fine Sand (-No. 40 + No. 200)	2	0	0
% Silt (0.074 - 0.005 mm)	19	11	38
% Clay (-0.005 mm)	79	88	61
Liquid Limit (-No. 40)	83	94	89
Plasticity Index (-No. 40)	54	64	65
Plastic Limit	29	30	24
Soil Color	Gry	Gry	Gry
Textural Class	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(63)	A-7-5(76)	A-7-6(75)
Frost Class	F3	F3	F3
Optimum Moisture (%)			
Maximum Dry Density (pcf)			
Ph of Soil			
% Organic Content			
Pocket Pentrometer			
Depth (Ft.) | Moisture (%)			
Avg. Moisture (%)	24.9	25.9	19.6

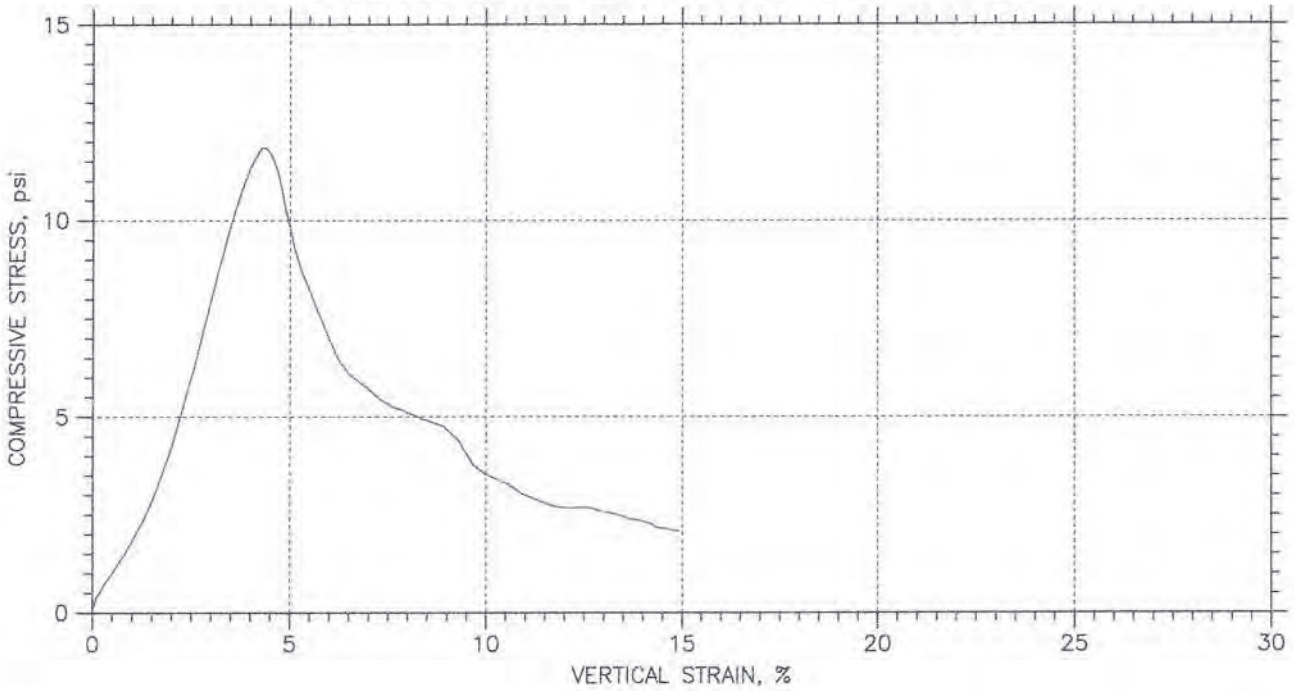
FIG. B-18
Sheet 7 of 7

FIG. B-18
Sheet 7 of 7

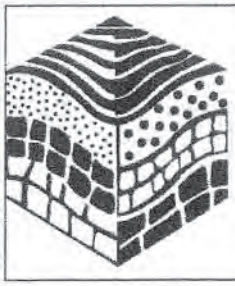
Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 10/23/2013

55-422-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-24-13			
Initial	Diameter, in	2.822			
	Height, in	5.518			
	Water Content, %	28.02			
	Dry Density, pcf	97.86			
	Saturation, %	107.51			
	Void Ratio	0.691			
Unconfined Compressive Strength, psi		11.85			
Undrained Shear Strength, psi		5.923			
Time to Failure, min		4.1633			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B10

Sample Type: Undisturbed

Description: Total length 23" Top 4" of tube Brn sandy clay,

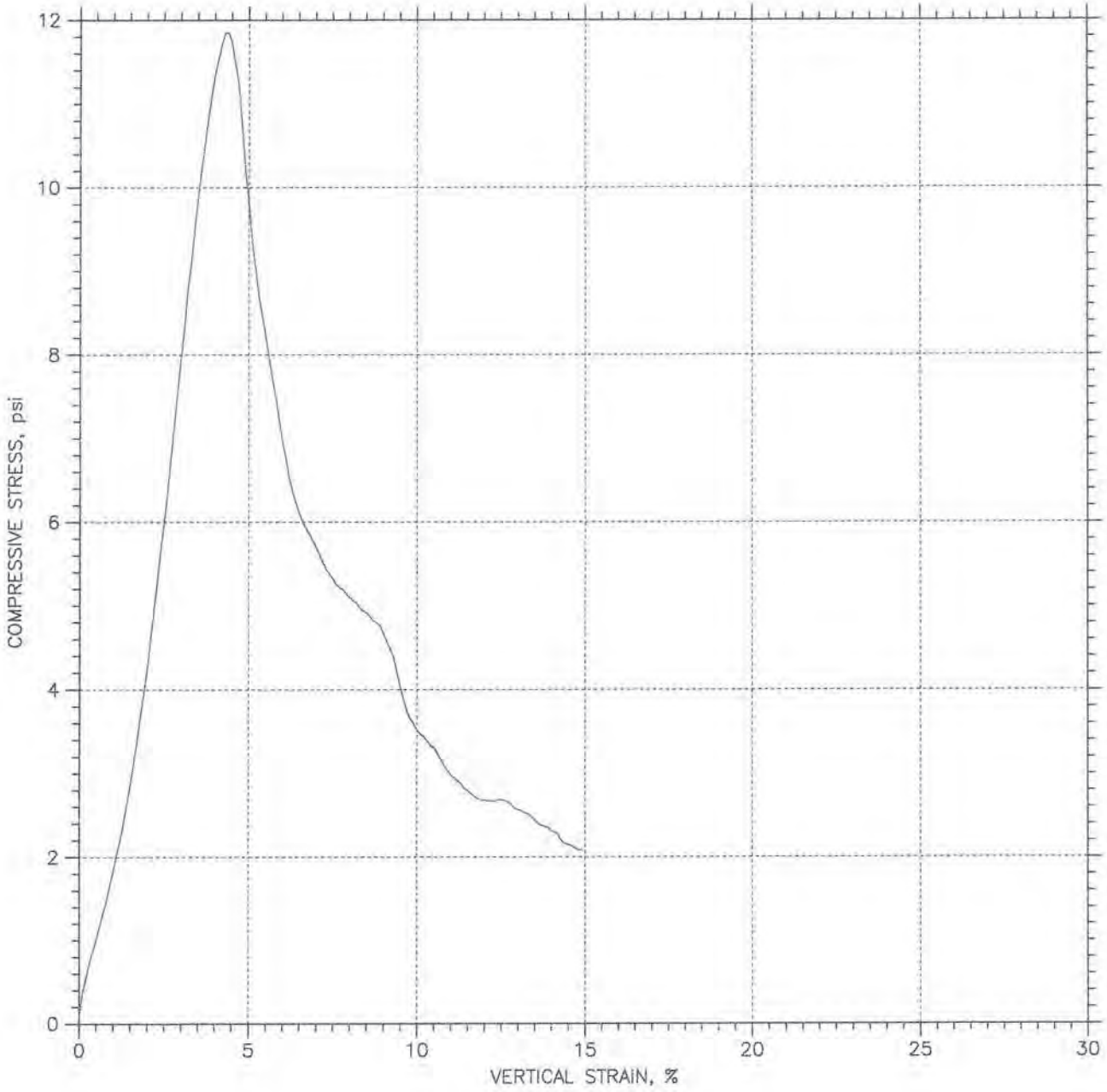
Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.

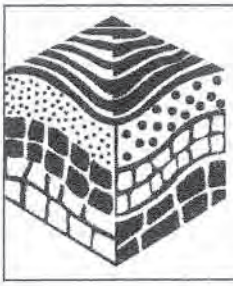
FIG. B-19

on, 23-SEP-2013 07:39:19

SS-422-13

UNCONFINED COMPRESSION TEST REPORT





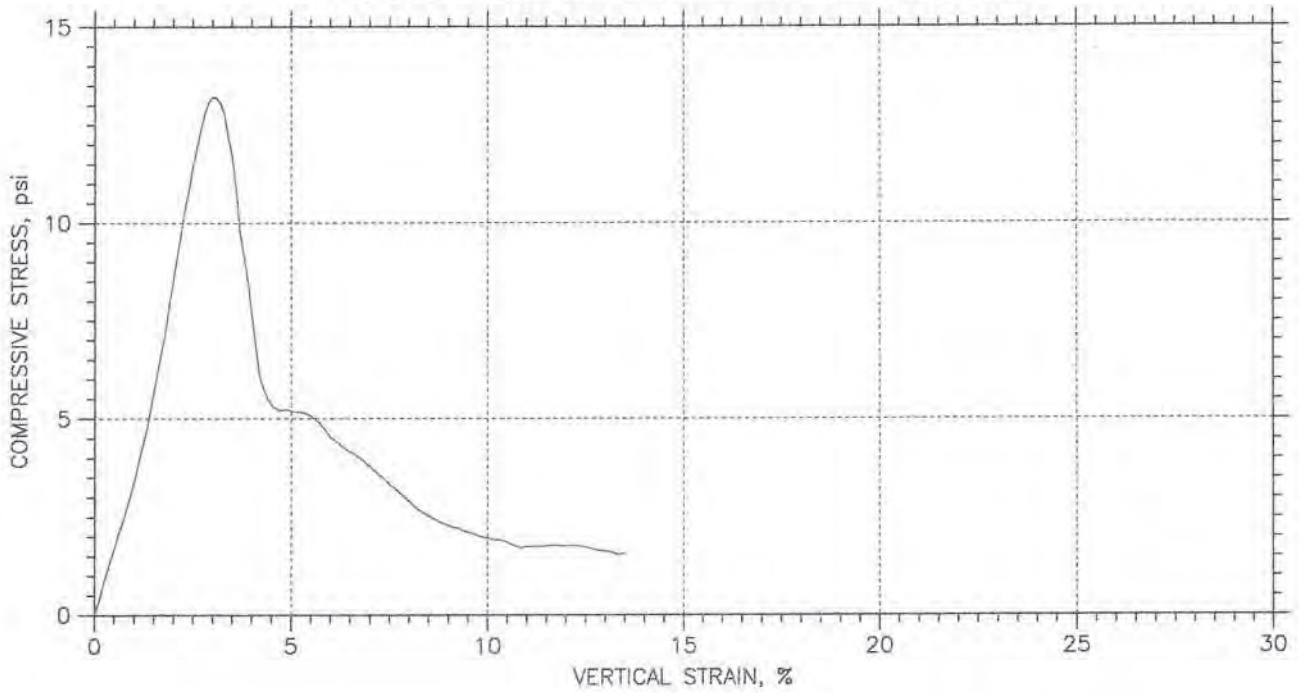
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Tested By: DT	Checked By: SS
Sample No.: SS-422-13	Test Date: 9/19/2013	Depth: 10.0-12.0
Test No.: UC-24-13	Sample Type: Undisturbed	Elevation:
Description: Total length 23" Top 4" of tube Brn sandy clay,		
Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.		

FIG. B-19
Sheet 2 of 2

ion, 23-SEP-2013 07:39:19

55-422-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-25-13			
Initial	Diameter, in	2.829			
	Height, in	5.57			
	Water Content, %	29.82			
	Dry Density, pcf	94.42			
	Saturation, %	105.06			
	Void Ratio	0.752			
Unconfined Compressive Strength, psi		13.2			
Undrained Shear Strength, psi		6.599			
Time to Failure, min		3.0186			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B10

Sample Type: Undisturbed

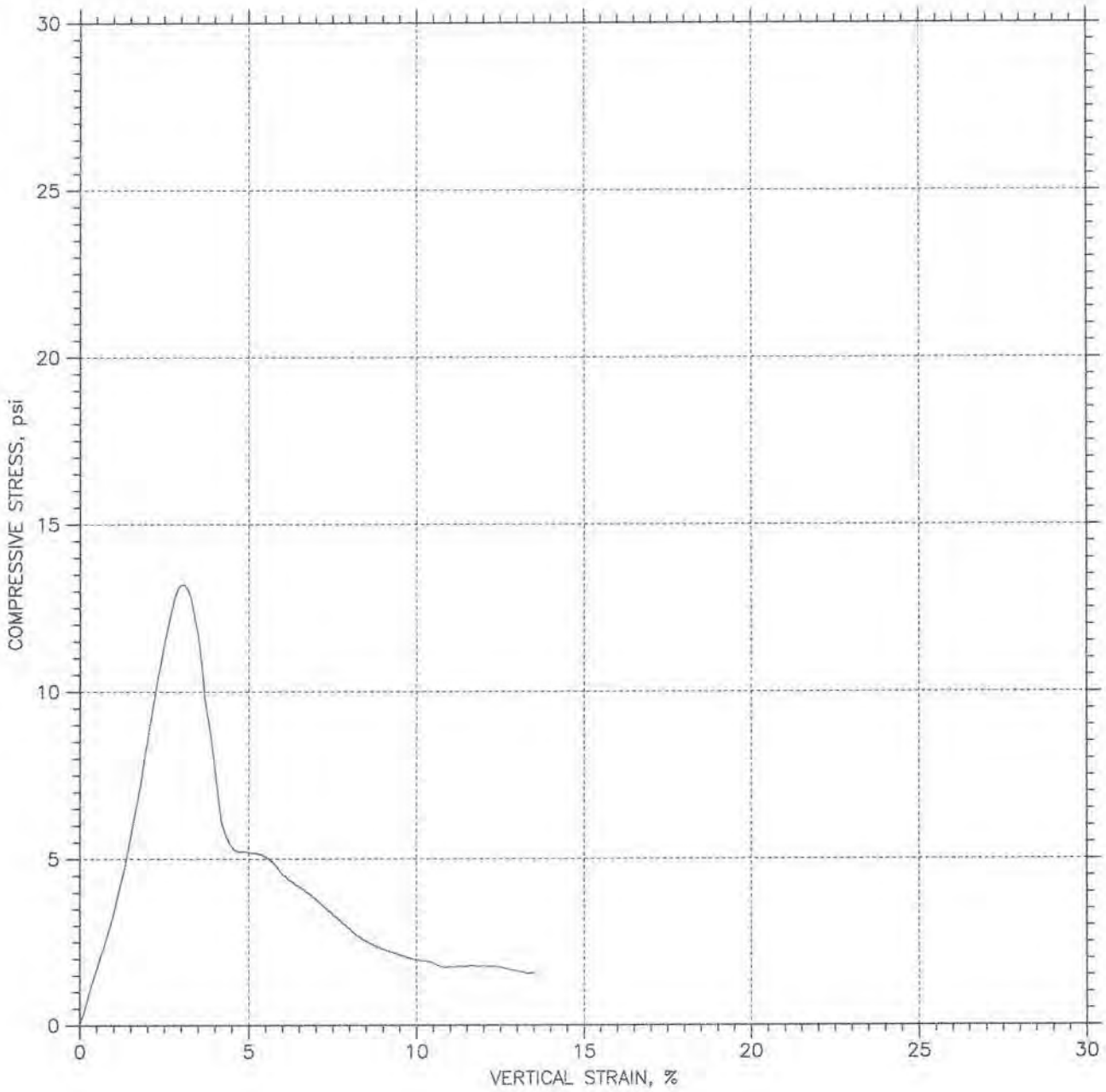
Description: Total length 23" Top 4" of tube Brn sandy clay,

Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.

FIG. B-20
Sheet 1 of 2

SS-422-13

UNCONFINED COMPRESSION TEST REPORT



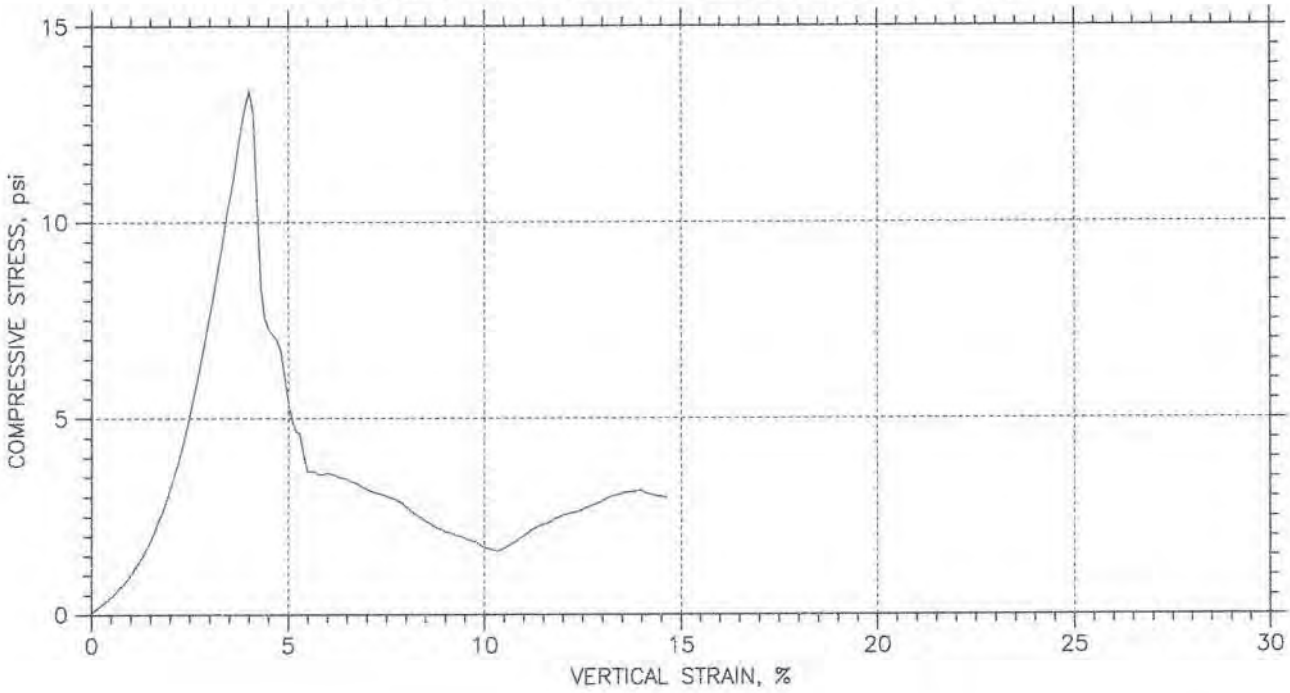
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Tested By: DT	Checked By: SS
Sample No.: SS-422-13	Test Date: 9/19/2013	Depth: 10.0-12.0
Test No.: UC-25-13	Sample Type: Undisturbed	Elevation:
Description: Total length 23" Top 4" of tube Brn sandy clay,		
Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.		

FIG. B-20
Sheet 2 of 2

Mon, 23-SEP-2013 07:45:40

25-422-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-26-13			
Initial	Diameter, in	2.809			
	Height, in	5.533			
	Water Content, %	32.61			
	Dry Density, pcf	90.78			
	Saturation, %	105.09			
	Void Ratio	0.822			
Unconfined Compressive Strength, psi		13.35			
Undrained Shear Strength, psi		6.673			
Time to Failure, min		3.8495			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B10

Sample Type: Undisturbed

Description: Total length 23" Top 4" of tube Brn sandy clay,

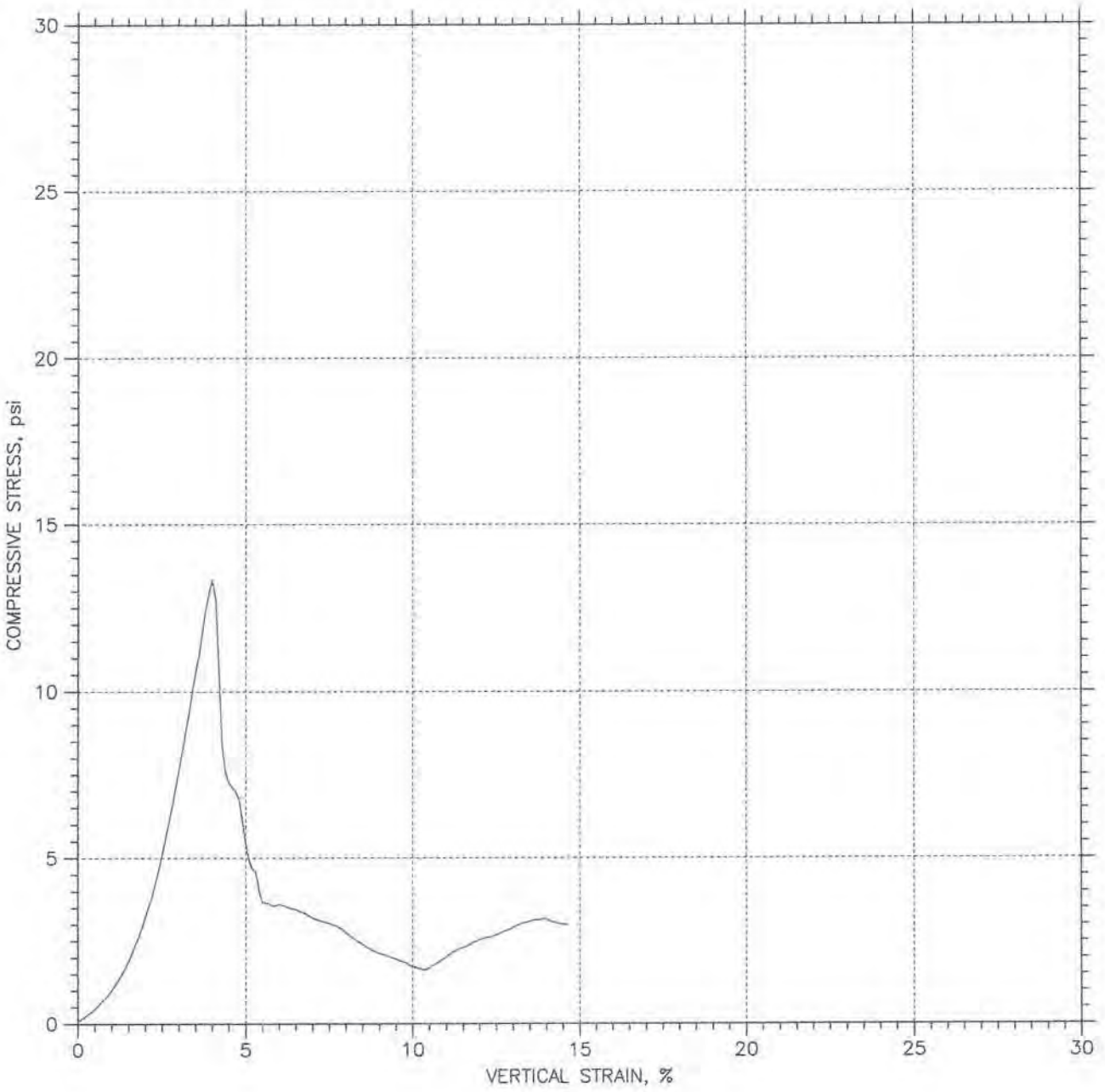
Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.

FIG. B-21

Mon, 23-SEP-2013 07:49:26

SS-422-13

UNCONFINED COMPRESSION TEST REPORT



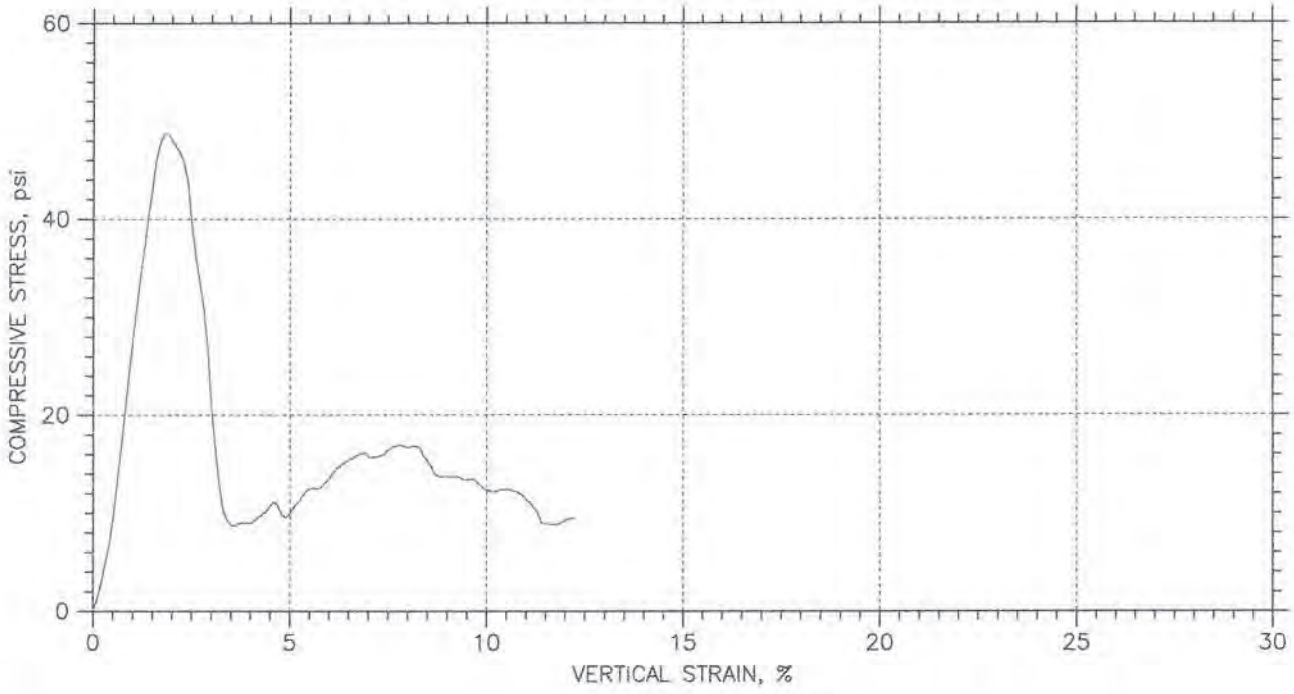
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Tested By: DT	Checked By: SS
Sample No.: SS-422-13	Test Date: 9/19/2013	Depth: 10.0-12.0
Test No.: UC-26-13	Sample Type: Undisturbed	Elevation:
Description: Total length 23" Top 4" of tube Brn sandy clay,		
Remarks: then changes to Brn silty clay loam. Bottom 1" changed to Blk clay.		

FIG. B-21

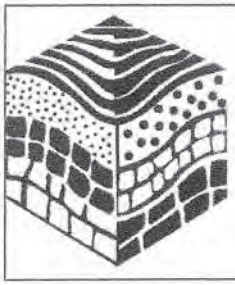
Mon, 23-SEP-2013 07:49:26

17-1124-15

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-27-13			
Initial	Diameter, in	2.845			
	Height, in	5.553			
	Water Content, %	27.58			
	Dry Density, pcf	93.53			
	Saturation, %	95.08			
	Void Ratio	0.769			
Unconfined Compressive Strength, psi		48.7			
Undrained Shear Strength, psi		24.35			
Time to Failure, min		1.7105			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B10

Sample Type: Undisturbed

Description: Total length 17" 4" of tube cut off, Gry Clay, Bottom 3" of tube coal.

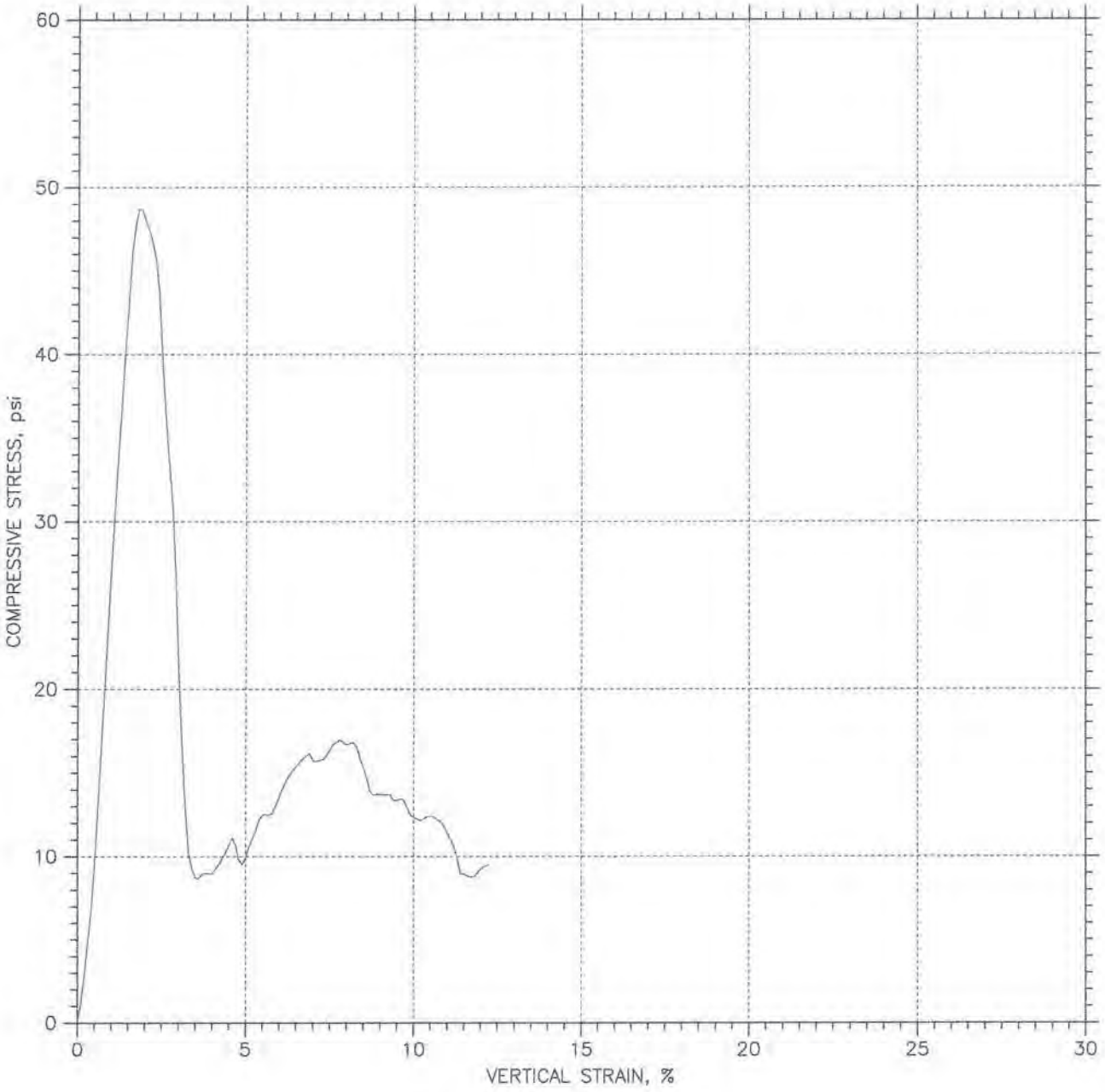
Remarks:

FIG. B-22

on, 30-SEP-2013 09:37:09

SS-432-13

UNCONFINED COMPRESSION TEST REPORT



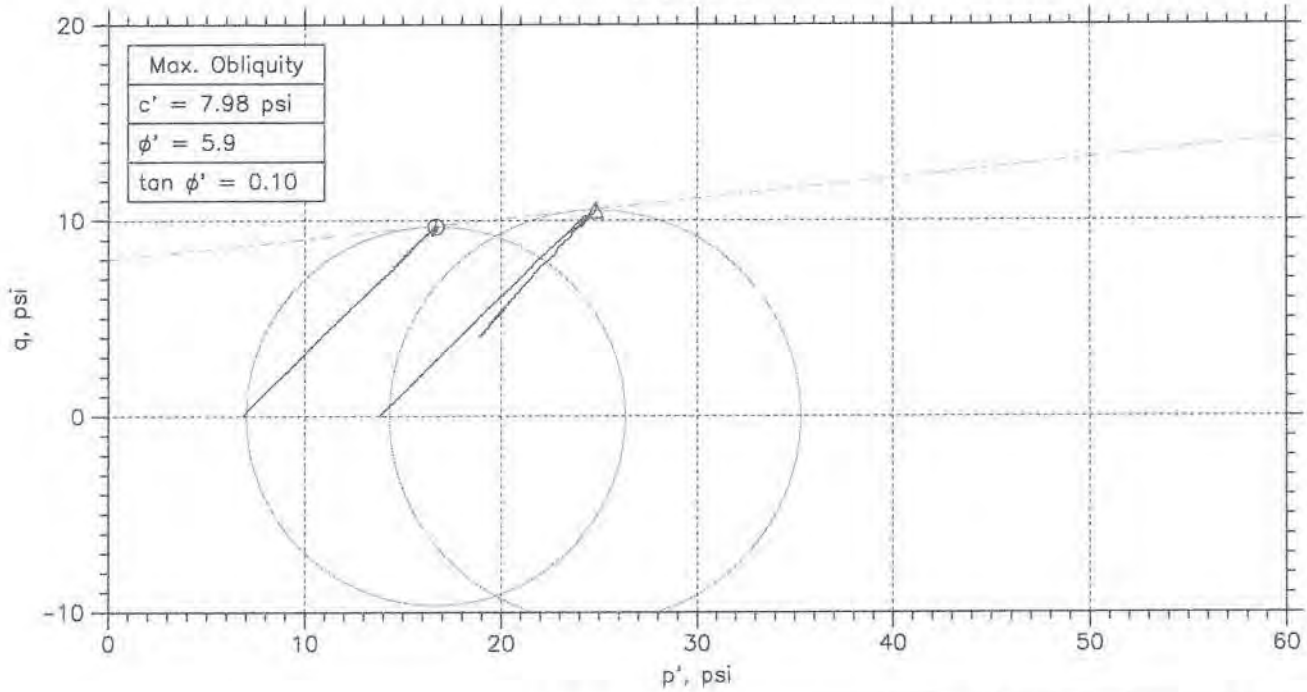
	Project: SER-5-094(093)031	Location:	Project No.:
	Boring No.: B10	Tested By: DT	Checked By: SS
	Sample No.: SS-432-13	Test Date: 9/23/2013	Depth: 30.0-31.5
	Test No.: UC-27-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 17" 4" of tube cut off, Gry Clay, Bottom 3" of tube coal.		
	Remarks:		

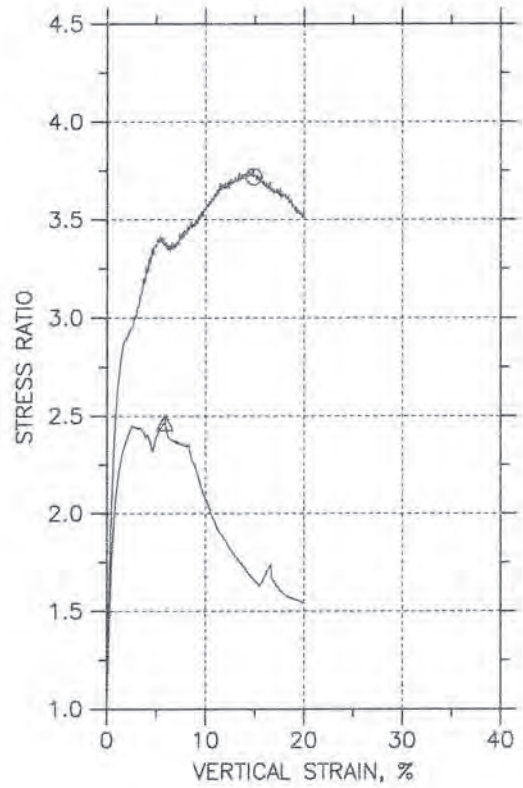
FIG. B-22
Sheet 2 of 2

lon, 30-SEP-2013 09:37:09

SS-424-13

Test File





Symbol		⊙	△		
Sample No.		SS-424-13	SS-424-13		
Test No.		UU-66-13	UU-67-13		
Depth		14.0-16.0	14.0-16.0		
Initial	Diameter, in	2.811	2.783		
	Height, in	5.56	5.564		
	Water Content, %	33.9	34.3		
	Dry Density, pcf	87.05	88.43		
	Saturation, %	99.7	104.5		
	Void Ratio	0.901	0.871		
Before Shear	Water Content, %	33.9	32.8		
	Dry Density, pcf	87.09	88.48		
	Saturation*, %	99.8	100.0		
	Void Ratio	0.899	0.87		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		6.853	13.8		
Shear Strength, psi		9.678	10.5		
Strain at Failure, %		14.9	5.9		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031

Location:

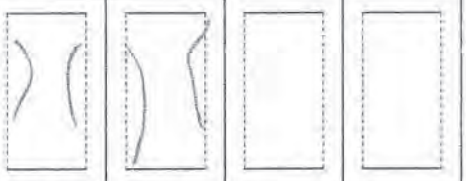
Project No.:

Boring No.: B10

Sample Type:

Description: Total length 22" Top 7" Brn sandy clay loam, changing to gry/brn

Remarks: silty clay.



Phase calculations based on start and end of test.

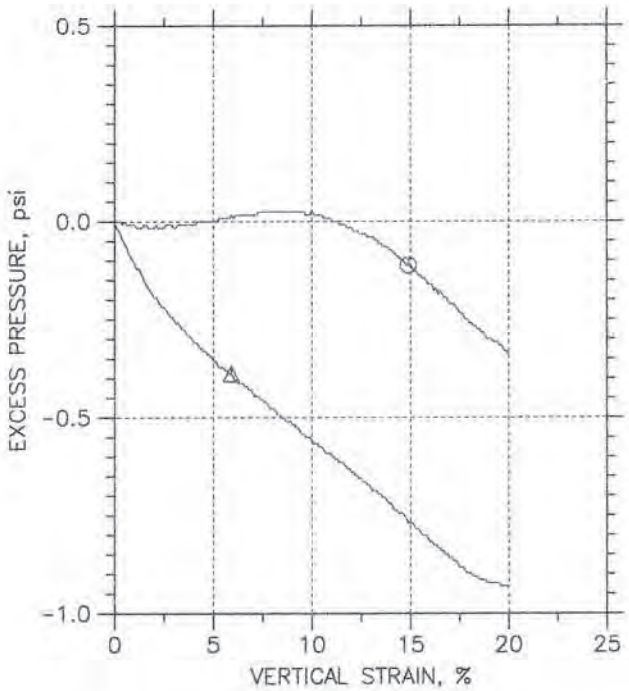
* Saturation is set to 100% for phase calculations.

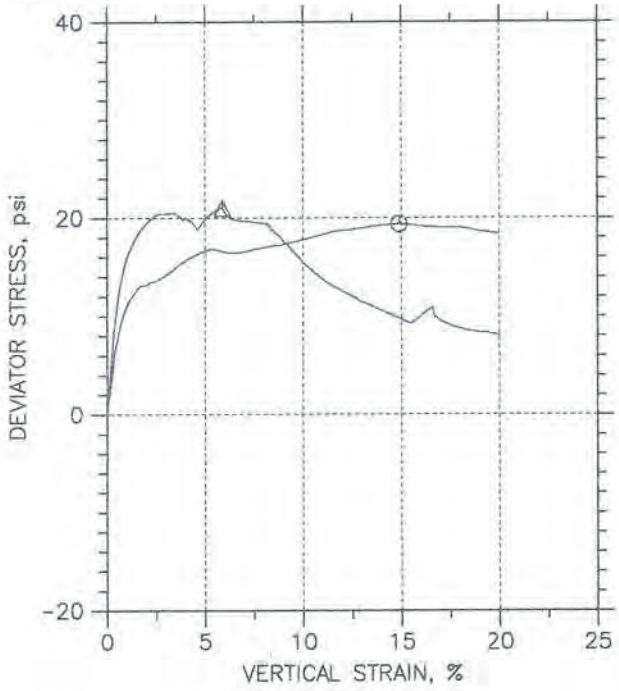
ue, 24-SEP-2013 07:10:37

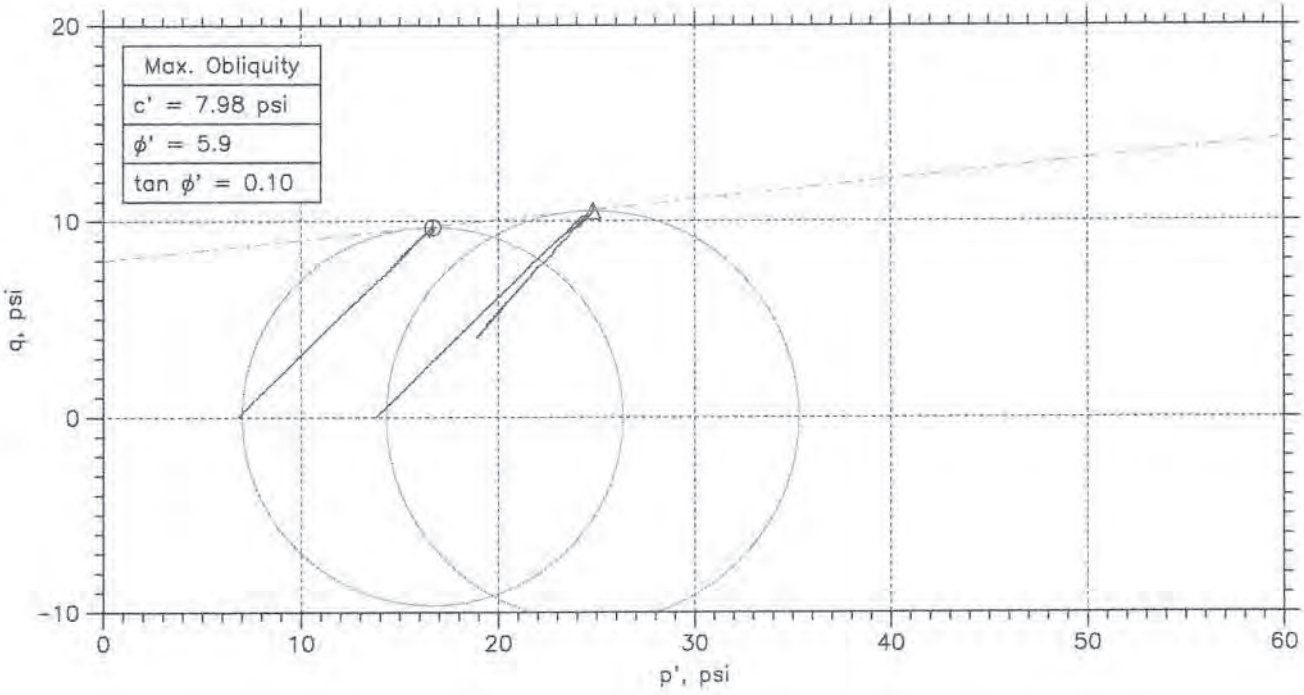
FIG. B-23

SS-424-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-424-13	UU-66-13	14.0-16.0	DT	9/23/13	SS		UU-66-2013.dat
△	SS-424-13	UU-67-13	14.0-16.0	DT	9/23/13	SS		UU-67-2013.dat

NDDOT
North Dakota Department of Transportation

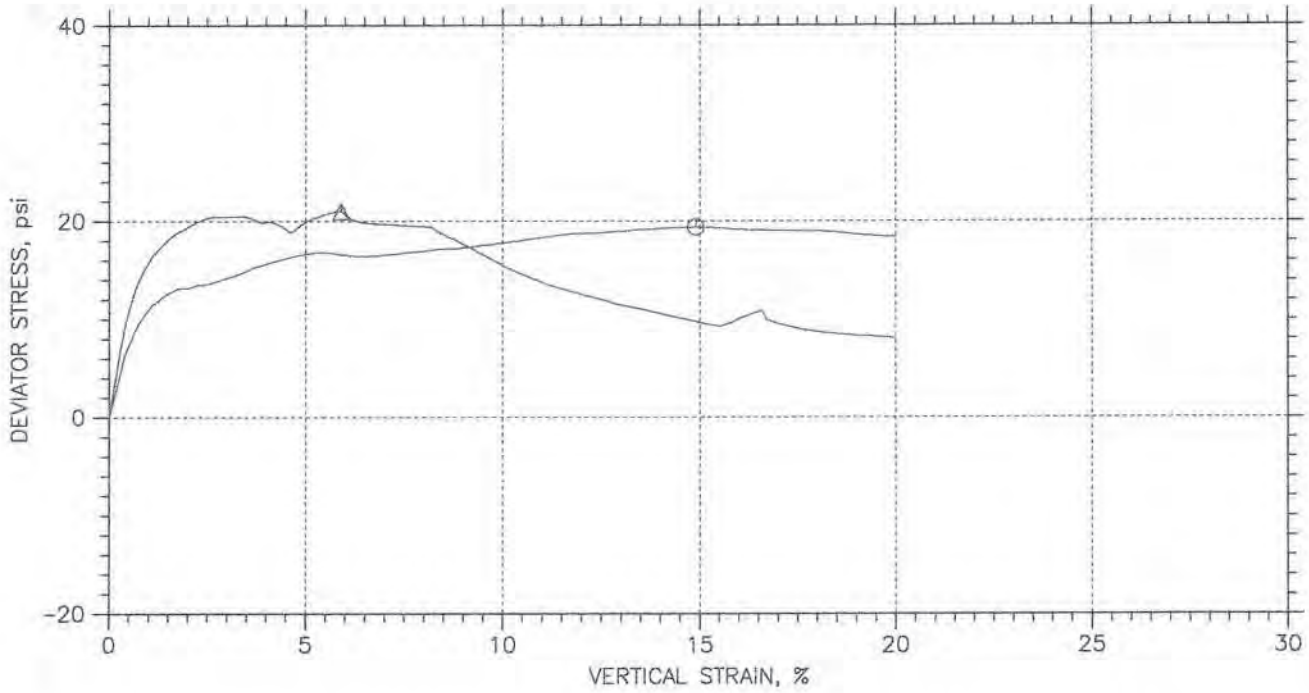
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 22" Top 7" Brn sandy clay loam, changing to gry/brn		
Remarks: silty clay.		

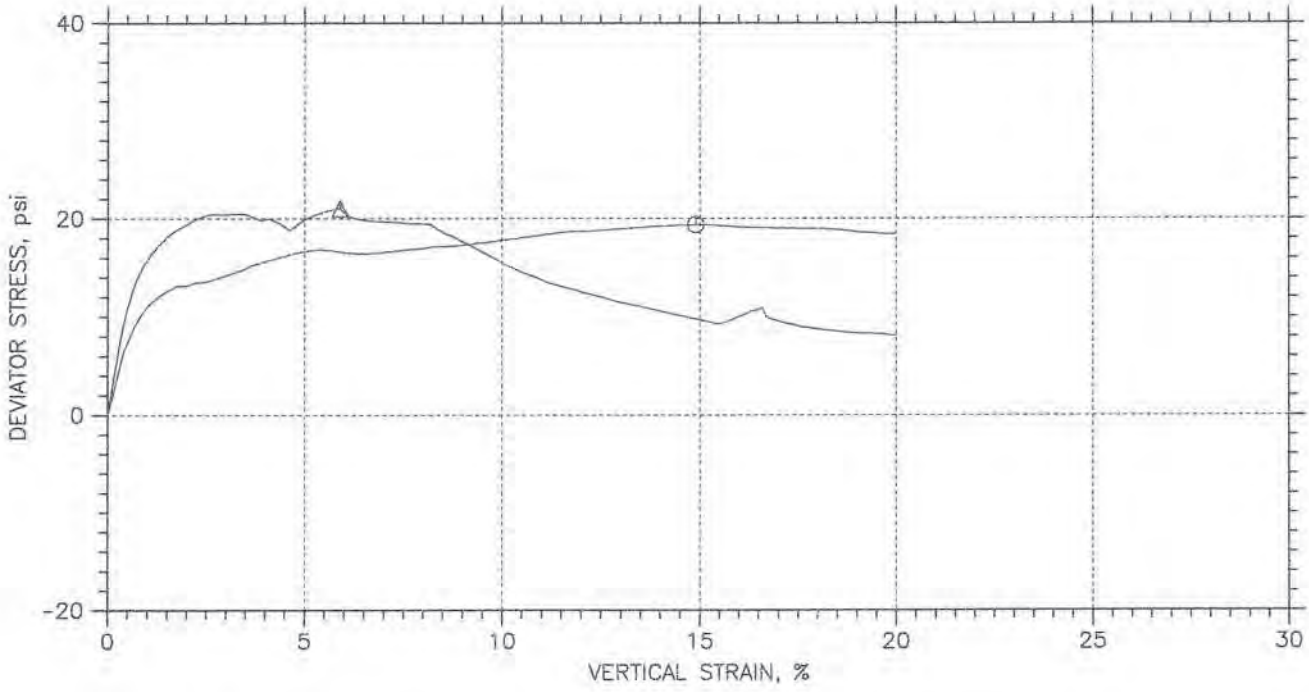
FIG. B-23
Sheet 2 of 5

ue, 24-SEP-2013 07:10:37

SS-424-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-424-13	UU-66-13	14.0-16.0	DT	9/23/13	SS		UU-66-2013.dat
△	SS-424-13	UU-67-13	14.0-16.0	DT	9/23/13	SS		UU-67-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 22" Top 7" Brn sandy clay loam, changing to gry/brn		
Remarks: silty clay.		

FIG. B-23

Tue, 24-SEP-2013 07:10:37

57-404-15

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-424-13
Test No.: UU-66-13

Location:
Tested By: DT
Test Date: 9/23/13
Sample Type:

Project No.:
Checked By: SS
Depth: 14.0-16.0
Elevation:

Soil Description: Total length 22" Top 7" Brn sandy clay loam, changing to gry/brn
Remarks: silty clay.

Specimen Height: 5.56 in
Specimen Area: 6.21 in^2
Specimen Volume: 565.44 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s10	---		
Wt. Container + Wet Soil, gm	44.36	---	---	0
Wt. Container + Dry Soil, gm	37.44	---	---	0
Wt. Container, gm	17.02	---	---	0
Wt. Wet Soil, gm	27.34	1055.6	788.42	0
Wt. Dry Soil, gm	20.42	788.42	788.42	0
Wt. Water, gm	6.92	267.18	-1.1642e-013	0
Water Content, %	33.89	33.89	-0.00	0.00
Void Ratio	---	0.90	0.90	---
Degree of Saturation, %	---	99.72	-0.00	---
Dry Unit Weight, pcf	---	87.046	87.094	---

Initial

Height: 5.56 in
Area: 6.206 in^2
Volume: 565.44 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.046 pcf
Saturation: 99.72 %

End of Initialization
Time: 3.3152 min
Total Vertical Stress: 6.8535 psi
Total Horizontal Stress: 6.87 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8535 psi
Effective Horizontal Stress: 6.87 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 0 cc

Height: 5.559 in
Area: 6.206 in^2
Volume: 565.13 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: 99.84 %

End of Consolidation/A
Time: 3.3152 min
Total Vertical Stress: 6.8535 psi
Total Horizontal Stress: 6.87 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8535 psi
Effective Horizontal Stress: 6.87 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 0 cc

Height: 5.559 in
Area: 6.206 in^2
Volume: 565.13 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: 99.84 %

End of Saturation
Time: 3.3152 min
Total Vertical Stress: 6.8535 psi
Total Horizontal Stress: 6.87 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8535 psi
Effective Horizontal Stress: 6.87 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 0 cc

Height: 5.559 in
Area: 6.206 in^2
Volume: 565.13 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: 99.84 %

End of Consolidation/B
Time: 3.3152 min
Total Vertical Stress: 6.8535 psi
Total Horizontal Stress: 6.87 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8535 psi
Effective Horizontal Stress: 6.87 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 0 cc

Height: 5.559 in
Area: 6.206 in^2
Volume: 565.13 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: 99.84 %

End of Shear
Time: 23.578 min
Total Vertical Stress: 25.357 psi
Total Horizontal Stress: 6.9265 psi
Pore Pressure: -0.33997 psi
Effective Vertical Stress: 25.697 psi
Effective Horizontal Stress: 7.2665 psi

Height Change: 1.1129 in
Area Change: -1.5488 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 267.18 cc

Height: 4.4471 in
Area: 7.7548 in^2
Volume: 565.13 cc

Moisture: -0.00 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: -0.00 %

At Failure
Time: 18.402 min
Total Vertical Stress: 26.362 psi
Total Horizontal Stress: 7.0072 psi
Pore Pressure: -0.11332 psi
Effective Vertical Stress: 26.476 psi
Effective Horizontal Stress: 7.1205 psi

Height Change: 0.82941 in
Area Change: -1.0881 in^2
Volume Change: 0.31025 cc
Water Change: -0.0021452 cc
Correction: 0 cc

Height: 4.7306 in
Area: 7.2941 in^2
Volume: 565.13 cc

Moisture: 33.89 %
Void Ratio: 0.90
Dry Unit Weight: 87.094 pcf
Saturation: 99.84 %

FIG. B-23
Sheet 4 of 5

SS-424-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-424-13
Test No.: UU-67-13

Location:
Tested By: DT
Test Date: 9/23/13
Sample Type:

Project No.:
Checked By: SS
Depth: 14.0-16.0
Elevation:

Soil Description: Total length 22" Top 7" Brn sandy clay loam, changing to gry/brn
Remarks: silty clay.

Specimen Height: 5.56 in
Specimen Area: 6.08 in^2
Specimen Volume: 554.63 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s17	---		
Wt. Container + Wet Soil, gm	52.19	---	---	0
Wt. Container + Dry Soil, gm	43.23	---	---	0
Wt. Container, gm	17.14	---	---	0
Wt. Wet Soil, gm	35.05	1055.5	785.66	0
Wt. Dry Soil, gm	26.09	785.66	785.66	0
Wt. Water, gm	8.96	269.81	-1.1642e-013	0
Water Content, %	34.34	34.34	-0.00	0.00
Void Ratio	---	0.87	0.87	---
Degree of Saturation, %	---	104.52	-0.00	---
Dry Unit Weight, pcf	---	88.431	88.48	---

Initial

Height: 5.564 in
Area: 6.083 in^2
Volume: 554.63 cc

Moisture: 34.34 %
Void Ratio: 0.87
Dry Unit Weight: 88.431 pcf
Saturation: 104.52 %

End of Initialization
Time: 1.9847 min
Total Vertical Stress: 13.796 psi
Total Horizontal Stress: 13.805 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.796 psi
Effective Horizontal Stress: 13.805 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 11.967 cc

Height: 5.563 in
Area: 6.083 in^2
Volume: 554.33 cc

Moisture: 32.82 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 1.9847 min
Total Vertical Stress: 13.796 psi
Total Horizontal Stress: 13.805 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.796 psi
Effective Horizontal Stress: 13.805 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 11.967 cc

Height: 5.563 in
Area: 6.083 in^2
Volume: 554.33 cc

Moisture: 32.82 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: 100.00 %

End of Saturation
Time: 1.9847 min
Total Vertical Stress: 13.796 psi
Total Horizontal Stress: 13.805 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.796 psi
Effective Horizontal Stress: 13.805 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 11.967 cc

Height: 5.563 in
Area: 6.083 in^2
Volume: 554.33 cc

Moisture: 32.82 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 1.9847 min
Total Vertical Stress: 13.796 psi
Total Horizontal Stress: 13.805 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.796 psi
Effective Horizontal Stress: 13.805 psi

Height Change: 0.0010169 in
Area Change: 0 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 11.967 cc

Height: 5.563 in
Area: 6.083 in^2
Volume: 554.33 cc

Moisture: 32.82 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: 100.00 %

End of Shear
Time: 22.256 min
Total Vertical Stress: 22.015 psi
Total Horizontal Stress: 13.942 psi
Pore Pressure: -0.93088 psi
Effective Vertical Stress: 22.946 psi
Effective Horizontal Stress: 14.873 psi

Height Change: 1.1137 in
Area Change: -1.5181 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 269.82 cc

Height: 4.4503 in
Area: 7.6011 in^2
Volume: 554.33 cc

Moisture: -0.00 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: -0.00 %

At Failure
Time: 7.9881 min
Total Vertical Stress: 34.934 psi
Total Horizontal Stress: 13.934 psi
Pore Pressure: -0.38854 psi
Effective Vertical Stress: 35.323 psi
Effective Horizontal Stress: 14.322 psi

Height Change: 0.32938 in
Area Change: -0.38284 in^2
Volume Change: 0.3041 cc
Water Change: -0.0064356 cc
Correction: 0 cc

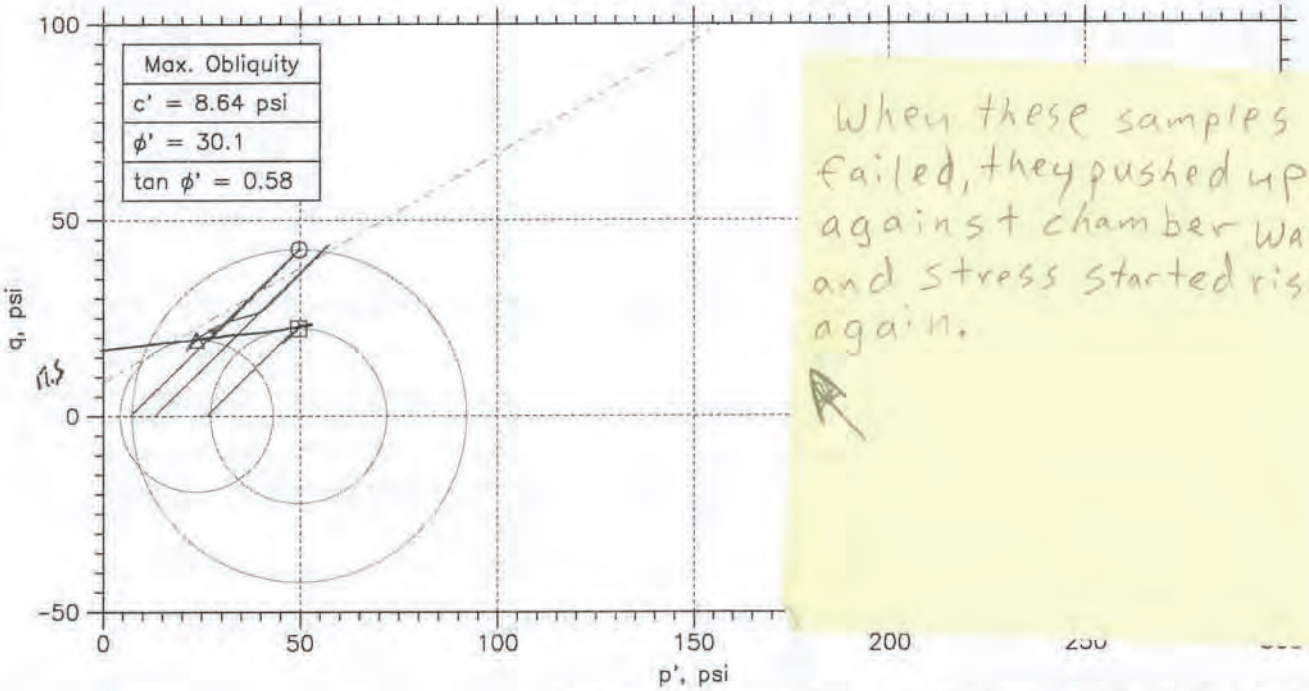
Height: 5.2346 in
Area: 6.4658 in^2
Volume: 554.33 cc

Moisture: 32.82 %
Void Ratio: 0.87
Dry Unit Weight: 88.48 pcf
Saturation: 100.00 %

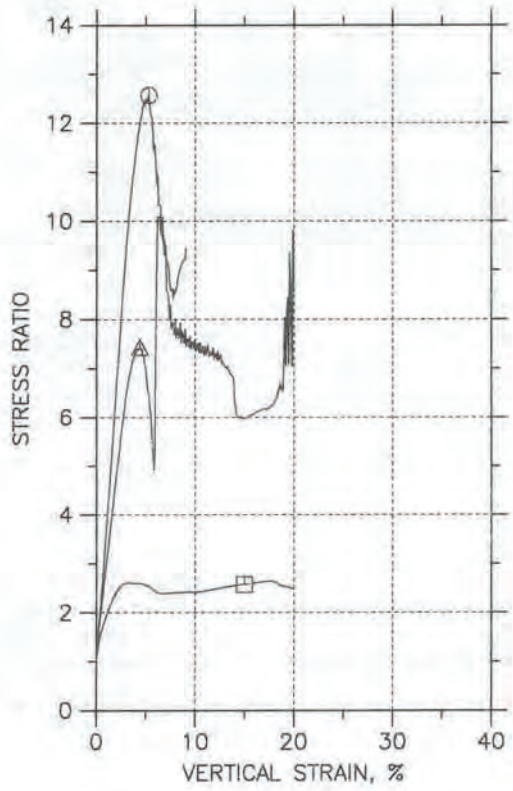
FIG. B-23
Sheet 5 of 5

SS-426-13

Test File



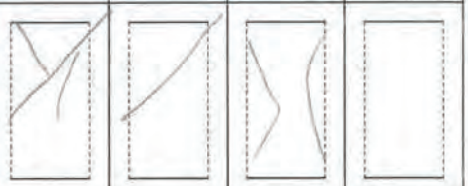
When these samples failed, they pushed up against chamber wall and stress started rising again.



Symbol		⊙	△	⊡
Sample No.		SS-426-13	SS-426-13	SS-426-13
Test No.		UU-68-13	UU-69-13	UU-70-13
Depth		18.0 - 20.0	18.0 - 20.0	18.0 - 20.0
Initial	Diameter, in	2.853	2.845	2.852
	Height, in	5.562	5.56	5.563
	Water Content, %	25.2	26.3	27.2
	Dry Density, pcf	99.63	99.03	96.22
	Saturation, %	101.2	103.8	100.3
	Void Ratio	0.661	0.671	0.719
Before Shear	Water Content, %	24.9	25.3	27.0
	Dry Density, pcf	99.7	99.11	96.42
	Saturation*, %	100.0	100.0	100.0
	Void Ratio	0.659	0.669	0.716
	Back Press., psi	.0	.0	.0
Ver. Eff. Cons. Stress, psi		6.846	13.18	26.38
Shear Strength, psi		42.43	43.6	21.45
Strain at Failure, %		5.3	4.4	15
Strain Rate, %/min		1	1	1
B-Value		---	---	---
Estimated Specific Gravity		2.65	2.65	2.65
Liquid Limit		---	---	---
Plastic Limit		---	---	---

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031
Location:
Project No.:
Boring No.: B10
Sample Type:
Description: Total length 24" Gry Silty Clay
Remarks: .



Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

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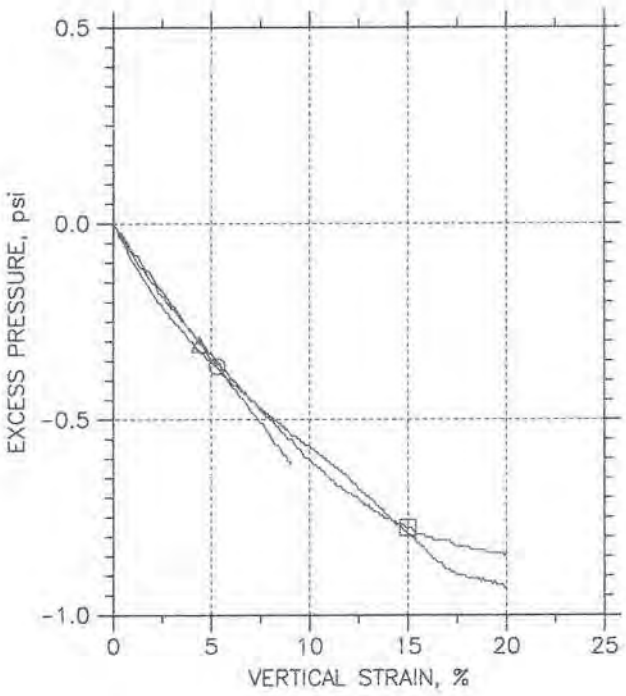
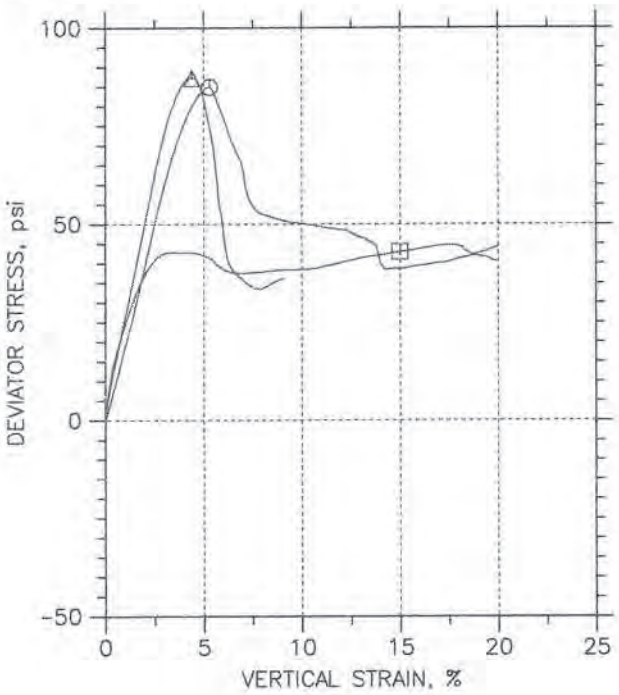
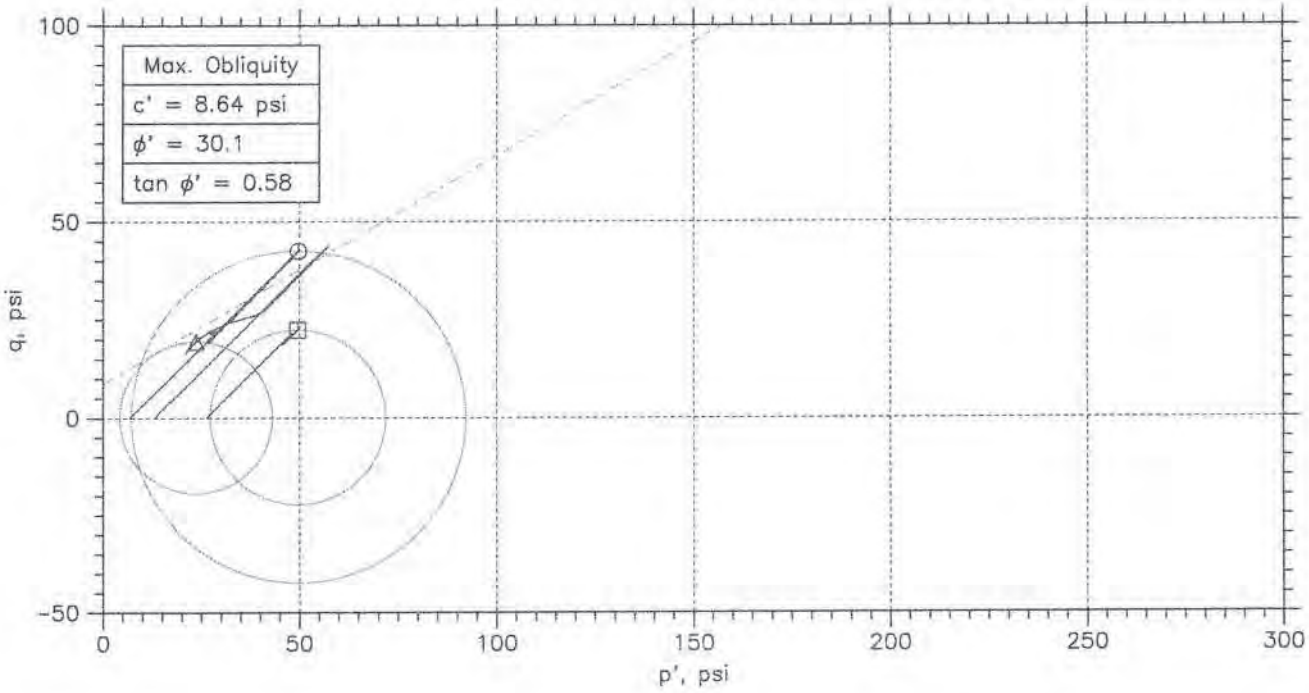
FIG. B-24
Sheet 1 of 6

55-426-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-426-13	UU-68-13	18.0 - 20.0	DT	9/23/13	SS		UU-68-2013.dat
△	SS-426-13	UU-69-13	18.0 - 20.0	DT	9/23/13	SS		UU-69-2013.dat
□	SS-426-13	UU-70-13	18.0 - 20.0	DT	9/23/13	SS		UU-70-2013.dat

NDDOT North Dakota Department of Transportation

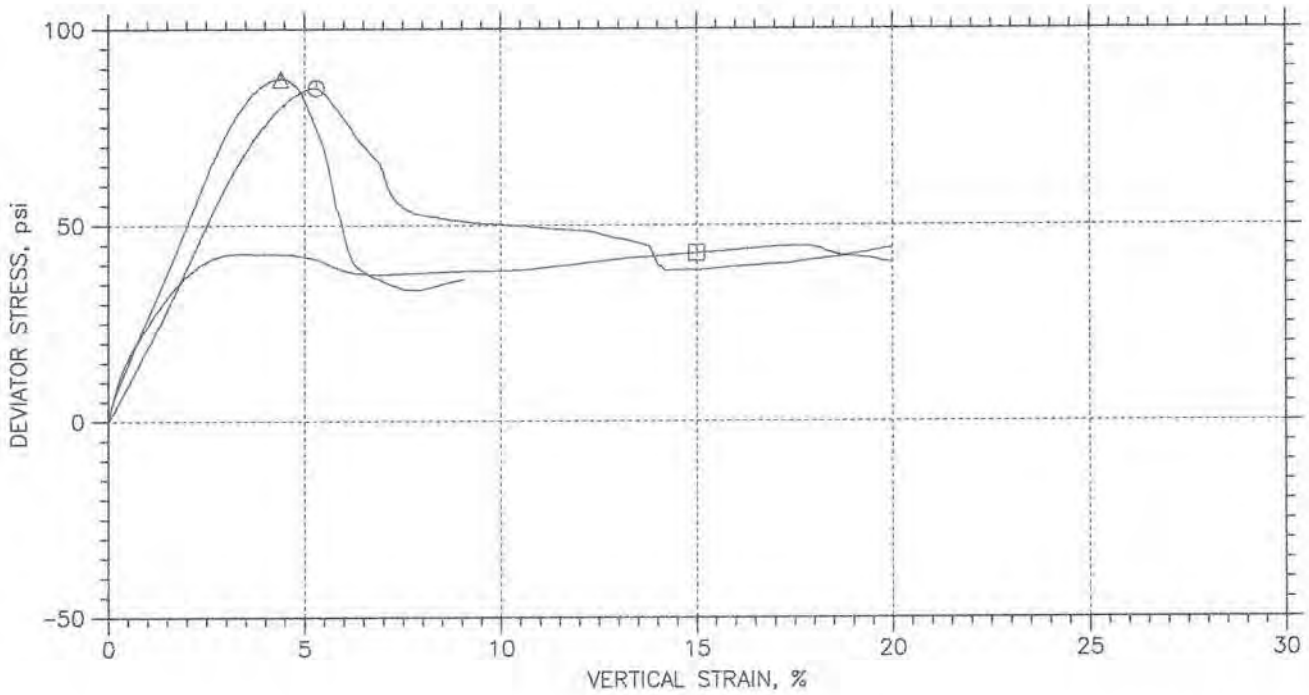
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 24" Gry Silty Clay		
Remarks: .		

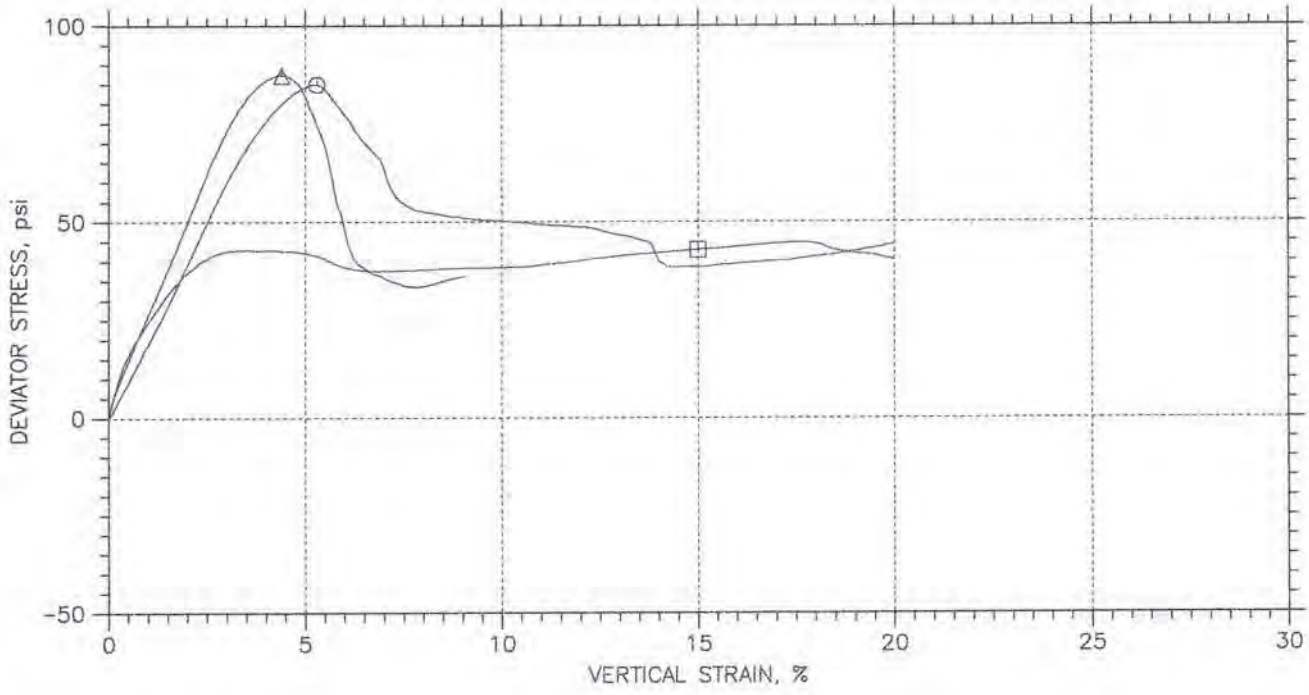
FIG. B-24

ue, 24-SEP-2013 07:23:30

SS-426-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⏲	SS-426-13	UU-68-13	18.0 - 20.0	DT	9/23/13	SS		UU-68-2013.dat
△	SS-426-13	UU-69-13	18.0 - 20.0	DT	9/23/13	SS		UU-69-2013.dat
⊡	SS-426-13	UU-70-13	18.0 - 20.0	DT	9/23/13	SS		UU-70-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 24" Gry Silty Clay		
Remarks: .		

FIG. B-24

Tue, 24-SEP-2013 07:23:30

SS-426-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-426-13
Test No.: UU-68-13

Location:
Tested By: DT
Test Date: 9/23/13
Sample Type:

Project No.:
Checked By: SS
Depth: 18.0 - 20.0
Elevation:

Soil Description: Total length 24'' Gry Silty Clay
Remarks: .

Specimen Height: 5.56 in
Specimen Area: 6.39 in^2
Specimen Volume: 582.67 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s4	---		
Wt. Container + Wet Soil, gm	48.99	---	---	0
Wt. Container + Dry Soil, gm	42.57	---	---	0
Wt. Container, gm	17.11	---	---	0
Wt. Wet Soil, gm	31.88	1164.3	929.86	0
Wt. Dry Soil, gm	25.46	929.86	929.86	0
Wt. Water, gm	6.42	234.47	0	0
Water Content, %	25.22	25.22	0.00	0.00
Void Ratio	---	0.66	0.66	---
Degree of Saturation, %	---	101.16	0.00	---
Dry Unit Weight, pcf	---	99.625	99.7	---

Initial

Height: 5.562 in
Area: 6.3928 in^2
Volume: 582.67 cc

Moisture: 25.22 %
Void Ratio: 0.66
Dry Unit Weight: 99.625 pcf
Saturation: 101.16 %

End of Initialization
Time: 2.6653 min
Total Vertical Stress: 6.8457 psi
Total Horizontal Stress: 6.8619 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8457 psi
Effective Horizontal Stress: 6.8619 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.4358 cc
Water Change: -0.010726 cc
Correction: 3.1351 cc

Height: 5.5606 in
Area: 6.3928 in^2
Volume: 582.24 cc

Moisture: 24.88 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 2.6653 min
Total Vertical Stress: 6.8457 psi
Total Horizontal Stress: 6.8619 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8457 psi
Effective Horizontal Stress: 6.8619 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.4358 cc
Water Change: -0.010726 cc
Correction: 3.1351 cc

Height: 5.5606 in
Area: 6.3928 in^2
Volume: 582.24 cc

Moisture: 24.88 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 100.00 %

End of Saturation
Time: 2.6653 min
Total Vertical Stress: 6.8457 psi
Total Horizontal Stress: 6.8619 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8457 psi
Effective Horizontal Stress: 6.8619 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.4358 cc
Water Change: -0.010726 cc
Correction: 3.1351 cc

Height: 5.5606 in
Area: 6.3928 in^2
Volume: 582.24 cc

Moisture: 24.88 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 2.6653 min
Total Vertical Stress: 6.8457 psi
Total Horizontal Stress: 6.8619 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.8457 psi
Effective Horizontal Stress: 6.8619 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.4358 cc
Water Change: -0.010726 cc
Correction: 3.1351 cc

Height: 5.5606 in
Area: 6.3928 in^2
Volume: 582.24 cc

Moisture: 24.88 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 100.00 %

End of Shear
Time: 22.972 min
Total Vertical Stress: 49.093 psi
Total Horizontal Stress: 4.8921 psi
Pore Pressure: -0.93898 psi
Effective Vertical Stress: 50.032 psi
Effective Horizontal Stress: 5.8311 psi

Height Change: 1.1136 in
Area Change: -1.5944 in^2
Volume Change: 0.43634 cc
Water Change: -0.01019 cc
Correction: 234.48 cc

Height: 4.4484 in
Area: 7.9872 in^2
Volume: 582.24 cc

Moisture: 0.00 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 0.00 %

At Failure
Time: 8.1161 min
Total Vertical Stress: 91.824 psi
Total Horizontal Stress: 6.9669 psi
Pore Pressure: -0.37235 psi
Effective Vertical Stress: 92.197 psi
Effective Horizontal Stress: 7.3392 psi

Height Change: 0.29619 in
Area Change: -0.3597 in^2
Volume Change: 0.43526 cc
Water Change: -0.01019 cc
Correction: 0 cc

Height: 5.2658 in
Area: 6.7525 in^2
Volume: 582.24 cc

Moisture: 24.88 %
Void Ratio: 0.66
Dry Unit Weight: 99.7 pcf
Saturation: 100.00 %

FIG. B-24
Sheet 4 of 6

SS-426-13

TRIAXIAL TEST

Project: SER-8-094(093)031
Boring No.: B10
Sample No.: SS-426-13
Test No.: UU-69-13

Location:
Tested By: DT
Test Date: 9/23/13
Sample Type:

Project No.:
Checked By: SS
Depth: 18.0 - 20.0
Elevation:

Soil Description: Total length 24'' Gry Silty Clay
Remarks: .

Specimen Height: 5.56 in
Specimen Area: 6.36 in^2
Specimen Volume: 579.20 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s24	---		
Wt. Container + Wet Soil, gm	54.01	---	---	0
Wt. Container + Dry Soil, gm	46.3	---	---	0
Wt. Container, gm	16.95	---	---	0
Wt. Wet Soil, gm	37.06	1160.1	918.77	0
Wt. Dry Soil, gm	29.35	918.77	918.77	0
Wt. Water, gm	7.71	241.35	0	0
Water Content, %	26.27	26.27	0.00	0.00
Void Ratio	---	0.67	0.67	---
Degree of Saturation, %	---	103.81	0.00	---
Dry Unit Weight, pcf	---	99.027	99.111	---

Initial

Height: 5.56 in
Area: 6.357 in^2
Volume: 579.2 cc

Moisture: 26.27 %
Void Ratio: 0.67
Dry Unit Weight: 99.027 pcf
Saturation: 103.81 %

End of Initialization
Time: 9.3527 min
Total Vertical Stress: 13.177 psi
Total Horizontal Stress: 13.183 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.177 psi
Effective Horizontal Stress: 13.183 psi

Height Change: 0.0015716 in
Area Change: 0 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 9.3798 cc

Height: 5.5584 in
Area: 6.357 in^2
Volume: 578.71 cc

Moisture: 25.25 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 9.3527 min
Total Vertical Stress: 13.177 psi
Total Horizontal Stress: 13.183 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.177 psi
Effective Horizontal Stress: 13.183 psi

Height Change: 0.0015716 in
Area Change: 0 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 9.3798 cc

Height: 5.5584 in
Area: 6.357 in^2
Volume: 578.71 cc

Moisture: 25.25 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 100.00 %

End of Saturation
Time: 9.3527 min
Total Vertical Stress: 13.177 psi
Total Horizontal Stress: 13.183 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.177 psi
Effective Horizontal Stress: 13.183 psi

Height Change: 0.0015716 in
Area Change: 0 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 9.3798 cc

Height: 5.5584 in
Area: 6.357 in^2
Volume: 578.71 cc

Moisture: 25.25 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 9.3527 min
Total Vertical Stress: 13.177 psi
Total Horizontal Stress: 13.183 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.177 psi
Effective Horizontal Stress: 13.183 psi

Height Change: 0.0015716 in
Area Change: 0 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 9.3798 cc

Height: 5.5584 in
Area: 6.357 in^2
Volume: 578.71 cc

Moisture: 25.25 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 100.00 %

End of Shear
Time: 18.649 min
Total Vertical Stress: 39.834 psi
Total Horizontal Stress: 3.657 psi
Pore Pressure: -0.62329 psi
Effective Vertical Stress: 40.457 psi
Effective Horizontal Stress: 4.2803 psi

Height Change: 0.50544 in
Area Change: -0.62975 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 241.39 cc

Height: 5.0546 in
Area: 6.9868 in^2
Volume: 578.71 cc

Moisture: 0.00 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 0.00 %

At Failure
Time: 13.872 min
Total Vertical Stress: 100.44 psi
Total Horizontal Stress: 13.239 psi
Pore Pressure: -0.31569 psi
Effective Vertical Stress: 100.75 psi
Effective Horizontal Stress: 13.555 psi

Height Change: 0.24636 in
Area Change: -0.29513 in^2
Volume Change: 0.49114 cc
Water Change: -0.033787 cc
Correction: 0 cc

Height: 5.3136 in
Area: 6.6522 in^2
Volume: 578.71 cc

Moisture: 25.25 %
Void Ratio: 0.67
Dry Unit Weight: 99.111 pcf
Saturation: 100.00 %

FIG. B-24
Sheet 5 of 6

SS-426-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-426-13
Test No.: UU-70-13

Location:
Tested By: DT
Test Date: 9/23/13
Sample Type:

Project No.:
Checked By: SS
Depth: 18.0 - 20.0
Elevation:

Soil Description: Total length 24'' Gry Silty Clay
Remarks: .

Specimen Height: 5.56 in
Specimen Area: 6.39 in^2
Specimen Volume: 582.37 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	sB	---		
Wt. Container + Wet Soil, gm	49.74	---	---	0
Wt. Container + Dry Soil, gm	42.72	---	---	0
Wt. Container, gm	16.93	---	---	0
Wt. Wet Soil, gm	32.81	1141.9	897.57	0
Wt. Dry Soil, gm	25.79	897.57	897.57	0
Wt. Water, gm	7.02	244.32	0	0
Water Content, %	27.22	27.22	0.00	0.00
Void Ratio	---	0.72	0.72	---
Degree of Saturation, %	---	100.27	0.00	---
Dry Unit Weight, pcf	---	96.216	96.423	---

Initial

Height: 5.563 in
Area: 6.3884 in^2
Volume: 582.37 cc

Moisture: 27.22 %
Void Ratio: 0.72
Dry Unit Weight: 96.216 pcf
Saturation: 100.27 %

End of Initialization
Time: 5.0521 min
Total Vertical Stress: 26.377 psi
Total Horizontal Stress: 26.39 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 26.377 psi
Effective Horizontal Stress: 26.39 psi

Height Change: 0.0039751 in
Area Change: 0 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 1.9235 cc

Height: 5.559 in
Area: 6.3884 in^2
Volume: 581.12 cc

Moisture: 27.01 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 5.0521 min
Total Vertical Stress: 26.377 psi
Total Horizontal Stress: 26.39 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 26.377 psi
Effective Horizontal Stress: 26.39 psi

Height Change: 0.0039751 in
Area Change: 0 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 1.9235 cc

Height: 5.559 in
Area: 6.3884 in^2
Volume: 581.12 cc

Moisture: 27.01 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 100.00 %

End of Saturation
Time: 5.0521 min
Total Vertical Stress: 26.377 psi
Total Horizontal Stress: 26.39 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 26.377 psi
Effective Horizontal Stress: 26.39 psi

Height Change: 0.0039751 in
Area Change: 0 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 1.9235 cc

Height: 5.559 in
Area: 6.3884 in^2
Volume: 581.12 cc

Moisture: 27.01 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 5.0521 min
Total Vertical Stress: 26.377 psi
Total Horizontal Stress: 26.39 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 26.377 psi
Effective Horizontal Stress: 26.39 psi

Height Change: 0.0039751 in
Area Change: 0 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 1.9235 cc

Height: 5.559 in
Area: 6.3884 in^2
Volume: 581.12 cc

Moisture: 27.01 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 100.00 %

End of Shear
Time: 25.369 min
Total Vertical Stress: 66.952 psi
Total Horizontal Stress: 26.511 psi
Pore Pressure: -0.84184 psi
Effective Vertical Stress: 67.793 psi
Effective Horizontal Stress: 27.353 psi

Height Change: 1.1158 in
Area Change: -1.5857 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 244.34 cc

Height: 4.4472 in
Area: 7.9741 in^2
Volume: 581.12 cc

Moisture: 0.00 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 0.00 %

At Failure
Time: 20.296 min
Total Vertical Stress: 69.345 psi
Total Horizontal Stress: 26.448 psi
Pore Pressure: -0.77708 psi
Effective Vertical Stress: 70.123 psi
Effective Horizontal Stress: 27.225 psi

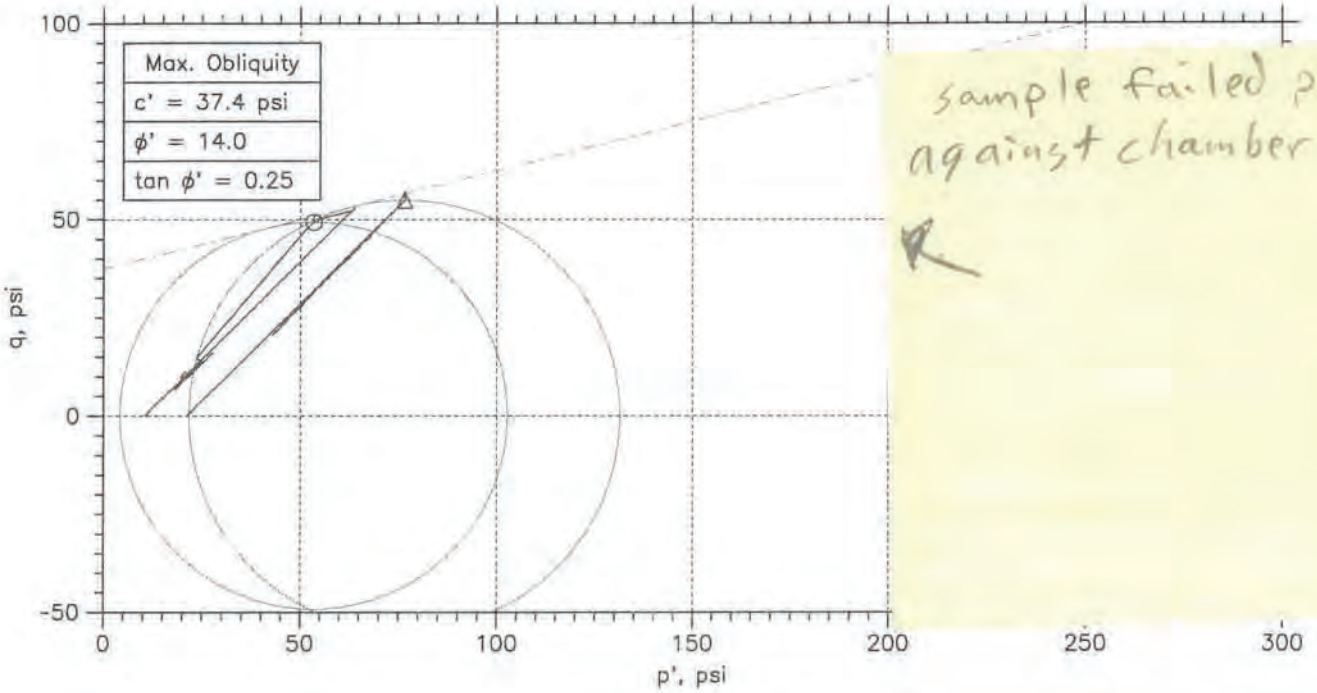
Height Change: 0.83778 in
Area Change: -1.1329 in^2
Volume Change: 1.2484 cc
Water Change: -0.020916 cc
Correction: 0 cc

Height: 4.7252 in
Area: 7.5213 in^2
Volume: 581.12 cc

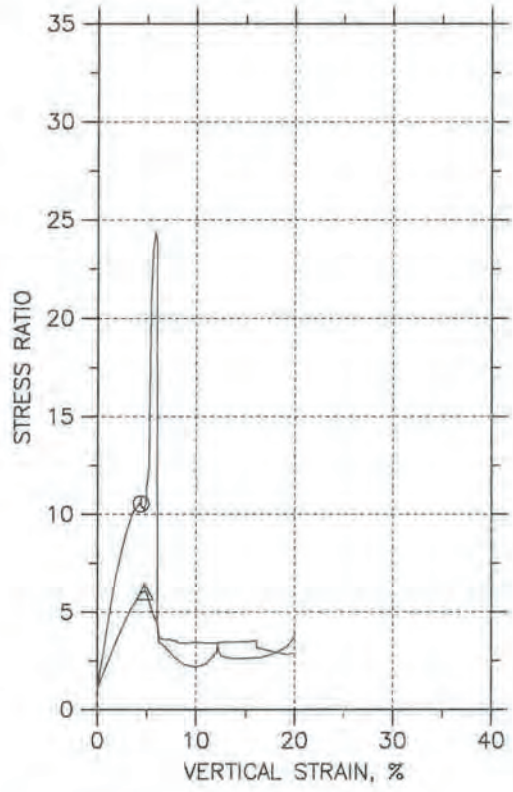
Moisture: 27.01 %
Void Ratio: 0.72
Dry Unit Weight: 96.423 pcf
Saturation: 100.00 %

FIG. B-24
Sheet 6 of 6

Test File



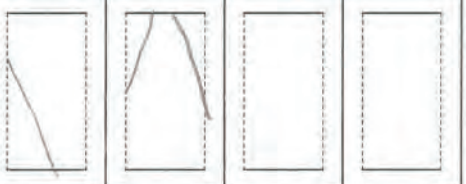
sample failed pushed against chamber wall



Symbol		⊙	△		
Sample No.		SS-428-13	SS-428-13		
Test No.		UU-71-13	UU-72-13		
Depth		22.0-24.0	22.0-24.0		
Initial	Diameter, in	2.857	2.841		
	Height, in	5.556	5.553		
	Water Content, %	24.2	32.6		
	Dry Density, pcf	103.1	95.5		
	Saturation, %	106.1	118.1		
	Void Ratio	0.604	0.732		
Before Shear	Water Content, %	22.6	27.4		
	Dry Density, pcf	103.4	95.77		
	Saturation*, %	100.0	100.0		
	Void Ratio	0.6	0.727		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		10.56	21.28		
Shear Strength, psi		52.86	55.04		
Strain at Failure, %		4.41	4.8		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031
Location:
Project No.:
Boring No.: B10
Sample Type:
Description: Total length 24.5" Gry Silty Clay
Remarks: .



Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

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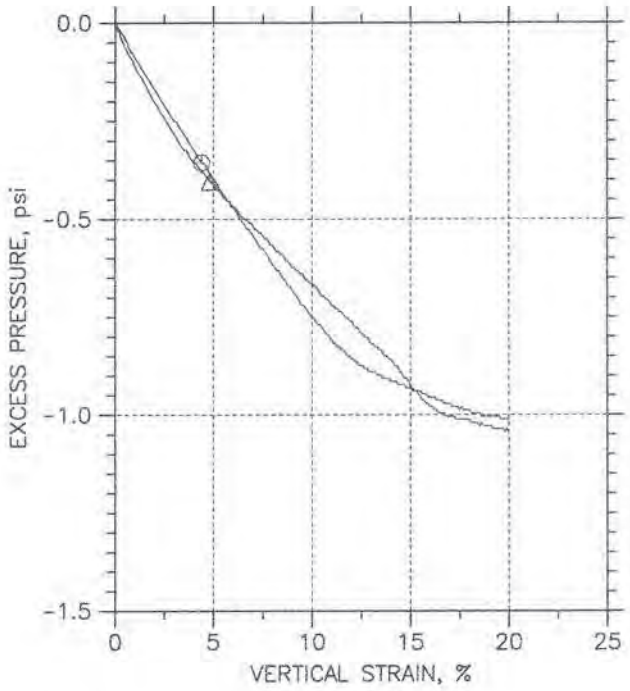
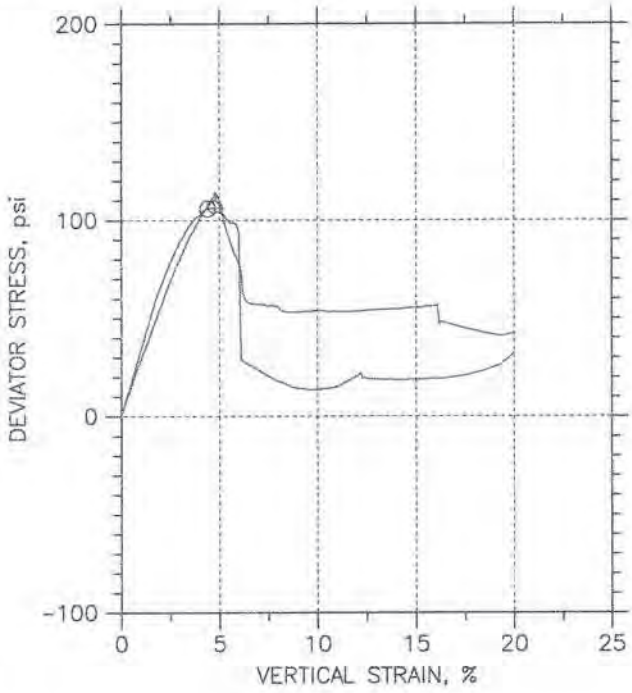
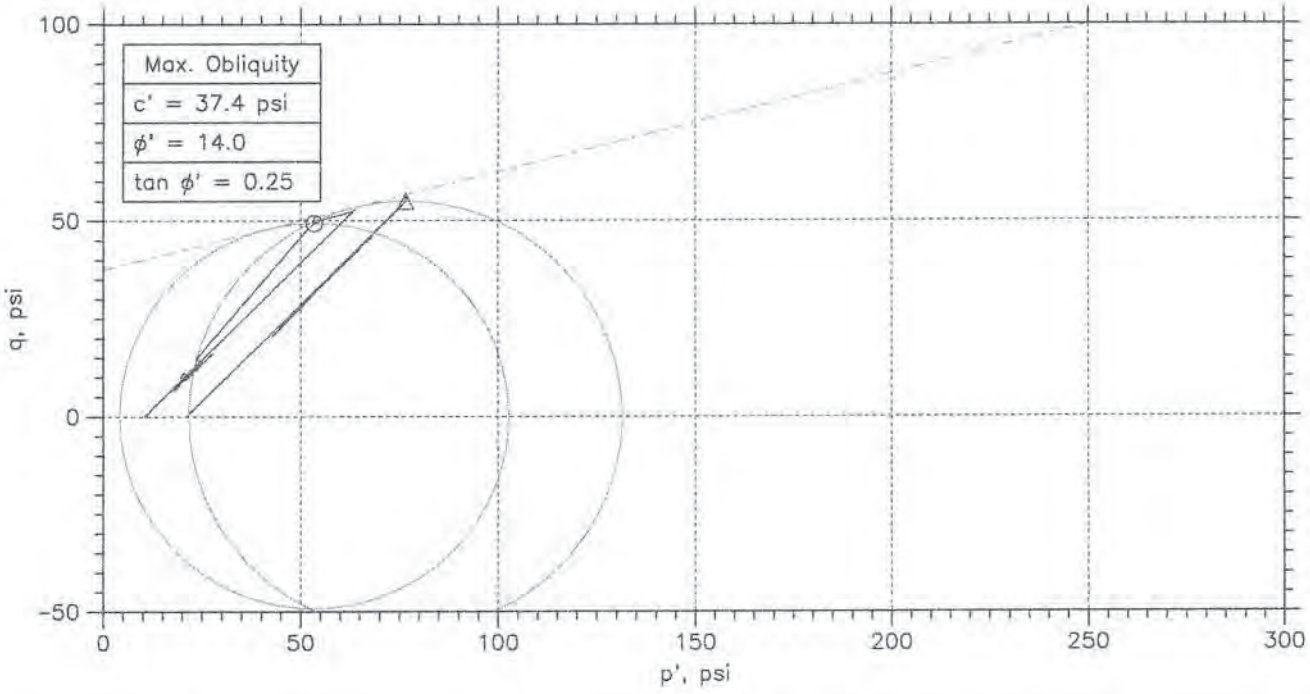
FIG. B-25
Sheet 1 of 5

SS-428-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-428-13	UU-71-13	22.0-24.0	DT	9/24/13	SS		UU-71-2013.dat
△	SS-428-13	UU-72-13	22.0-24.0	DT	9/24/13	SS		UU-72-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 24.5'' Gry Silty Clay		
Remarks: .		

FIG. B-25
Sheet 2 of 5

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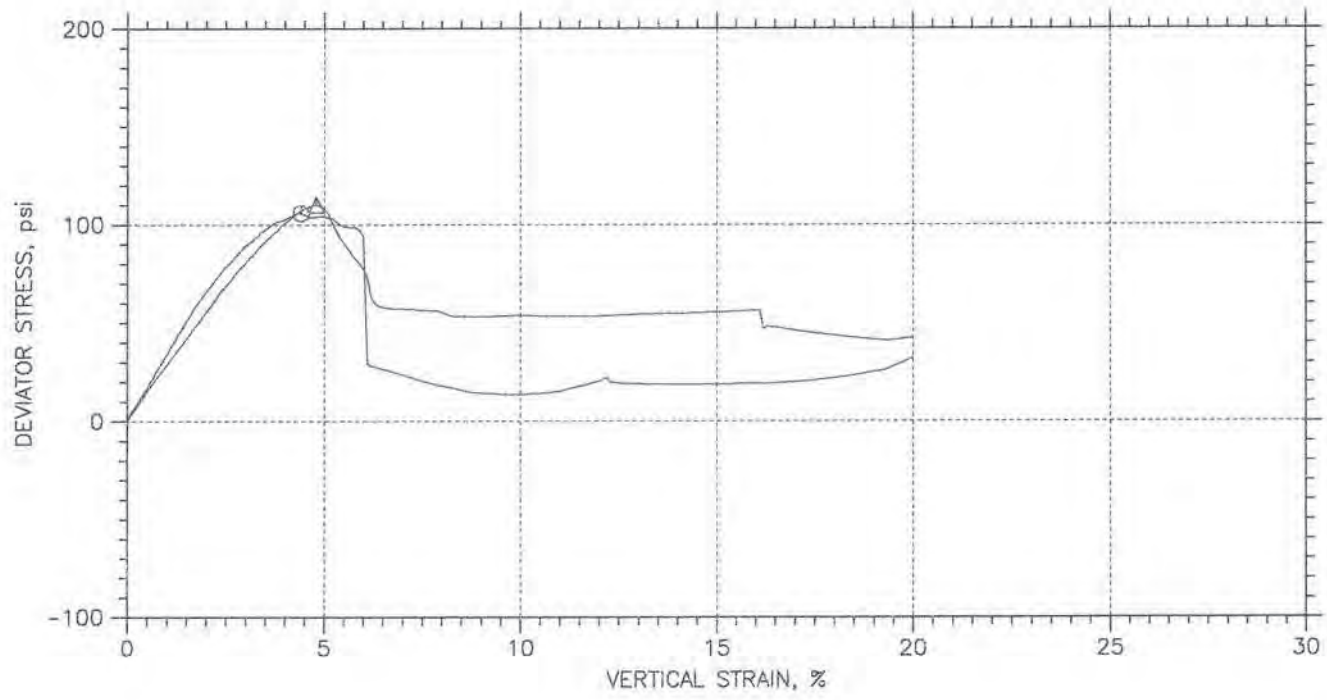
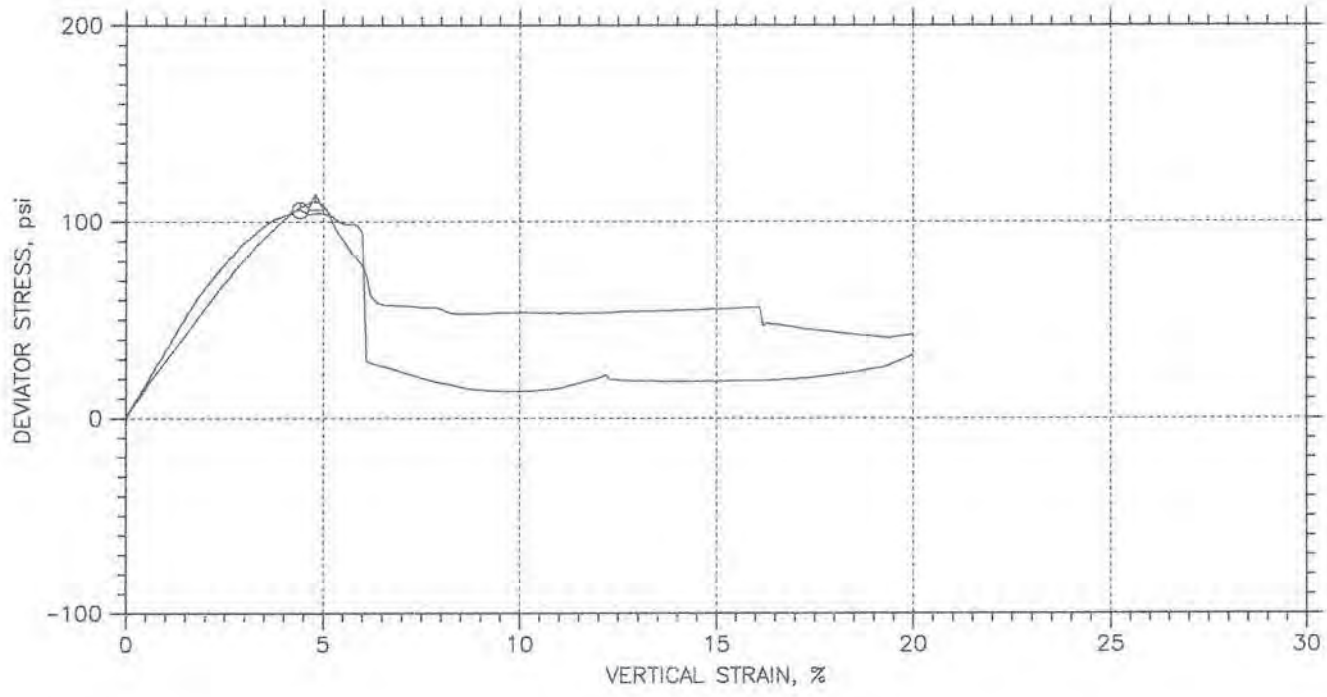
SS-428-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-428-13	UU-71-13	22.0-24.0	DT	9/24/13	SS		UU-71-2013.dat
△	SS-428-13	UU-72-13	22.0-24.0	DT	9/24/13	SS		UU-72-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 24.5" Gry Silty Clay		
Remarks: .		

FIG. B-25
Sheet 3 of 5

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SS-428-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-428-13
Test No.: UU-71-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 22.0-24.0
Elevation:

Soil Description: Total length 24.5'' Gry Silty Clay
Remarks: .

Specimen Height: 5.56 in
Specimen Area: 6.41 in^2
Specimen Volume: 583.68 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s18	---		
Wt. Container + Wet Soil, gm	52.73	---	---	0
Wt. Container + Dry Soil, gm	45.76	---	---	0
Wt. Container, gm	16.93	---	---	0
Wt. Wet Soil, gm	35.8	1197.5	964.36	0
Wt. Dry Soil, gm	28.83	964.36	964.36	0
Wt. Water, gm	6.97	233.14	1.1642e-013	0
Water Content, %	24.18	24.18	0.00	0.00
Void Ratio	---	0.60	0.60	---
Degree of Saturation, %	---	106.09	0.00	---
Dry Unit Weight, pcf	---	103.14	103.42	---

Initial

Height: 5.556 in
Area: 6.4108 in^2
Volume: 583.68 cc

Moisture: 24.18 %
Void Ratio: 0.60
Dry Unit Weight: 103.14 pcf
Saturation: 106.09 %

End of Initialization
Time: 6.5108 min
Total Vertical Stress: 10.559 psi
Total Horizontal Stress: 10.575 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.559 psi
Effective Horizontal Stress: 10.575 psi

Height Change: 0.0049458 in
Area Change: 0 in^2
Volume Change: 1.5587 cc
Water Change: -0.031642 cc
Correction: 14.964 cc

Height: 5.5511 in
Area: 6.4108 in^2
Volume: 582.12 cc

Moisture: 22.63 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 6.5108 min
Total Vertical Stress: 10.559 psi
Total Horizontal Stress: 10.575 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.559 psi
Effective Horizontal Stress: 10.575 psi

Height Change: 0.0049458 in
Area Change: 0 in^2
Volume Change: 1.5587 cc
Water Change: -0.031642 cc
Correction: 14.964 cc

Height: 5.5511 in
Area: 6.4108 in^2
Volume: 582.12 cc

Moisture: 22.63 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 100.00 %

End of Saturation
Time: 6.5108 min
Total Vertical Stress: 10.559 psi
Total Horizontal Stress: 10.575 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.559 psi
Effective Horizontal Stress: 10.575 psi

Height Change: 0.0049458 in
Area Change: 0 in^2
Volume Change: 1.5587 cc
Water Change: -0.031642 cc
Correction: 14.964 cc

Height: 5.5511 in
Area: 6.4108 in^2
Volume: 582.12 cc

Moisture: 22.63 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 6.5108 min
Total Vertical Stress: 10.559 psi
Total Horizontal Stress: 10.575 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.559 psi
Effective Horizontal Stress: 10.575 psi

Height Change: 0.0049458 in
Area Change: 0 in^2
Volume Change: 1.5587 cc
Water Change: -0.031642 cc
Correction: 14.964 cc

Height: 5.5511 in
Area: 6.4108 in^2
Volume: 582.12 cc

Moisture: 22.63 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 100.00 %

End of Shear
Time: 26.796 min
Total Vertical Stress: 42.893 psi
Total Horizontal Stress: 10.632 psi
Pore Pressure: -1.0118 psi
Effective Vertical Stress: 43.905 psi
Effective Horizontal Stress: 11.644 psi

Height Change: 1.1152 in
Area Change: -1.5884 in^2
Volume Change: 1.5587 cc
Water Change: -0.032178 cc
Correction: 233.18 cc

Height: 4.4408 in
Area: 7.9992 in^2
Volume: 582.12 cc

Moisture: 0.00 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 0.00 %

At Failure
Time: 11.06 min
Total Vertical Stress: 116.48 psi
Total Horizontal Stress: 10.753 psi
Pore Pressure: -0.35616 psi
Effective Vertical Stress: 116.84 psi
Effective Horizontal Stress: 11.109 psi

Height Change: 0.24965 in
Area Change: -0.30198 in^2
Volume Change: 1.5593 cc
Water Change: -0.032178 cc
Correction: 0 cc

Height: 5.3064 in
Area: 6.7127 in^2
Volume: 582.12 cc

Moisture: 22.63 %
Void Ratio: 0.60
Dry Unit Weight: 103.42 pcf
Saturation: 100.00 %

FIG. B-25
Sheet 4 of 5

25-728-15

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-428-13
Test No.: UU-72-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 22.0-24.0
Elevation:

Soil Description: Total length 24.5'' Gry Silty Clay
Remarks: .

Specimen Height: 5.55 in
Specimen Area: 6.34 in^2
Specimen Volume: 576.85 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s40	---		
Wt. Container + Wet Soil, gm	55.14	---	---	0
Wt. Container + Dry Soil, gm	45.76	---	---	0
Wt. Container, gm	17.01	---	---	0
Wt. Wet Soil, gm	38.13	1170.3	882.44	0
Wt. Dry Soil, gm	28.75	882.44	882.44	0
Wt. Water, gm	9.38	287.9	0	0
Water Content, %	32.63	32.63	0.00	0.00
Void Ratio	---	0.73	0.73	---
Degree of Saturation, %	---	118.06	0.00	---
Dry Unit Weight, pcf	---	95.499	95.77	---

Initial

Height: 5.553 in
Area: 6.3392 in^2
Volume: 576.85 cc

Moisture: 32.63 %
Void Ratio: 0.73
Dry Unit Weight: 95.499 pcf
Saturation: 118.06 %

End of Initialization
Time: 2.5017 min
Total Vertical Stress: 21.281 psi
Total Horizontal Stress: 21.288 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 21.281 psi
Effective Horizontal Stress: 21.288 psi

Height Change: 0.0052231 in
Area Change: 0 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 45.693 cc

Height: 5.5478 in
Area: 6.3392 in^2
Volume: 575.22 cc

Moisture: 27.45 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 2.5017 min
Total Vertical Stress: 21.281 psi
Total Horizontal Stress: 21.288 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 21.281 psi
Effective Horizontal Stress: 21.288 psi

Height Change: 0.0052231 in
Area Change: 0 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 45.693 cc

Height: 5.5478 in
Area: 6.3392 in^2
Volume: 575.22 cc

Moisture: 27.45 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 100.00 %

End of Saturation
Time: 2.5017 min
Total Vertical Stress: 21.281 psi
Total Horizontal Stress: 21.288 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 21.281 psi
Effective Horizontal Stress: 21.288 psi

Height Change: 0.0052231 in
Area Change: 0 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 45.693 cc

Height: 5.5478 in
Area: 6.3392 in^2
Volume: 575.22 cc

Moisture: 27.45 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 2.5017 min
Total Vertical Stress: 21.281 psi
Total Horizontal Stress: 21.288 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 21.281 psi
Effective Horizontal Stress: 21.288 psi

Height Change: 0.0052231 in
Area Change: 0 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 45.693 cc

Height: 5.5478 in
Area: 6.3392 in^2
Volume: 575.22 cc

Moisture: 27.45 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 100.00 %

End of Shear
Time: 22.808 min
Total Vertical Stress: 63.951 psi
Total Horizontal Stress: 21.433 psi
Pore Pressure: -1.0442 psi
Effective Vertical Stress: 64.995 psi
Effective Horizontal Stress: 22.478 psi

Height Change: 1.1149 in
Area Change: -1.5701 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 287.92 cc

Height: 4.4381 in
Area: 7.9092 in^2
Volume: 575.22 cc

Moisture: 0.00 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 0.00 %

At Failure
Time: 7.4396 min
Total Vertical Stress: 131.48 psi
Total Horizontal Stress: 21.401 psi
Pore Pressure: -0.40473 psi
Effective Vertical Stress: 131.89 psi
Effective Horizontal Stress: 21.806 psi

Height Change: 0.27165 in
Area Change: -0.32622 in^2
Volume Change: 1.6277 cc
Water Change: -0.013944 cc
Correction: 0 cc

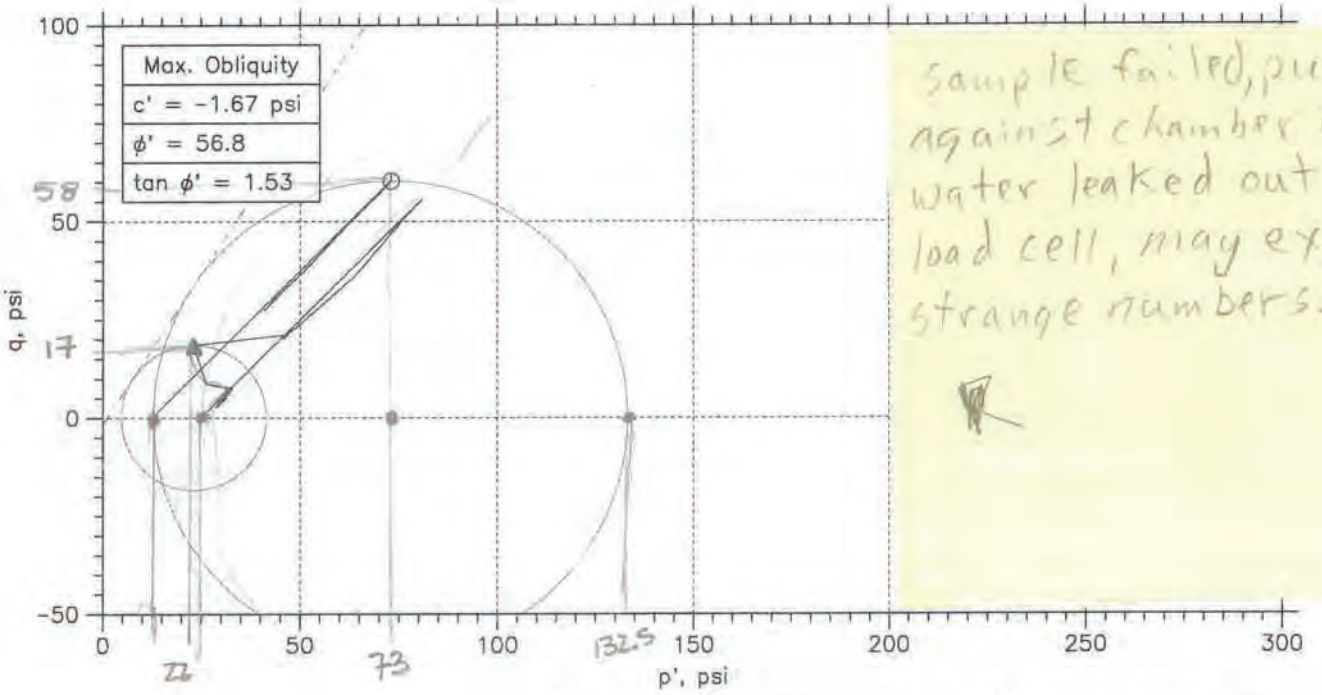
Height: 5.2814 in
Area: 6.6654 in^2
Volume: 575.22 cc

Moisture: 27.45 %
Void Ratio: 0.73
Dry Unit Weight: 95.77 pcf
Saturation: 100.00 %

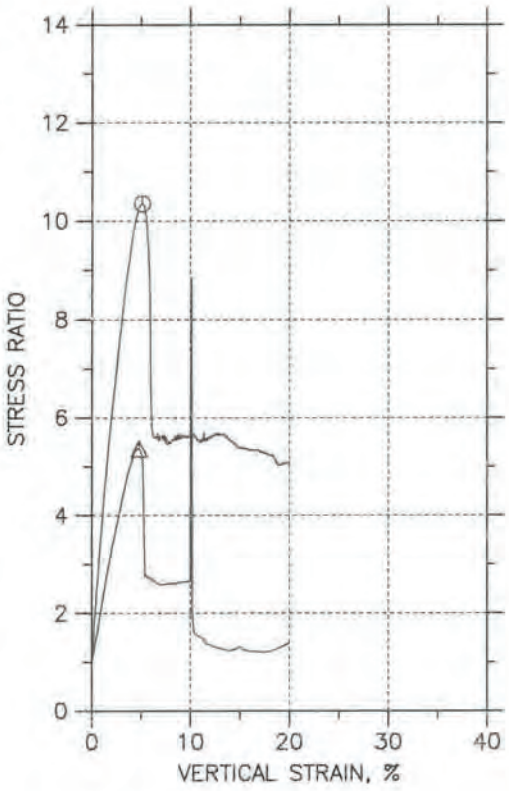
FIG. B-25
Sheet 5 of 5

SS-430-13

Test File



Sample failed, pushed against chamber wall water leaked out of load cell, may explain strange numbers.



Symbol		⊙	△		
Sample No.		SS-430-13	SS-430-13		
Test No.		UU-73-13	UU-74-13		
Depth		26.0-28.0	26.0-28.0		
Initial	Diameter, in	2.838	2.829		
	Height, in	5.553	5.872		
	Water Content, %	25.6	24.4		
	Dry Density, pcf	101.6	98.58		
	Saturation, %	108.2	95.4		
	Void Ratio	0.628	0.678		
Before Shear	Water Content, %	23.7	24.4		
	Dry Density, pcf	101.6	98.87		
	Saturation*, %	100.0	96.1		
	Void Ratio	0.628	0.673		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		12.47	24.94		
Shear Strength, psi		60.2	55.49		
Strain at Failure, %		5.1	4.8		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B10

Sample Type:

Description: Total length 27.5" Tube bent, Gry Silty Clay, with 1" rock

Remarks: .

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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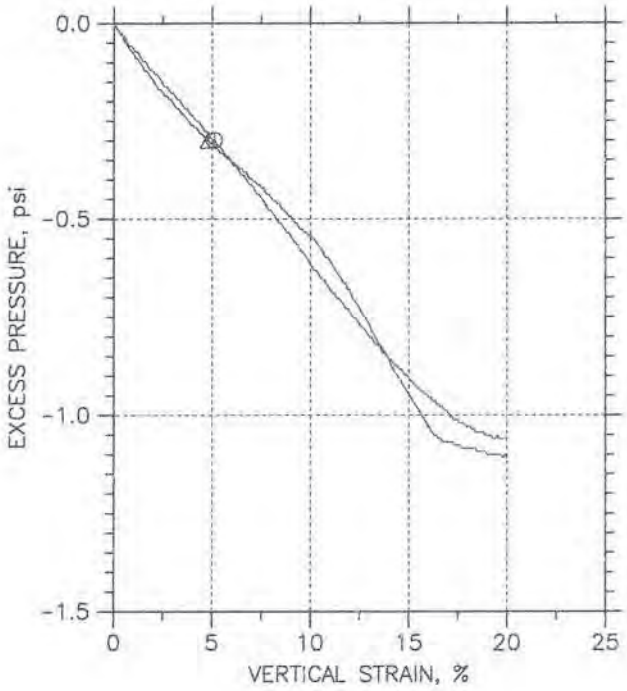
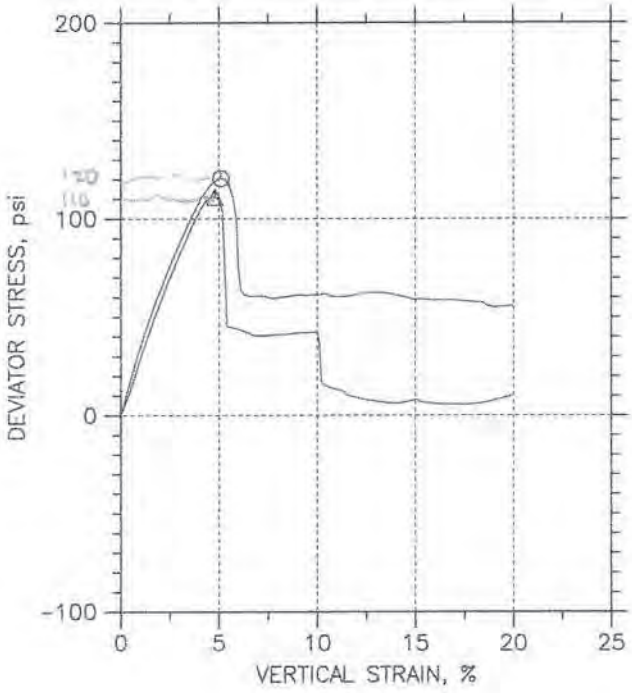
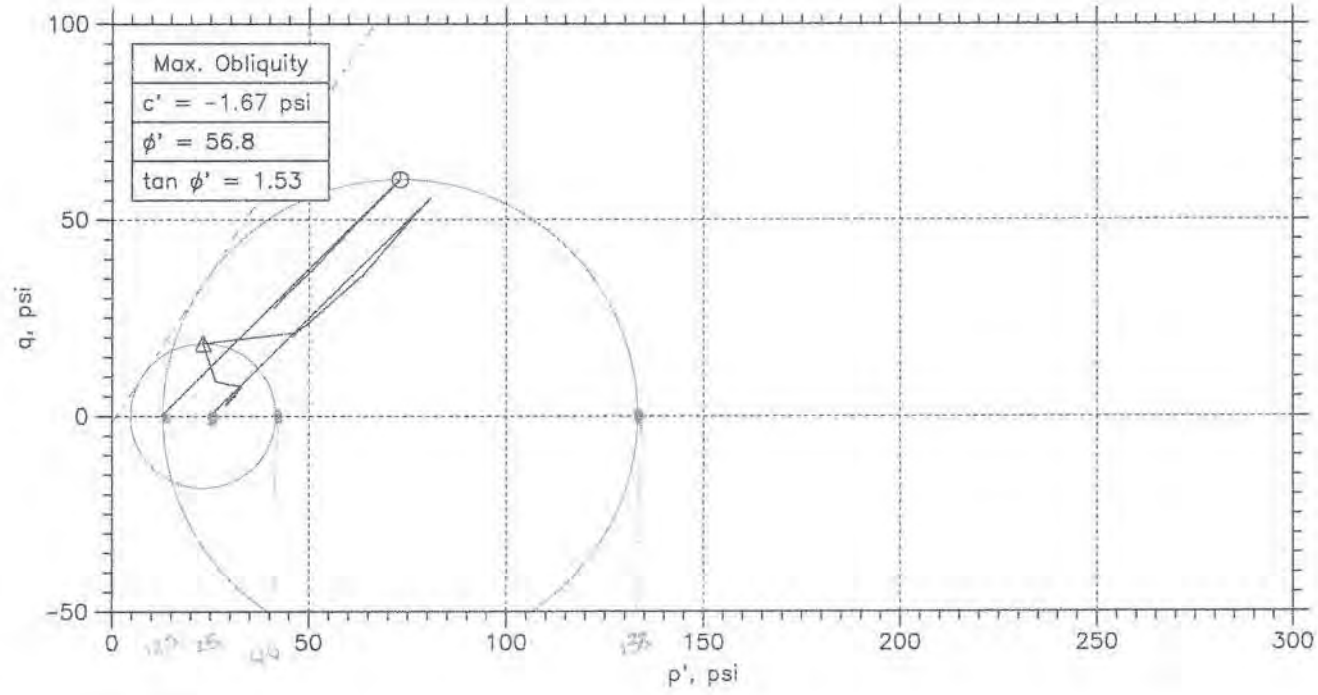
FIG. B-26

SG-430-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-430-13	UU-73-13	26.0-28.0	DT	9/24/13	SS		UU-73-2013.dat
△	SS-430-13	UU-74-13	26.0-28.0	DT	9/24/13	SS		UU-74-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 27.5" Tube bent, Gry Silty Clay, with 1" rock		
Remarks: .		

FIG. B-26
Sheet 2 of 5

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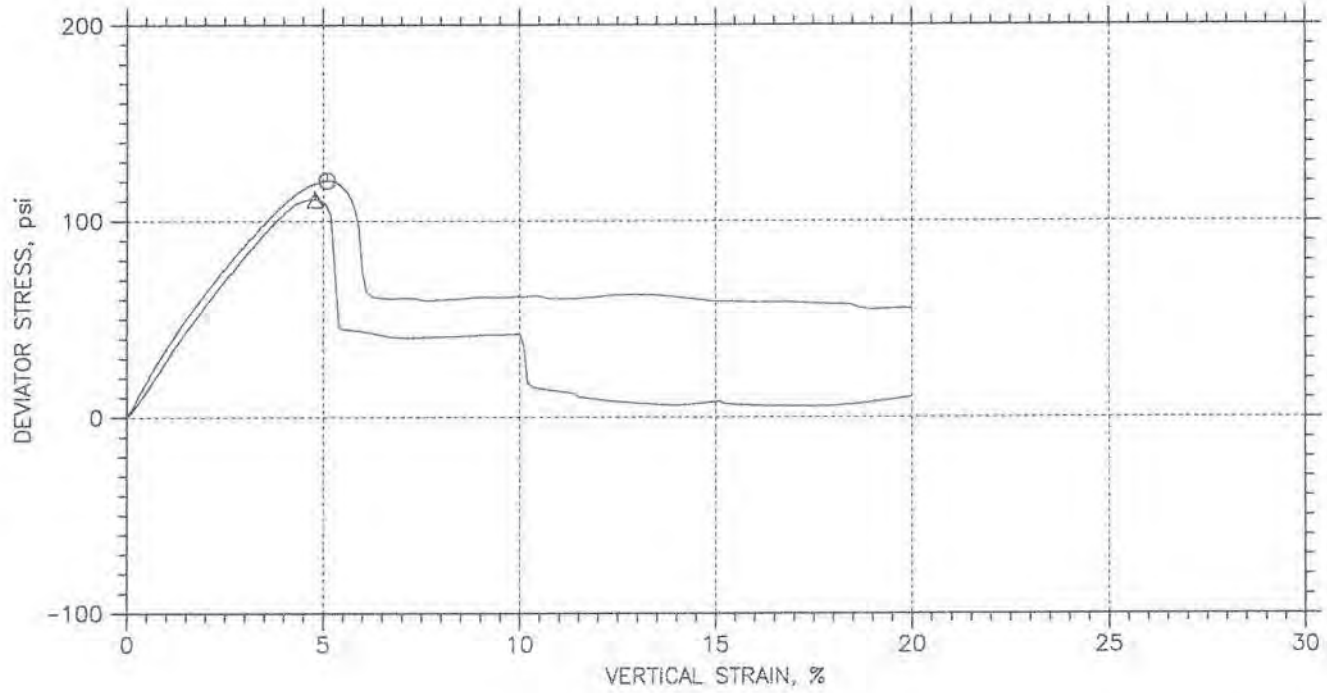
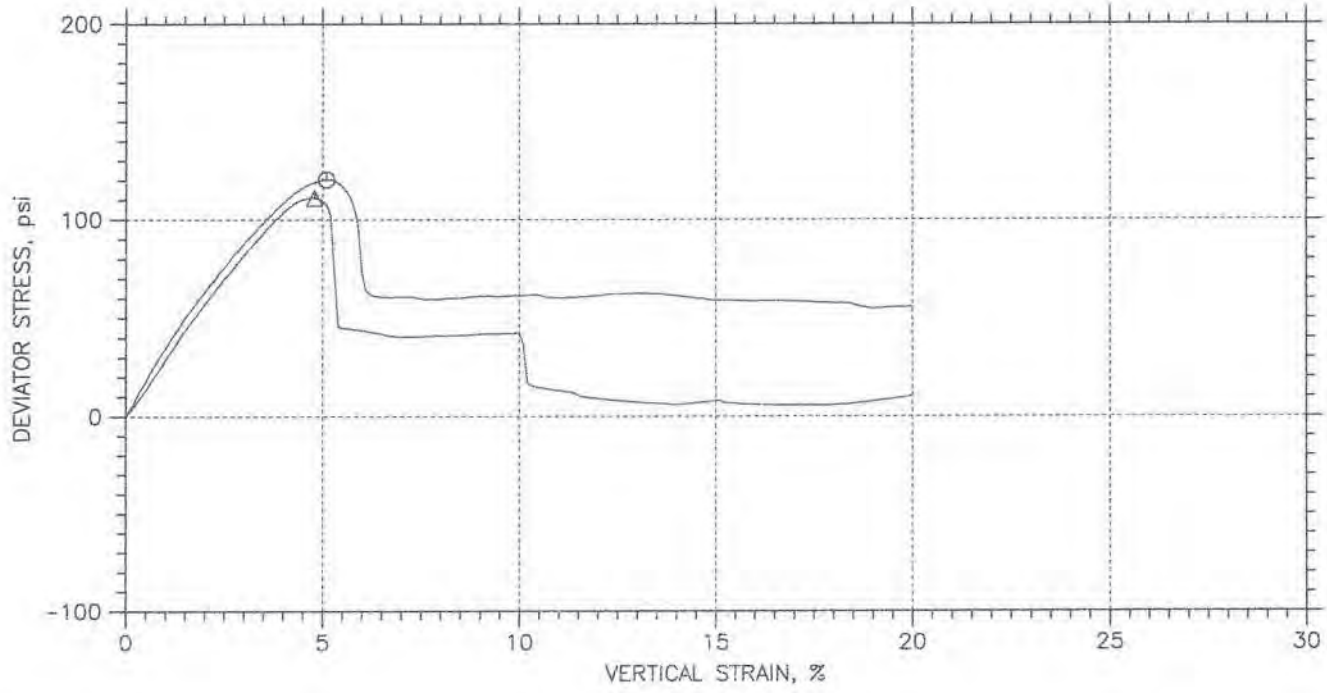
SS-430-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-430-13	UU-73-13	26.0-28.0	DT	9/24/13	SS		UU-73-2013.dat
△	SS-430-13	UU-74-13	26.0-28.0	DT	9/24/13	SS		UU-74-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B10	Sample Type:	
Description: Total length 27.5" Tube bent, Gry Silty Clay, with 1" rock		
Remarks: .		

FIG. B-26
Sheet 3 of 5

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SS-430-13

TRIAXIAL TEST

Project: SER-S-094(093)031
Boring No.: B10
Sample No.: SS-430-13
Test No.: UU-73-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 26.0-28.0
Elevation:

Soil Description: Total length 27.5'' Tube bent, Gry Silty Clay, with 1" rock
Remarks: .

Specimen Height: 5.55 in
Specimen Area: 6.33 in^2
Specimen Volume: 575.63 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s9	---		
Wt. Container + Wet Soil, gm	54.95	---	---	0
Wt. Container + Dry Soil, gm	47.23	---	---	0
Wt. Container, gm	17.21	---	---	0
Wt. Wet Soil, gm	37.74	1177.2	936.99	0
Wt. Dry Soil, gm	30.04	936.99	936.99	0
Wt. Water, gm	7.7	240.17	1.1642e-013	0
Water Content, %	25.63	25.63	0.00	0.00
Void Ratio	---	0.63	0.63	---
Degree of Saturation, %	---	108.16	0.00	---
Dry Unit Weight, pcf	---	101.62	101.62	---

Initial

Height: 5.553 in
Area: 6.3258 in^2
Volume: 575.63 cc

Moisture: 25.63 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 108.16 %

End of Initialization
Time: 6.5018 min
Total Vertical Stress: 12.47 psi
Total Horizontal Stress: 12.481 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.47 psi
Effective Horizontal Stress: 12.481 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 18.173 cc

Height: 5.5529 in
Area: 6.3258 in^2
Volume: 575.6 cc

Moisture: 23.70 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 6.5018 min
Total Vertical Stress: 12.47 psi
Total Horizontal Stress: 12.481 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.47 psi
Effective Horizontal Stress: 12.481 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 18.173 cc

Height: 5.5529 in
Area: 6.3258 in^2
Volume: 575.6 cc

Moisture: 23.70 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 100.00 %

End of Saturation
Time: 6.5018 min
Total Vertical Stress: 12.47 psi
Total Horizontal Stress: 12.481 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.47 psi
Effective Horizontal Stress: 12.481 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 18.173 cc

Height: 5.5529 in
Area: 6.3258 in^2
Volume: 575.6 cc

Moisture: 23.70 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 6.5018 min
Total Vertical Stress: 12.47 psi
Total Horizontal Stress: 12.481 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.47 psi
Effective Horizontal Stress: 12.481 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 18.173 cc

Height: 5.5529 in
Area: 6.3258 in^2
Volume: 575.6 cc

Moisture: 23.70 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 100.00 %

End of Shear
Time: 26.844 min
Total Vertical Stress: 68.144 psi
Total Horizontal Stress: 12.545 psi
Pore Pressure: -1.0604 psi
Effective Vertical Stress: 69.205 psi
Effective Horizontal Stress: 13.606 psi

Height Change: 1.1108 in
Area Change: -1.5814 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 240.19 cc

Height: 4.4422 in
Area: 7.9072 in^2
Volume: 575.6 cc

Moisture: 0.00 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 0.00 %

At Failure
Time: 11.78 min
Total Vertical Stress: 132.98 psi
Total Horizontal Stress: 12.577 psi
Pore Pressure: -0.2995 psi
Effective Vertical Stress: 133.28 psi
Effective Horizontal Stress: 12.877 psi

Height Change: 0.2833 in
Area Change: -0.34032 in^2
Volume Change: 0.028749 cc
Water Change: -0.021452 cc
Correction: 0 cc

Height: 5.2697 in
Area: 6.6661 in^2
Volume: 575.6 cc

Moisture: 23.70 %
Void Ratio: 0.63
Dry Unit Weight: 101.62 pcf
Saturation: 100.00 %

FIG. B-26
Sheet 4 of 5

SS-430-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B10
Sample No.: SS-430-13
Test No.: UU-74-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 26.0-28.0
Elevation:

Soil Description: Total length 27.5'' Tube bent, Gry Silty Clay, with 1" rock
Remarks: .

Specimen Height: 5.87 in
Specimen Area: 6.29 in^2
Specimen Volume: 604.84 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s15	---		
Wt. Container + Wet Soil, gm	52.41	---	---	0
Wt. Container + Dry Soil, gm	45.49	---	---	0
Wt. Container, gm	17.15	---	---	0
Wt. Wet Soil, gm	35.26	1188.3	955.1	0
Wt. Dry Soil, gm	28.34	955.1	955.1	0
Wt. Water, gm	6.92	233.22	0	0
Water Content, %	24.42	24.42	0.00	0.00
Void Ratio	---	0.68	0.67	---
Degree of Saturation, %	---	95.41	0.00	---
Dry Unit Weight, pcf	---	98.58	98.869	---

Initial
Height: 5.872 in
Area: 6.2857 in^2
Volume: 604.84 cc
Moisture: 24.42 %
Void Ratio: 0.68
Dry Unit Weight: 98.58 pcf
Saturation: 95.41 %

End of Initialization
Time: 4.1462 min
Total Vertical Stress: 24.942 psi
Total Horizontal Stress: 24.969 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.942 psi
Effective Horizontal Stress: 24.969 psi
Height Change: 0.0057316 in
Area Change: 0 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 0 cc
Height: 5.8663 in
Area: 6.2857 in^2
Volume: 603.07 cc
Moisture: 24.42 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 96.12 %

End of Consolidation/A
Time: 4.1462 min
Total Vertical Stress: 24.942 psi
Total Horizontal Stress: 24.969 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.942 psi
Effective Horizontal Stress: 24.969 psi
Height Change: 0.0057316 in
Area Change: 0 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 0 cc
Height: 5.8663 in
Area: 6.2857 in^2
Volume: 603.07 cc
Moisture: 24.42 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 96.12 %

End of Saturation
Time: 4.1462 min
Total Vertical Stress: 24.942 psi
Total Horizontal Stress: 24.969 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.942 psi
Effective Horizontal Stress: 24.969 psi
Height Change: 0.0057316 in
Area Change: 0 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 0 cc
Height: 5.8663 in
Area: 6.2857 in^2
Volume: 603.07 cc
Moisture: 24.42 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 96.12 %

End of Consolidation/B
Time: 4.1462 min
Total Vertical Stress: 24.942 psi
Total Horizontal Stress: 24.969 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.942 psi
Effective Horizontal Stress: 24.969 psi
Height Change: 0.0057316 in
Area Change: 0 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 0 cc
Height: 5.8663 in
Area: 6.2857 in^2
Volume: 603.07 cc
Moisture: 24.42 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 96.12 %

End of Shear
Time: 24.347 min
Total Vertical Stress: 35.31 psi
Total Horizontal Stress: 25.123 psi
Pore Pressure: -1.109 psi
Effective Vertical Stress: 36.419 psi
Effective Horizontal Stress: 26.232 psi
Height Change: 1.179 in
Area Change: -1.5561 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 233.23 cc
Height: 4.693 in
Area: 7.8418 in^2
Volume: 603.07 cc
Moisture: 0.00 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 0.00 %

At Failure
Time: 9.032 min
Total Vertical Stress: 136.12 psi
Total Horizontal Stress: 25.147 psi
Pore Pressure: -0.2995 psi
Effective Vertical Stress: 136.42 psi
Effective Horizontal Stress: 25.446 psi
Height Change: 0.28732 in
Area Change: -0.32357 in^2
Volume Change: 1.7711 cc
Water Change: -0.016625 cc
Correction: 0 cc
Height: 5.5847 in
Area: 6.6093 in^2
Volume: 603.07 cc
Moisture: 24.42 %
Void Ratio: 0.67
Dry Unit Weight: 98.869 pcf
Saturation: 96.12 %

FIG. B-26
Sheet 5 of 5

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Slope - 1:2.0

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	11				SER-5-094(093):03
Project Location	**County**	**Date Started**			**Date Finished**
Painted Canyon Slide	Billings	7-30-13			7.30-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS. TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS. TICITY (Y/N)	REMARKS
SS #1	1	0.0	2.0	2 3	1.7 2.0	1	444	0.0	3.0	Brn	fn Sand	Very loose	Y	N	N	Organics 1'0
Dri	ll to	2.0														
SS #2	2	2.0	4.0	2 3	2.0 2.0	2	445	3.0	8.2	Brn Gry	Sndy Clay	Soft	Y	N	Y	IO Dep.
Dri	ll	4.0														
3TW #1	3	4.0	6.0		2.0 2.0		446			Brn Gry	Sndy Clay					
SS #3	4	6.0	8.0	4 5	2.0 2.0	3	447			Brn Gry	Sndy Clay	Soft	Y	N	Y	IO Dep. Sndstone
Dri	ll to	8.0														
3TW #2	5	8.0	10.0		0.2 2.0		448									Bent Tube No Rec.
SS #4	6	10.0	12.0	10 12	2.0 2.0	4	449	8.2	8.7	Tan	Sndstone	med Dense	Y	Y	Y	Sandstone sndy Clay. Dist.
Dri	ll to	12.0														
3TW #3	7	12.0	14.0		1.0 2.0		449	8.7	24.0	Tan	Sndy Clay					1 0 Rec. no Tbr
SS #5	8	14.0	16.0	4 5	2.0 2.0	5	450			Tan	Sndy Clay	Soft	Y	Y	Y	IO Dep.
Dri	ll to	16.0														
3TW #4	9	16.0	IFD		2.0 2.0		451			Tan	Sndy Clay					
SS #6	10	18.0	20.0	4 7	2.0 2.0	6	452			Tan	Sndy Clay	med Stiff	Y	Y	Y	IO Dep.

FIG. B-27
Sheet 1 of 3

FIG. B-27
Sheet 1 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division

SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	11				SER-5-0794(093)03
Project Location		**County**	**Date Started**		**Date Finished**
			7-30-13		7-30-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
Dc	11 to	22.0														
STW #5	11	22.0	24.0		2.0 / 2.0		453	24.0	37.5	Brn Blk	Silty Clay					Coal Dep.
SS #7		24.0	26.0	9 / 11	2.0 / 2.0	7	454			Blk Gry	Silty Clay	Stiff	N	N	Y	Coal Dep. more silt at 25.0
Dc	11	26.0														
STW #6	13	26.0	28.0		2.0 / 2.0		455			Blk Gry	Silty Clay					TO. coal Dep.
SS #8	14	28.0	30.0	12 / 16	2.0 / 2.0	8	456			Gry	Silty Clay	Stiff	N	N	Y	coal Dep.
Dc	11 to	30.0														
STW #7	15	30.0	32.0		1.4 / 2.0		457			Gry	Silty Clay					1.4 Re. coal Dep.
SS #9	16	32.0	34.0	10 / 15	2.0 / 2.0	9	458			Gry	Silty Clay	Stiff	N	N	Y	coal Dep
Dc	11 to	34.0														
STW #8	17	34.0	35.5		1.5 / 1.5		459			Gry	Silty Clay					coal Dep
SS #10	18	35.5	37.5	10 / 15	2.0 / 2.0	10	460			Gry	Silty Clay	Stiff	N	N	Y	coal Dep. Bottom 0.3 Sandy clay Lam
Dc	11	to 37.5														
STW #9	19	37.5	38.5		1.0 / 1.0		461	37.5	39.5	Gry	Sandy Clay					coal Dep.
SS #11	20	38.5	40.5	28 / 29	2.0 / 2.0	11	462	39.5	43.3	Gry	Silty Clay	Very Stiff	N	N	Y	coal Dep.

FIG. B-27
Sheet 2 of 3

FIG. B-27
Sheet 2 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J NAUMANN	11				SER-5-094(093)0
Project Location	**County**	**Date Started**			**Date Finished**
	Billings	7-30-13			7-30-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS. TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS. TICITY (Y/N)	REMARKS
Drill to		43.0														
SS #12	21	43.0	45.0	19/21	2.0/2.0	12	463	43.3	43.6	Gry	Sndy Cly	Very stiff	Y	N	Y	Sandstone at 43.3, 0.3 thick
Drill to		45.0														
SS #13	22	45.0	47.0	10/13	2.0/2.0	13	464	43.6	/	Gry	Silty Cly	Stiff	N	N	Y	Slt Lap.
Drill to		47.5														
SS #14	23	47.5	49.5	16/21	2.0/2.0	14	465			Blk Gry	Silty Cly	Very Stiff	N	N	Y	coal Lap.
Drill to		50.0														
SS #15	24	50.0	52.0	16/21	2.0/2.0	15	466			Gry	Silty Cly	Very Stiff	N	N	Y	coal Lap, slt Lap
Drill to		55.0														
Stop																
End 13	20															

FIG. B-27
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FIG. B-27
Sheet 3 of 3

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	444	445	446	447
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	4.0 - 6.0	6.0 - 8.0
Field Sample No.	444	445	446	447
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	1	0	0	0
% Fine Sand (-No. 40 + No. 200)	56	31	1	3
% Silt (0.074 - 0.005 mm)	26	40	68	66
% Clay (-0.005 mm)	18	29	31	31
Liquid Limit (-No. 40)	27	31	47	42
Plasticity Index (-No. 40)	4	14	25	21
Plastic Limit	23	17	23	21
Soil Color	Brn	Brn Gry	Brn Gry	Brn Gry
Textural Class	SNDY LM	CLY LM	SLTY CLY	SLTY CLY
Soil Class (AASHTO M-145)	A-4(0)	A-6(7)	A-7-6(27)	A-7-6(21)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	5.3	18.9	24.9	20.5

FIG. B-28
Sheet 1 of 6

FIG. B-28 Sheet 1 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	448	449	450	451
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	10.0 - 12.0	12.0 - 14.0	14.0 - 16.0	16.0 - 18.0
Field Sample No.	448	449	450	451
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	99	100	100
% Pass. No. 10 Sieve	100	99	100	100
% Coarse Sand (-No. 10 + No.40)	1	4	0	0
% Fine Sand (-No. 40 + No. 200)	9	3	1	1
% Silt (0.074 - 0.005 mm)	67	64	68	75
% Clay (-0.005 mm)	24	29	31	25
Liquid Limit (-No. 40)	34	41	44	39
Plasticity Index (-No. 40)	12	18	21	16
Plastic Limit	22	23	23	23
Soil Color	Tan	Tan	Tan	Tan
Textural Class	SLTY CLY LM	SLTY CLY LM	SLTY CLY	SLTY CLY LM
Soil Class (AASHTO M-145)	A-6(11)	A-7-6(18)	A-7-6(23)	A-6(18)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	19.1	18.8	25.0	26.0

FIG. B-28
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FIG. B-28
Sheet 2 of 6

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Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	452	453	454	455
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	18.0 - 20.0	22.0 - 24.0	24.0 - 26.0	26.0 - 28.0
Field Sample No.	452	453	454	455
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	1	1	1	1
% Silt (0.074 - 0.005 mm)	71	72	31	6
% Clay (-0.005 mm)	28	28	68	93
Liquid Limit (-No. 40)	41	39	77	88
Plasticity Index (-No. 40)	20	18	54	59
Plastic Limit	21	21	23	29
Soil Color	Tan	Brn Blk	Blk Gry	Blk Gry
Textural Class	SLTY CLY LM	SLTY CLY LM	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(22)	A-6(20)	A-7-6(61)	A-7-6(69)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	25.4	24.1	23.8	30.1

FIG. B-28
Sheet 3 of 6

FIG. B-28
Sheet 3 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	456	457	458	459
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	28.0 - 30.0	30.0 - 32.0	32.0 - 34.0	34.0 - 35.5
Field Sample No.	456	457	458	459
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	3	0	0	0
% Fine Sand (-No. 40 + No. 200)	4	0	0	0
% Silt (0.074 - 0.005 mm)	13	23	17	52
% Clay (-0.005 mm)	80	77	83	48
Liquid Limit (-No. 40)	77	94	96	84
Plasticity Index (-No. 40)	46	69	71	63
Plastic Limit	30	25	25	22
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-5(51)	A-7-6(80)	A-7-6(82)	A-7-6(72)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	28.8	26.5	26.8	23.4

FIG. B-28
Sheet 4 of 6

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FIG. B-28
Sheet 4 of 6

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	460	461	462	463
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	35.5 - 37.5	37.5 - 38.5	38.5 - 40.5	43.0 - 45.0
Field Sample No.	460	461	462	463
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	1	1	7	12
% Silt (0.074 - 0.005 mm)	44	60	58	49
% Clay (-0.005 mm)	55	39	35	38
Liquid Limit (-No. 40)	81	83	66	69
Plasticity Index (-No. 40)	58	59	43	48
Plastic Limit	23	24	23	20
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	SLTY CLY	SLTY CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(67)	A-7-6(68)	A-7-6(44)	A-7-6(46)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	20.0	22.2	17.5	23.2

FIG. B-28
Sheet 5 of 6

FIG. B-28 Sheet 5 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-24-2013	**Date Reported**	8/28/2013	**Boring Number**	11
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	464	465	466
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft
Depth, Ft.	45.0 - 47.0	47.5 - 49.5	50.0 - 52.0
Field Sample No.	464	465	466
% Pass. 3/8" Sieve	100	100	100
% Pass. No. 4 Sieve	100	100	100
% Pass. No. 10 Sieve	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	1	0
% Silt (0.074 - 0.005 mm)	16	6	37
% Clay (-0.005 mm)	84	94	63
Liquid Limit (-No. 40)	105	100	78
Plasticity Index (-No. 40)	79	69	55
Plastic Limit	26	32	23
Soil Color	Gry	Blk Gry	Gry
Textural Class	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(92)	A-7-5(82)	A-7-6(63)
Frost Class	F3	F3	F3
Optimum Moisture (%)			
Maximum Dry Density (pcf)			
Ph of Soil			
% Organic Content			
Pocket Pentrometer			
Depth (Ft.) | Moisture (%)			
Avg. Moisture (%)	24.8	29.4	21.5

FIG. B-28
Sheet 6 of 6

FIG. B-28
Sheet 6 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Torvane Shear Strengths

Boring No. 11 Station _____ Offset _____

Project No. SER-S-094(093)031 Date 7-30-13 County Billings

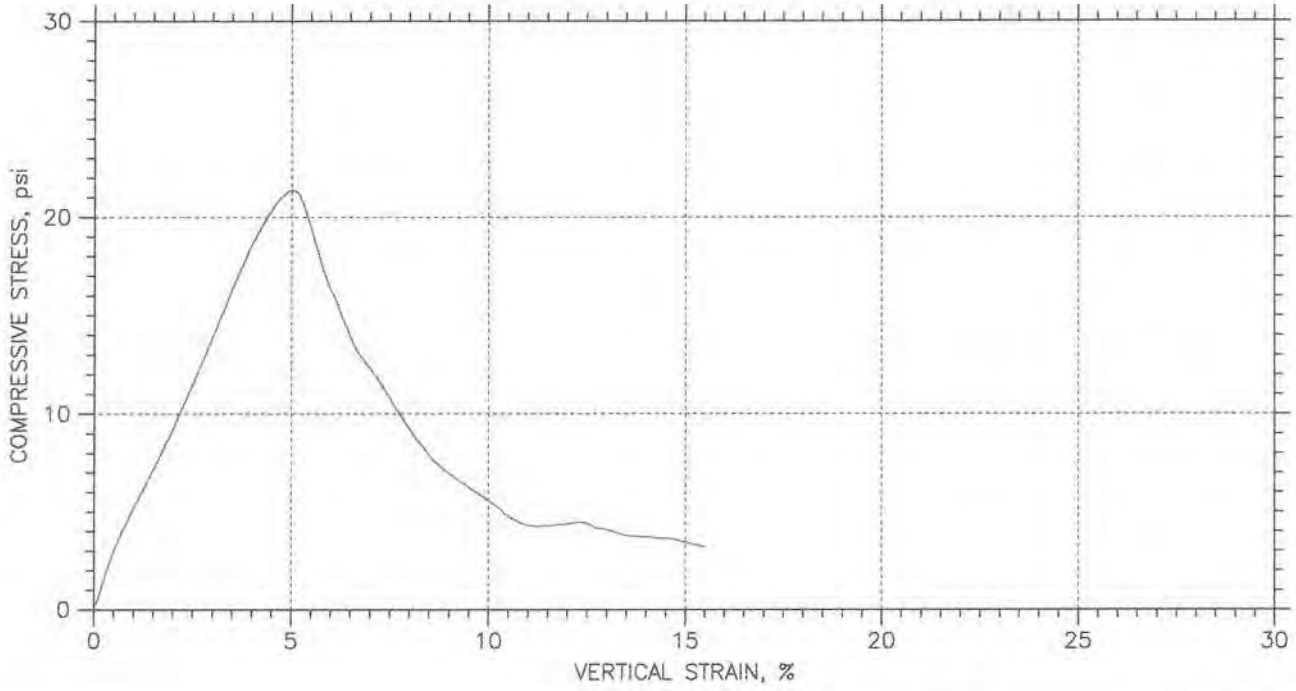
Depth (ft.)	Stress Reading	Factor	Shear Strength (kg/cm^2)	Shear Strength *(lbs/ft^2)
4.0-6.0	0,65	1.0	0,65	1331.2

* kg/cm^2 x 2048 = lbs/ft^2

FIG. B-29

55-446-15

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-28-13			
Initial	Diameter, in	2.832			
	Height, in	5.535			
	Water Content, %	24.80			
	Dry Density, pcf	99.44			
	Saturation, %	99.02			
	Void Ratio	0.664			
Unconfined Compressive Strength, psi		21.36			
Undrained Shear Strength, psi		10.68			
Time to Failure, min		4.7999			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 23" Lt. Brn Silty Clay Loam

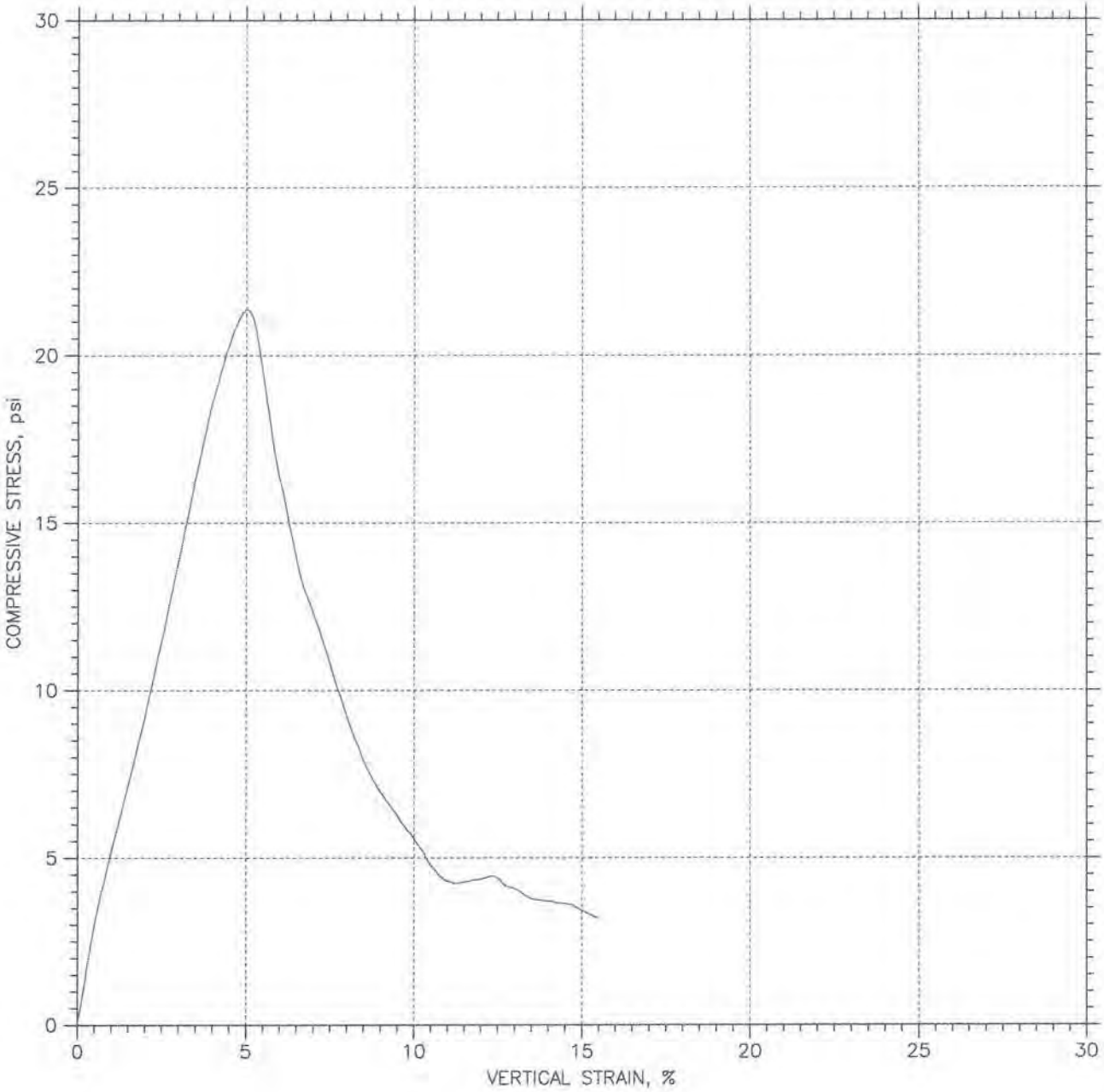
Remarks:

FIG. B-30

Sheet 1 of 2

SS-446-U

UNCONFINED COMPRESSION TEST REPORT



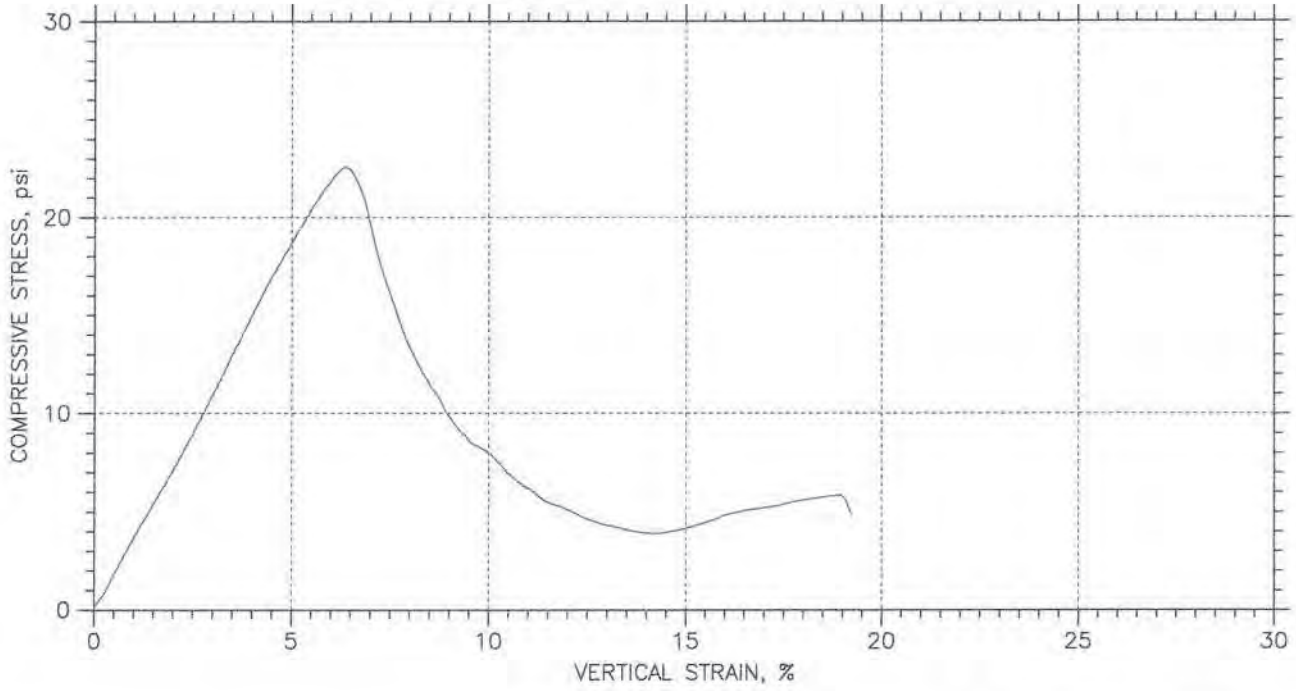
	Project: SER-5-094(093)031	Location:	Project No.:
	Boring No.: B11	Tested By: DT	Checked By: SS
	Sample No.: SS-446-13	Test Date: 9/30/2013	Depth: 4.0-6.0
	Test No.: UC-28-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 23" Lt. Brn Silty Clay Loam		
	Remarks:		

FIG. B-30
Sheet 2 of 2

ue, 01-OCT-2013 07:44:38

74-7710-15

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-29-13			
Initial	Diameter, in	2.84			
	Height, in	5.561			
	Water Content, %	25.05			
	Dry Density, pcf	100.1			
	Saturation, %	101.77			
	Void Ratio	0.652			
Unconfined Compressive Strength, psi		22.55			
Undrained Shear Strength, psi		11.28			
Time to Failure, min		6.1702			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 23" Lt. Brn Silty Clay Loam

Remarks:

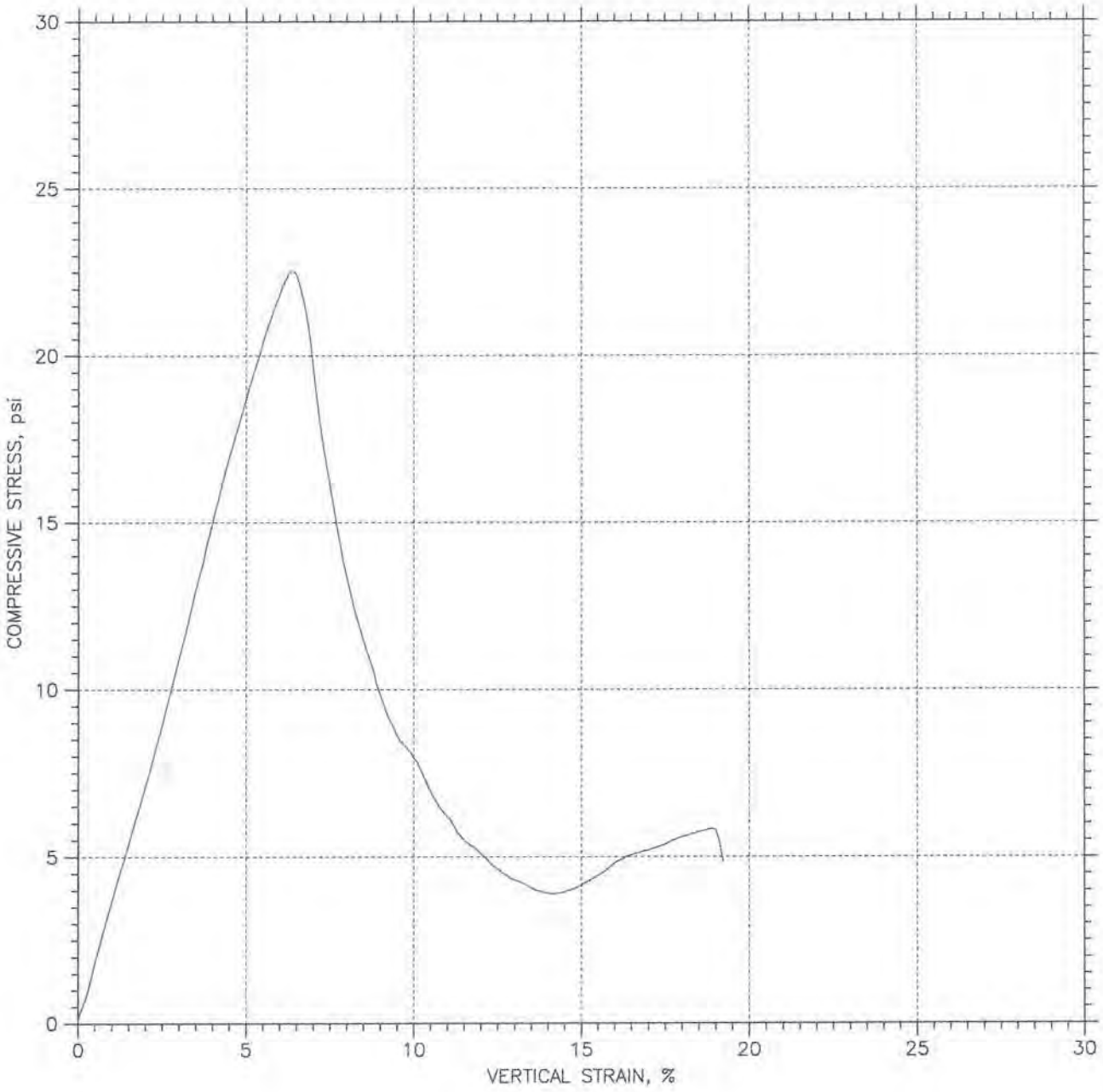
FIG. B-31

Sheet 1 of 2

Date, 01-OCT-2013 07:46:55

77-7446'15

UNCONFINED COMPRESSION TEST REPORT



	Project: SER-5-094(093)031	Location:	Project No.:
	Boring No.: B11	Tested By: DT	Checked By: SS
	Sample No.: SS-446-13	Test Date: 9/30/2013	Depth: 4.0-6.0
	Test No.: UC-29-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 23" Lt. Brn Silty Clay Loam		
	Remarks:		

FIG. B-31
Sheet 2 of 2

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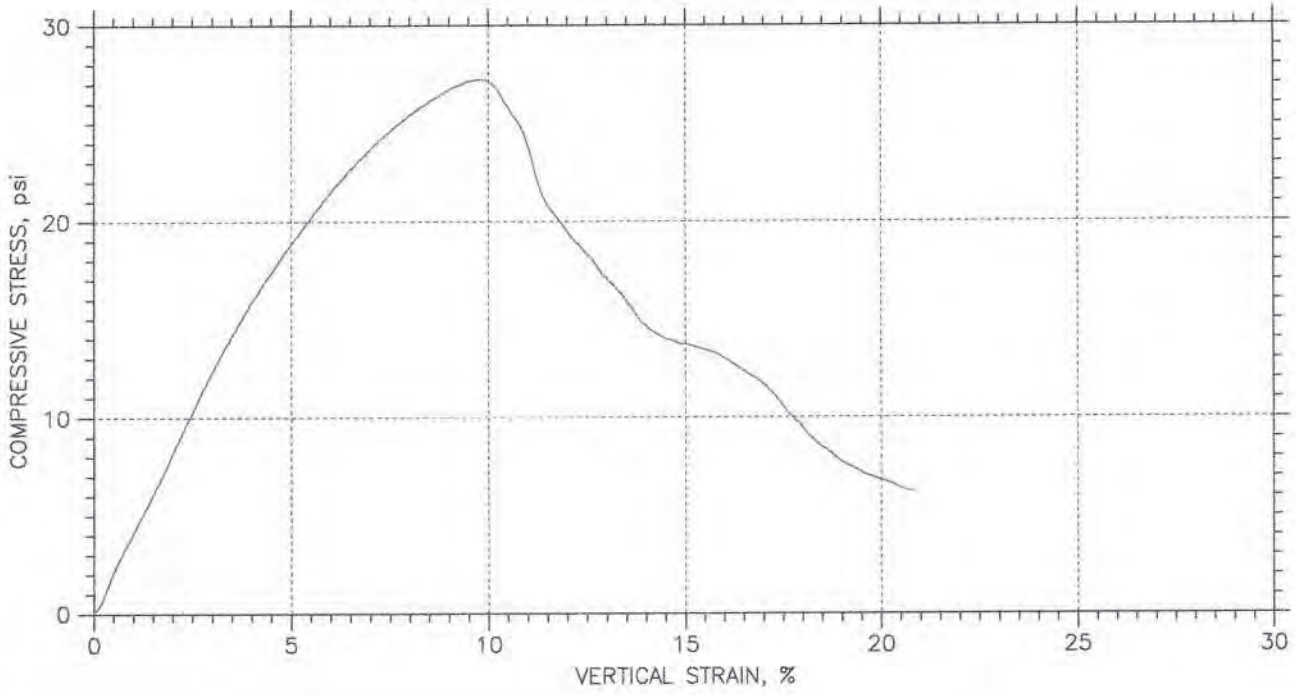
55-446-13

UNCONFINED COMPRESSION TEST REPORT



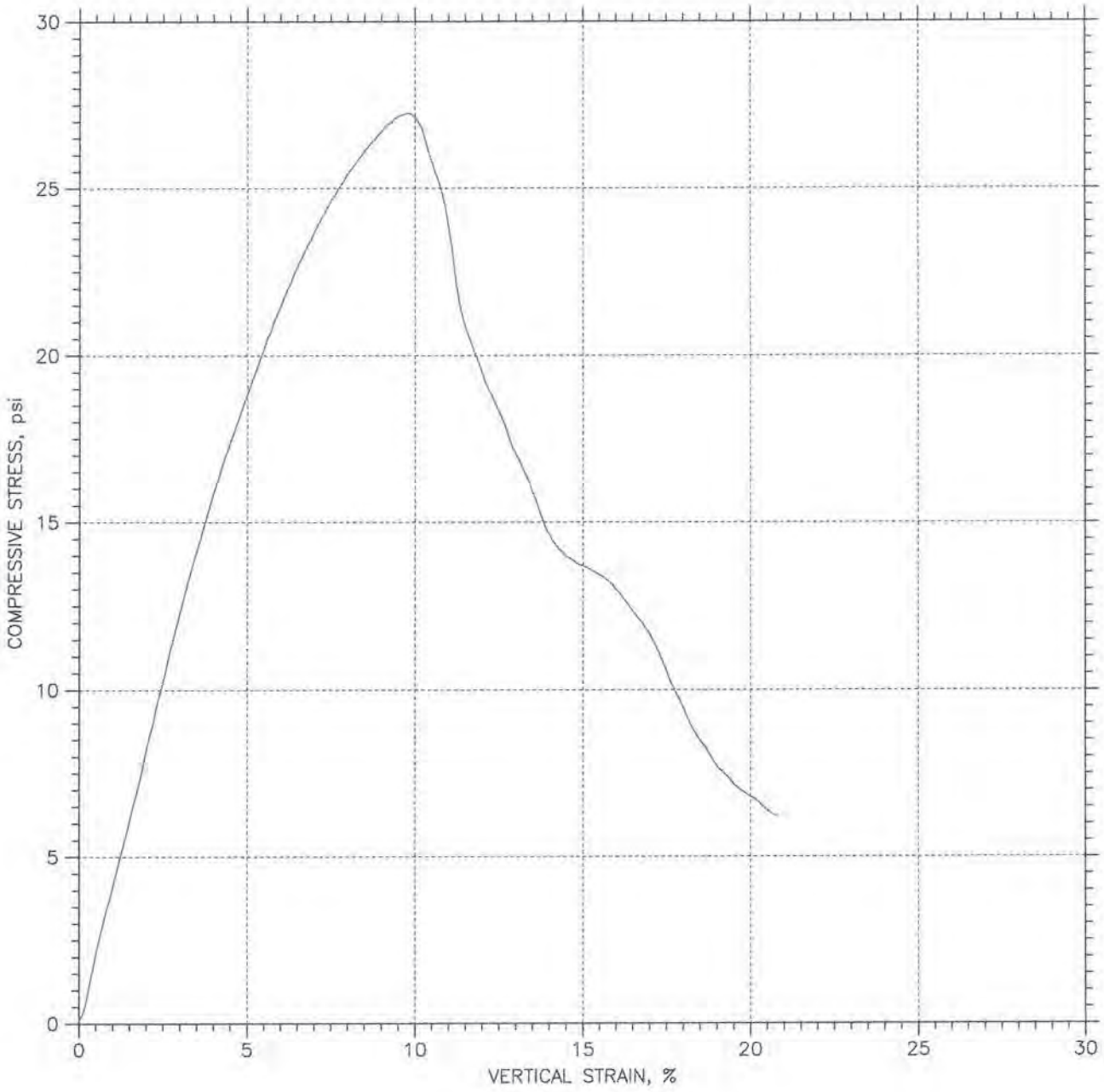
Symbol					
Test No.		UC-30-13			
Initial	Diameter, in	2.823			
	Height, in	5.559			
	Water Content, %	24.80			
	Dry Density, pcf	101.			
	Saturation, %	103.06			
	Void Ratio	0.638			
Unconfined Compressive Strength, psi		27.24			
Undrained Shear Strength, psi		13.62			
Time to Failure, min		9.4099			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031
Location:
Project No.:
Boring No.: B11
Sample Type: Undisturbed
Description: Total length 23" Lt. Brn Silty Clay Loam
Remarks:

FIG. B-32
Sheet 1 of 2

SS-446-13

UNCONFINED COMPRESSION TEST REPORT



Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-446-13	Test Date: 9/30/2013	Depth: 4.0-6.0
Test No.: UC-30-13	Sample Type: Undisturbed	Elevation:
Description: Total length 23" Lt. Brn Silty Clay Loam		
Remarks:		

FIG. B-32
Sheet 2 of 2

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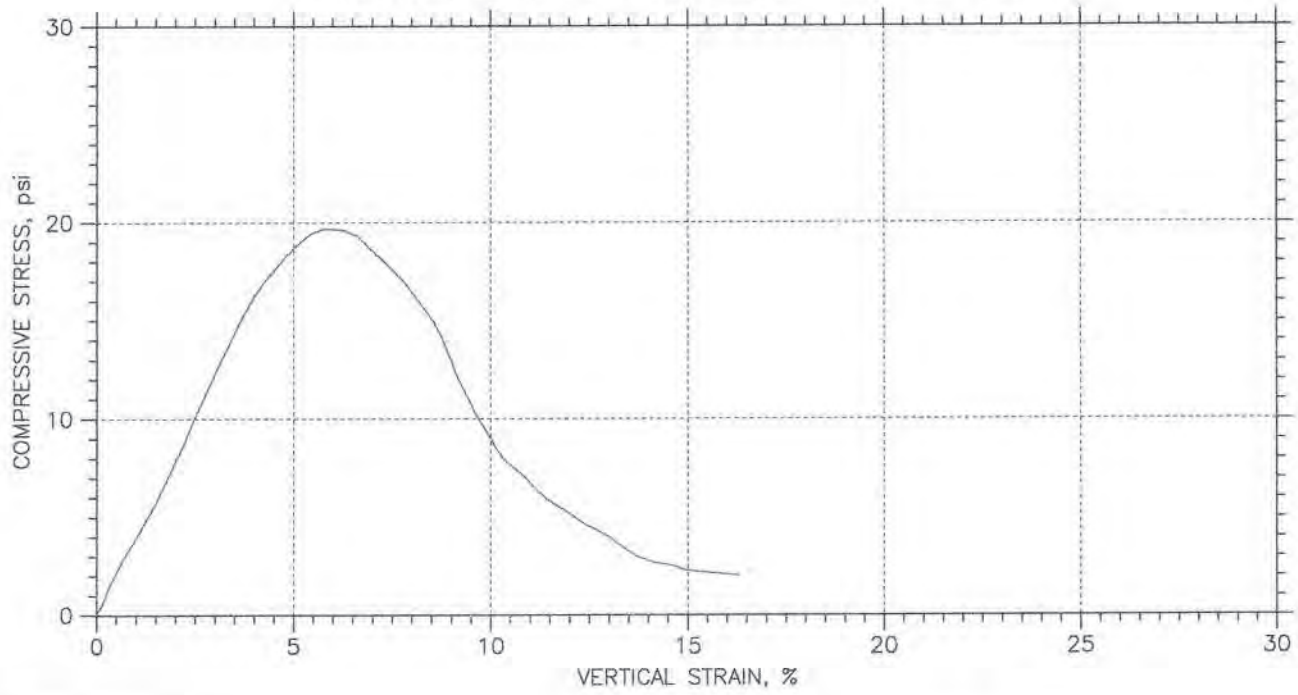
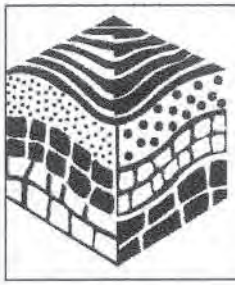
SS-444-15

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-31-13			
Initial	Diameter, in	2.855			
	Height, in	5.544			
	Water Content, %	18.75			
	Dry Density, pcf	110.6			
	Saturation, %	100.26			
	Void Ratio	0.496			
Unconfined Compressive Strength, psi		19.67			
Undrained Shear Strength, psi		9.837			
Time to Failure, min		5.6044			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 14" Lt. Brn Silty Clay Loam

Remarks:

FIG. B-33

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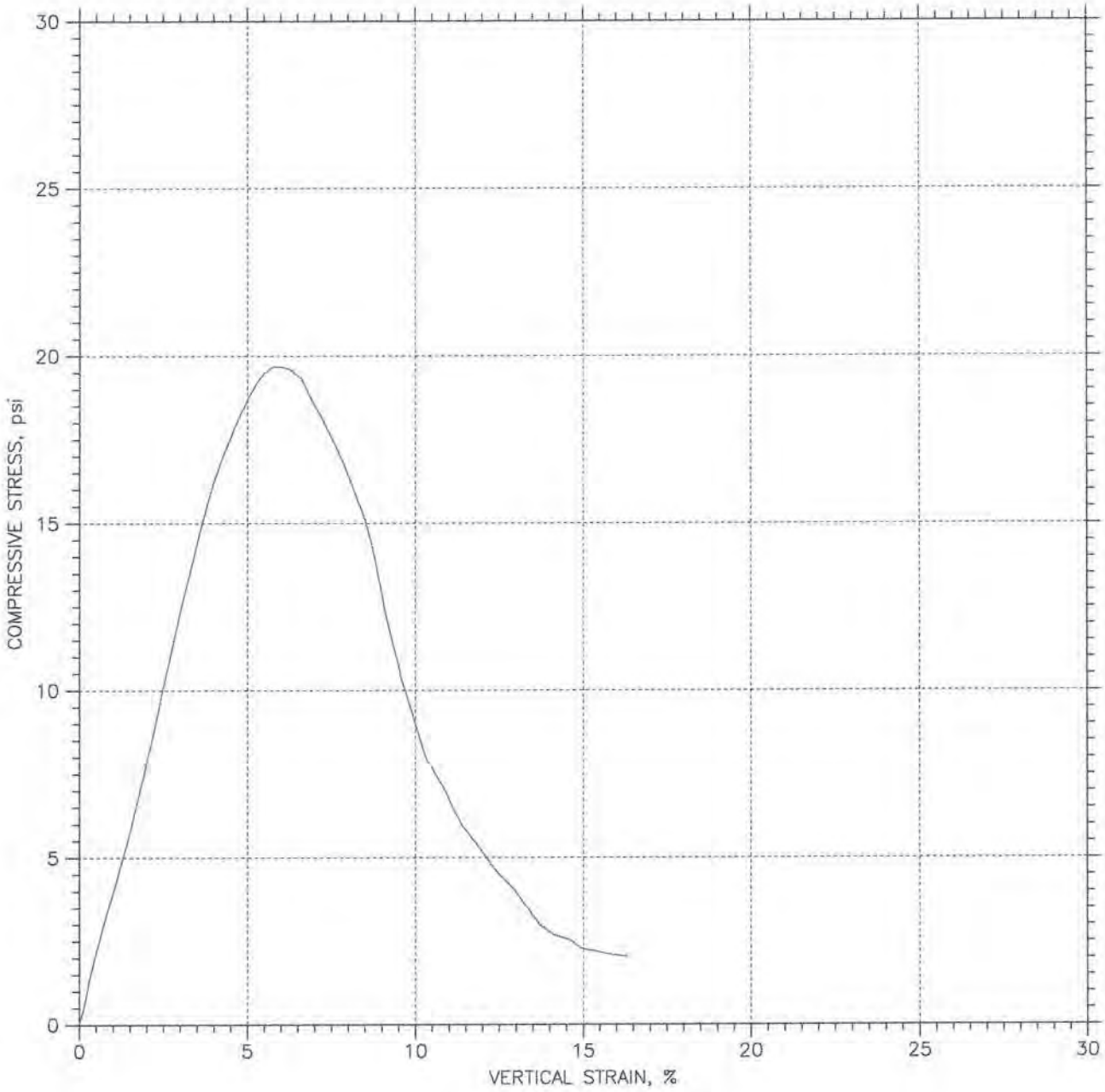
55-449-13

UNCONFINED COMPRESSION TEST REPORT



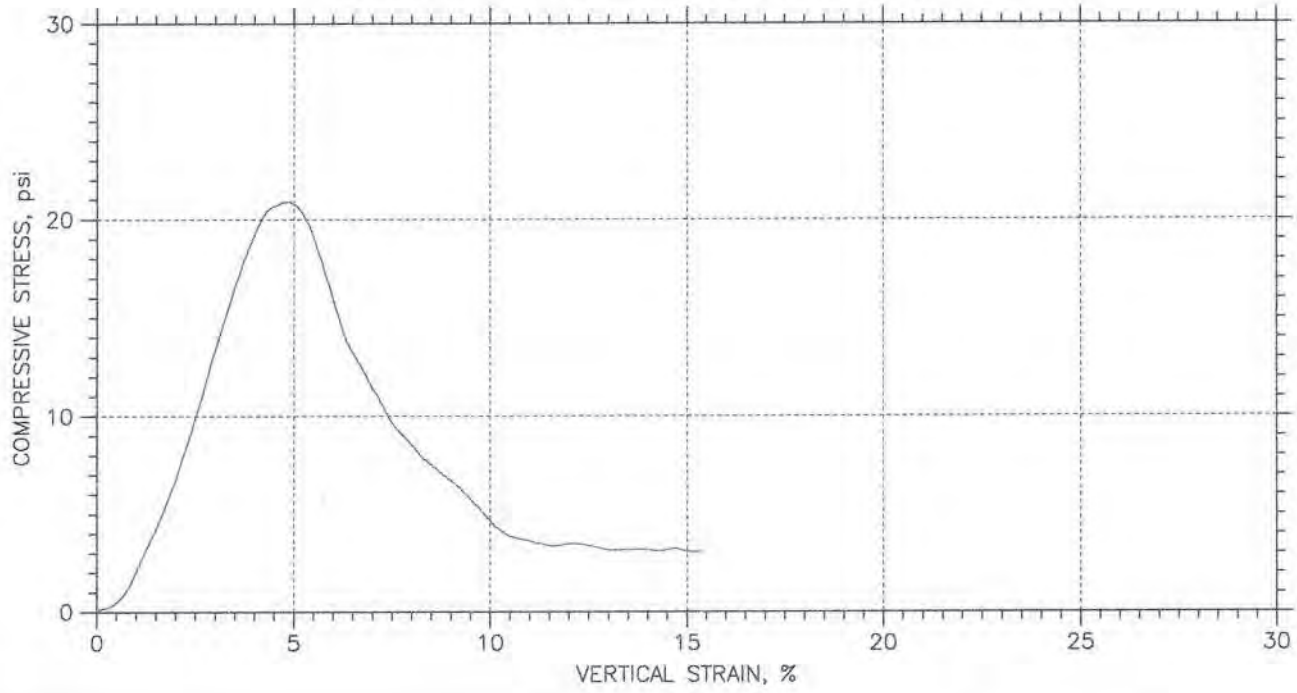
	Project: SER-5-094(093)031	Location:	Project No.:
	Boring No.: B11	Tested By: DT	Checked By: SS
	Sample No.: SS-449-13	Test Date: 9/30/2013	Depth: 12.0 - 14.0
	Test No.: UC-31-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 14" Lt. Brn Silty Clay Loam		
	Remarks:		

FIG. B-33
Sheet 2 of 2

ue, 01-OCT-2013 07:52:32

55-451-15

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-32-13			
Initial	Diameter, in	2.831			
	Height, in	5.543			
	Water Content, %	26.73			
	Dry Density, pcf	100.1			
	Saturation, %	108.54			
	Void Ratio	0.653			
Unconfined Compressive Strength, psi		20.89			
Undrained Shear Strength, psi		10.44			
Time to Failure, min		4.6187			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

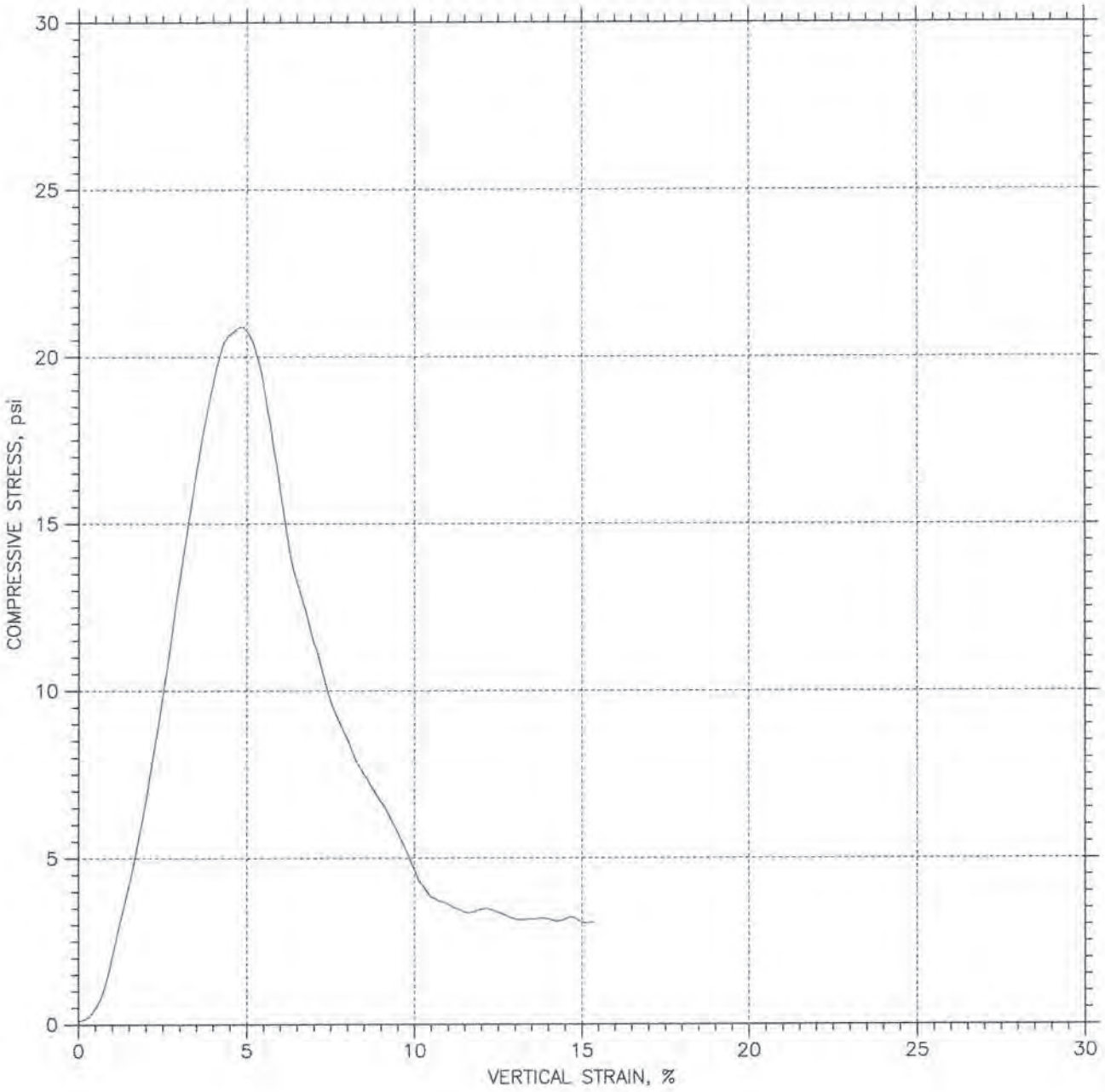
Description: Total length 24" Lt. Brn Silty Clay Loam

Remarks:

FIG. B-34
Sheet 1 of 2

SS-451-13

UNCONFINED COMPRESSION TEST REPORT



Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-451-13	Test Date: 9/30/2013	Depth: 16.0 - 18.0
Test No.: UC-32-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24" Lt. Brn Silty Clay Loam		
Remarks:		

FIG. B-34

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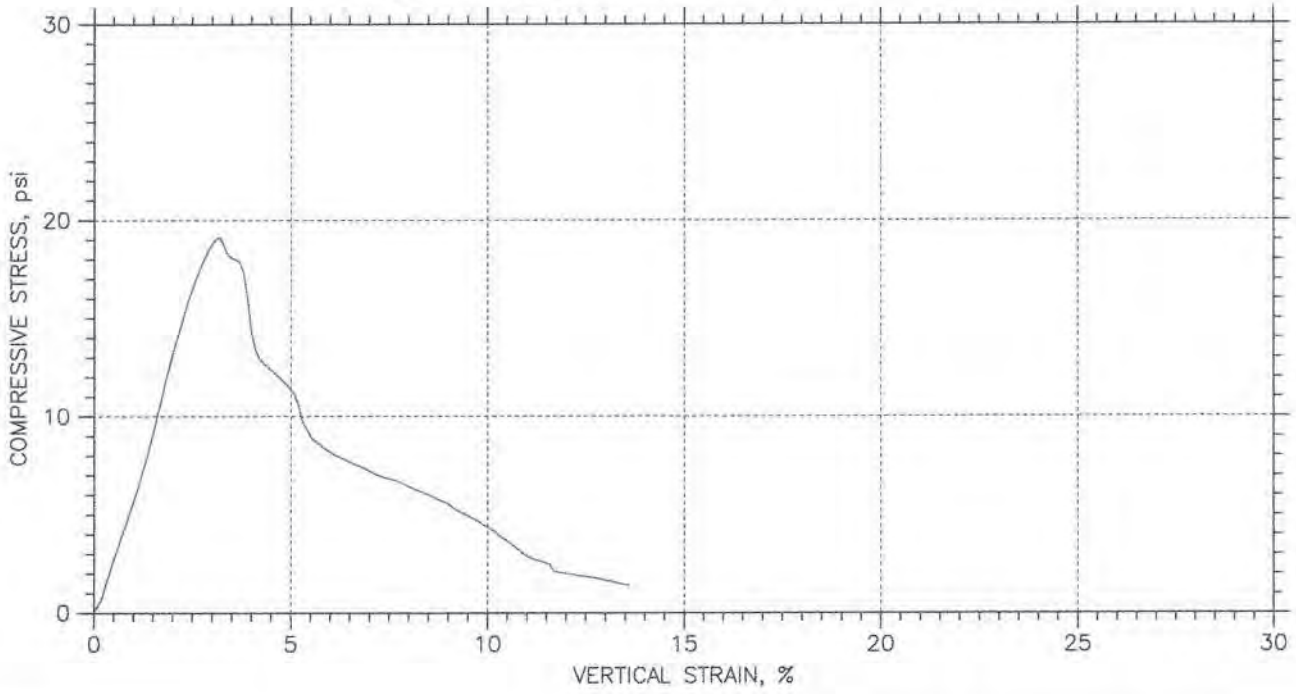
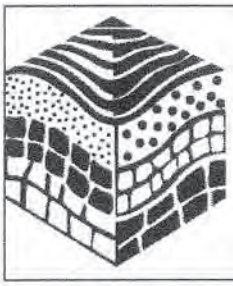
55-451-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-33-13			
Initial	Diameter, in	2.825			
	Height, in	5.551			
	Water Content, %	25.78			
	Dry Density, pcf	101.5			
	Saturation, %	108.53			
	Void Ratio	0.63			
Unconfined Compressive Strength, psi		19.11			
Undrained Shear Strength, psi		9.555			
Time to Failure, min		3.1115			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 24" Lt. Brn Silty Clay Loam

Remarks:

FIG. B-35

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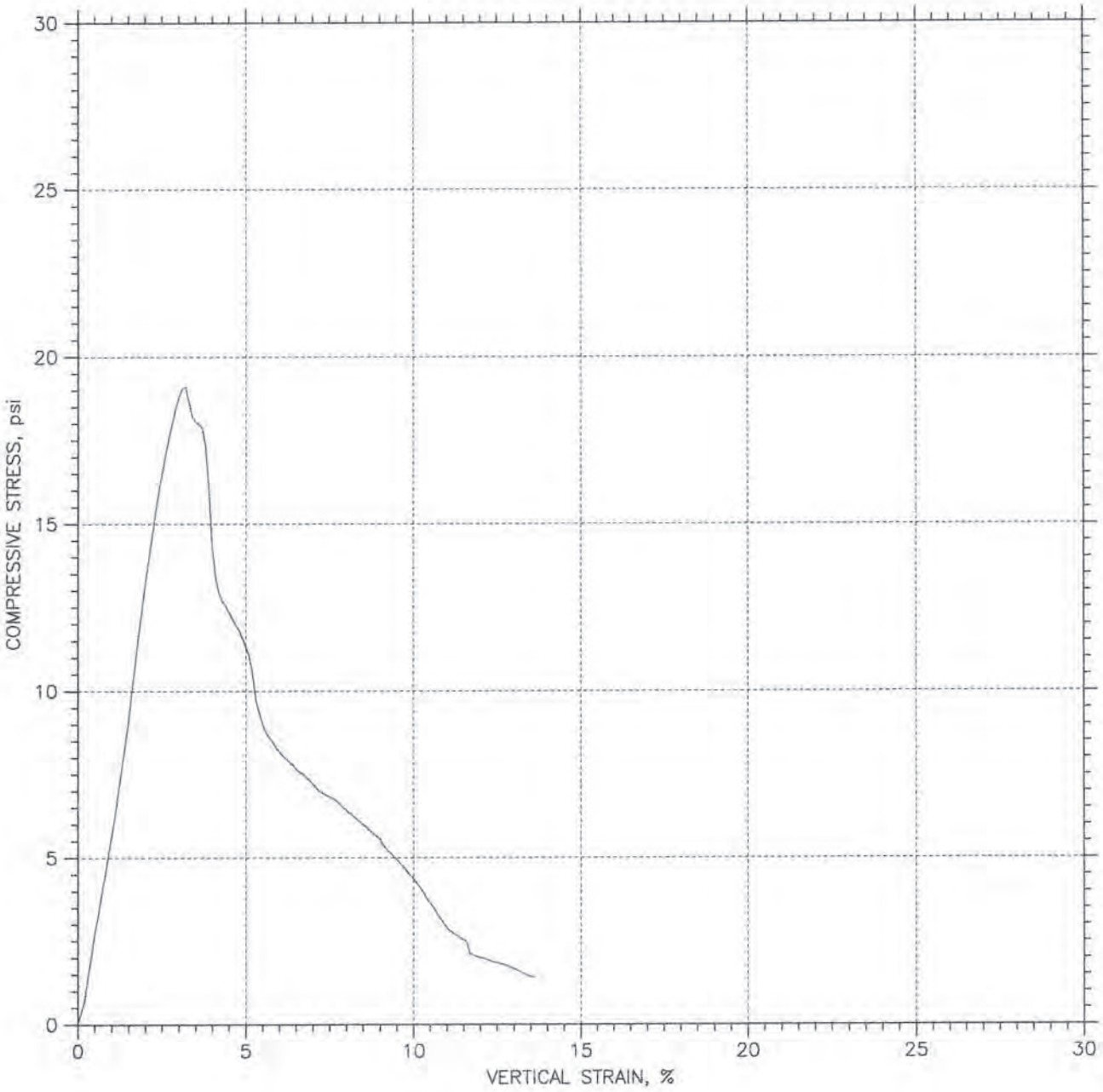
SS-451-13

UNCONFINED COMPRESSION TEST REPORT



Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-451-13	Test Date: 9/30/2013	Depth: 16.0 - 18.0
Test No.: UC-33-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24" Lt. Brn Silty Clay Loam		
Remarks:		

FIG. B-35
Sheet 2 of 2

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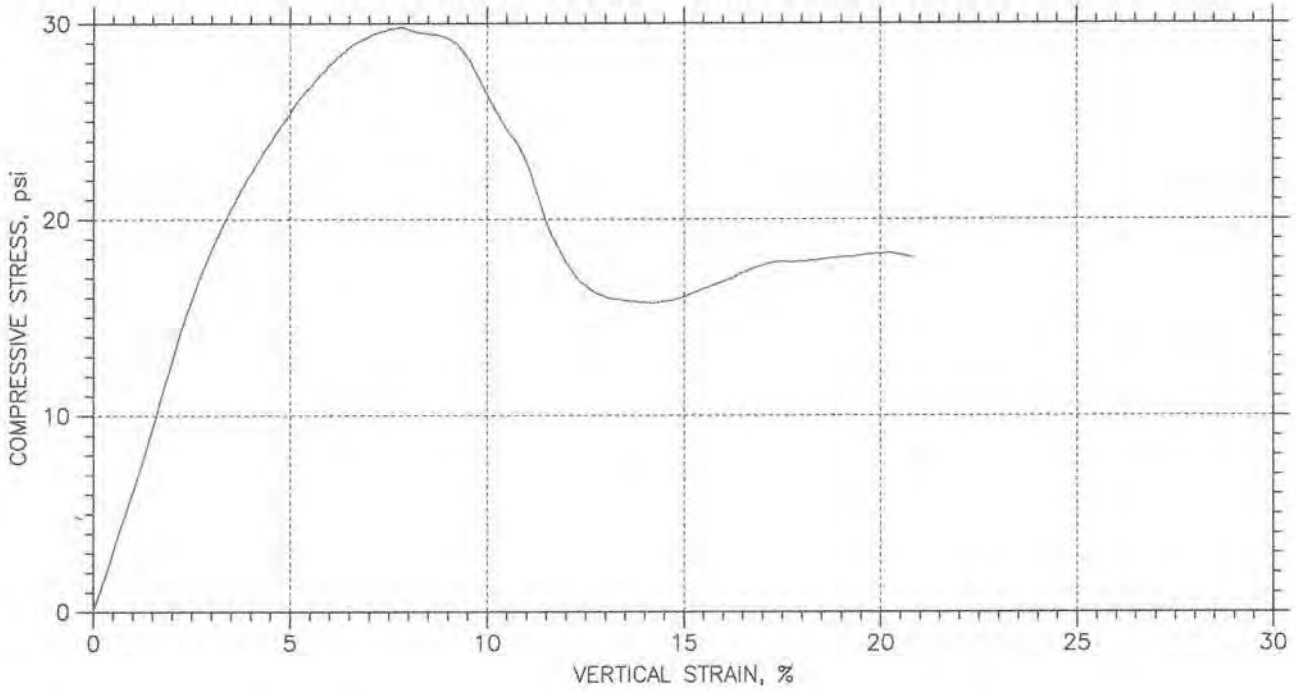
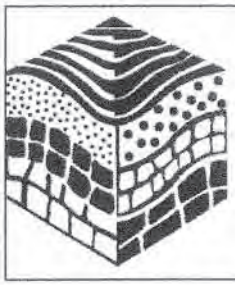
55-451-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-34-13			
Initial	Diameter, in	2.836			
	Height, in	5.55			
	Water Content, %	25.62			
	Dry Density, pcf	100.6			
	Saturation, %	105.24			
	Void Ratio	0.645			
Unconfined Compressive Strength, psi		29.8			
Undrained Shear Strength, psi		14.9			
Time to Failure, min		7.527			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

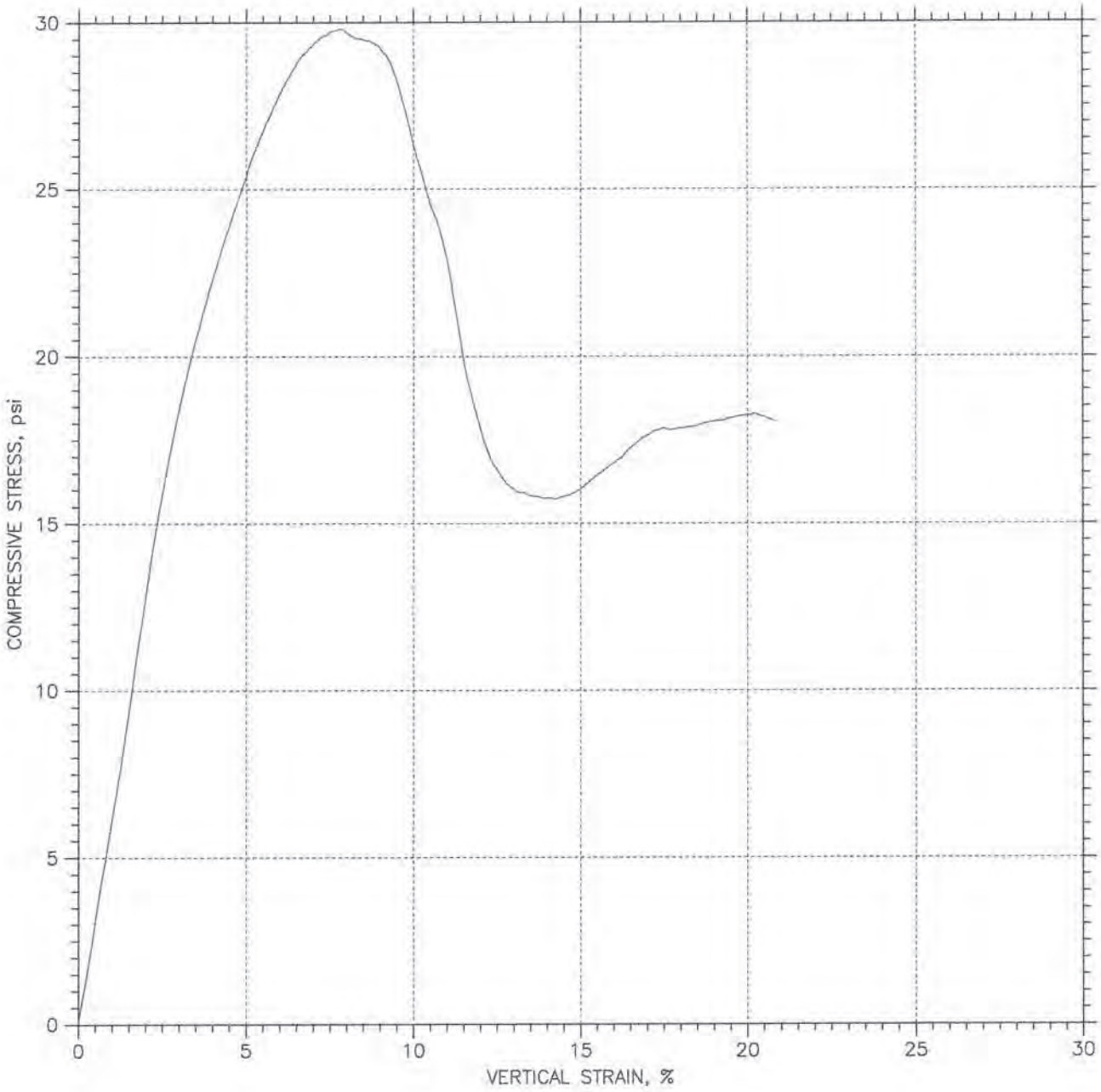
Description: Total length 24" Lt. Brn Silty Clay Loam

Remarks:

FIG. B-36

SS-451-13

UNCONFINED COMPRESSION TEST REPORT



Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-451-13	Test Date: 9/30/2013	Depth: 16.0 - 18.0
Test No.: UC-34-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24" Lt. Brn Silty Clay Loam		
Remarks:		

FIG. B-36
Sheet 2 of 2

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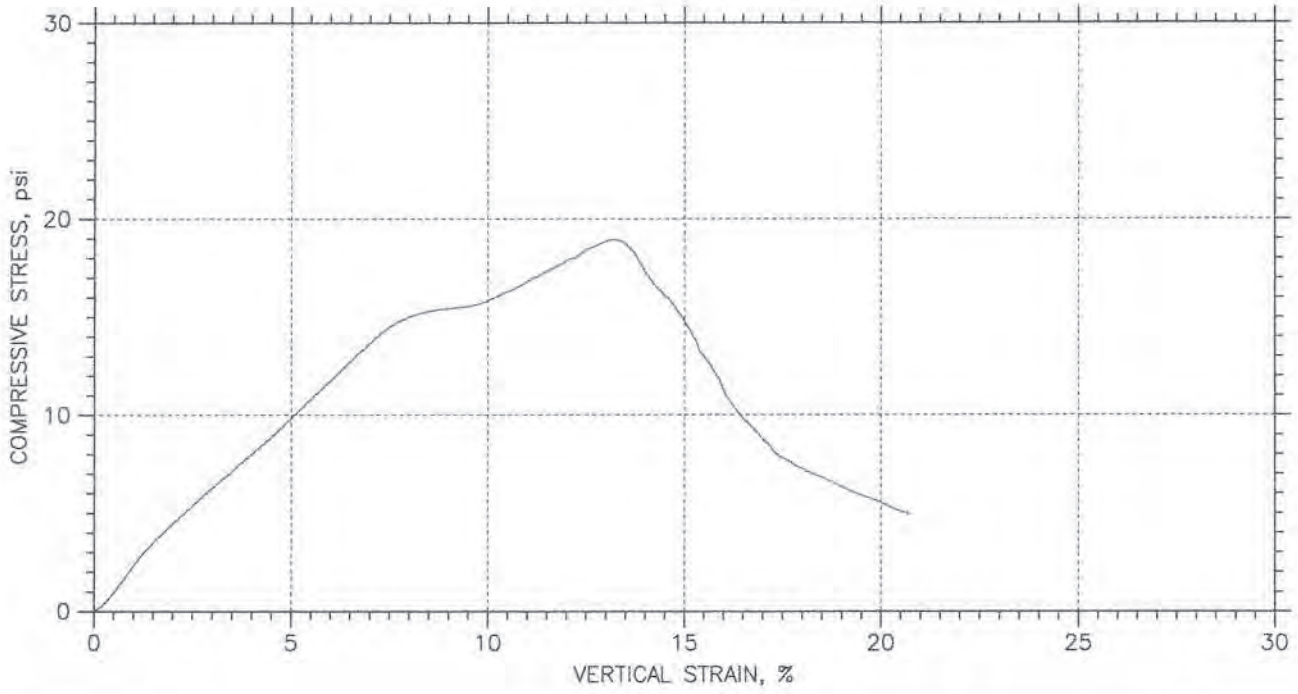
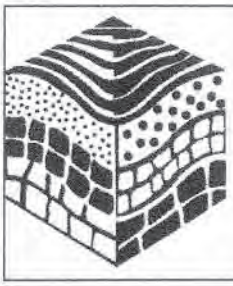
55-453-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-35-13			
Initial	Diameter, in	2.837			
	Height, in	5.531			
	Water Content, %	26.07			
	Dry Density, pcf	100.5			
	Saturation, %	106.87			
	Void Ratio	0.646			
Unconfined Compressive Strength, psi		18.93			
Undrained Shear Strength, psi		9.466			
Time to Failure, min		12.743			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to

Remarks: gry/brn silty clay, slicken sided clay, trace of coal.

FIG. B-37

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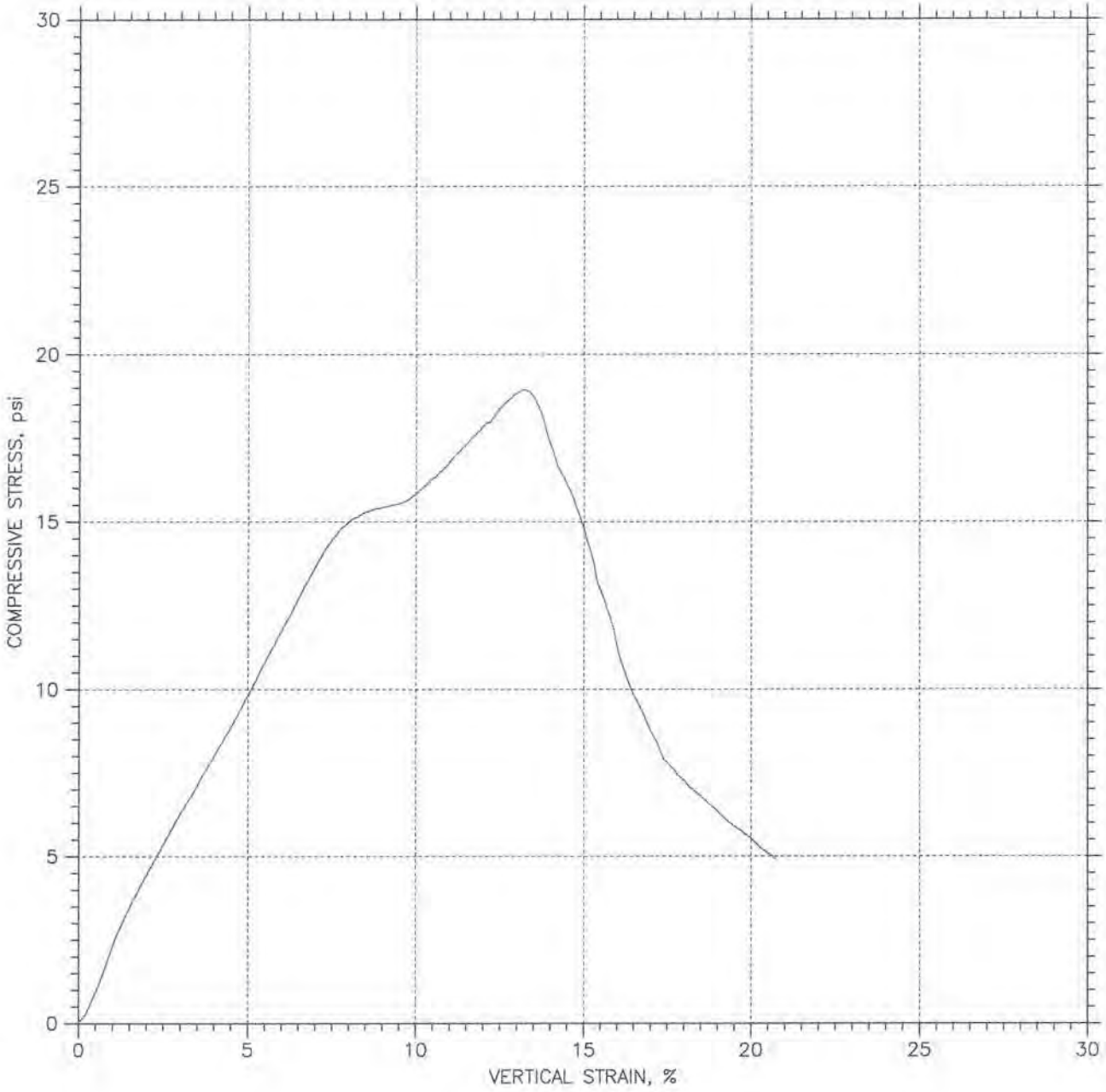
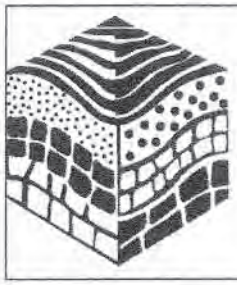
SS-453-13

UNCONFINED COMPRESSION TEST REPORT





Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-453-13	Test Date: 10/1/2013	Depth: 22.0-24.0
Test No.: UC-35-13	Sample Type: Undisturbed	Elevation:
Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to		
Remarks: gry/brn silty clay, slicken sided clay, trace of coal.		

FIG. B-37
Sheet 2 of 2

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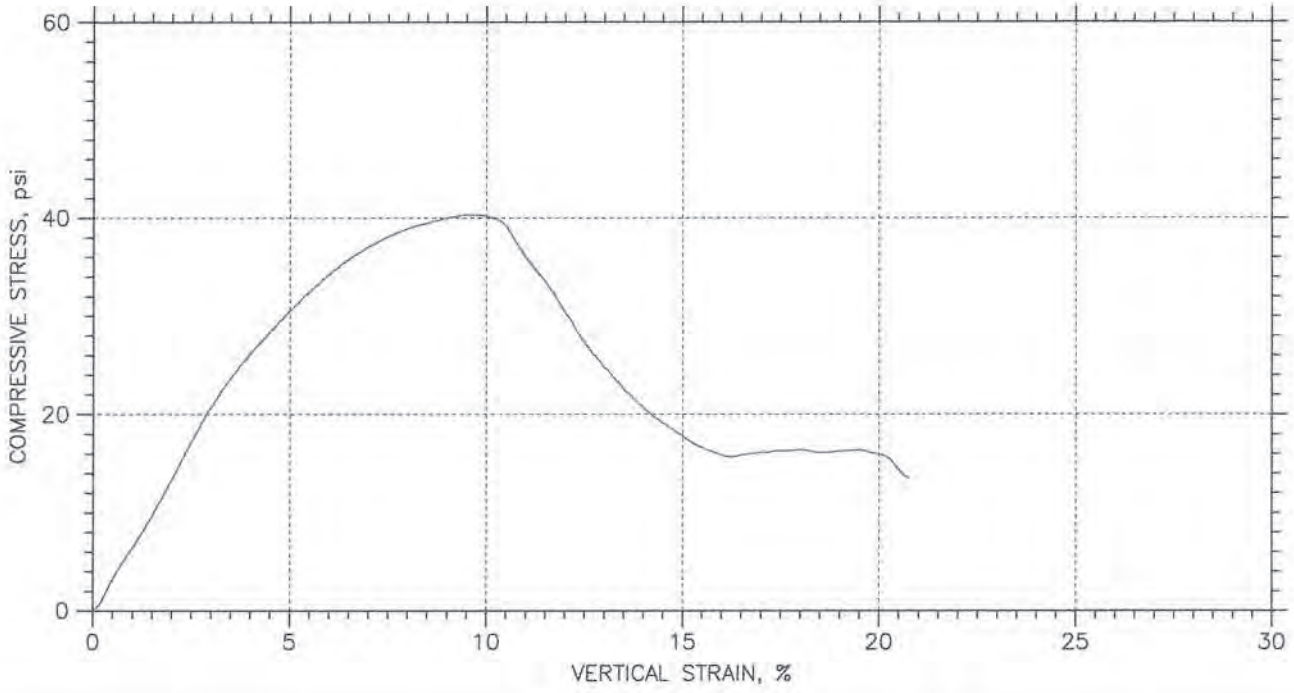
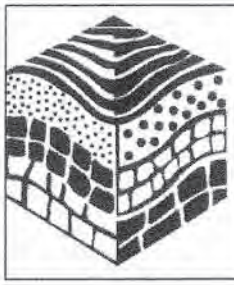
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-36-13			
Initial	Diameter, in	2.845			
	Height, in	5.542			
	Water Content, %	22.98			
	Dry Density, pcf	103.9			
	Saturation, %	102.76			
	Void Ratio	0.593			
Unconfined Compressive Strength, psi		40.3			
Undrained Shear Strength, psi		20.15			
Time to Failure, min		9.3393			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

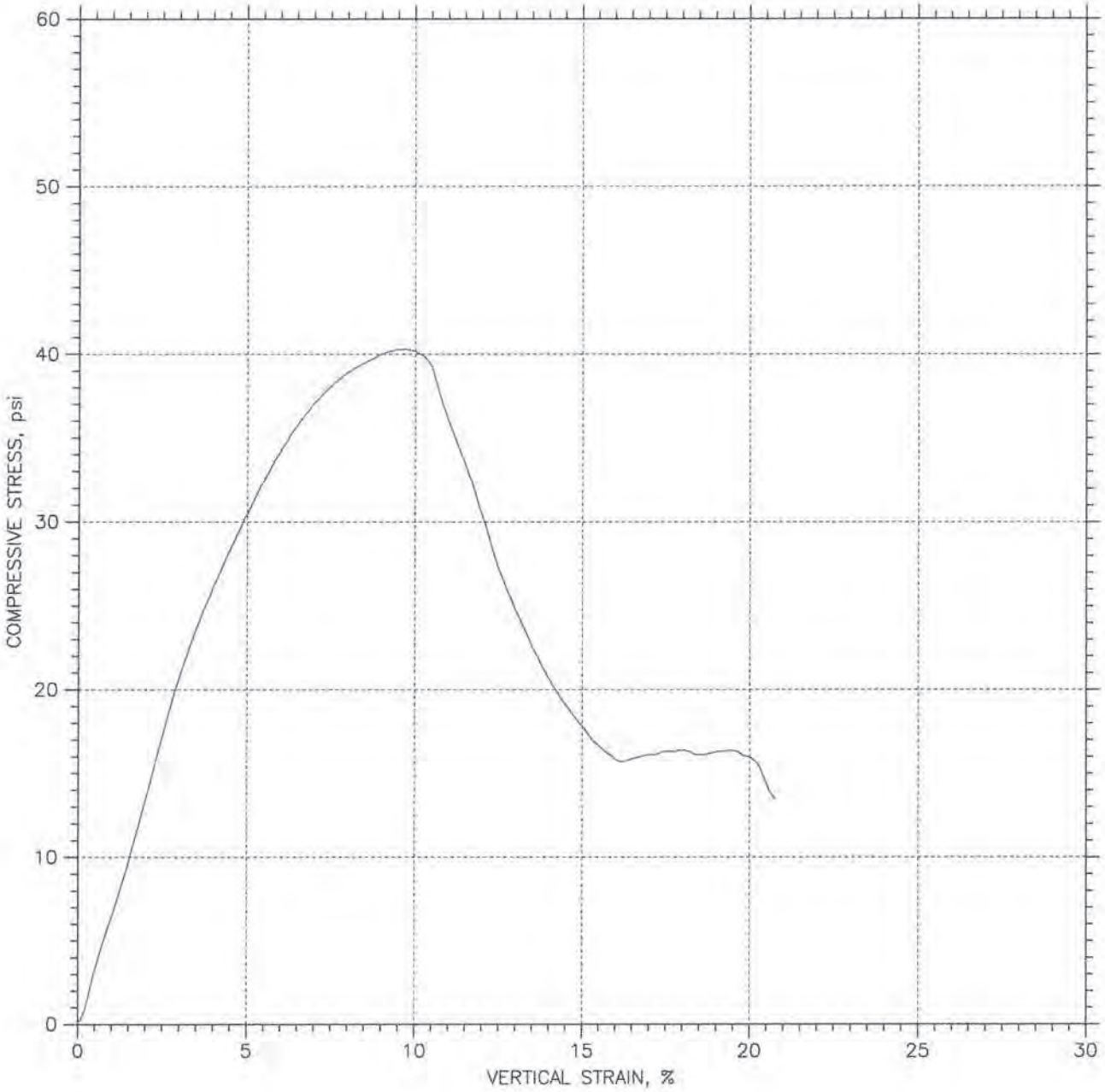
Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to

Remarks: gry/brn silty clay, slicken sided, trace of coal.

FIG. B-38

SS-453-13

UNCONFINED COMPRESSION TEST REPORT



Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-453-13	Test Date: 10/1/2013	Depth: 22.0-24.0
Test No.: UC-36-13	Sample Type: Undisturbed	Elevation:
Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to		
Remarks: gry/brn silty clay, slicken sided, trace of coal.		

FIG. B-38
Sheet 2 of 2

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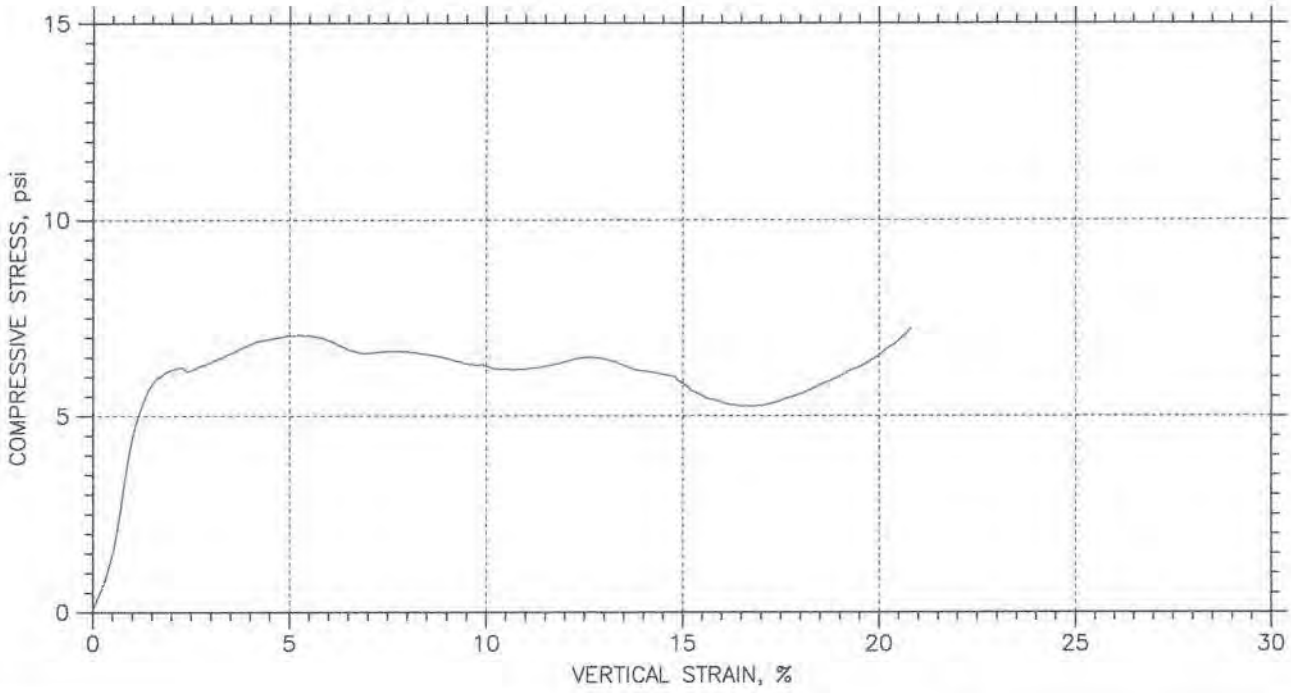
55-453-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-37-13			
Initial	Diameter, in	2.849			
	Height, in	5.557			
	Water Content, %	23.73			
	Dry Density, pcf	99.47			
	Saturation, %	94.84			
	Void Ratio	0.663			
Unconfined Compressive Strength, psi		7.22			
Undrained Shear Strength, psi		3.61			
Time to Failure, min		20.005			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

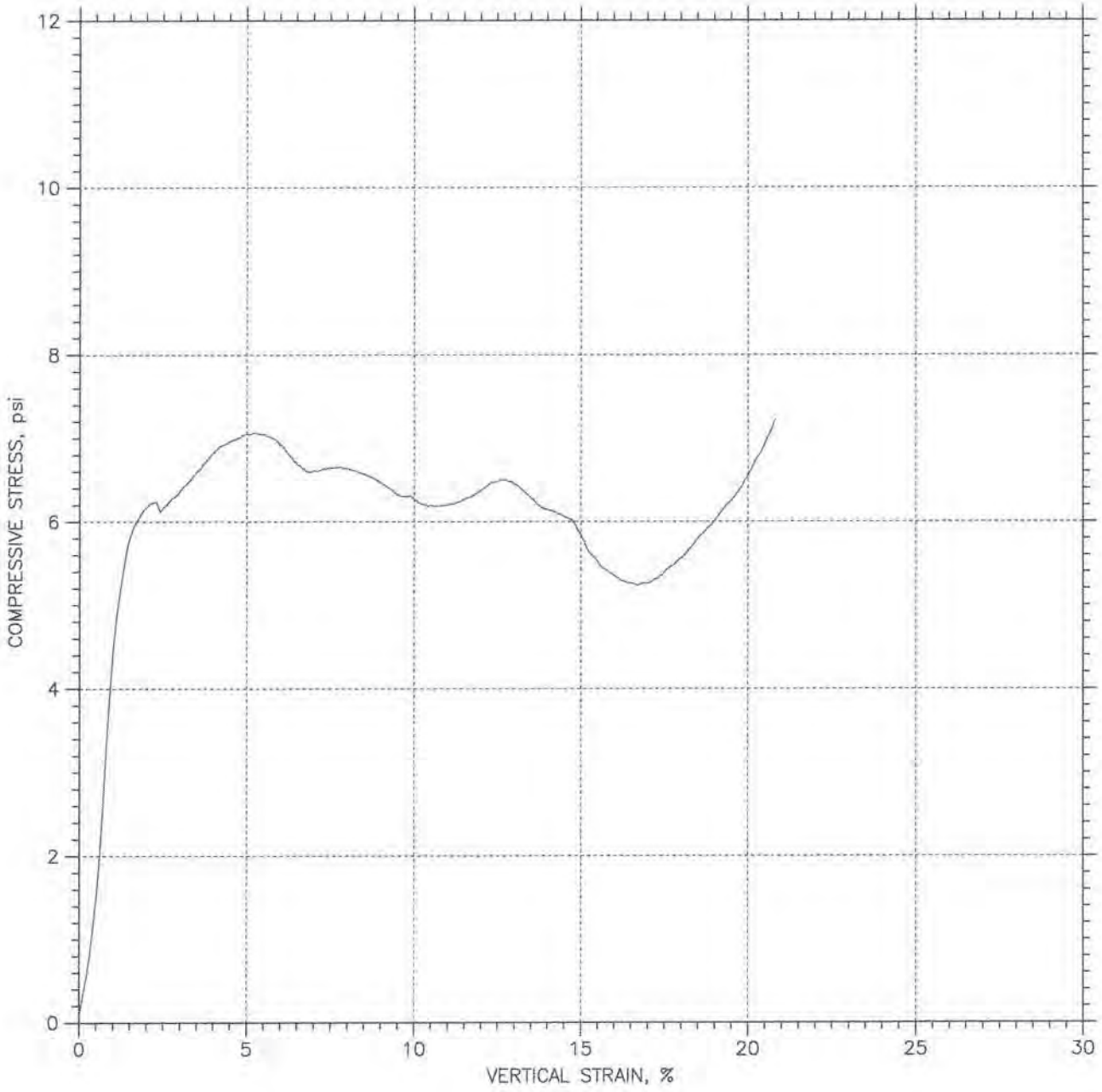
Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to

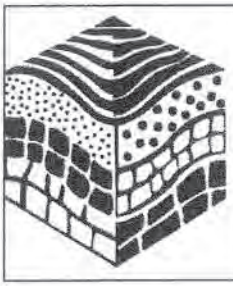
Remarks: gry/brn silty clay, slicken sided, trace of coal.

FIG. B-39

SS-453-13

UNCONFINED COMPRESSION TEST REPORT





Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-453-13	Test Date: 10/1/2013	Depth: 22.0-24.0
Test No.: UC-37-13	Sample Type: Undisturbed	Elevation:
Description: Total length 22" Lt. Brn Silty Clay Loam, bottom 5" of tube changing to		
Remarks: gry/brn silty clay, slicken sided, trace of coal.		

FIG. B-39
Sheet 2 of 2

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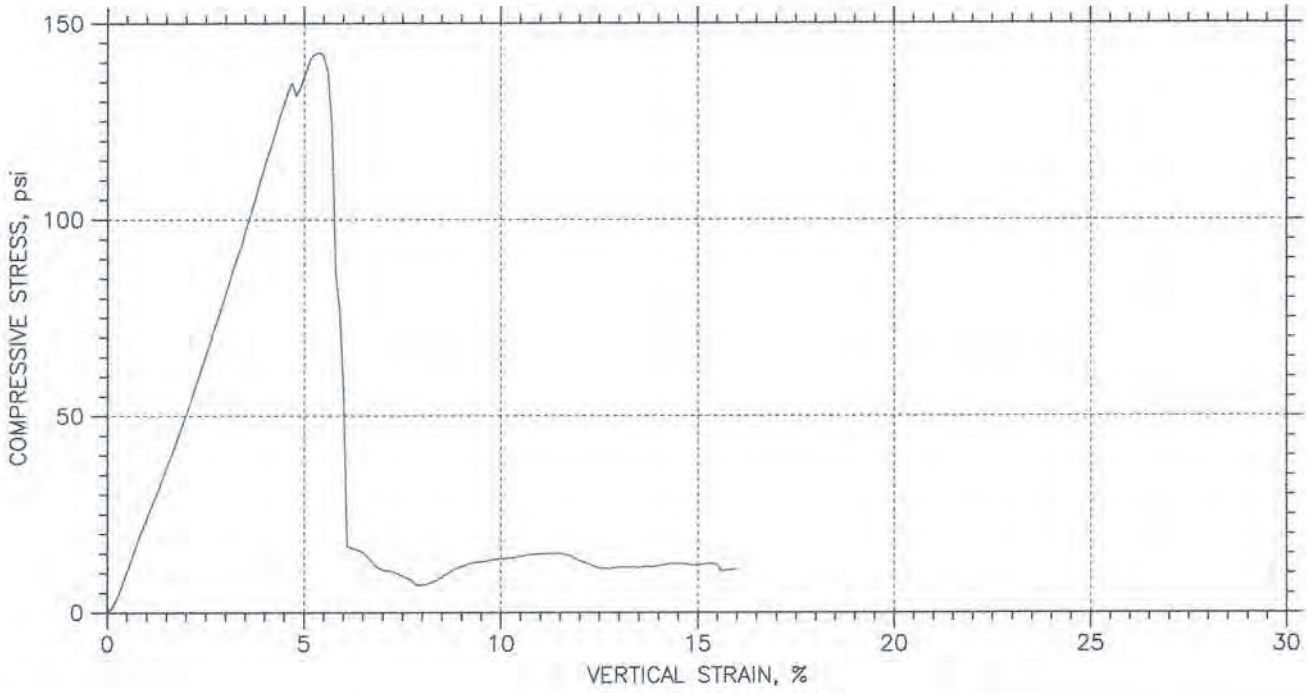
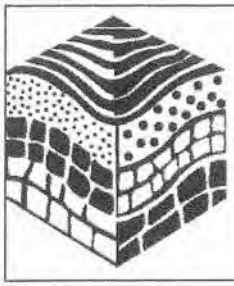
UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-38-13			
Initial	Diameter, in	2.841			
	Height, in	5.552			
	Water Content, %	27.06			
	Dry Density, pcf	101.4			
	Saturation, %	113.51			
	Void Ratio	0.632			
Unconfined Compressive Strength, psi		142.5			
Undrained Shear Strength, psi		71.26			
Time to Failure, min		5.3125			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type: Undisturbed

Description: Total length 18" Top 10" of tube disturbed, ran uc on remaining gry,

Remarks: silty clay. Ran moisture density on another portion that was too small to test.

FIG. B-40
Sheet 1 of 2

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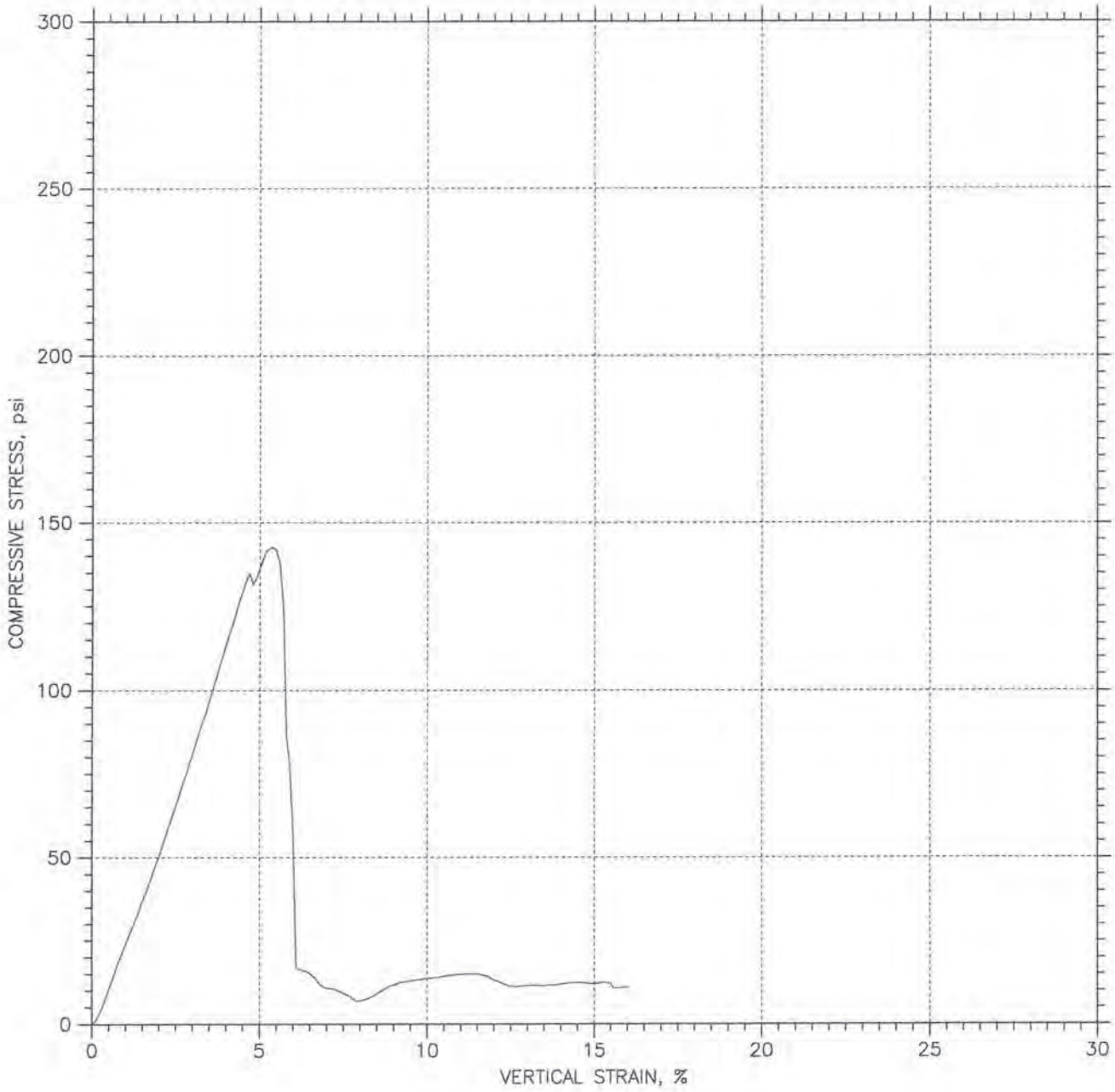
SS-457-13

UNCONFINED COMPRESSION TEST REPORT



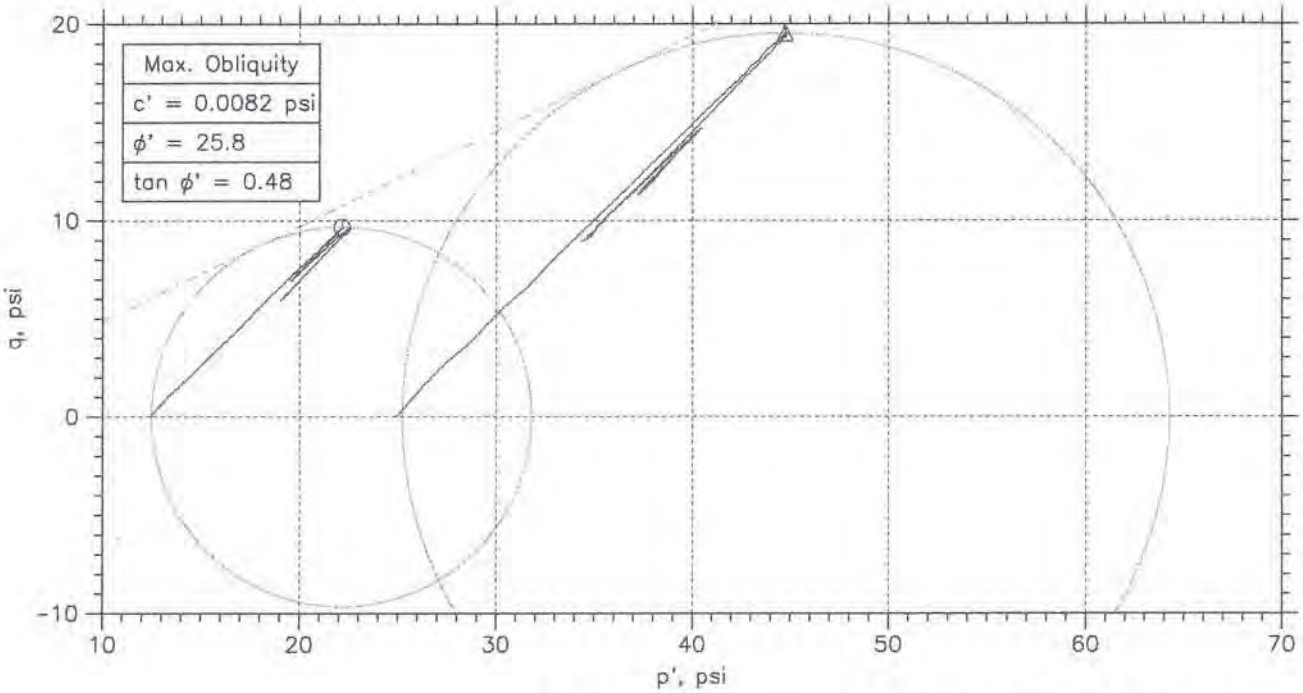
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Tested By: DT	Checked By: SS
Sample No.: SS-457-13	Test Date: 10/1/2013	Depth: 30.0-32.0
Test No.: UC-38-13	Sample Type: Undisturbed	Elevation:
Description: Total length 18" Top 10" of tube disturbed, ran uc on remaining gry,		
Remarks: silty clay. Ran moisture density on another portion that was too small to test.		

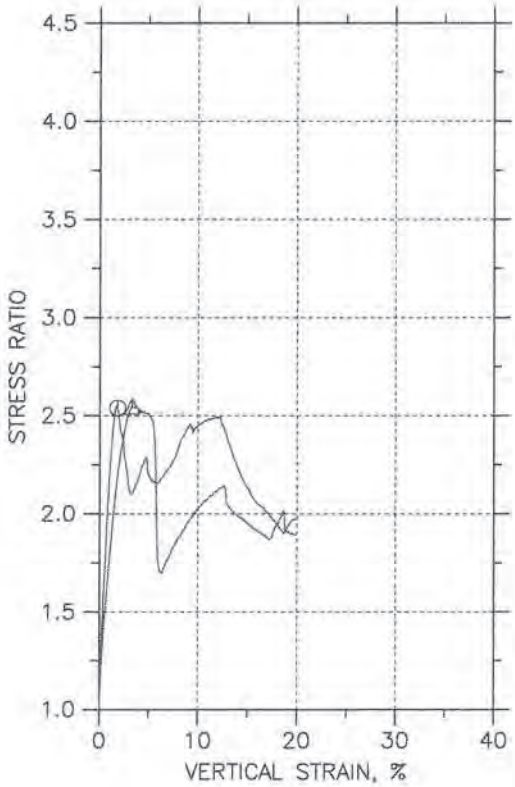
FIG. B-40
Sheet 2 of 2

Wed, 02-OCT-2013 08:59:35

SS-455-13

Test File





Symbol		⏲	△		
Sample No.		SS-455-13	SS-455-13		
Test No.		UU-75-13	UU-76-13		
Depth		26.0-28.0	26.0-28.0		
Initial	Diameter, in	2.839	2.844		
	Height, in	5.558	5.572		
	Water Content, %	29.2	31.0		
	Dry Density, pcf	92.76	89.84		
	Saturation, %	98.7	97.7		
	Void Ratio	0.783	0.841		
Before Shear	Water Content, %	29.2	31.0		
	Dry Density, pcf	92.91	90.54		
	Saturation*, %	99.1	99.4		
	Void Ratio	0.781	0.827		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		12.44	24.89		
Shear Strength, psi		9.677	19.52		
Strain at Failure, %		1.8	3.3		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

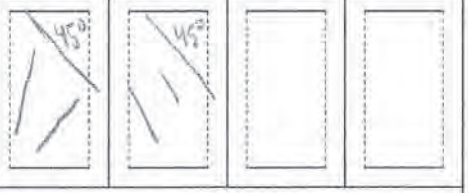
Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B11

Sample Type:



Description: Total length 24" Top 12" of tube disturbed, uu ran on gry silty clay.

Remarks: samples fractured throughout entire specimen. slicken sided clay, trace coal.

Phase calculations based on start and end of test.

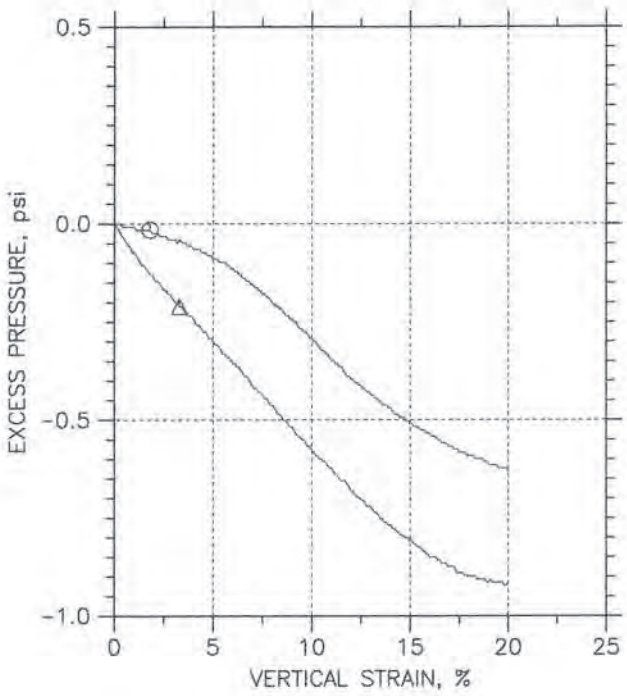
* Saturation is set to 100% for phase calculations.

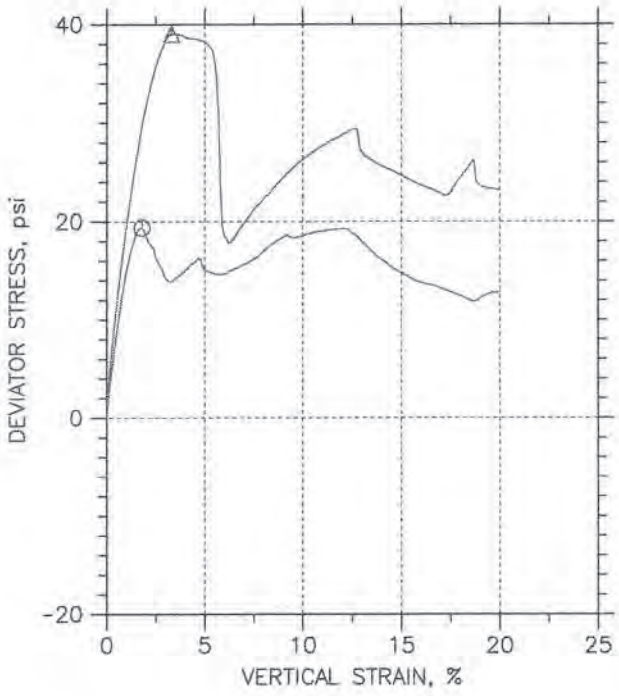
'ed, 02-OCT-2013 08:42:20

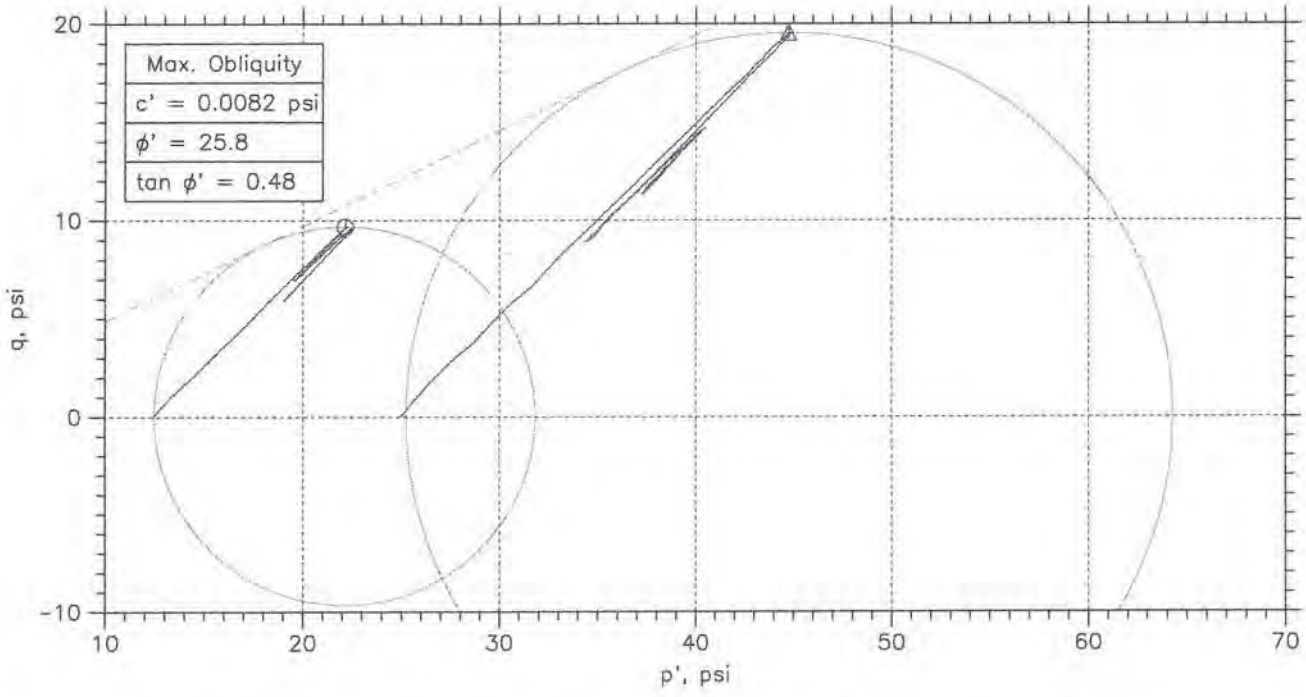
FIG. B-41

SS-455-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-455-13	UU-75-13	26.0-28.0	DT	9/24/13	SS		UU-75-2013.dat
△	SS-455-13	UU-76-13	26.0-28.0	DT	9/24/13	SS		UU-76-2013.dat

NDDOT
North Dakota Department of Transportation

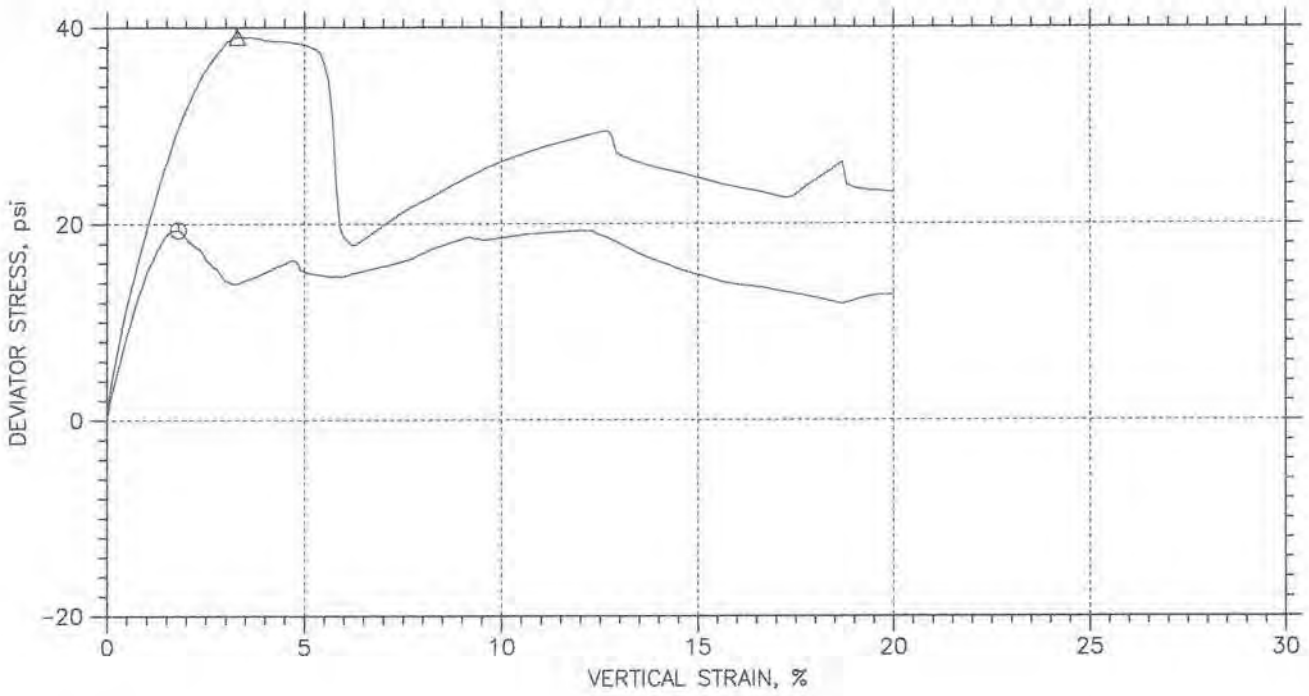
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Sample Type:	
Description: Total length 24" Top 12" of tube disturbed, uu ran on gry silty clay.		
Remarks: samples fractured throughout entire specimen. slicken sided clay, trace coal.		

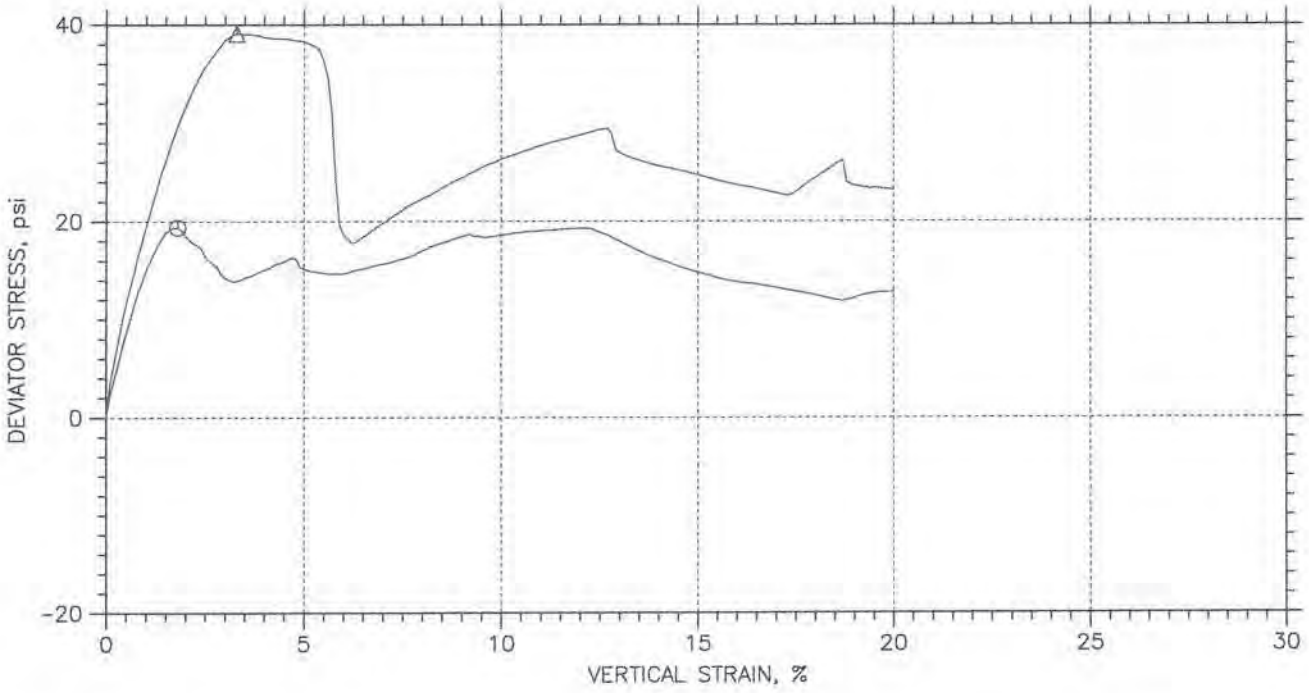
FIG. B-41
Sheet 2 of 5

Wed, 02-OCT-2013 08:42:20

SS-455-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-455-13	UU-75-13	26.0-28.0	DT	9/24/13	SS		UU-75-2013.dat
△	SS-455-13	UU-76-13	26.0-28.0	DT	9/24/13	SS		UU-76-2013.dat

NDDOT
North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B11	Sample Type:	
Description: Total length 24" Top 12" of tube disturbed, uu ran on gry silty clay.		
Remarks: samples fractured throughout entire specimen. slicken sided clay, trace coal.		

FIG. B-41
Sheet 3 of 5

Ved, 02-OCT-2013 08:42:20

SS-455-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B11
Sample No.: SS-455-13
Test No.: UU-75-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 26.0-28.0
Elevation:

Soil Description: Total length 24" Top 12" of tube disturbed, uu ran on gry silty clay.
Remarks: samples fractured throughout entire specimen. slicken sided clay, trace coal.

Specimen Height: 5.56 in
Specimen Area: 6.33 in^2
Specimen Volume: 576.55 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s42	---		
Wt. Container + Wet Soil, gm	57.11	---	---	0
Wt. Container + Dry Soil, gm	48.06	---	---	0
Wt. Container, gm	17.04	---	---	0
Wt. Wet Soil, gm	40.07	1106.6	856.68	0
Wt. Dry Soil, gm	31.02	856.68	856.68	0
Wt. Water, gm	9.05	249.94	1.1642e-013	0
Water Content, %	29.17	29.17	0.00	0.00
Void Ratio	---	0.78	0.78	---
Degree of Saturation, %	---	98.68	0.00	---
Dry Unit Weight, pcf	---	92.76	92.913	---

Initial

Height: 5.558 in
Area: 6.3302 in^2
Volume: 576.55 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.76 pcf
Saturation: 98.68 %

End of Initialization
Time: 5.8432 min
Total Vertical Stress: 12.44 psi
Total Horizontal Stress: 12.44 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.44 psi
Effective Horizontal Stress: 12.44 psi

Height Change: 0.0030507 in
Area Change: 0 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 0 cc

Height: 5.5549 in
Area: 6.3302 in^2
Volume: 575.61 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 99.05 %

End of Consolidation/A
Time: 5.8432 min
Total Vertical Stress: 12.44 psi
Total Horizontal Stress: 12.44 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.44 psi
Effective Horizontal Stress: 12.44 psi

Height Change: 0.0030507 in
Area Change: 0 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 0 cc

Height: 5.5549 in
Area: 6.3302 in^2
Volume: 575.61 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 99.05 %

End of Saturation
Time: 5.8432 min
Total Vertical Stress: 12.44 psi
Total Horizontal Stress: 12.44 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.44 psi
Effective Horizontal Stress: 12.44 psi

Height Change: 0.0030507 in
Area Change: 0 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 0 cc

Height: 5.5549 in
Area: 6.3302 in^2
Volume: 575.61 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 99.05 %

End of Consolidation/B
Time: 5.8432 min
Total Vertical Stress: 12.44 psi
Total Horizontal Stress: 12.44 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 12.44 psi
Effective Horizontal Stress: 12.44 psi

Height Change: 0.0030507 in
Area Change: 0 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 0 cc

Height: 5.5549 in
Area: 6.3302 in^2
Volume: 575.61 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 99.05 %

End of Shear
Time: 26.11 min
Total Vertical Stress: 25.305 psi
Total Horizontal Stress: 12.513 psi
Pore Pressure: -0.62329 psi
Effective Vertical Stress: 25.928 psi
Effective Horizontal Stress: 13.136 psi

Height Change: 1.1142 in
Area Change: -1.5741 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 249.94 cc

Height: 4.4438 in
Area: 7.9044 in^2
Volume: 575.61 cc

Moisture: 0.00 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 0.00 %

At Failure
Time: 7.7225 min
Total Vertical Stress: 31.914 psi
Total Horizontal Stress: 12.561 psi
Pore Pressure: -0.016189 psi
Effective Vertical Stress: 31.931 psi
Effective Horizontal Stress: 12.578 psi

Height Change: 0.10308 in
Area Change: -0.11963 in^2
Volume Change: 0.94938 cc
Water Change: -0.0010726 cc
Correction: 0 cc

Height: 5.4549 in
Area: 6.4499 in^2
Volume: 575.61 cc

Moisture: 29.17 %
Void Ratio: 0.78
Dry Unit Weight: 92.913 pcf
Saturation: 99.05 %

FIG. B-41
Sheet 4 of 5

SS-455-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B11
Sample No.: SS-455-13
Test No.: UU-76-13

Location:
Tested By: DT
Test Date: 9/24/13
Sample Type:

Project No.:
Checked By: SS
Depth: 26.0-28.0
Elevation:

Soil Description: Total length 24" Top 12" of tube disturbed, uu ran on gry silty clay.
Remarks: samples fractured throughout entire specimen. slicken sided clay, trace coal.

Specimen Height: 5.57 in
Specimen Area: 6.35 in^2
Specimen Volume: 580.04 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s32	---		
Wt. Container + Wet Soil, gm	51.53	---	---	0
Wt. Container + Dry Soil, gm	43.32	---	---	0
Wt. Container, gm	16.85	---	---	0
Wt. Wet Soil, gm	34.68	1093.6	834.73	0
Wt. Dry Soil, gm	26.47	834.73	834.73	0
Wt. Water, gm	8.21	258.9	1.1642e-013	0
Water Content, %	31.02	31.02	0.00	0.00
Void Ratio	---	0.84	0.83	---
Degree of Saturation, %	---	97.68	0.00	---
Dry Unit Weight, pcf	---	89.839	90.539	---

Initial

Height: 5.572 in
Area: 6.3526 in^2
Volume: 580.04 cc

Moisture: 31.02 %
Void Ratio: 0.84
Dry Unit Weight: 89.839 pcf
Saturation: 97.68 %

End of Initialization
Time: 4.8931 min
Total Vertical Stress: 24.893 psi
Total Horizontal Stress: 24.929 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.893 psi
Effective Horizontal Stress: 24.929 psi

Height Change: 0.014375 in
Area Change: 0 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 0 cc

Height: 5.5576 in
Area: 6.3526 in^2
Volume: 575.56 cc

Moisture: 31.02 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 99.37 %

End of Consolidation/A
Time: 4.8931 min
Total Vertical Stress: 24.893 psi
Total Horizontal Stress: 24.929 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.893 psi
Effective Horizontal Stress: 24.929 psi

Height Change: 0.014375 in
Area Change: 0 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 0 cc

Height: 5.5576 in
Area: 6.3526 in^2
Volume: 575.56 cc

Moisture: 31.02 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 99.37 %

End of Saturation
Time: 4.8931 min
Total Vertical Stress: 24.893 psi
Total Horizontal Stress: 24.929 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.893 psi
Effective Horizontal Stress: 24.929 psi

Height Change: 0.014375 in
Area Change: 0 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 0 cc

Height: 5.5576 in
Area: 6.3526 in^2
Volume: 575.56 cc

Moisture: 31.02 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 99.37 %

End of Consolidation/B
Time: 4.8931 min
Total Vertical Stress: 24.893 psi
Total Horizontal Stress: 24.929 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 24.893 psi
Effective Horizontal Stress: 24.929 psi

Height Change: 0.014375 in
Area Change: 0 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 0 cc

Height: 5.5576 in
Area: 6.3526 in^2
Volume: 575.56 cc

Moisture: 31.02 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 99.37 %

End of Shear
Time: 25.178 min
Total Vertical Stress: 48.34 psi
Total Horizontal Stress: 24.985 psi
Pore Pressure: -0.9066 psi
Effective Vertical Stress: 49.246 psi
Effective Horizontal Stress: 25.892 psi

Height Change: 1.1261 in
Area Change: -1.5474 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 258.92 cc

Height: 4.4459 in
Area: 7.9 in^2
Volume: 575.56 cc

Moisture: 0.00 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 0.00 %

At Failure
Time: 8.2934 min
Total Vertical Stress: 64.073 psi
Total Horizontal Stress: 25.034 psi
Pore Pressure: -0.20237 psi
Effective Vertical Stress: 64.275 psi
Effective Horizontal Stress: 25.236 psi

Height Change: 0.19778 in
Area Change: -0.23396 in^2
Volume Change: 4.4893 cc
Water Change: -0.015016 cc
Correction: 0 cc

Height: 5.3742 in
Area: 6.5865 in^2
Volume: 575.56 cc

Moisture: 31.02 %
Void Ratio: 0.83
Dry Unit Weight: 90.539 pcf
Saturation: 99.37 %

FIG. B-41
Sheet 5 of 5

Start 1140
Stop 520

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. Neumann	12				SER-5-094(093)031

Project Location	County	Date Started	Date Finished
Painted Canyon Side	Billings	7-30-13	7-30-13

Start 4:50

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	DEPTH	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	DEPTH TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
SS #1	1	0.0	2.0		3/4	1.5/2.0	1	466,1	0.0	24.0	Brn	Sndy Cly	Soft	Y	N	Y	I.O Dep
Drill to 2.0																	
SS #2	2	2.0	4.0		3/4	1.5/2.0	2	467			Brn	Sndy Cly	Soft	Y	N	Y	I.O Dep
Drill to 4																	
SS #3	3	4.0	6.0		2/3	1.7/2.0	3	468			Brn	Sndy Cly	Silt	Y	N	Y	I.O Dep
Drill to 6.0																	
3TW #1	4	6.0	8.0			1.0/2.0		469			Brn	Sndy Cly					~~I.O~~ Dep
SS #4	5	8.0	10.0		3/3	2.0/2.0	4	470			Brn	Sndy Cly	Soft	Y	N	Y	I.O Dep
Drill to 10.0																	
3TW #2	6	10.0	12.0			1.8/2.0		471			Brn	Sndy Cly					I.O, coal Dep
SS #5	7	12.0	14.0		5/6	1.7/2.0	5	472			Brn	Sndy Cly	med stiff	Y	N	Y	I.O, coal Dep
Drill to 14.0																	
3TW #3	8	14.0	16.0			1.8/2.0		473			Brn	Sndy Cly					I.O, coal Dep
SS #6	9	16.0	18.0		5/6	1.8/2.0	6	474			Brn	Sndy Cly	med stiff	Y	N	Y	I.O, coal Dep.
Drill to 20.0																	

FIG. B-42
Sheet 1 of 3

FIG. B-42
Sheet 1 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	12				SER-5-094(093)031
Project Location	**County**	**Date Started**			**Date Finished**
Painted Canyon Slide	Billings	7-30-13			7-30-13

SAMP. TYPE	CORE NO.	CORE: FROM	CORE: TO	DEPTH	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
3TW #4	10	19.0	20.0			2.0 / 2.0		475			Brn	Sndy Cly					Silt Dip, Coal, IO
SS #7	11	20.0	22.0		6 / 7	2.0 / 2.0	7	476			Brn	Sndy Cly	med Stiff	Y	N	Y	Silt, coal, IO Dip
Dri	11 to 220																
3TW #5	12	22.0	24.0			1.8 / 2.0		477	24.0	31.0	Drk Gry	Silty Cly					IO, coal Dip
SS #8	13	24.0	26.0		11 / 13	2.0 / 2.0	8	478			Drk Gry	Silty Cly	Stiff	N	N	Y	IO, coal Dip
Dri	11 to 26.0																
2TW #6	14	26.0	27.0			1.0 / 1.0		479			Gry	Silty Cly					Hit Rock Bent Tube Drilled through
Dri	1 to 28.0																
SS #9	15	28.0	30.0		11 / 12	2.0 / 2.0	9	480			Gry	Silty Cly	Stiff	N	N	Y	Silt lenses
Dri	11 to 30.0																
3TW #7	16	30.0	31.0			1.5 / 1.8		481	31.0	/	Gry	fn Snd					Bent tube, 1.5 Rec. Pushed 1.8'
SS #10	17	31.0	33.0		20 / 21	2.0 / 2.0	10	482			Gry	fn Snd	med Dense	Y	N	Y	Layers of Sndy Cly
Dri	11 to 33.0																
SS #11	18	33.0	35.0		18 / 21	2.0 / 2.0	11	483			Gry	fn Snd	med Dense	Y	N	Y	Layers of Sndy Cly, Coal
Dri	11 to 35.0																

FIG. B-42
Sheet 2 of 3

FIG. B-42
Sheet 2 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division

SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. Nauman	12				SER-5-094(093)031

Project Location	County	Date Started	Date Finished
Painted Canyon Slide	Billings	7-30-13	7-30-13

SAMP. TYPE	CORE NO.	CORE FROM	CORE TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	DEPTH TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
SS #12	19	35.0	37.0	14	2.0											
				16	2.0	12	484			Gry	fn snd	med Dense	Y	N	Y	Trace cly
Dri	ll to	38	8.0													
SS #13	20	38.0	40.0	14	2.0											
				15	2.0	13	485			Gry	fn snd	med Dense	Y	N	Y	Trace cly
Dri	ll	45.0														
	Stop															

FIG. B-42
Sheet 3 of 3

FIG. B-42
Sheet 3 of 3

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-25-2013	**Date Reported**	8/28/2013	**Boring Number**	12
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	466.1	467	468	469
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	4.0 - 6.0	6.0 - 8.0
Field Sample No.	466.1	467	468	469
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	99	100	99
% Coarse Sand (-No. 10 + No.40)	1	1	1	0
% Fine Sand (-No. 40 + No. 200)	4	5	2	1
% Silt (0.074 - 0.005 mm)	43	34	33	34
% Clay (-0.005 mm)	53	60	64	64
Liquid Limit (-No. 40)	44	47	52	49
Plasticity Index (-No. 40)	21	28	32	28
Plastic Limit	23	18	20	20
Soil Color	Brn	Brn	Brn	Brn
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(22)	A-7-6(28)	A-7-6(34)	A-7-6(30)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	8.3	18.5	20.8	24.0

FIG. B-43
Sheet 1 of 5

FIG. B-43
Sheet 1 of 5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-25-2013	**Date Reported**	8/28/2013	**Boring Number**	12
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	470	471	472	473
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	8.0 - 10.0	10.0 - 12.0	12.0 - 14.0	14.0 - 16.0
Field Sample No.	470	471	472	473
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	99	100	100
% Coarse Sand (-No. 10 + No.40)	1	0	2	0
% Fine Sand (-No. 40 + No. 200)	3	4	3	1
% Silt (0.074 - 0.005 mm)	39	27	29	37
% Clay (-0.005 mm)	57	68	66	62
Liquid Limit (-No. 40)	45	47	43	48
Plasticity Index (-No. 40)	27	28	25	27
Plastic Limit	18	18	18	20
Soil Color	Brn	Brn	Brn	Brn
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(28)	A-7-6(29)	A-7-6(25)	A-7-6(30)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	25.4	21.0	22.1	25.8

FIG. B-43
Sheet 2 of 5

FIG. B-43 Sheet 2 of 5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-25-2013	**Date Reported**	8/28/2013	**Boring Number**	12
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	474	475	476	477
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	16.0 - 18.0	18.0 - 20.0	20.0 - 22.0	22.0 - 24.0
Field Sample No.	474	475	476	477
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	99	100	98
% Coarse Sand (-No. 10 + No.40)	1	0	0	1
% Fine Sand (-No. 40 + No. 200)	4	9	3	1
% Silt (0.074 - 0.005 mm)	26	40	30	28
% Clay (-0.005 mm)	68	49	67	69
Liquid Limit (-No. 40)	49	36	51	59
Plasticity Index (-No. 40)	29	18	31	37
Plastic Limit	20	18	20	22
Soil Color	Brn	Brn	Brn	Drk Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(29)	A-6(16)	A-7-6(32)	A-7-6(41)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	22.8	18.9	26.7	25.7

FIG. B-43
Sheet 3 of 5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

FIG. B-43
Sheet 3 of 5

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-25-2013	**Date Reported**	8/28/2013	**Boring Number**	12
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	478	479	480	481
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	24.0 - 26.0	26.0 - 28.0	28.0 - 30.0	30.0 - 31.0
Field Sample No.	478	479	480	481
% Pass. 3/8" Sieve	100		100	100
% Pass. No. 4 Sieve	100		100	100
% Pass. No. 10 Sieve	100		100	100
% Coarse Sand (-No. 10 + No.40)	0		0	3
% Fine Sand (-No. 40 + No. 200)	0		1	15
% Silt (0.074 - 0.005 mm)	39		52	52
% Clay (-0.005 mm)	61		47	31
Liquid Limit (-No. 40)	65		66	57
Plasticity Index (-No. 40)	43		46	35
Plastic Limit	22		21	22
Soil Color	Drk Gry	Gry	Gry	Gry
Textural Class	CLY		CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(49)		A-7-6(51)	A-7-6(30)
Frost Class	F3		F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	20.6		19.8	23.2

FIG. B-43
Sheet 4 of 5

FIG. B-43 Sheet 4 of 5

Scott W. Wutzke
Testing Lab. Supervisor

Date Printed: 11/19/2013

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-25-2013	**Date Reported**	8/28/2013	**Boring Number**	12
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	482	483	484	485
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	31.0 - 33.0	33.0 - 35.0	35.0 - 37.0	38.0 - 40.0
Field Sample No.	482	483	484	485
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	99	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	14	5	2	1
% Silt (0.074 - 0.005 mm)	51	58	67	64
% Clay (-0.005 mm)	34	37	31	35
Liquid Limit (-No. 40)	54	46	67	68
Plasticity Index (-No. 40)	33	26	45	45
Plastic Limit	21	20	22	23
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	SLTY CLY	SLTY CLY	SLTY CLY
Soil Class (AASHTO M-145)	A-7-6(30)	A-7-6(27)	A-7-6(51)	A-7-6(50)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	26.3	25.0	20.4	20.8

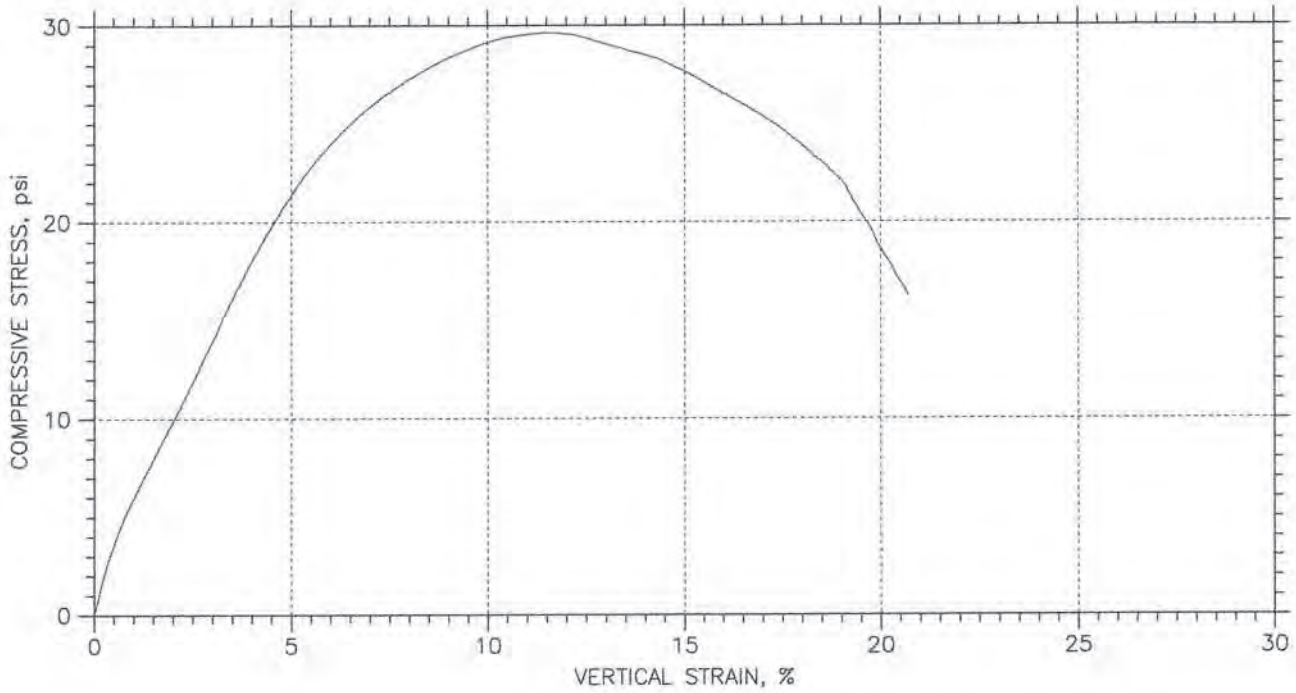
FIG. B-43
Sheet 5 of 5

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

FIG. B-43
Sheet 5 of 5

55-475-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-44-13			
Initial	Diameter, in	2.821			
	Height, in	5.552			
	Water Content, %	20.48			
	Dry Density, pcf	108.2			
	Saturation, %	102.65			
	Void Ratio	0.529			
Unconfined Compressive Strength, psi		29.62			
Undrained Shear Strength, psi		14.81			
Time to Failure, min		11.12			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 12

Sample Type: Undisturbed

Description: Total length 21", top 5" disturbed, Gry silty clay, Bottom 7"" changes

Remarks: to silty clay loam, traces of coal.

FIG. B-44

Sheet 1 of 2

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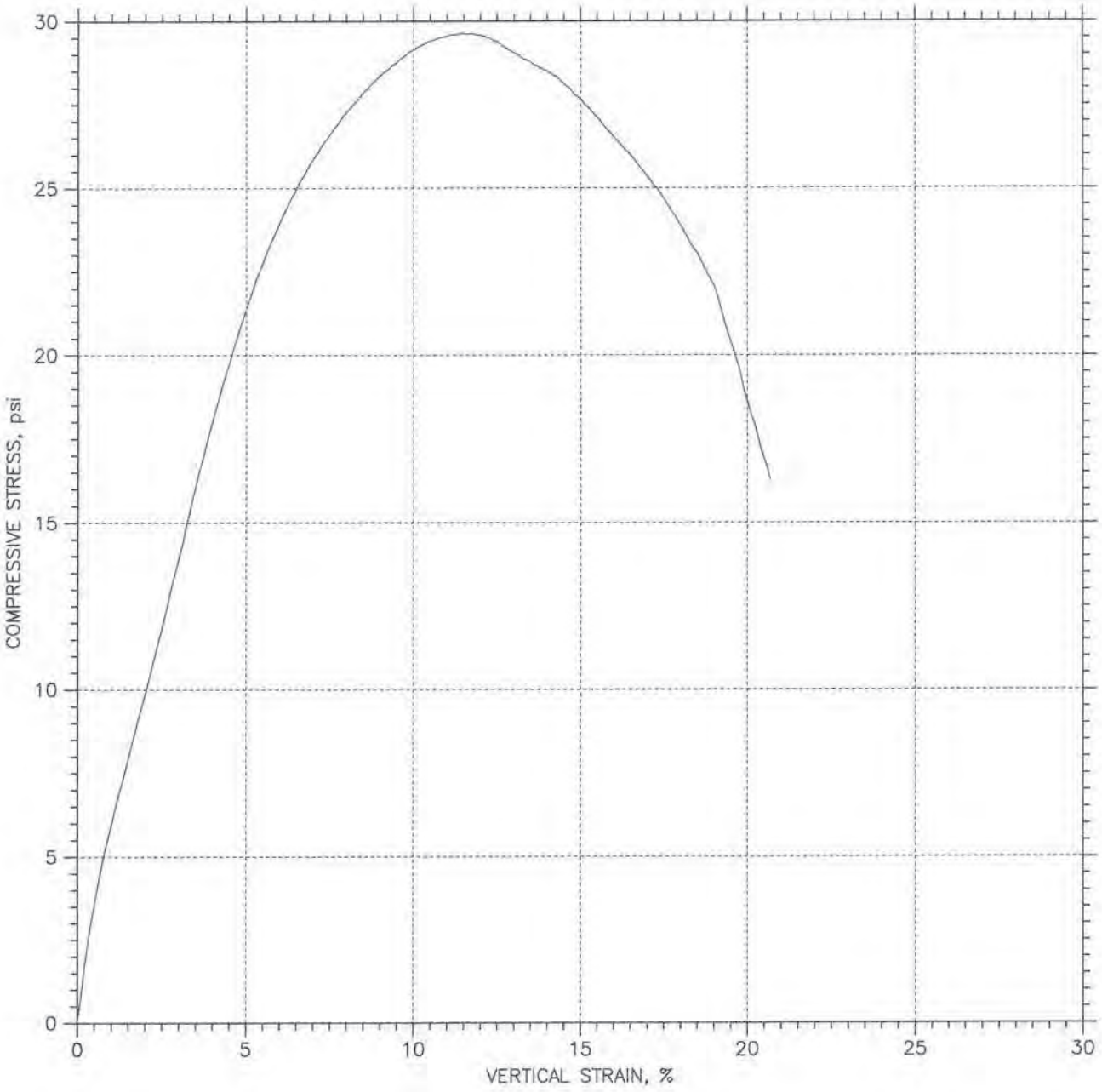
SS-475-13

UNCONFINED COMPRESSION TEST REPORT



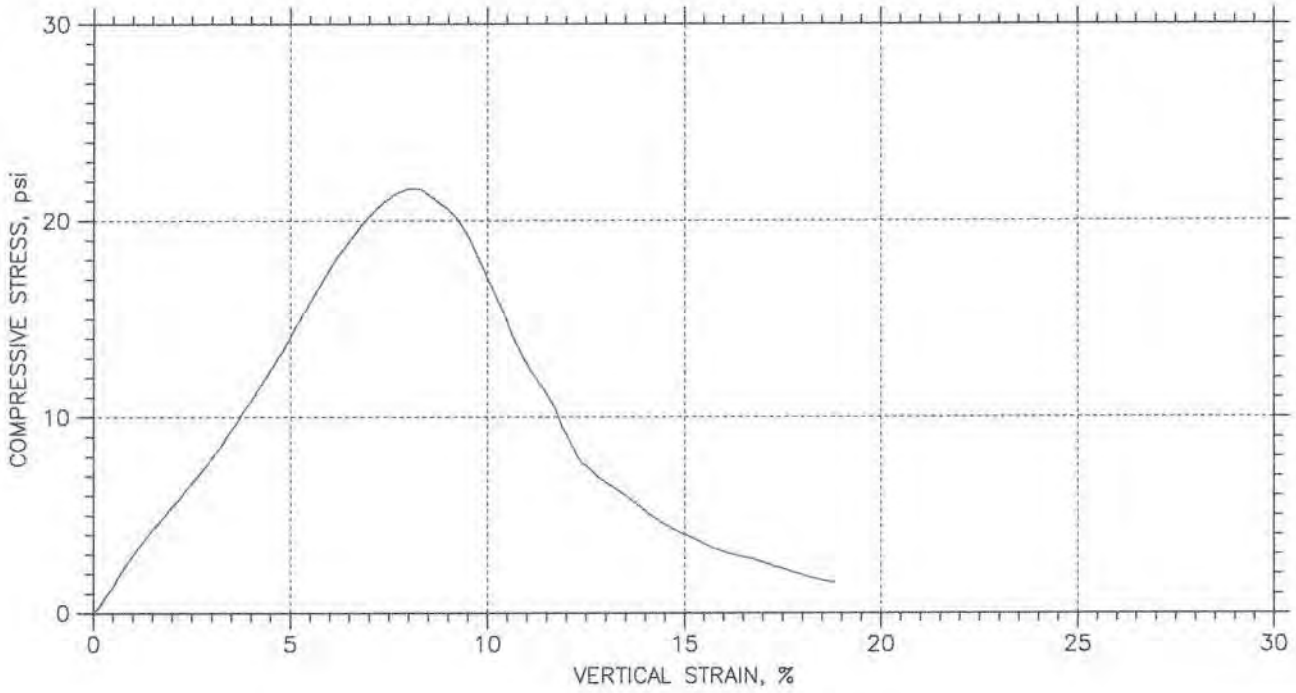
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 12	Tested By: DT	Checked By: SS
Sample No.: SS-475-13	Test Date: 10/9/2013	Depth: 18.0 - 20.0
Test No.: UC-44-13	Sample Type: Undisturbed	Elevation:
Description: Total length 21", top 5" disturbed, Gry silty clay, Bottom 7"' changes		
Remarks: to silty clay loam, traces of coal.		

FIG. B-44
Sheet 2 of 2

hu, 10-OCT-2013 07:22:58

SS-475-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-45-13			
Initial	Diameter, in	2.822			
	Height, in	5.524			
	Water Content, %	17.82			
	Dry Density, pcf	106.8			
	Saturation, %	85.93			
	Void Ratio	0.55			
Unconfined Compressive Strength, psi		21.61			
Undrained Shear Strength, psi		10.8			
Time to Failure, min		7.8365			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 12

Sample Type: Undisturbed

Description: Total length 21" top 5" disturbed, Gry silty clay, Bottom 7"" changes

Remarks: to silty clay loam, traces of coal.

FIG. B-45

Sheet 1 of 2

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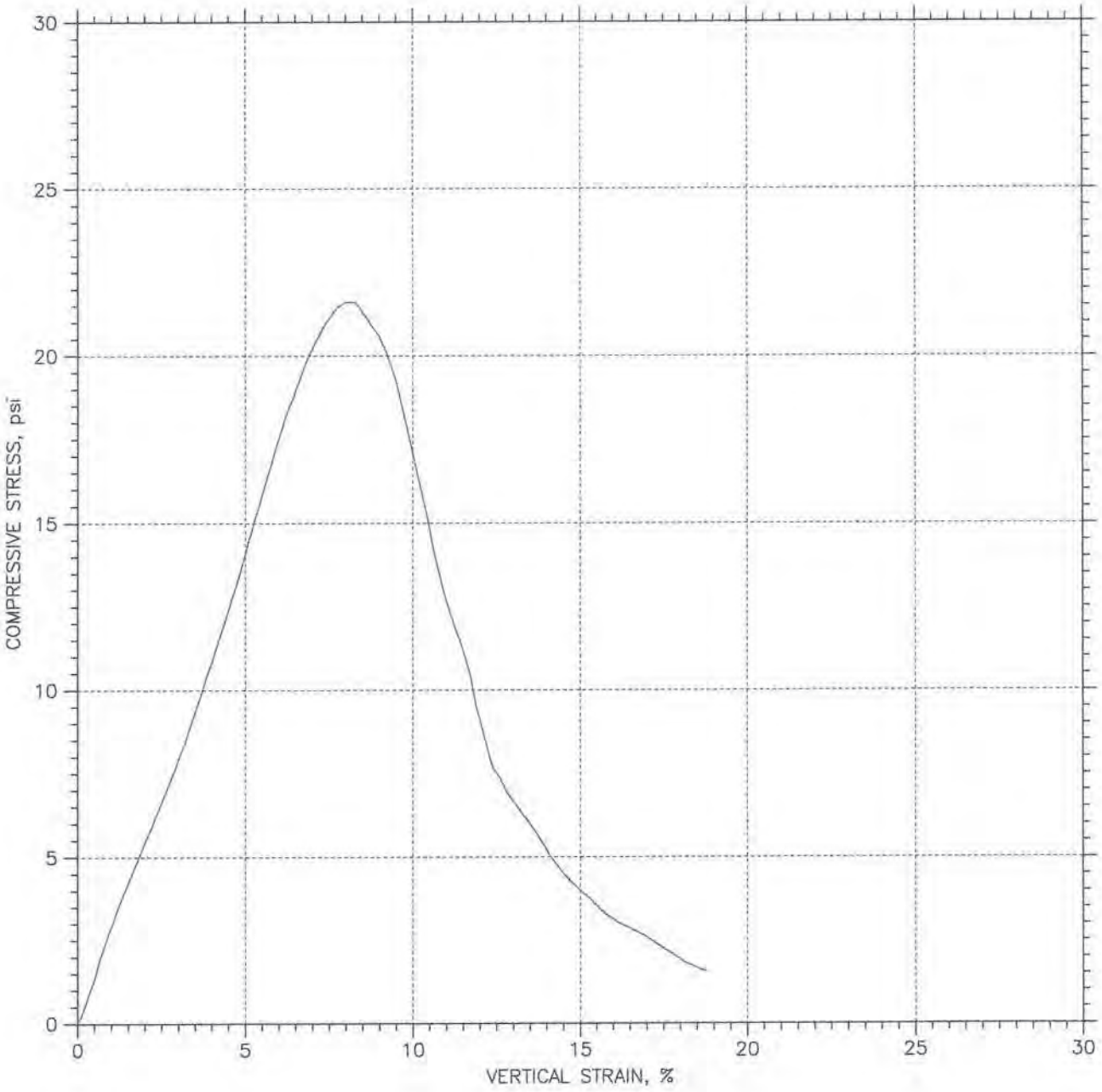
SS-475-13

UNCONFINED COMPRESSION TEST REPORT



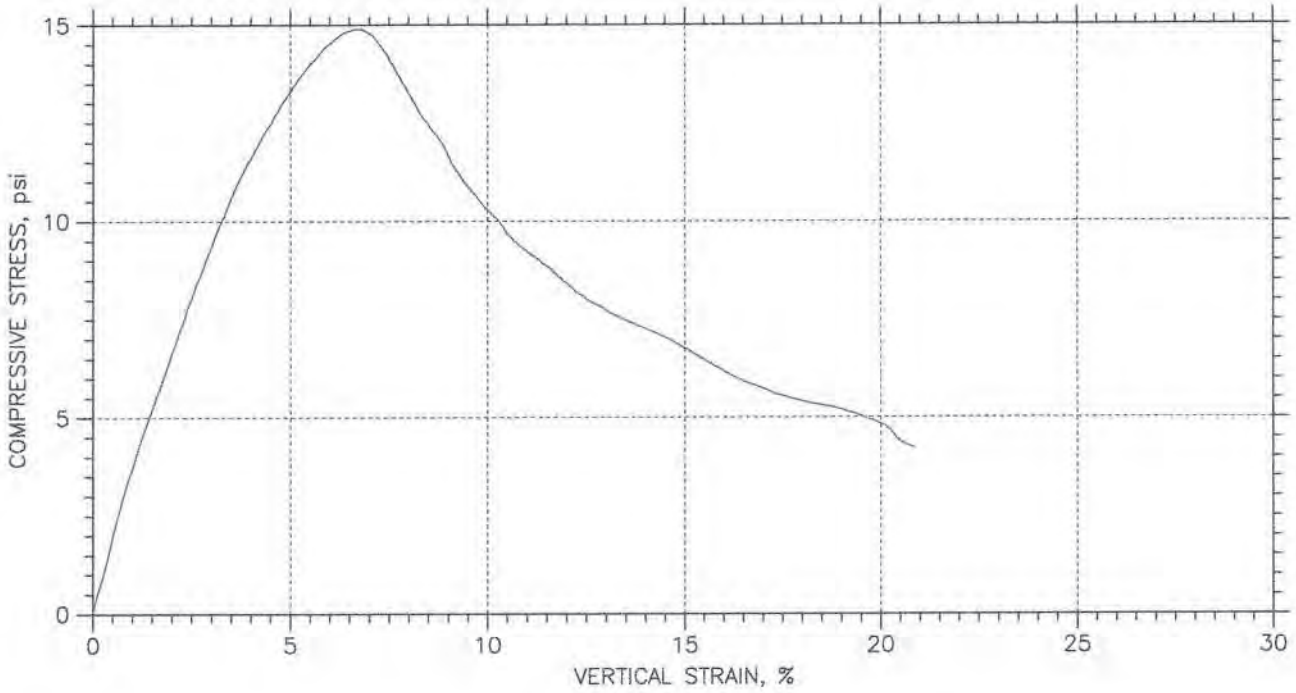
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 12	Tested By: DT	Checked By: SS
Sample No.: SS-475-13	Test Date: 10/9/2013	Depth: 18.0 - 20.0
Test No.: UC-45-13	Sample Type: Undisturbed	Elevation:
Description: Total length 21" top 5" disturbed, Gry silty clay, Bottom 7"" changes		
Remarks: to silty clay loam, traces of coal.		

FIG. B-45
Sheet 2 of 2

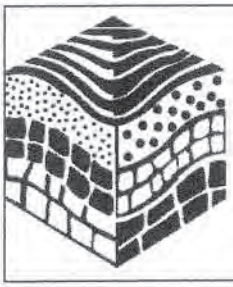
hu, 10-OCT-2013 07:24:46

55-475-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-46-13			
Initial	Diameter, in	2.848			
	Height, in	5.549			
	Water Content, %	18.40			
	Dry Density, pcf	106.4			
	Saturation, %	87.95			
	Void Ratio	0.554			
Unconfined Compressive Strength, psi		14.89			
Undrained Shear Strength, psi		7.445			
Time to Failure, min		6.4398			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 12

Sample Type: Undisturbed

Description: Total length 21" top 5" disturbed, Gry silty clay, Bottom 7"" changes

Remarks: to silty clay loam, traces of coal.

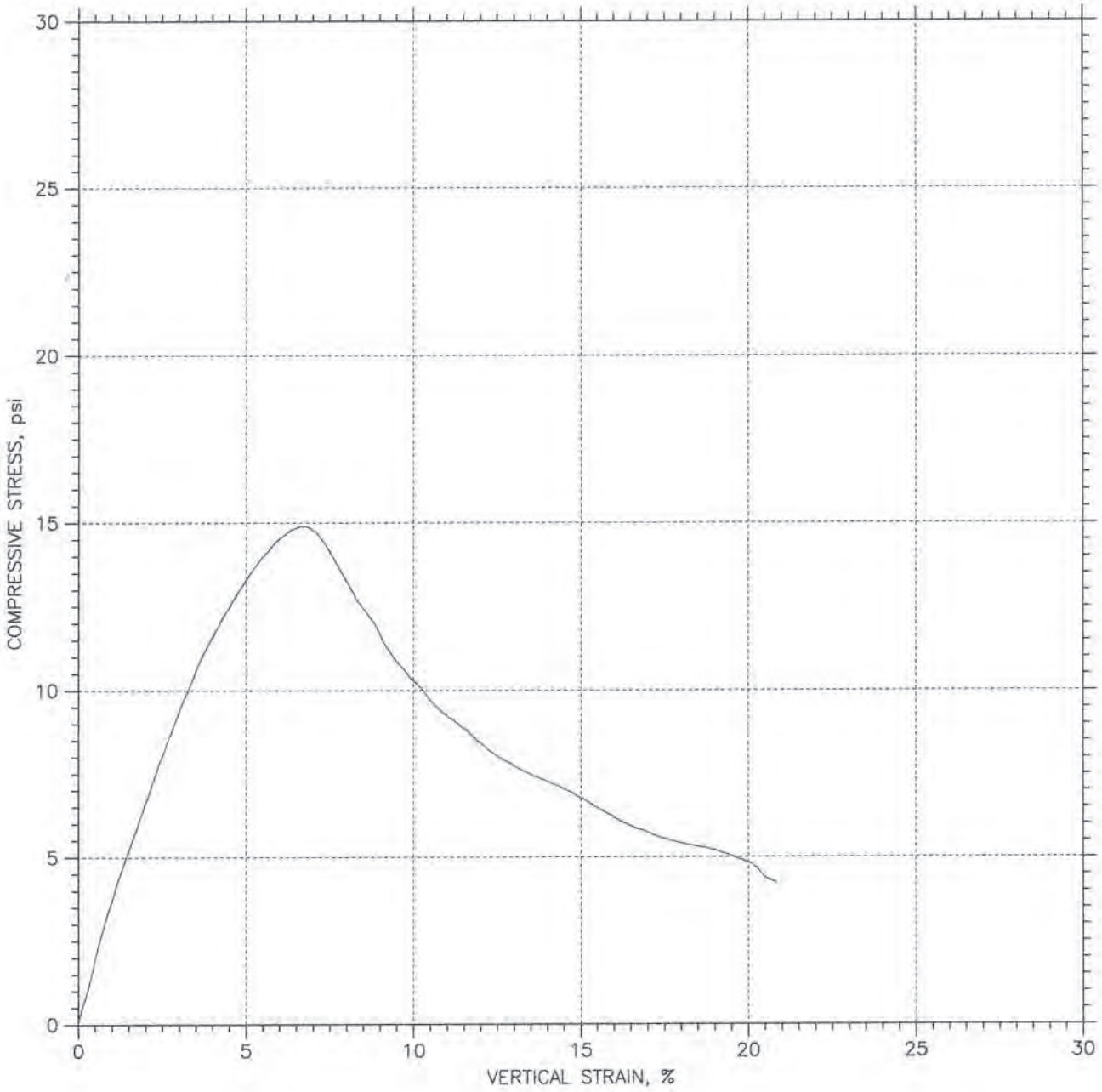
FIG. B-46

Sheet 1 of 2

hu, 10-OCT-2013 07:26:17

SS-475-13

UNCONFINED COMPRESSION TEST REPORT



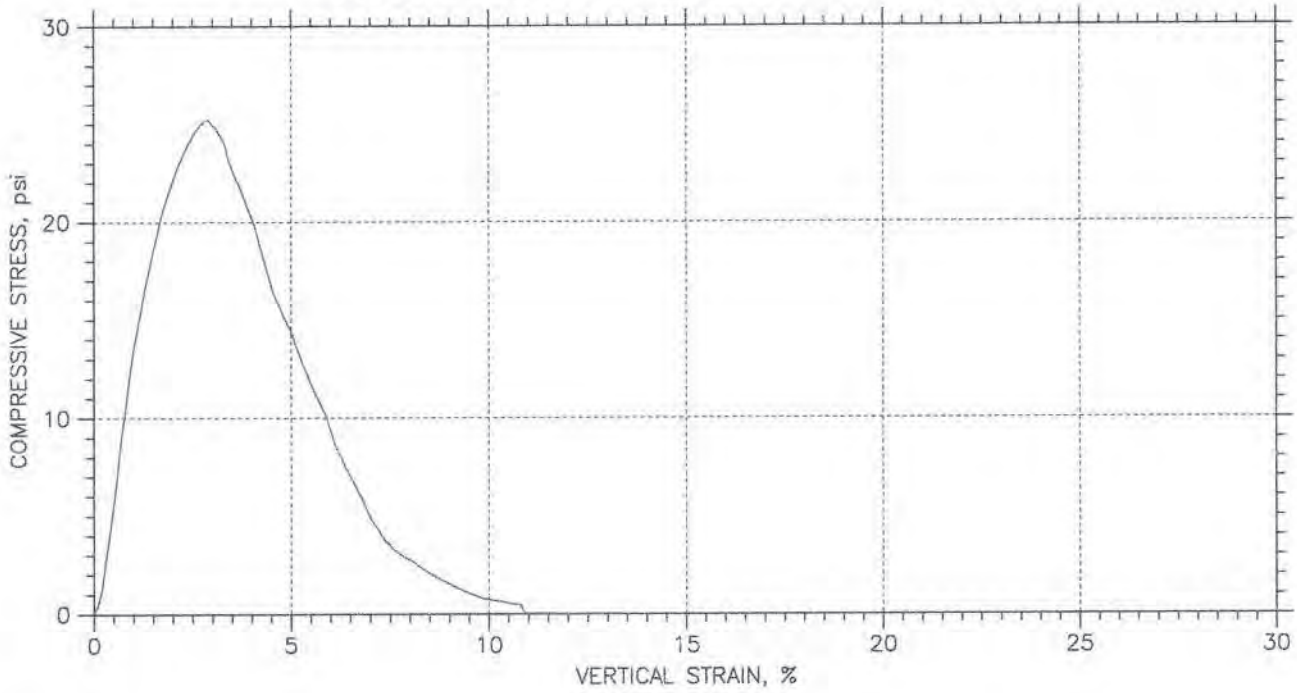
	Project: ser-5-094-093-031	Location:	Project No.:
	Boring No.: 12	Tested By: DT	Checked By: SS
	Sample No.: SS-475-13	Test Date: 10/9/2013	Depth: 18.0 - 20.0
	Test No.: UC-46-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 21" top 5" disturbed, Gry silty clay, Bottom 7"" changes		
	Remarks: to silty clay loam, traces of coal.		

FIG. B-46
Sheet 2 of 2

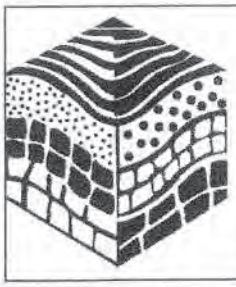
Thu, 10-OCT-2013 07:26:17

SS-477-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-47-13			
Initial	Diameter, in	2.838			
	Height, in	5.604			
	Water Content, %	27.31			
	Dry Density, pcf	99.3			
	Saturation, %	108.68			
	Void Ratio	0.666			
Unconfined Compressive Strength, psi		25.23			
Undrained Shear Strength, psi		12.61			
Time to Failure, min		2.8065			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					



Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 12

Sample Type: Undisturbed

Description: Total length 24" Top 3" disturbed, Brn silty clay w/ taces of coal and

Remarks: pockets of Brn silt. Bottom 10" of tube changes to Gry silty clay.

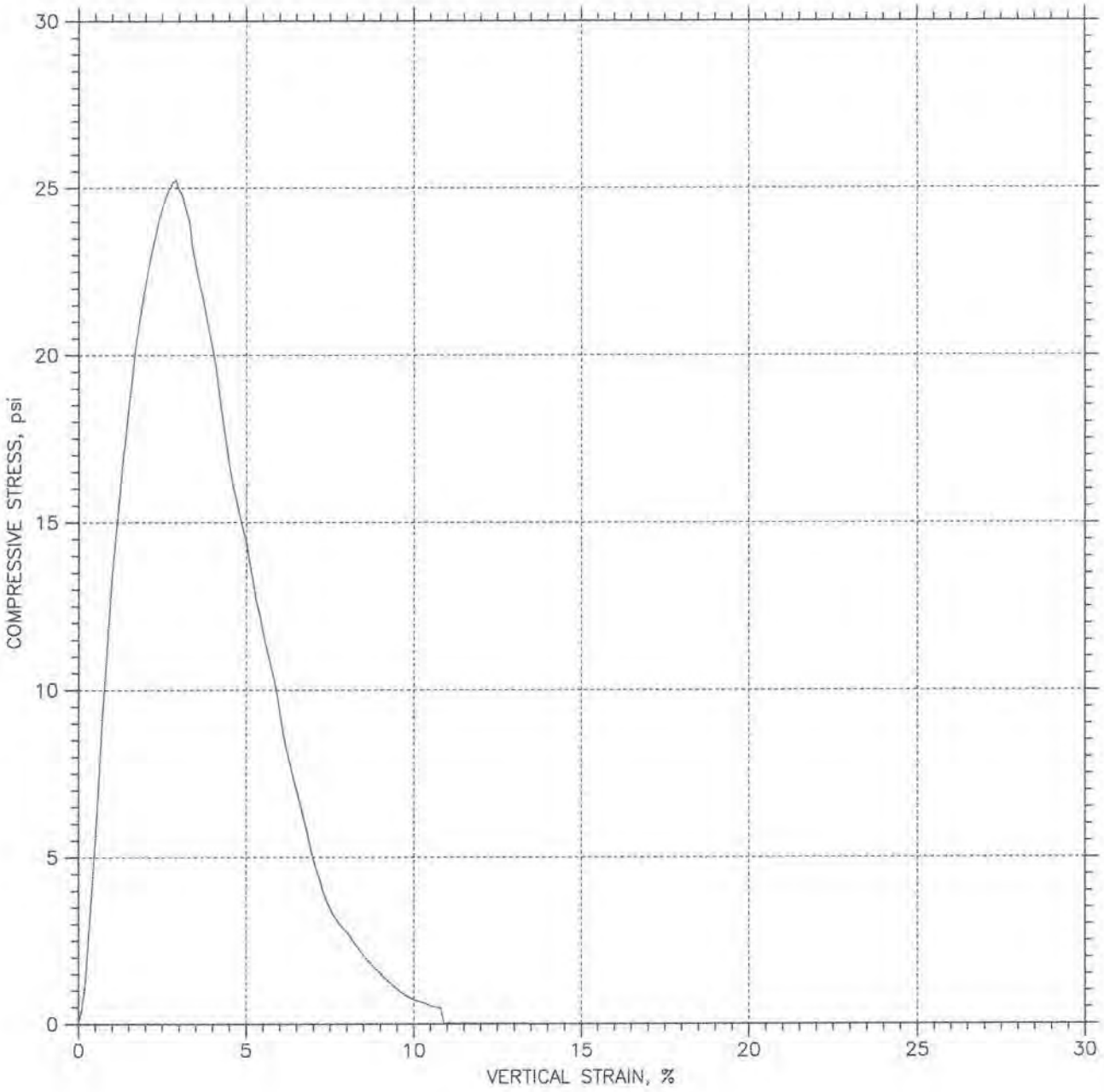
FIG. B-47

Sheet 1 of 2

Thu, 10-OCT-2013 07:32:06

77-411-13

UNCONFINED COMPRESSION TEST REPORT



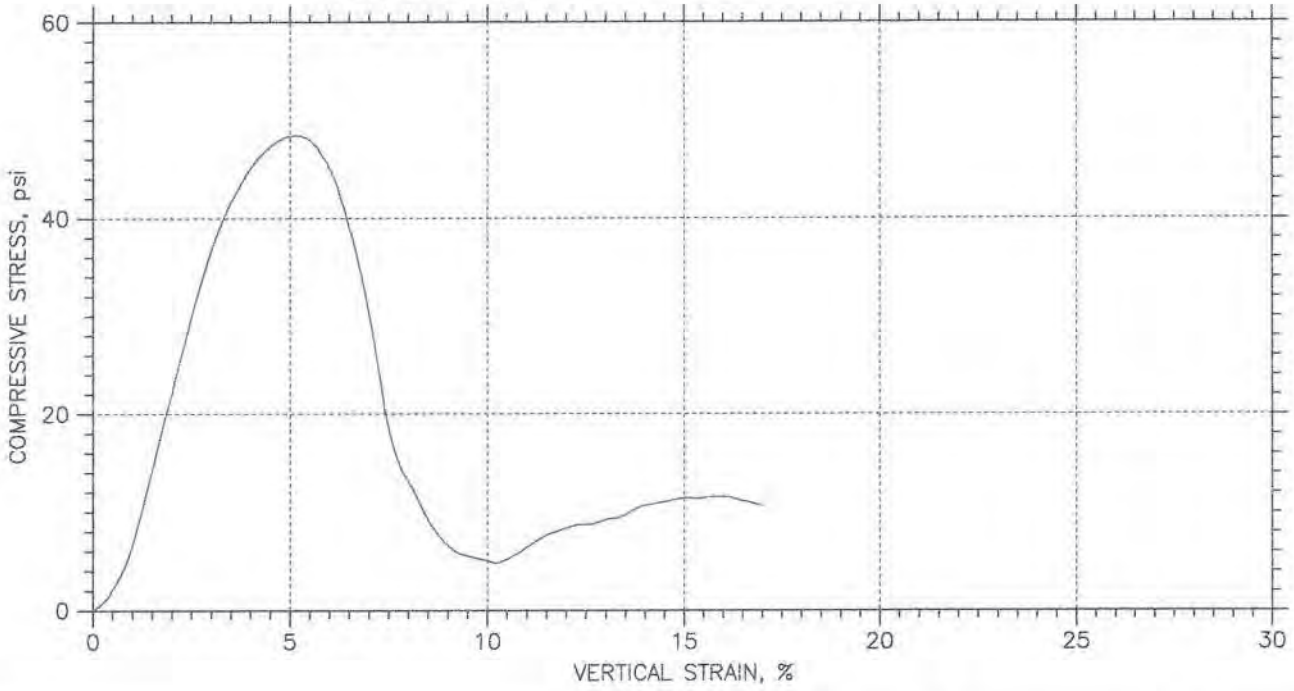
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 12	Tested By: DT	Checked By: SS
Sample No.: SS-477-13	Test Date: 10/9/2013	Depth: 22.0 - 24.0
Test No.: UC-47-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24" Top 3" disturbed, Brn silty clay w/ taces of coal and		
Remarks: pockets of Brn silt. Bottom 10" of tube changes to Gry silty clay.		

FIG. B-47
Sheet 2 of 2

Thu, 10-OCT-2013 07:32:06

55-911-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-48-13			
Initial	Diameter, in	2.841			
	Height, in	5.566			
	Water Content, %	24.05			
	Dry Density, pcf	98.38			
	Saturation, %	93.50			
	Void Ratio	0.682			
Unconfined Compressive Strength, psi		48.4			
Undrained Shear Strength, psi		24.2			
Time to Failure, min		5.0033			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 12

Sample Type: Undisturbed

Description: Total length 24", Top 3" disturbed, Brn silty clay w/ taces of coal and

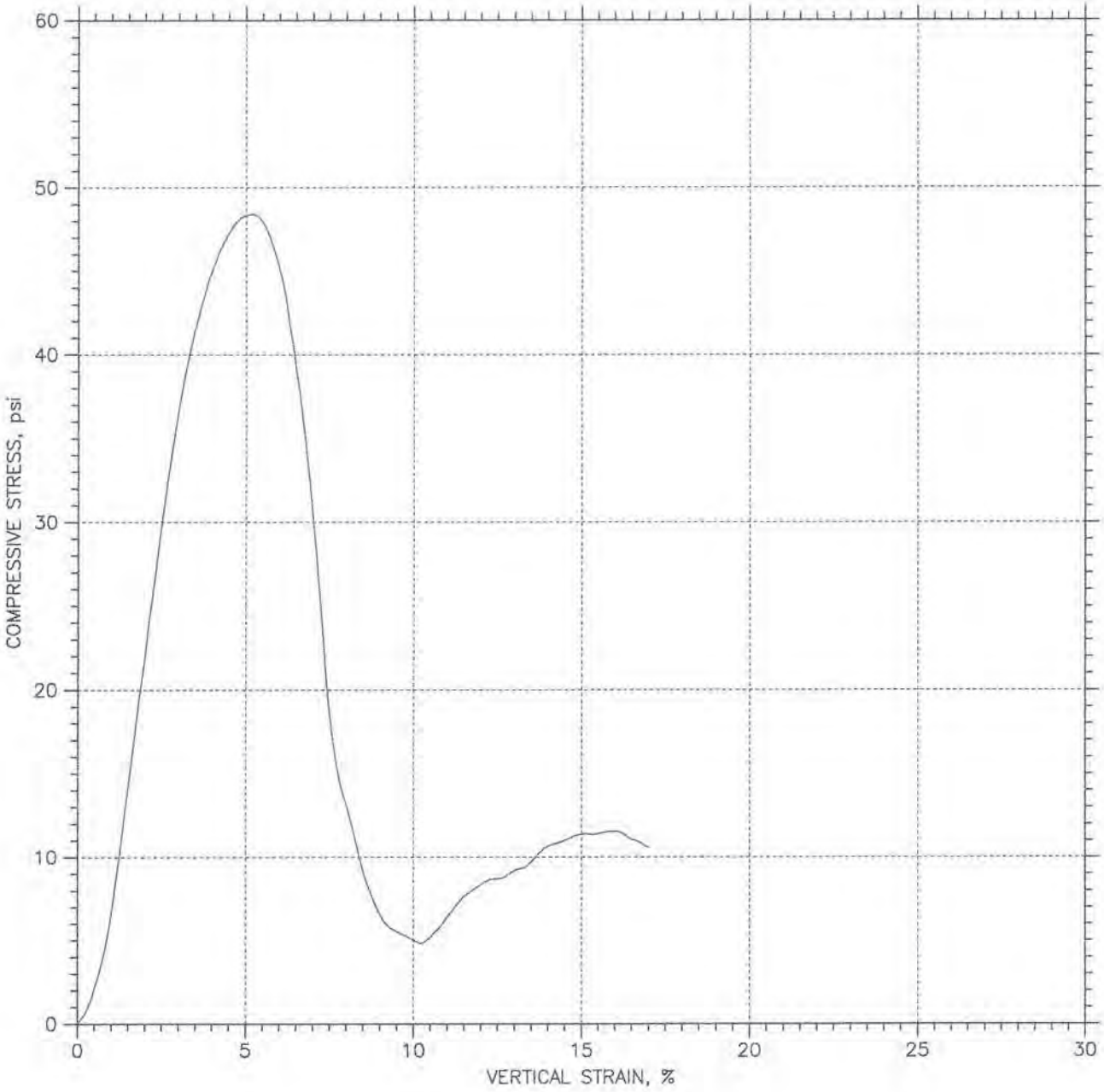
Remarks: pockets of Brn silt. Bottom 10" changes to Gry silty clay.

FIG. B-48

Thu, 10-OCT-2013 07:35:17

SS-477-13

UNCONFINED COMPRESSION TEST REPORT



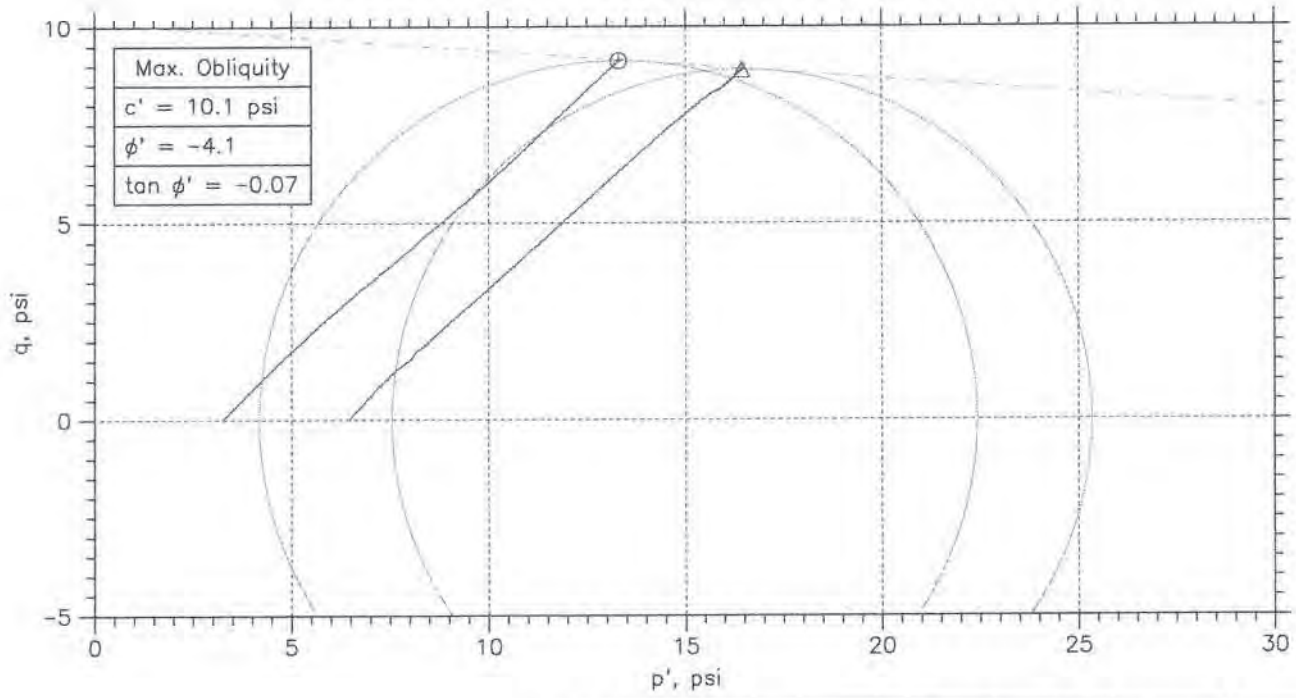
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 12	Tested By: DT	Checked By: SS
Sample No.: SS-477-13	Test Date: 10/9/2013	Depth: 22.0 - 24.0
Test No.: UC-48-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24", Top 3" disturbed, Brn silty clay w/ taces of coal and		
Remarks: pockets of Brn silt. Bottom 10" changes to Gry silty clay.		

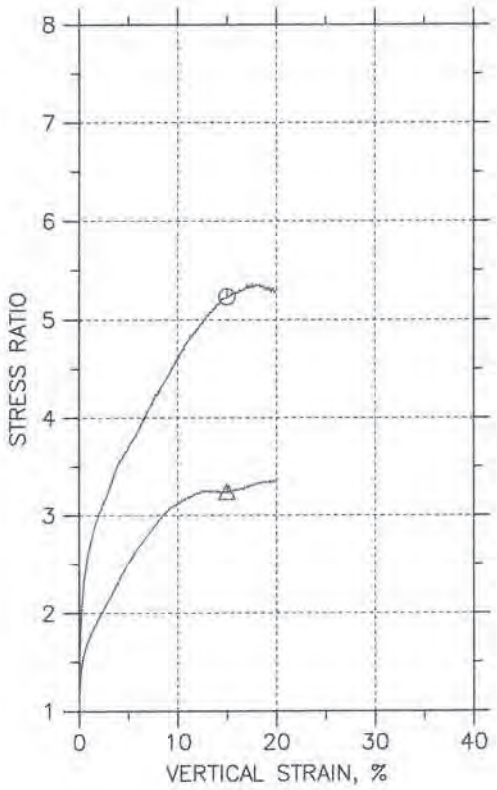
FIG. B-48

Thu, 10-OCT-2013 07:35:17

SS-469-15

Test File





		Symbol	⏲	△		
		Sample No.	SS-469-13	SS-469-13		
		Test No.	UU-77-13	UU-78-13		
		Depth	6.0-8.0	6.0-8.0		
Initial		Diameter, in	2.774	2.791		
		Height, in	5.541	5.56		
		Water Content, %	22.3	25.7		
		Dry Density, pcf	102.4	98.03		
		Saturation, %	96.2	98.9		
		Void Ratio	0.615	0.688		
Before Shear		Water Content, %	22.3	25.7		
		Dry Density, pcf	102.4	98.03		
		Saturation*, %	96.2	98.9		
		Void Ratio	0.615	0.688		
		Back Press., psi	-.008095	.0		
Ver. Eff. Cons. Stress, psi			3.245	6.461		
Shear Strength, psi			8.784	8.401		
Strain at Failure, %			15	15		
Strain Rate, %/min			1	1		
B-Value			---	---		
Estimated Specific Gravity			2.65	2.65		
Liquid Limit			---	---		
Plastic Limit			---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031

Location:

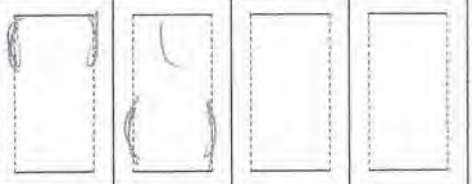
Project No.:

Boring No.: B12

Sample Type:

Description: Total length 16.5" Gry silty clay with layers of silty clay loam

Remarks:



Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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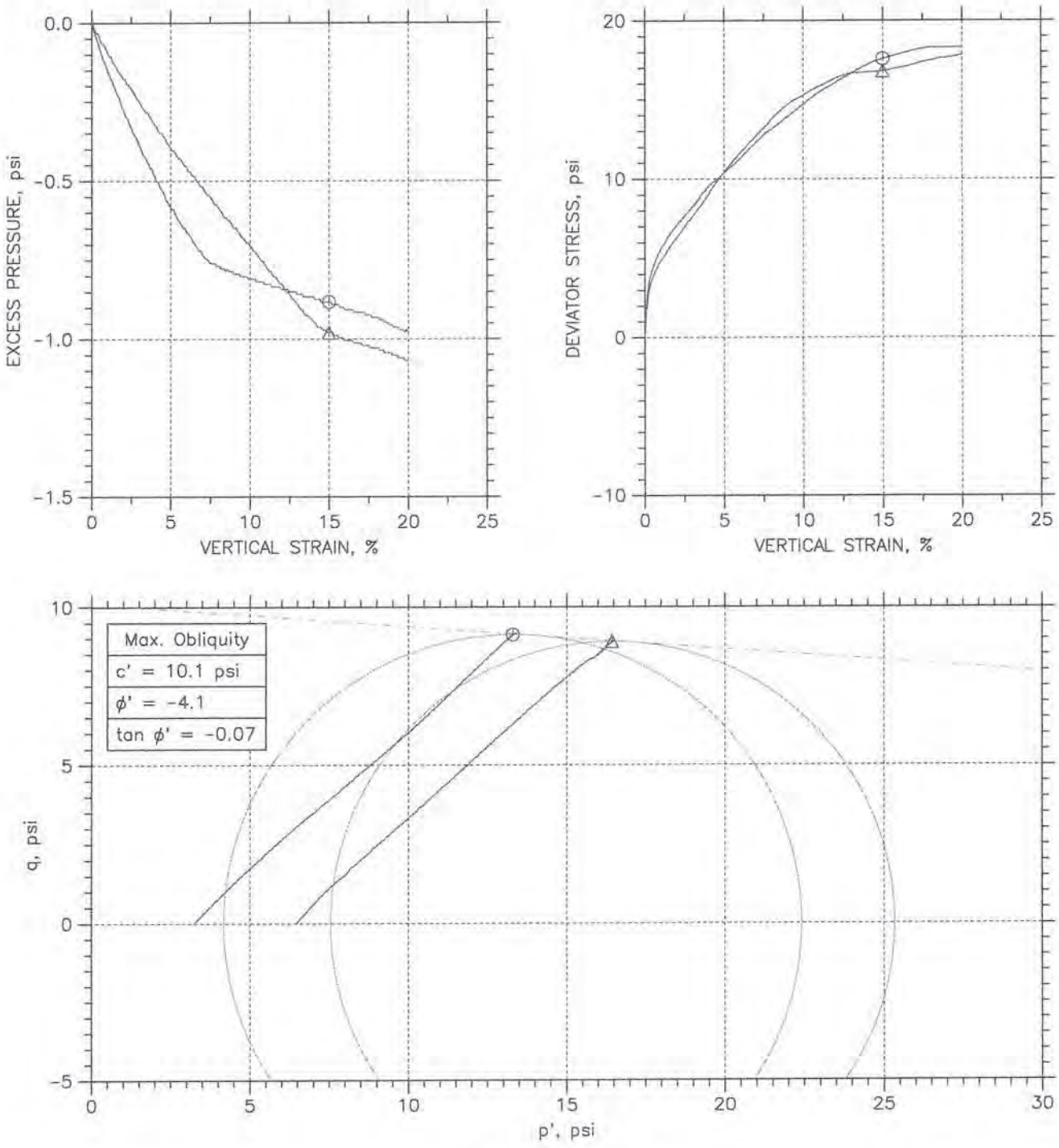
FIG. B-49

Test File



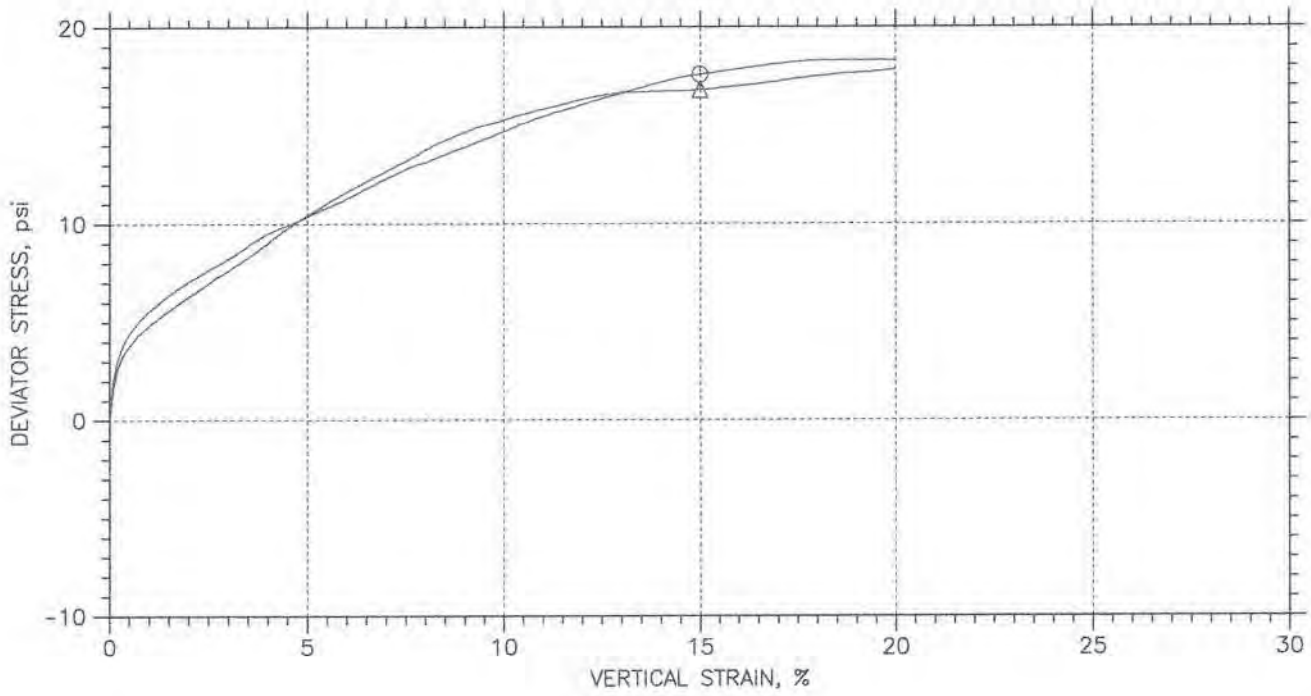
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊕	SS-469-13	UU-77-13	6.0-8.0	DT	10/8/13	SS		UU-77-2013.dat
△	SS-469-13	UU-78-13	6.0-8.0	DT	10/8/13	SS		UU-78-2013.dat

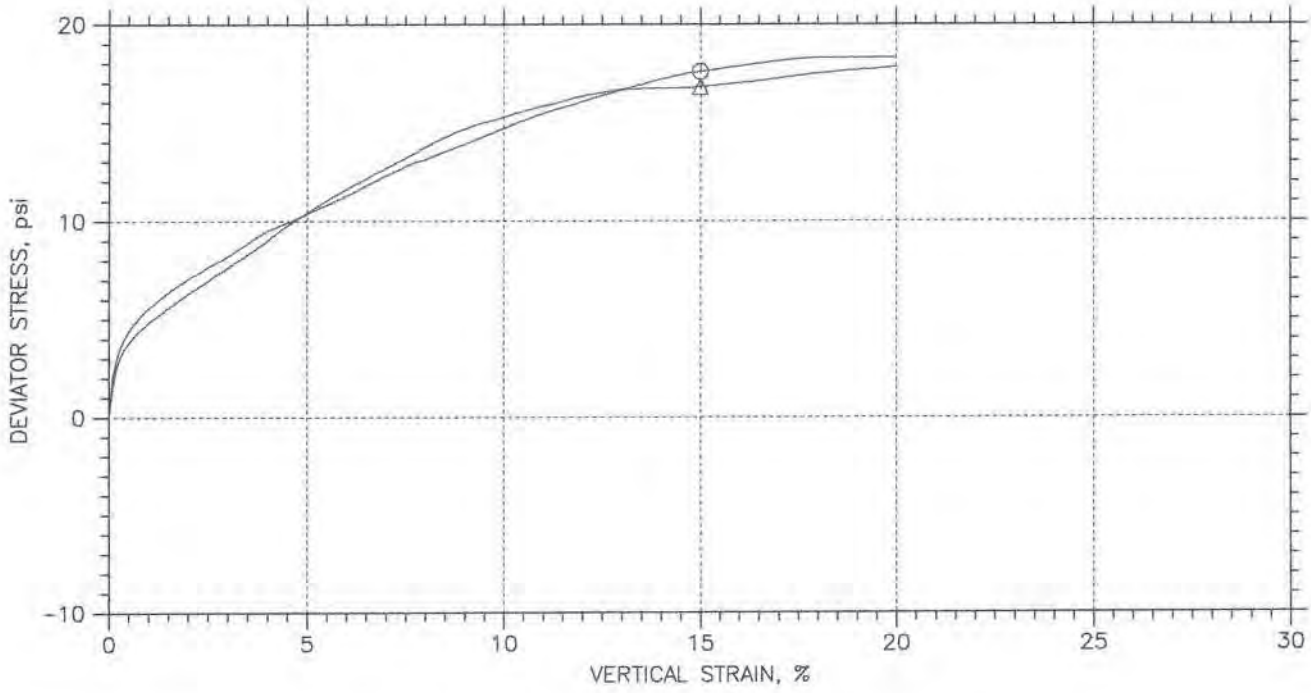
NDDOT
North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 16.5" Gry silty clay with layers of silty clay loam		
Remarks:		

FIG. B-49
Sheet 2 of 5

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-469-13	UU-77-13	6.0-8.0	DT	10/8/13	SS		UU-77-2013.dat
△	SS-469-13	UU-78-13	6.0-8.0	DT	10/8/13	SS		UU-78-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 16.5" Gry silty clay with layers of silty clay loam		
Remarks:		

FIG. B-49
Sheet 3 of 5

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TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B12
Sample No.: SS-469-13
Test No.: UU-77-13

Location:
Tested By: DT
Test Date: 10/8/13
Sample Type:

Project No.:
Checked By: SS
Depth: 6.0-8.0
Elevation:

Soil Description: Total length 16.5" Gry silty clay with layers of silty clay loam
Remarks:

Specimen Height: 5.54 in
Specimen Area: 6.04 in^2
Specimen Volume: 548.77 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s23	---		
Wt. Container + Wet Soil, gm	59.39	---	---	0
Wt. Container + Dry Soil, gm	51.67	---	---	0
Wt. Container, gm	17.08	---	---	0
Wt. Wet Soil, gm	42.31	1101.5	900.54	0
Wt. Dry Soil, gm	34.59	900.54	900.54	0
Wt. Water, gm	7.72	200.99	0	0
Water Content, %	22.32	22.32	0.00	0.00
Void Ratio	---	0.61	0.62	---
Degree of Saturation, %	---	96.19	0.00	---
Dry Unit Weight, pcf	---	102.45	102.42	---

Initial

Height: 5.541 in
Area: 6.0437 in^2
Volume: 548.77 cc

Moisture: 22.32 %
Void Ratio: 0.61
Dry Unit Weight: 102.45 pcf
Saturation: 96.19 %

End of Initialization
Time: 3.0853 min
Total Vertical Stress: 3.2364 psi
Total Horizontal Stress: 3.2453 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 3.2445 psi
Effective Horizontal Stress: 3.2534 psi

Height Change: -0.00036978 in
Area Change: 0 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 0 cc

Height: 5.5414 in
Area: 6.0437 in^2
Volume: 548.88 cc

Moisture: 22.32 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 96.15 %

End of Consolidation/A
Time: 3.0853 min
Total Vertical Stress: 3.2364 psi
Total Horizontal Stress: 3.2453 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 3.2445 psi
Effective Horizontal Stress: 3.2534 psi

Height Change: -0.00036978 in
Area Change: 0 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 0 cc

Height: 5.5414 in
Area: 6.0437 in^2
Volume: 548.88 cc

Moisture: 22.32 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 96.15 %

End of Saturation
Time: 3.0853 min
Total Vertical Stress: 3.2364 psi
Total Horizontal Stress: 3.2453 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 3.2445 psi
Effective Horizontal Stress: 3.2534 psi

Height Change: -0.00036978 in
Area Change: 0 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 0 cc

Height: 5.5414 in
Area: 6.0437 in^2
Volume: 548.88 cc

Moisture: 22.32 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 96.15 %

End of Consolidation/B
Time: 3.0853 min
Total Vertical Stress: 3.2364 psi
Total Horizontal Stress: 3.2453 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 3.2445 psi
Effective Horizontal Stress: 3.2534 psi

Height Change: -0.00036978 in
Area Change: 0 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 0 cc

Height: 5.5414 in
Area: 6.0437 in^2
Volume: 548.88 cc

Moisture: 22.32 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 96.15 %

End of Shear
Time: 23.344 min
Total Vertical Stress: 21.562 psi
Total Horizontal Stress: 3.2695 psi
Pore Pressure: -0.98754 psi
Effective Vertical Stress: 22.55 psi
Effective Horizontal Stress: 4.257 psi

Height Change: 1.1079 in
Area Change: -1.512 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 201.01 cc

Height: 4.4331 in
Area: 7.5557 in^2
Volume: 548.88 cc

Moisture: 0.00 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 0.00 %

At Failure
Time: 18.291 min
Total Vertical Stress: 20.83 psi
Total Horizontal Stress: 3.2614 psi
Pore Pressure: -0.89041 psi
Effective Vertical Stress: 21.721 psi
Effective Horizontal Stress: 4.1518 psi

Height Change: 0.83084 in
Area Change: -1.0663 in^2
Volume Change: -0.10987 cc
Water Change: -0.020379 cc
Correction: 0 cc

Height: 4.7102 in
Area: 7.11 in^2
Volume: 548.88 cc

Moisture: 22.32 %
Void Ratio: 0.62
Dry Unit Weight: 102.42 pcf
Saturation: 96.15 %

FIG. B-49
Sheet 4 of 5

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B12
Sample No.: SS-469-13
Test No.: UU-78-13

Location:
Tested By: DT
Test Date: 10/8/13
Sample Type:

Project No.:
Checked By: SS
Depth: 6.0-8.0
Elevation:

Soil Description: Total length 16.5" Gry silty clay with layers of silty clay loam
Remarks:

Specimen Height: 5.56 in
Specimen Area: 6.12 in^2
Specimen Volume: 557.42 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s3	---		
Wt. Container + Wet Soil, gm	56.64	---	---	0
Wt. Container + Dry Soil, gm	48.63	---	---	0
Wt. Container, gm	17.41	---	---	0
Wt. Wet Soil, gm	39.23	1099.9	875.28	0
Wt. Dry Soil, gm	31.22	875.28	875.28	0
Wt. Water, gm	8.01	224.57	0	0
Water Content, %	25.66	25.66	0.00	0.00
Void Ratio	---	0.69	0.69	---
Degree of Saturation, %	---	98.87	0.00	---
Dry Unit Weight, pcf	---	98.026	98.031	---

Initial

Height: 5.56 in
Area: 6.118 in^2
Volume: 557.42 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.026 pcf
Saturation: 98.87 %

End of Initialization
Time: 6.4975 min
Total Vertical Stress: 6.4612 psi
Total Horizontal Stress: 6.4663 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.4612 psi
Effective Horizontal Stress: 6.4663 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 0 cc

Height: 5.5599 in
Area: 6.118 in^2
Volume: 557.4 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 98.90 %

End of Consolidation/A
Time: 6.4975 min
Total Vertical Stress: 6.4612 psi
Total Horizontal Stress: 6.4663 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.4612 psi
Effective Horizontal Stress: 6.4663 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 0 cc

Height: 5.5599 in
Area: 6.118 in^2
Volume: 557.4 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 98.90 %

End of Saturation
Time: 6.4975 min
Total Vertical Stress: 6.4612 psi
Total Horizontal Stress: 6.4663 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.4612 psi
Effective Horizontal Stress: 6.4663 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 0 cc

Height: 5.5599 in
Area: 6.118 in^2
Volume: 557.4 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 98.90 %

End of Consolidation/B
Time: 6.4975 min
Total Vertical Stress: 6.4612 psi
Total Horizontal Stress: 6.4663 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.4612 psi
Effective Horizontal Stress: 6.4663 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 0 cc

Height: 5.5599 in
Area: 6.118 in^2
Volume: 557.4 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 98.90 %

End of Shear
Time: 26.716 min
Total Vertical Stress: 24.326 psi
Total Horizontal Stress: 6.4986 psi
Pore Pressure: -1.0685 psi
Effective Vertical Stress: 25.395 psi
Effective Horizontal Stress: 7.5671 psi

Height Change: 1.1123 in
Area Change: -1.5296 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 224.6 cc

Height: 4.4477 in
Area: 7.6476 in^2
Volume: 557.4 cc

Moisture: 0.00 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 0.00 %

At Failure
Time: 21.69 min
Total Vertical Stress: 23.318 psi
Total Horizontal Stress: 6.516 psi
Pore Pressure: -0.97945 psi
Effective Vertical Stress: 24.298 psi
Effective Horizontal Stress: 7.4955 psi

Height Change: 0.83408 in
Area Change: -1.0802 in^2
Volume Change: 0.027804 cc
Water Change: -0.034323 cc
Correction: 0 cc

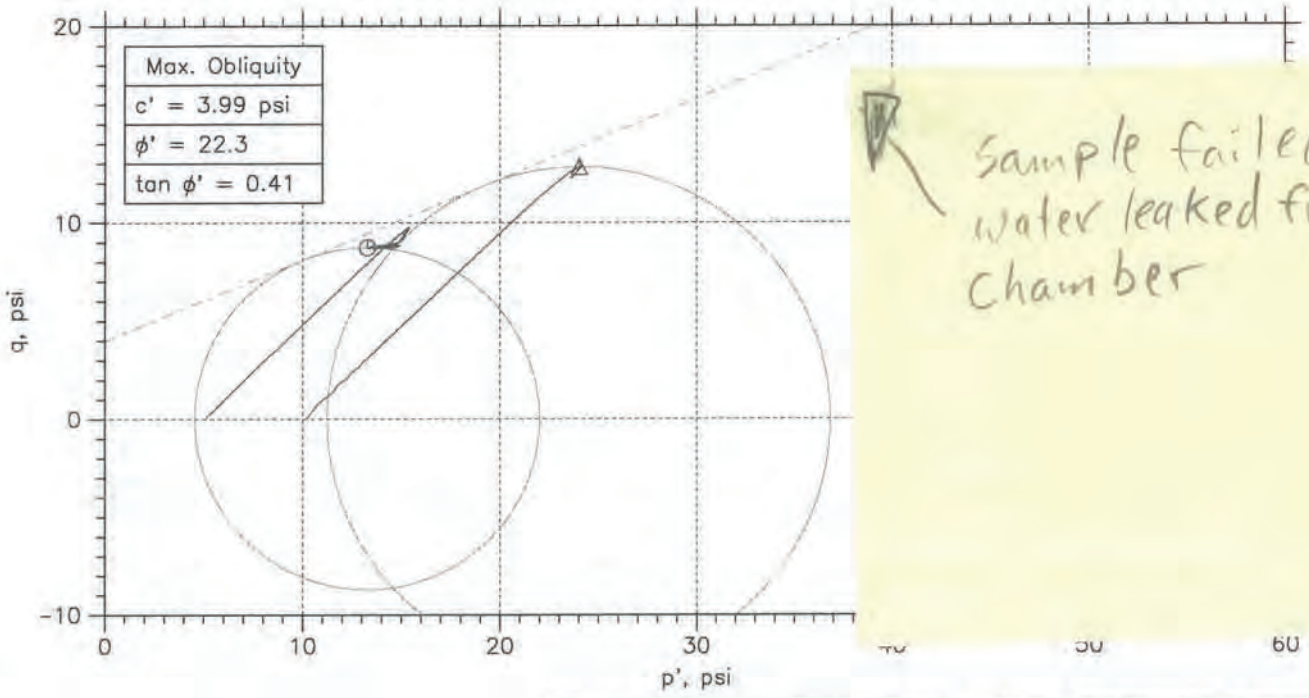
Height: 4.7259 in
Area: 7.1982 in^2
Volume: 557.4 cc

Moisture: 25.66 %
Void Ratio: 0.69
Dry Unit Weight: 98.031 pcf
Saturation: 98.90 %

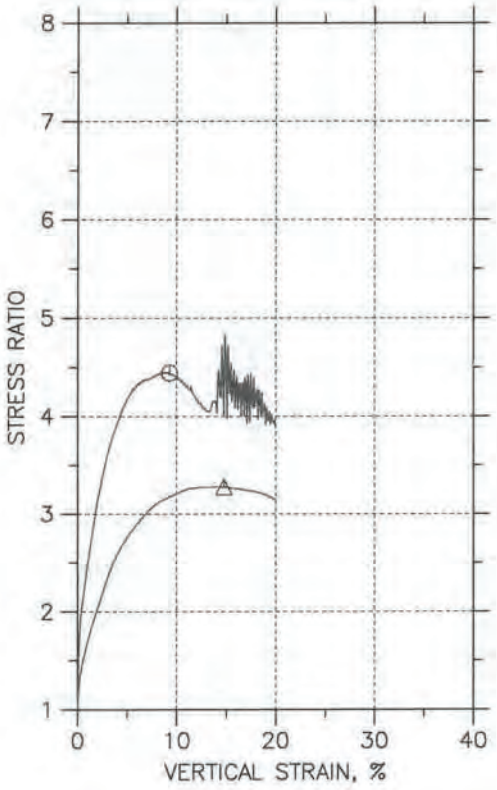
FIG. B-49
Sheet 5 of 5

SS-471-13

Test File



Sample failed, water leaked from chamber



Symbol		⊙	△		
Sample No.		SS-471-13	SS-471-13		
Test No.		UU-79-13	UU-80-13		
Depth		10.0-12.0	10.0-12.0		
Initial	Diameter, in	2.823	2.843		
	Height, in	5.55	5.543		
	Water Content, %	21.2	20.8		
	Dry Density, pcf	107.4	107.9		
	Saturation, %	104.2	103.5		
	Void Ratio	0.54	0.533		
Before Shear	Water Content, %	20.4	20.0		
	Dry Density, pcf	107.3	108.2		
	Saturation*, %	100.0	100.0		
	Void Ratio	0.541	0.529		
	Back Press., psi	-.008095	.0		
Ver. Eff. Cons. Stress, psi		5.096	10.17		
Shear Strength, psi		9.737	12.85		
Strain at Failure, %		9.3	14.8		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B12

Sample Type:

Description: Total length 23" Top 8" disturbed material, uu ran on gry silty clay.

Remarks:

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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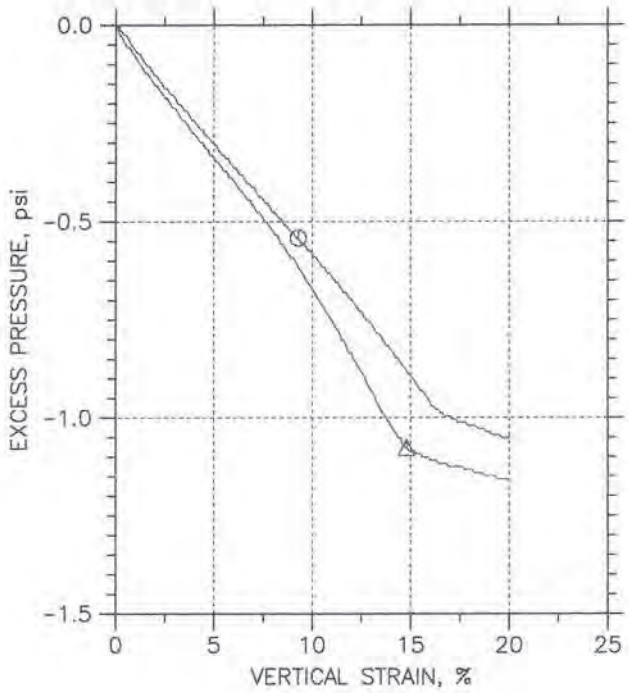
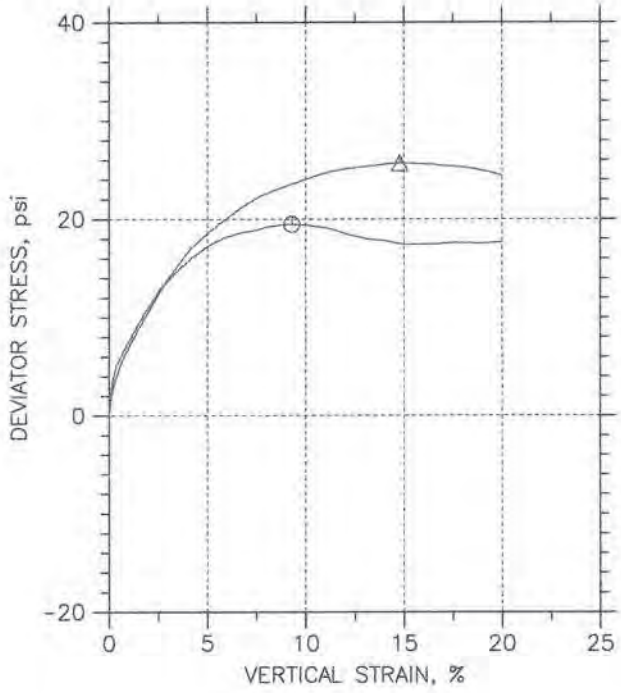
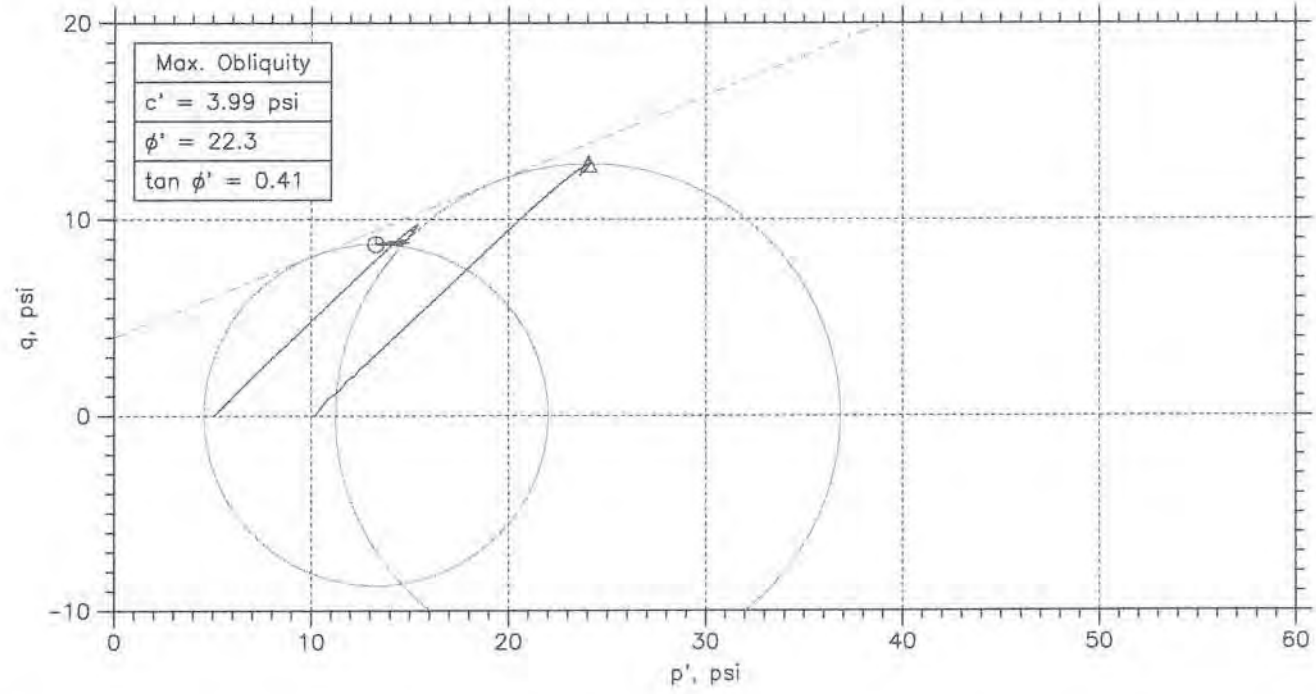
FIG. B-50

SS-471-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-471-13	UU-79-13	10.0-12.0	DT	10/8/13	SS		UU-79-2013.dat
△	SS-471-13	UU-80-13	10.0-12.0	DT	10/8/13	SS		UU-80-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 23" Top 8" disturbed material, uu ran on gry silty clay.		
Remarks:		

FIG. B-50

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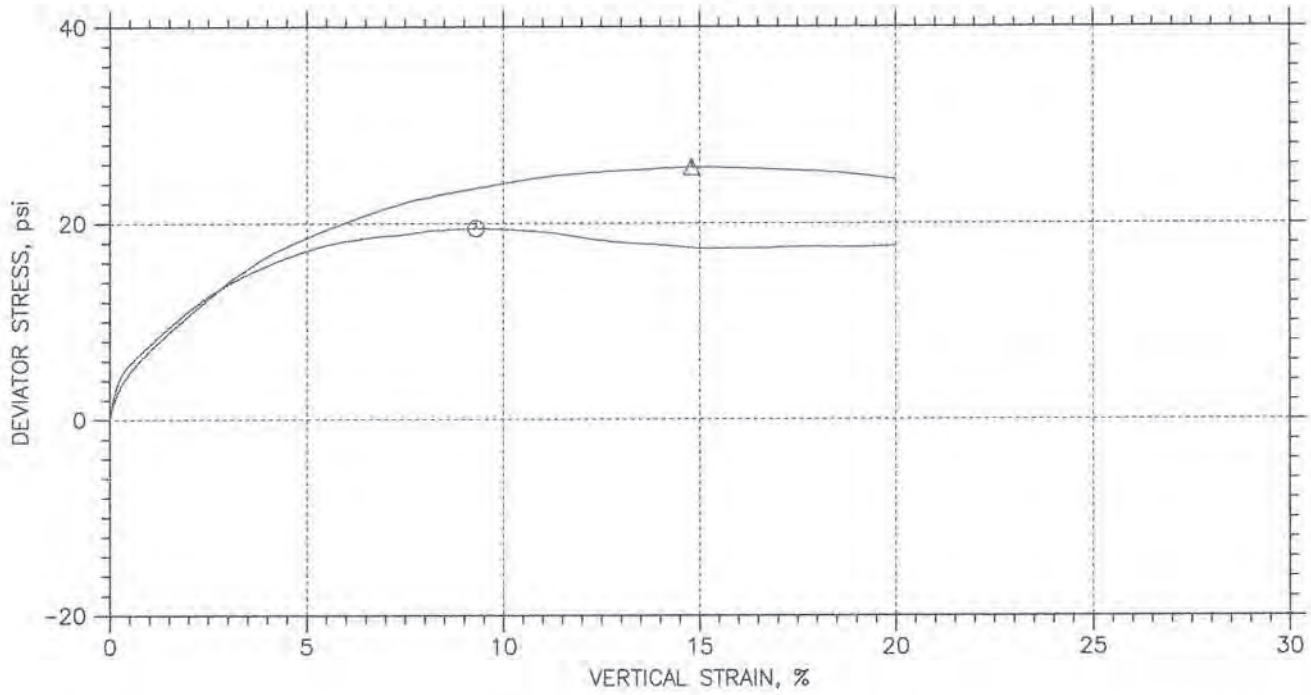
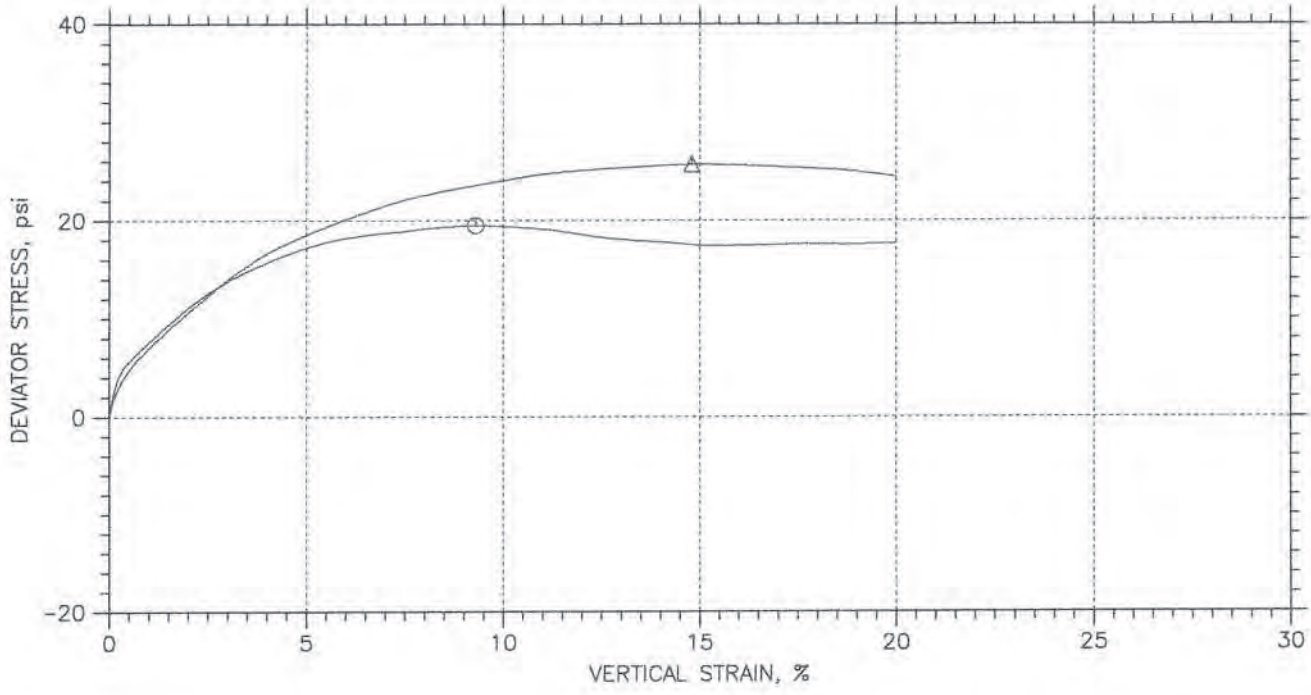
SS-471-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⏲	SS-471-13	UU-79-13	10.0-12.0	DT	10/8/13	SS		UU-79-2013.dat
△	SS-471-13	UU-80-13	10.0-12.0	DT	10/8/13	SS		UU-80-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 23" Top 8" disturbed material, uu ran on gry silty clay.		
Remarks:		

FIG. B-50
Sheet 3 of 5

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SS-471-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B12
Sample No.: SS-471-13
Test No.: UU-79-13

Location:
Tested By: DT
Test Date: 10/8/13
Sample Type:

Project No.:
Checked By: SS
Depth: 10.0-12.0
Elevation:

Soil Description: Total length 23" Top 8" disturbed material, uu tan on gry silty clay.
Remarks:

Specimen Height: 5.55 in
Specimen Area: 6.26 in^2
Specimen Volume: 569.25 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s54	---		
Wt. Container + Wet Soil, gm	46.98	---	---	0
Wt. Container + Dry Soil, gm	41.73	---	---	0
Wt. Container, gm	17.02	---	---	0
Wt. Wet Soil, gm	29.96	1187.5	979.41	0
Wt. Dry Soil, gm	24.71	979.41	979.41	0
Wt. Water, gm	5.25	208.09	0	0
Water Content, %	21.25	21.25	0.00	0.00
Void Ratio	---	0.54	0.54	---
Degree of Saturation, %	---	104.22	0.00	---
Dry Unit Weight, pcf	---	107.41	107.35	---

Initial

Height: 5.55 in
Area: 6.2591 in^2
Volume: 569.25 cc

Moisture: 21.25 %
Void Ratio: 0.54
Dry Unit Weight: 107.41 pcf
Saturation: 104.22 %

End of Initialization
Time: 8.7692 min
Total Vertical Stress: 5.0882 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 5.0963 psi
Effective Horizontal Stress: 5.1021 psi

Height Change: -0.0010169 in
Area Change: 0 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 8.146 cc

Height: 5.551 in
Area: 6.2591 in^2
Volume: 569.57 cc

Moisture: 20.42 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 8.7692 min
Total Vertical Stress: 5.0882 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 5.0963 psi
Effective Horizontal Stress: 5.1021 psi

Height Change: -0.0010169 in
Area Change: 0 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 8.146 cc

Height: 5.551 in
Area: 6.2591 in^2
Volume: 569.57 cc

Moisture: 20.42 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 100.00 %

End of Saturation
Time: 8.7692 min
Total Vertical Stress: 5.0882 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 5.0963 psi
Effective Horizontal Stress: 5.1021 psi

Height Change: -0.0010169 in
Area Change: 0 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 8.146 cc

Height: 5.551 in
Area: 6.2591 in^2
Volume: 569.57 cc

Moisture: 20.42 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 8.7692 min
Total Vertical Stress: 5.0882 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: -0.0080946 psi
Effective Vertical Stress: 5.0963 psi
Effective Horizontal Stress: 5.1021 psi

Height Change: -0.0010169 in
Area Change: 0 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 8.146 cc

Height: 5.551 in
Area: 6.2591 in^2
Volume: 569.57 cc

Moisture: 20.42 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 100.00 %

End of Shear
Time: 29.014 min
Total Vertical Stress: 22.718 psi
Total Horizontal Stress: 5.0617 psi
Pore Pressure: -1.0604 psi
Effective Vertical Stress: 23.778 psi
Effective Horizontal Stress: 6.1221 psi

Height Change: 1.1092 in
Area Change: -1.5677 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 208.12 cc

Height: 4.4408 in
Area: 7.8268 in^2
Volume: 569.57 cc

Moisture: 0.00 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 0.00 %

At Failure
Time: 18.22 min
Total Vertical Stress: 24.584 psi
Total Horizontal Stress: 5.1101 psi
Pore Pressure: -0.55043 psi
Effective Vertical Stress: 25.134 psi
Effective Horizontal Stress: 5.6605 psi

Height Change: 0.51633 in
Area Change: -0.64107 in^2
Volume Change: -0.3129 cc
Water Change: -0.033787 cc
Correction: 0 cc

Height: 5.0347 in
Area: 6.9002 in^2
Volume: 569.57 cc

Moisture: 20.42 %
Void Ratio: 0.54
Dry Unit Weight: 107.35 pcf
Saturation: 100.00 %

FIG. B-50
Sheet 4 of 5

SS-471-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B12
Sample No.: SS-471-13
Test No.: UU-80-13

Location:
Tested By: DT
Test Date: 10/8/13
Sample Type:

Project No.:
Checked By: SS
Depth: 10.0-12.0
Elevation:

Soil Description: Total length 23" Top 8" disturbed material, uu ran on gry silty clay.
Remarks:

Specimen Height: 5.54 in
Specimen Area: 6.35 in^2
Specimen Volume: 576.62 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s27	---		
Wt. Container + Wet Soil, gm	55.61	---	---	0
Wt. Container + Dry Soil, gm	48.95	---	---	0
Wt. Container, gm	16.96	---	---	0
Wt. Wet Soil, gm	38.65	1204.1	996.65	0
Wt. Dry Soil, gm	31.99	996.65	996.65	0
Wt. Water, gm	6.66	207.49	-1.1642e-013	0
Water Content, %	20.82	20.82	-0.00	0.00
Void Ratio	---	0.53	0.53	---
Degree of Saturation, %	---	103.47	-0.00	---
Dry Unit Weight, pcf	---	107.9	108.2	---

Initial

Height: 5.543 in
Area: 6.3481 in^2
Volume: 576.62 cc

Moisture: 20.82 %
Void Ratio: 0.53
Dry Unit Weight: 107.9 pcf
Saturation: 103.47 %

End of Initialization
Time: 11.019 min
Total Vertical Stress: 10.165 psi
Total Horizontal Stress: 10.172 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.165 psi
Effective Horizontal Stress: 10.172 psi

Height Change: 0.0051307 in
Area Change: 0 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 8.6136 cc

Height: 5.5379 in
Area: 6.3481 in^2
Volume: 575.02 cc

Moisture: 19.96 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 11.019 min
Total Vertical Stress: 10.165 psi
Total Horizontal Stress: 10.172 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.165 psi
Effective Horizontal Stress: 10.172 psi

Height Change: 0.0051307 in
Area Change: 0 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 8.6136 cc

Height: 5.5379 in
Area: 6.3481 in^2
Volume: 575.02 cc

Moisture: 19.96 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: 100.00 %

End of Saturation
Time: 11.019 min
Total Vertical Stress: 10.165 psi
Total Horizontal Stress: 10.172 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.165 psi
Effective Horizontal Stress: 10.172 psi

Height Change: 0.0051307 in
Area Change: 0 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 8.6136 cc

Height: 5.5379 in
Area: 6.3481 in^2
Volume: 575.02 cc

Moisture: 19.96 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 11.019 min
Total Vertical Stress: 10.165 psi
Total Horizontal Stress: 10.172 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.165 psi
Effective Horizontal Stress: 10.172 psi

Height Change: 0.0051307 in
Area Change: 0 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 8.6136 cc

Height: 5.5379 in
Area: 6.3481 in^2
Volume: 575.02 cc

Moisture: 19.96 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: 100.00 %

End of Shear
Time: 31.291 min
Total Vertical Stress: 34.704 psi
Total Horizontal Stress: 10.228 psi
Pore Pressure: -1.1575 psi
Effective Vertical Stress: 35.861 psi
Effective Horizontal Stress: 11.386 psi

Height Change: 1.1128 in
Area Change: -1.5726 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 207.54 cc

Height: 4.4302 in
Area: 7.9207 in^2
Volume: 575.02 cc

Moisture: -0.00 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: -0.00 %

At Failure
Time: 26.031 min
Total Vertical Stress: 35.907 psi
Total Horizontal Stress: 10.212 psi
Pore Pressure: -1.0766 psi
Effective Vertical Stress: 36.983 psi
Effective Horizontal Stress: 11.289 psi

Height Change: 0.82484 in
Area Change: -1.1104 in^2
Volume Change: 1.6012 cc
Water Change: -0.046658 cc
Correction: 0 cc

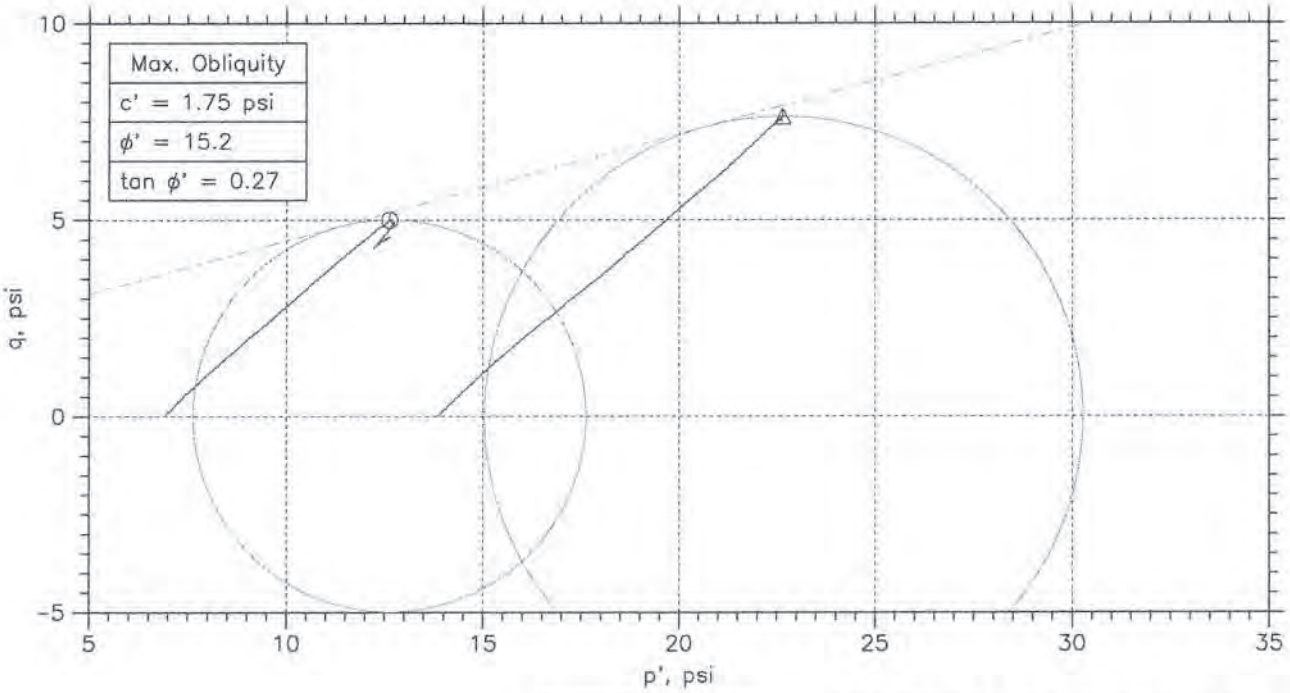
Height: 4.7182 in
Area: 7.4585 in^2
Volume: 575.02 cc

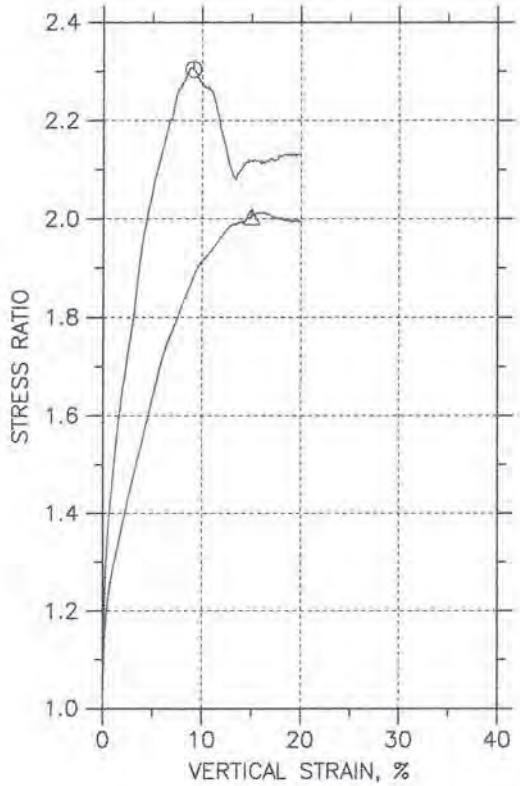
Moisture: 19.96 %
Void Ratio: 0.53
Dry Unit Weight: 108.2 pcf
Saturation: 100.00 %

FIG. B-50
Sheet 5 of 5

SS-473-13

Test File





Symbol		①	△		
Sample No.		SS-473-13	SS-473-13		
Test No.		UU-81-13	UU-82-13		
Depth		14.0-16.0	14.0-16.0		
Initial	Diameter, in	2.768	2.822		
	Height, in	5.531	5.594		
	Water Content, %	24.5	27.0		
	Dry Density, pcf	101.9	96.47		
	Saturation, %	104.1	100.1		
	Void Ratio	0.623	0.715		
Before Shear	Water Content, %	23.5	27.0		
	Dry Density, pcf	101.9	96.48		
	Saturation*, %	100.0	100.0		
	Void Ratio	0.623	0.715		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		6.922	13.84		
Shear Strength, psi		5.011	7.557		
Strain at Failure, %		9.1	15		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

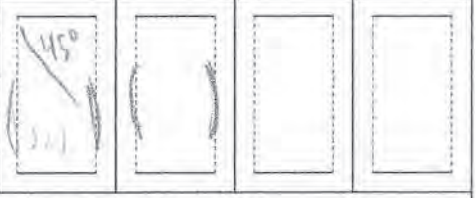
Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B12

Sample Type:



Description: Total length 20", 2" plus rock in sample, Lt. brn silty clay, w iron oxide,

Remarks: slicken sided clay.

Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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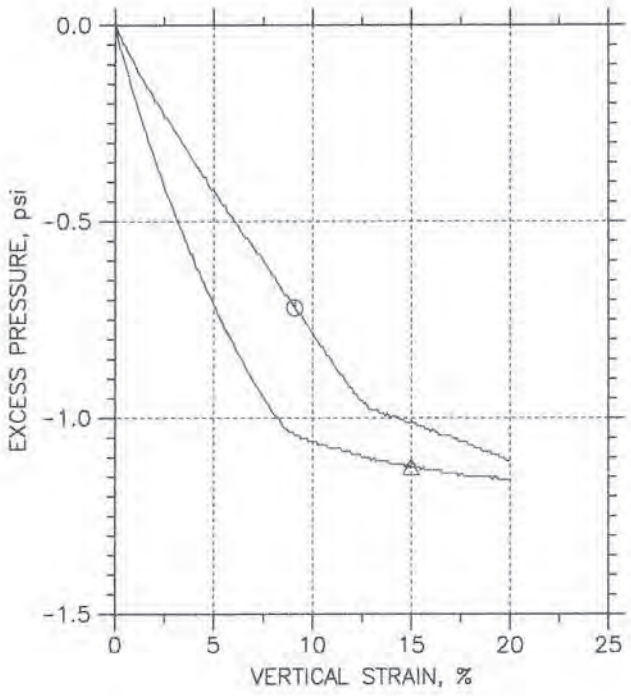
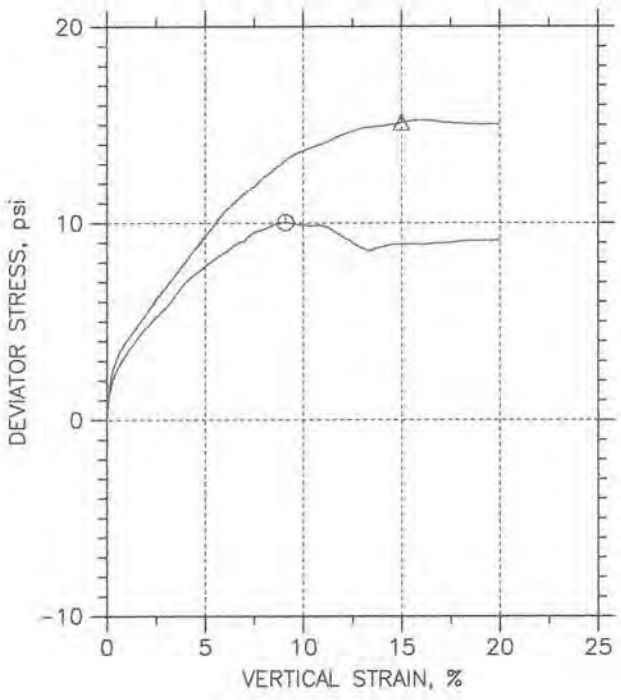
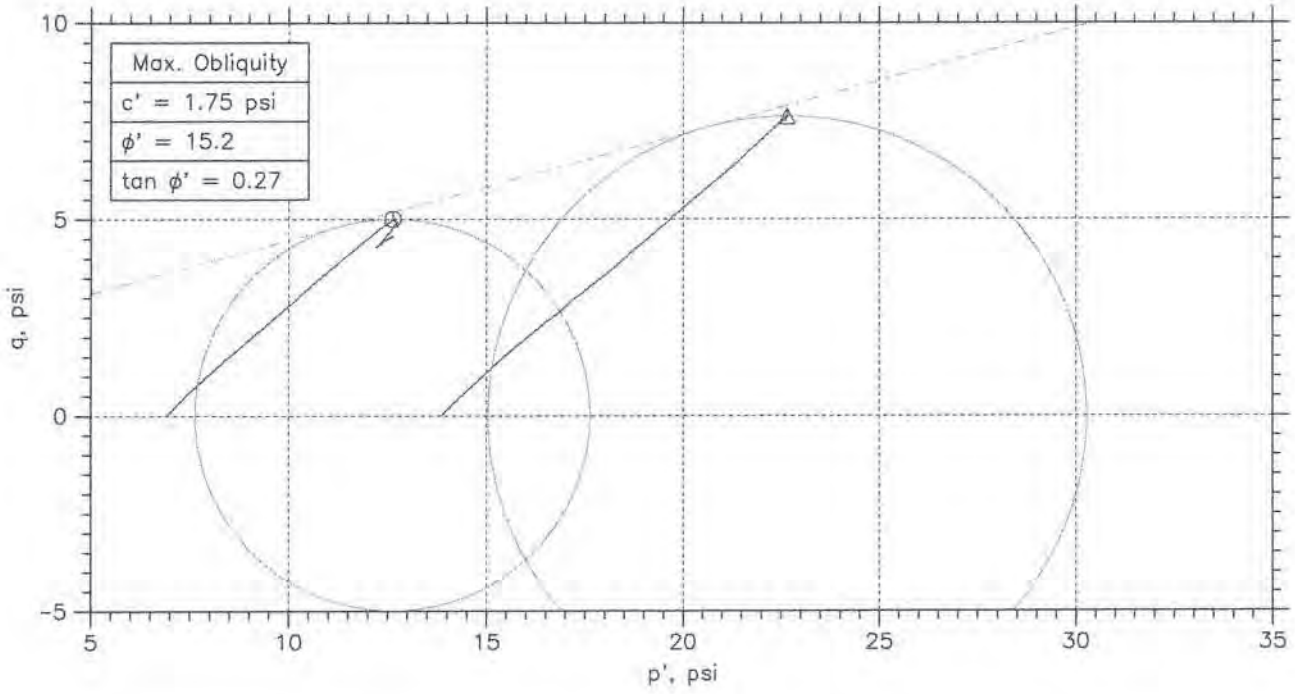
FIG. B-51

SS-473-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-473-13	UU-81-13	14.0-16.0	DT	10/9/13	SS		UU-81-2013.dat
△	SS-473-13	UU-82-13	14.0-16.0	DT	10/9/13	SS		UU-82-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 20", 2" plus rock in sample, Lt. brn silty clay, w iron oxide,		
Remarks: slicken sided clay.		

FIG. B-51

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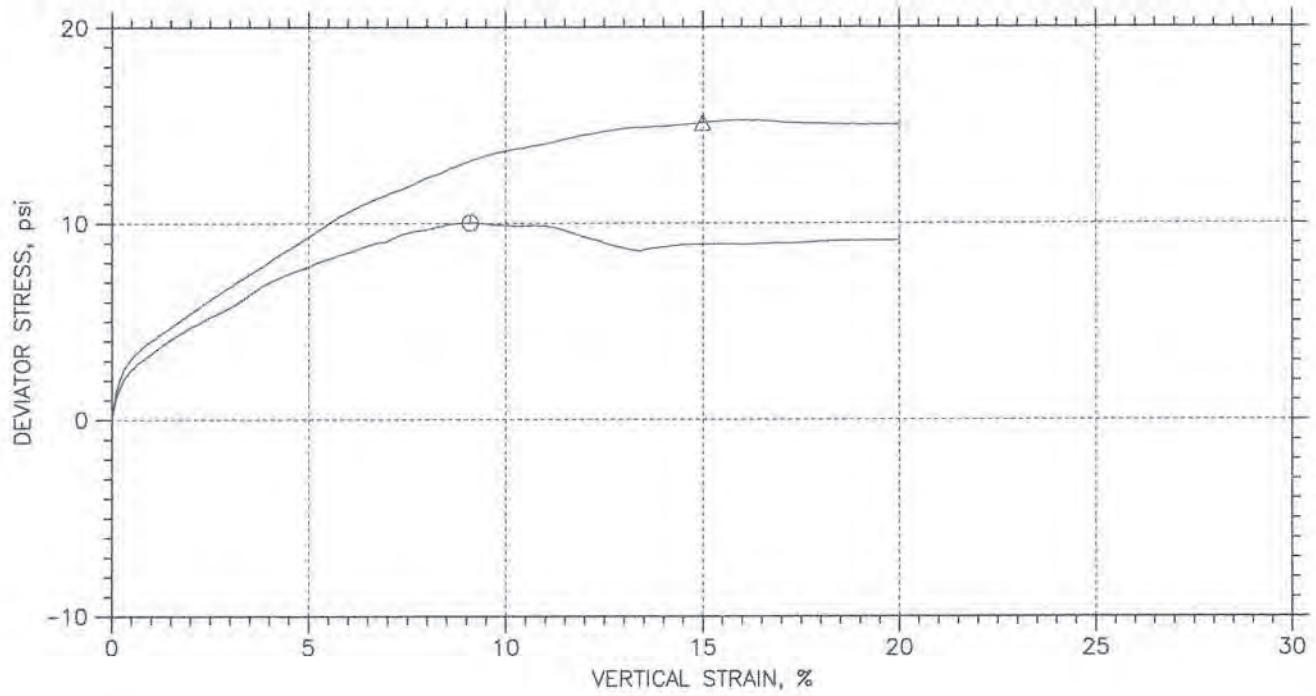
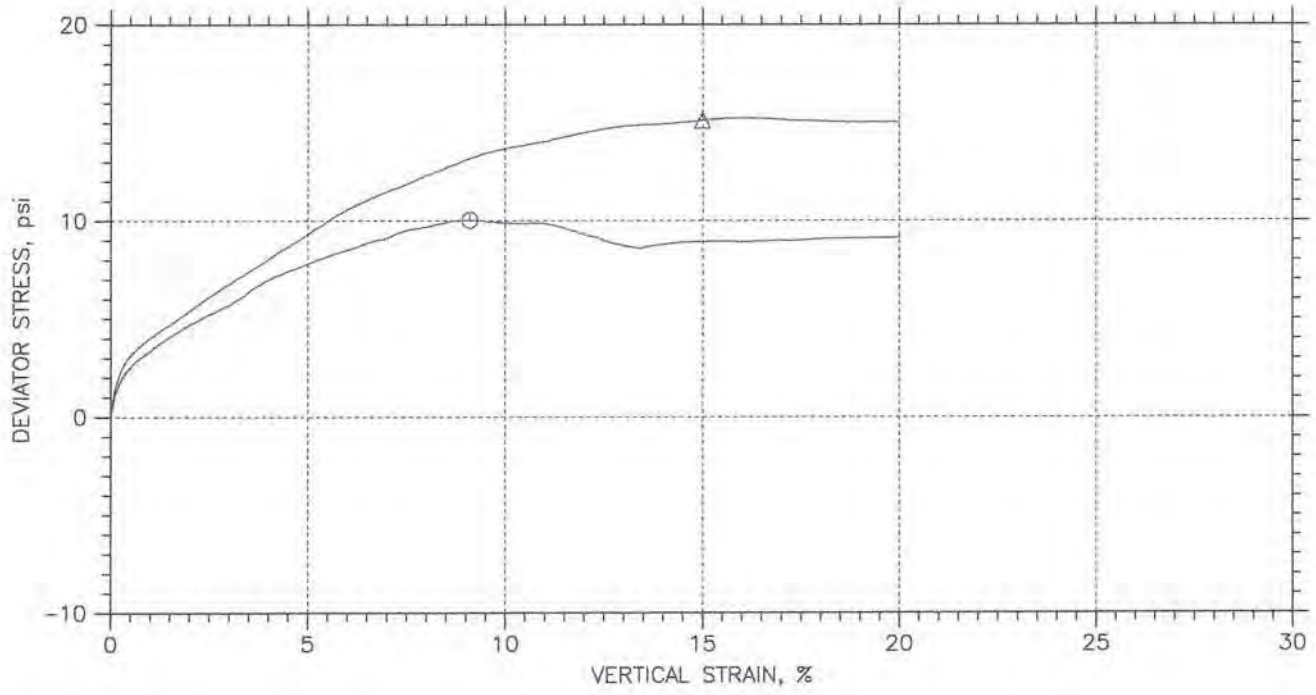
SS-473-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-473-13	UU-81-13	14.0-16.0	DT	10/9/13	SS		UU-81-2013.dat
△	SS-473-13	UU-82-13	14.0-16.0	DT	10/9/13	SS		UU-82-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B12	Sample Type:	
Description: Total length 20", 2" plus rock in sample, Lt. brn silty clay, w iron oxide,		
Remarks: slicken sided clay.		

FIG. B-51

hu, 10-OCT-2013 07:20:23

SS-473-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B12
Sample No.: SS-473-13
Test No.: UU-81-13

Location:
Tested By: DT
Test Date: 10/9/13
Sample Type:

Project No.:
Checked By: SS
Depth: 14.0-16.0
Elevation:

Soil Description: Total length 20", 2" plus rock in sample, Lt. brn silty clay, w iron oxide,
Remarks: slicken sided clay.

Specimen Height: 5.53 in
Specimen Area: 6.02 in^2
Specimen Volume: 545.41 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s24	---		
Wt. Container + Wet Soil, gm	65.45	---	---	0
Wt. Container + Dry Soil, gm	55.91	---	---	0
Wt. Container, gm	16.95	---	---	0
Wt. Wet Soil, gm	48.5	1108.4	890.41	0
Wt. Dry Soil, gm	38.96	890.41	890.41	0
Wt. Water, gm	9.54	218.03	1.1642e-013	0
Water Content, %	24.49	24.49	0.00	0.00
Void Ratio	---	0.62	0.62	---
Degree of Saturation, %	---	104.12	0.00	---
Dry Unit Weight, pcf	---	101.92	101.91	---

Initial

Height: 5.531 in
Area: 6.0176 in^2
Volume: 545.41 cc

Moisture: 24.49 %
Void Ratio: 0.62
Dry Unit Weight: 101.92 pcf
Saturation: 104.12 %

End of Initialization
Time: 7.0897 min
Total Vertical Stress: 6.9221 psi
Total Horizontal Stress: 6.9265 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.9221 psi
Effective Horizontal Stress: 6.9265 psi

Height Change: -0.00013867 in
Area Change: 0 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 8.6185 cc

Height: 5.5311 in
Area: 6.0176 in^2
Volume: 545.46 cc

Moisture: 23.52 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 7.0897 min
Total Vertical Stress: 6.9221 psi
Total Horizontal Stress: 6.9265 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.9221 psi
Effective Horizontal Stress: 6.9265 psi

Height Change: -0.00013867 in
Area Change: 0 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 8.6185 cc

Height: 5.5311 in
Area: 6.0176 in^2
Volume: 545.46 cc

Moisture: 23.52 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 100.00 %

End of Saturation
Time: 7.0897 min
Total Vertical Stress: 6.9221 psi
Total Horizontal Stress: 6.9265 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.9221 psi
Effective Horizontal Stress: 6.9265 psi

Height Change: -0.00013867 in
Area Change: 0 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 8.6185 cc

Height: 5.5311 in
Area: 6.0176 in^2
Volume: 545.46 cc

Moisture: 23.52 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 7.0897 min
Total Vertical Stress: 6.9221 psi
Total Horizontal Stress: 6.9265 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 6.9221 psi
Effective Horizontal Stress: 6.9265 psi

Height Change: -0.00013867 in
Area Change: 0 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 8.6185 cc

Height: 5.5311 in
Area: 6.0176 in^2
Volume: 545.46 cc

Moisture: 23.52 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 100.00 %

End of Shear
Time: 27.383 min
Total Vertical Stress: 16.092 psi
Total Horizontal Stress: 6.9588 psi
Pore Pressure: -1.109 psi
Effective Vertical Stress: 17.201 psi
Effective Horizontal Stress: 8.0677 psi

Height Change: 1.1061 in
Area Change: -1.5048 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 218.07 cc

Height: 4.4249 in
Area: 7.5224 in^2
Volume: 545.46 cc

Moisture: 0.00 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 0.00 %

At Failure
Time: 16.359 min
Total Vertical Stress: 16.989 psi
Total Horizontal Stress: 6.9669 psi
Pore Pressure: -0.72042 psi
Effective Vertical Stress: 17.71 psi
Effective Horizontal Stress: 7.6873 psi

Height Change: 0.50327 in
Area Change: -0.60283 in^2
Volume Change: -0.041022 cc
Water Change: -0.039686 cc
Correction: 0 cc

Height: 5.0277 in
Area: 6.6204 in^2
Volume: 545.46 cc

Moisture: 23.52 %
Void Ratio: 0.62
Dry Unit Weight: 101.91 pcf
Saturation: 100.00 %

FIG. B-51
Sheet 4 of 5

SS-473-13

TRIAXIAL TEST

Project: SER-5-094(093)03I
Boring No.: B12
Sample No.: SS-473-13
Test No.: UU-82-13

Location:
Tested By: DT
Test Date: 10/9/13
Sample Type:

Project No.:
Checked By: SS
Depth: 14.0-16.0
Elevation:

Soil Description: Total length 20", 2" plus rock in sample, Lt. brn silty clay, w iron oxide,
Remarks: slicken sided clay, traces of coal.

Specimen Height: 5.59 in
Specimen Area: 6.25 in^2
Specimen Volume: 573.36 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s37	---		
Wt. Container + Wet Soil, gm	61.88	---	---	0
Wt. Container + Dry Soil, gm	52.34	---	---	0
Wt. Container, gm	17	---	---	0
Wt. Wet Soil, gm	44.88	1125.2	886.02	0
Wt. Dry Soil, gm	35.34	886.02	886.02	0
Wt. Water, gm	9.54	239.18	0	0
Water Content, %	26.99	26.99	0.00	0.00
Void Ratio	---	0.71	0.71	---
Degree of Saturation, %	---	100.07	0.00	---
Dry Unit Weight, pcf	---	96.471	96.475	---

Initial

Height: 5.594 in
Area: 6.2547 in^2
Volume: 573.36 cc

Moisture: 26.99 %
Void Ratio: 0.71
Dry Unit Weight: 96.471 pcf
Saturation: 100.07 %

End of Initialization
Time: 2.8288 min
Total Vertical Stress: 13.836 psi
Total Horizontal Stress: 13.845 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.836 psi
Effective Horizontal Stress: 13.845 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 0.21541 cc

Height: 5.5939 in
Area: 6.2547 in^2
Volume: 573.33 cc

Moisture: 26.97 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 2.8288 min
Total Vertical Stress: 13.836 psi
Total Horizontal Stress: 13.845 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.836 psi
Effective Horizontal Stress: 13.845 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 0.21541 cc

Height: 5.5939 in
Area: 6.2547 in^2
Volume: 573.33 cc

Moisture: 26.97 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 100.00 %

End of Saturation
Time: 2.8288 min
Total Vertical Stress: 13.836 psi
Total Horizontal Stress: 13.845 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.836 psi
Effective Horizontal Stress: 13.845 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 0.21541 cc

Height: 5.5939 in
Area: 6.2547 in^2
Volume: 573.33 cc

Moisture: 26.97 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 2.8288 min
Total Vertical Stress: 13.836 psi
Total Horizontal Stress: 13.845 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 13.836 psi
Effective Horizontal Stress: 13.845 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 0.21541 cc

Height: 5.5939 in
Area: 6.2547 in^2
Volume: 573.33 cc

Moisture: 26.97 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 100.00 %

End of Shear
Time: 23.1 min
Total Vertical Stress: 28.988 psi
Total Horizontal Stress: 13.974 psi
Pore Pressure: -1.1575 psi
Effective Vertical Stress: 30.145 psi
Effective Horizontal Stress: 15.132 psi

Height Change: 1.119 in
Area Change: -1.5637 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 239.2 cc

Height: 4.475 in
Area: 7.8184 in^2
Volume: 573.33 cc

Moisture: 0.00 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 0.00 %

At Failure
Time: 18.034 min
Total Vertical Stress: 29.04 psi
Total Horizontal Stress: 13.926 psi
Pore Pressure: -1.1252 psi
Effective Vertical Stress: 30.165 psi
Effective Horizontal Stress: 15.051 psi

Height Change: 0.83918 in
Area Change: -1.1041 in^2
Volume Change: 0.028425 cc
Water Change: -0.019843 cc
Correction: 0 cc

Height: 4.7548 in
Area: 7.3588 in^2
Volume: 573.33 cc

Moisture: 26.97 %
Void Ratio: 0.71
Dry Unit Weight: 96.475 pcf
Saturation: 100.00 %

FIG. B-51
Sheet 5 of 5

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Stop 12:40

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. Naumann	13				SER-5-094(093)031

Project Location	County	Date Started	Date Finished
Painted Canyon Slide	Billings	7-31-13	7-31-13

Samp. Type	Core No.	Core Depth From	Core Depth To	SPT	Sample Recov.	Jar No.	Sample No.	Horizon Depth From	Horizon Depth To	Color	Text. Class	Consistency	Perm. (Y/N)	Water Bear. (Y/N)	Plasticity (Y/N)	Remarks
SS #1	1	0.0	2.0	3 / 3	1.8 / 2.0	1	486	0.0	7.0	Brn	Fn Snd	Very loose	Y	N	N	Organics
Drill to 2.0																
SS #2	2	2.0	4.0	2 / 2	1.8 / 2.0	2	487			Brn	Fn Snd	Very loose	Y	N	N	Trace clay in tip
Drill to 5.0																
STW #1	3	5.0	7.0		2.0 / 2.0		488			Brn	Fn Snd					V. moist, Io Dep
SS #3	4	7.0	9.0	3 / 3	1.1 / 2.0	3	489	7.0	25.0	Brn	Sndy cly	Soft	Y	Y	Y	Io Dep.
Drill to 10.0																
STW #2	5	10.0	12.0		2.0 / 2.0		490			Brn Gry	Sndy cly					Io, Coal Dep.
SS #4	6	12.0	14.0	10 / 12	2.0 / 2.0	4	491			Brn Gry	Sndy cly	Stiff	N	N	Y	Io, Coal Dep
Drill to 15.0																
STW #3	7	15.0	17.0		2.0 / 2.0		492			Gry	Sndy cly					Io, Coal Dep.
SS #5	8	17.0	19.0	10 / 13	2.0 / 2.0	5	493			Gry	Sndy cly	Stiff	N	N	Y	Io, Coal Dep.
Drill to 20.0																
STW #4	9	20.0	22.0		2.0 / 2.0		494			Gry	Sndy cly					Coal Dep 1.0 [illegible]. Pushed Twice. Disturbed
SS #6	10	22.0	24.0	10 / 12	2.0 / 2.0	6	495			Gry	Sndy cly	Stiff	N	N	Y	Coal Dep

FIG. B-52
Sheet 1 of 3

FIG. B-52
Sheet 1 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
J. NAUMANN	13				SER-5-094(093)031

Project Location	County	Date Started	Date Finished
Painter Canyon	Billings	7-31-13	7-31-13

SAMPLE TYPE	CORE NO.	CORE DEPTH FROM	CORE DEPTH TO	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON DEPTH FROM	HORIZON DEPTH TO	COLOR	TEXT. CLASS	CONSISTENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLASTICITY (Y/N)	REMARKS
Drill to 25.0																
3TW #5	11	25.0	27.0		2.0 / 2.0		496	25.0	32.0	Gry	silty cly					Coal Dep
SS #7	12	27.0	29.0	11 / 12	2.0 / 2.0	7	497			Gry	silty cly	stiff	N	N	Y	IO, coal dep.
Drill to 30.0																
3TW #6	13	30.0	32.0		2.0 / 2.0		498	32.0	33.5	Blk	Coal					Bent tube Coal in end. Clay on top.
SS #8	14	32.0	34.0	25 / 28	2.0 / 2.0	8	499	33.5	35.0	Gry	silty cly	Very Stiff	N	N	Y	Top 1.5 coal, Bottom cly Bagged
Drill to 35.0																
SS #9	15	35.0	37.0	24 / 51	2.0 / 2.0	9	500	35.0	42.0	Blk	Coal	Dence	Y	Y	N	Tried to push tube, wouldn't push coal
Drill to 37.0																
SS #10	16	37.0	39.0	41 / 78	2.0 / 2.0	10	501			Blk	Coal	Dence	Y	Y	N	Top 1.5 Dist. Disc
Drill to 40.0																
SS #11	17	40.0	42.0	25 / 27	2.0 / 2.0	11	502			Blk	Coal	Dence	Y	Y	N	Top 0.3 Gry Cly w/ silt Bagged coal
SS #12	18	42.0	44.0	12 / 24	2.0 / 2.0	12	503	42.0	50.0	GRY	CLY	Stiff	N	N	Y	Coal Dep. Didn't drill out 40.0-42.0, pushed through Driller decided to.

FIG. B-52
Sheet 2 of 3

DEEP FOUNDATION BORING LOG

Department of Transportation, Materials & Research Division
SFN 10078 (Rev. 11-98)

Crew Chief	Boring No.	Elevation of Boring	Station	Offset	Project No.
D. Naumann	13				SER-5-094(093)031
Project Location		**County**	**Date Started**		**Date Finished**
PAINTED CANYON		Billings	7-31-13		7-31-13

SAMP. TYPE	CORE NO.	CORE: FROM	CORE: TO	DEPTH	SPT	SAMPLE RECOV.	JAR NO.	SAMPLE NO.	HORIZON FROM	HORIZON TO	COLOR	TEXT. CLASS	CONSIS-TENCY	PERM. (Y/N)	WATER BEAR. (Y/N)	PLAS-TICITY (Y/N)	REMARKS
Drill to 45.0																	
3TW #7	19	45.0	47.0			2.0 / 2.0		504			Gry	sndy cly					Bent cw
SS #13	20	47.0	49.0		22 / 25	2.0 / 2.0	13	505			Gry	sndy cly	Very Stiff	Y	N	Y	sndy cly
Drill to 500																	
3TW #8	21	500	520			2.0 / 2.0		506	50.0	/	Gry	silty cly					silty cly very hard
SS #14	22	52.0	54.0		25 / 30	2.0 / 2.0	14	507			Gry	silty cly	Very Stiff	N	N	Y	coal det, Coal seam at 53 0.2' thick.
Drill to 55.0																	
3TW #9	23	55.0	56.5			1.5		508			Gry	silty cly					Coal Dep Bent Tube
SS #15	24	56.5	58.5		10 / 18	2.0 / 2.0	15	509			Gry	silty cly	Very Stiff	N	N	Y	Coal Dep
Drill to 65.0																	
	Stop																

FIG. B-52
Sheet 3 of 3

FIG. B-52
Sheet 3 of 3

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	486	487	488	489
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	0.0 - 2.0	2.0 - 4.0	5.0 - 7.0	7.0 - 9.0
Field Sample No.	486	487	488	489
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	99	100	100	100
% Pass. No. 10 Sieve	99	100	100	100
% Coarse Sand (-No. 10 + No.40)	1	1	0	0
% Fine Sand (-No. 40 + No. 200)	64	61	1	3
% Silt (0.074 - 0.005 mm)	25	27	74	77
% Clay (-0.005 mm)	9	11	24	20
Liquid Limit (-No. 40)	0	0	43	45
Plasticity Index (-No. 40)	0	0	21	24
Plastic Limit	0	0	22	22
Soil Color	Brn	Brn	Brn	Brn
Textural Class	SNDY LM	SNDY LM	SLTY CLY LM	SLTY CLY LM
Soil Class (AASHTO M-145)	A-2-4(0)	A-4(0)	A-7-6(23)	A-7-6(25)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	2.8	4.3	28.2	27.1

FIG. B-53
Sheet 1 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

FIG. B-53
Sheet 1 of 6

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	490	491	492	493
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	10.0 - 12.0	12.0 - 14.0	15.0 - 17.0	17.0 - 19.0
Field Sample No.	490	491	492	493
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	99	100	100	99
% Coarse Sand (-No. 10 + No.40)	3	0	0	1
% Fine Sand (-No. 40 + No. 200)	7	4	23	8
% Silt (0.074 - 0.005 mm)	24	39	55	62
% Clay (-0.005 mm)	66	57	21	28
Liquid Limit (-No. 40)	69	72	49	59
Plasticity Index (-No. 40)	39	48	30	36
Plastic Limit	29	24	19	22
Soil Color	Brn Gry	Brn Gry	Gry	Gry
Textural Class	CLY	CLY	SLTY CLY LM	SLTY CLY LM
Soil Class (AASHTO M-145)	A-7-6(40)	A-7-6(53)	A-7-6(22)	A-7-6(36)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	37.1	29.4	22.8	25.9

FIG. B-53
Sheet 2 of 6

FIG. B-53 Sheet 2 of 6

Scott W. Wutzke
Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	494	495	496	497
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	20.0 - 22.0	22.0 - 24.0	25.0 - 27.0	27.0 - 29.0
Field Sample No.	494	495	496	497
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	1	0	0	0
% Silt (0.074 - 0.005 mm)	64	47	44	47
% Clay (-0.005 mm)	35	52	56	53
Liquid Limit (-No. 40)	69	84	83	86
Plasticity Index (-No. 40)	48	62	59	63
Plastic Limit	20	22	24	23
Soil Color	Gry	Gry	Gry	Gry
Textural Class	SLTY CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(54)	A-7-6(71)	A-7-6(69)	A-7-6(72)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	22.1	25.7	24.8	26.2

FIG. B-53
Sheet 3 of 6

Scott W. Wutzke
Testing Lab. Supervisor
Date Printed: 11/19/2013

FIG. B-53
Sheet 3 of 6

Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	498	499	500	501
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	30.0 - 32.0	32.0 - 34.0	35.0 - 37.0	37.0 - 39.0
Field Sample No.	498	499	500	501
% Pass. 3/8" Sieve	100			
% Pass. No. 4 Sieve	100			
% Pass. No. 10 Sieve	100			
% Coarse Sand (-No. 10 + No.40)	0			
% Fine Sand (-No. 40 + No. 200)	1			
% Silt (0.074 - 0.005 mm)	16			
% Clay (-0.005 mm)	84			
Liquid Limit (-No. 40)	90			
Plasticity Index (-No. 40)	64			
Plastic Limit	27			
Soil Color	Blk	Gry	Blk	Blk
Textural Class	CLY			
Soil Class (AASHTO M-145)	A-7-6(74)			
Frost Class	F3			
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	27.3			

FIG. B-53
Sheet 4 of 6

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	502	503	504	505
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	40.0 - 42.0	42.0 - 44.0	45.0 - 47.0	47.0 - 49.0
Field Sample No.	502	503	504	505
% Pass. 3/8" Sieve		100	100	100
% Pass. No. 4 Sieve		100	100	100
% Pass. No. 10 Sieve		99	100	100
% Coarse Sand (-No. 10 + No.40)		1	0	0
% Fine Sand (-No. 40 + No. 200)		1	9	4
% Silt (0.074 - 0.005 mm)		32	63	63
% Clay (-0.005 mm)		66	28	33
Liquid Limit (-No. 40)		87	73	91
Plasticity Index (-No. 40)		64	51	71
Plastic Limit		23	22	20
Soil Color	Blk	Gry	Gry	Gry
Textural Class		CLY	SLTY CLY LM	SLTY CLY
Soil Class (AASHTO M-145)		A-7-6(72)	A-7-6(52)	A-7-6(77)
Frost Class		F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)		26.4	19.2	20.5

FIG. B-53
Sheet 5 of 6

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Testing Lab. Supervisor
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Deep Foundations Laboratory Analysis

Department of Transportation, Materials and Research Division
300 Airport Road, Bismarck ND 58504 (701) 328-6900

Report Number	SS-26-2013	**Date Reported**	8/28/2013	**Boring Number**	13
County	BILLINGS	**Submitted By**	Naumann	**Project Number**	SER-5-094(093)031
District		**Structure Location**		**PCN**	

Comments

Lab Number	506	507	508	509
Distance From CenterLine (Ft.)	0 ft	0 ft	0 ft	0 ft
Depth, Ft.	50.0 - 52.0	52.0 - 54.0	55.0 - 56.5	56.5 - 58.5
Field Sample No.	506	507	508	509
% Pass. 3/8" Sieve	100	100	100	100
% Pass. No. 4 Sieve	100	100	100	100
% Pass. No. 10 Sieve	100	100	100	100
% Coarse Sand (-No. 10 + No.40)	0	0	0	0
% Fine Sand (-No. 40 + No. 200)	0	1	0	0
% Silt (0.074 - 0.005 mm)	45	10	28	10
% Clay (-0.005 mm)	55	88	72	89
Liquid Limit (-No. 40)	90	89	94	97
Plasticity Index (-No. 40)	67	58	69	70
Plastic Limit	23	31	25	27
Soil Color	Gry	Gry	Gry	Gry
Textural Class	CLY	CLY	CLY	CLY
Soil Class (AASHTO M-145)	A-7-6(77)	A-7-5(69)	A-7-6(80)	A-7-6(82)
Frost Class	F3	F3	F3	F3
Optimum Moisture (%)				
Maximum Dry Density (pcf)				
Ph of Soil				
% Organic Content				
Pocket Pentrometer				
Depth (Ft.) | Moisture (%)				
Avg. Moisture (%)	25.3	22.6	22.9	19.3

FIG. B-53
Sheet 6 of 6

FIG. B-53
Sheet 6 of 6

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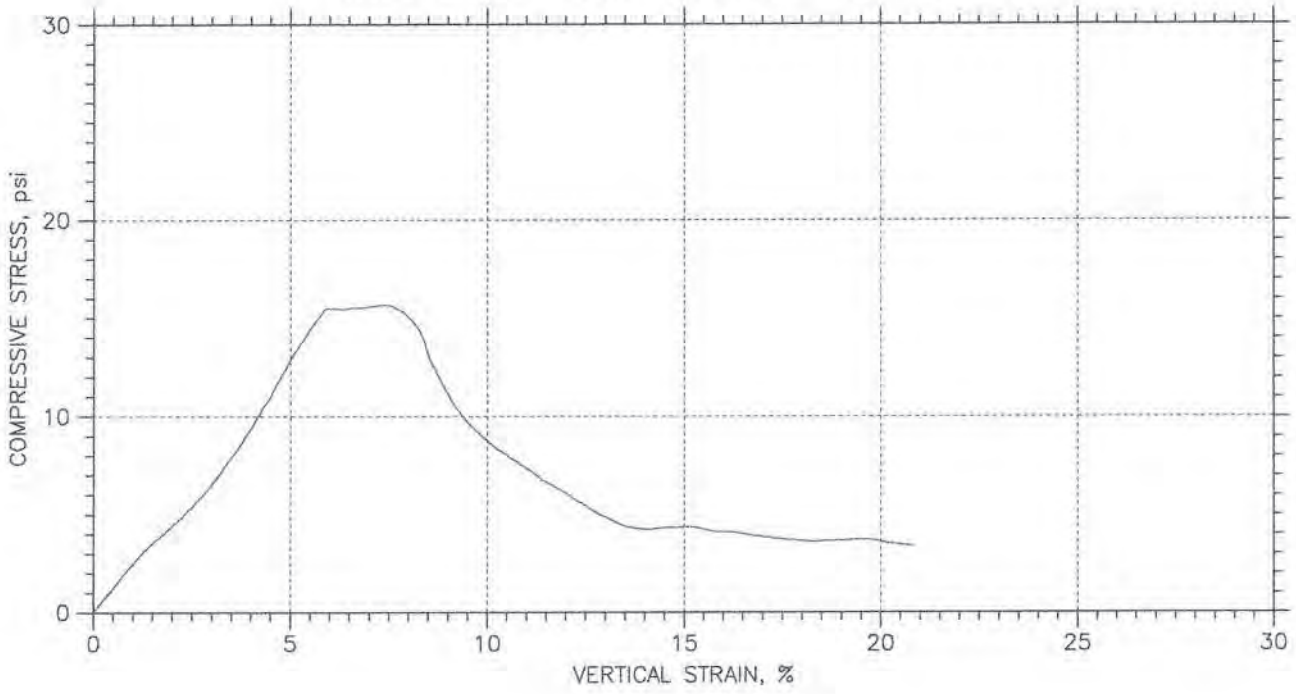
Testing Lab. Supervisor

Date Printed: 11/19/2013

SS-488-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-49-13			
Initial	Diameter, in	2.811			
	Height, in	5.59			
	Water Content, %	29.74			
	Dry Density, pcf	94.37			
	Saturation, %	104.66			
	Void Ratio	0.753			
Unconfined Compressive Strength, psi		15.65			
Undrained Shear Strength, psi		7.824			
Time to Failure, min		7.0366			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 13

Sample Type: Undisturbed

Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &

Remarks: organics Hard iron oxide 2" in dia.

FIG. B-54

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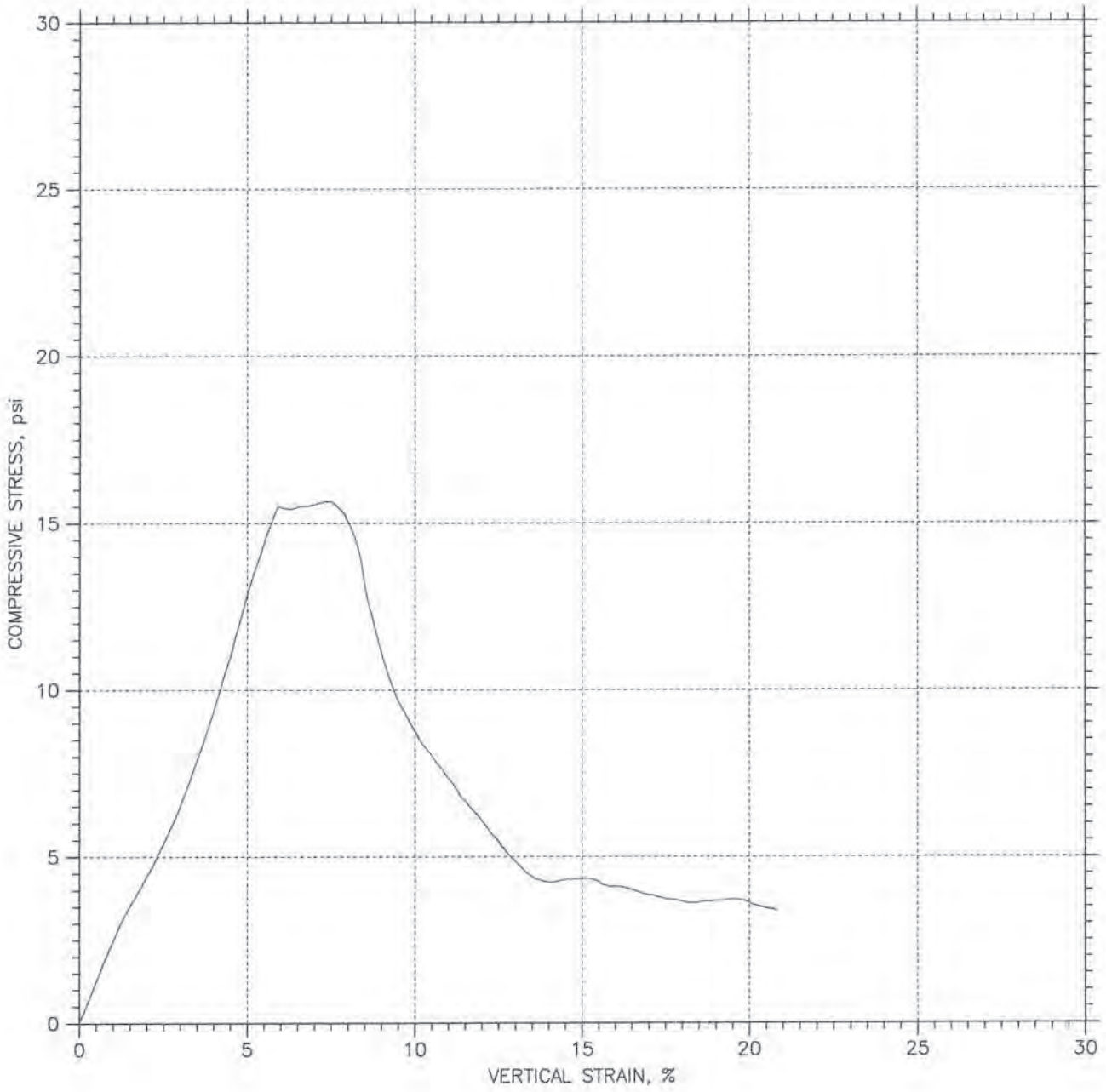
UNCONFINED COMPRESSION TEST REPORT



Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-488-13	Test Date: 10/21/2013	Depth: 5.0 - 7.0
Test No.: UC-49-13	Sample Type: Undisturbed	Elevation:
Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &		
Remarks: organics Hard iron oxide 2" in dia.		

FIG. B-54
Sheet 2 of 2

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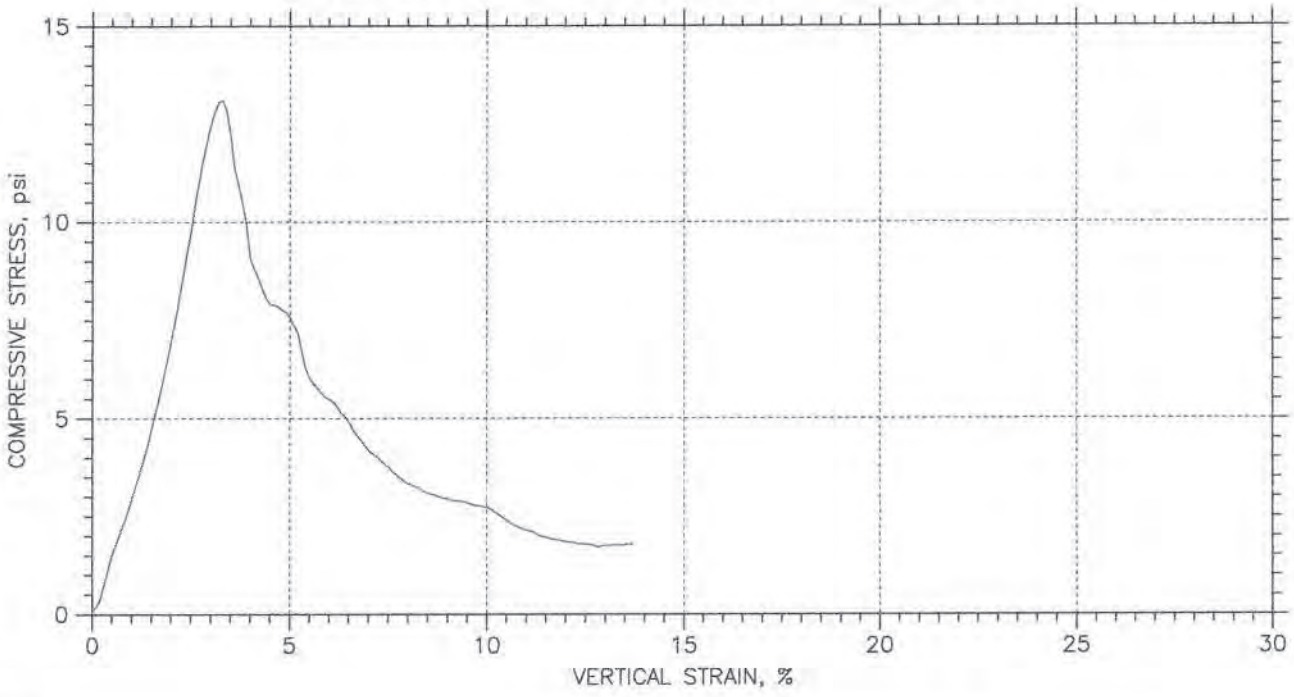
SS-488-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-50-13			
Initial	Diameter, in	2.789			
	Height, in	5.568			
	Water Content, %	27.89			
	Dry Density, pcf	97.04			
	Saturation, %	104.87			
	Void Ratio	0.705			
Unconfined Compressive Strength, psi		13.09			
Undrained Shear Strength, psi		6.543			
Time to Failure, min		3.2087			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 13

Sample Type: Undisturbed

Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &

Remarks: organics Hard iron oxide 2" in dia.

FIG. B-55

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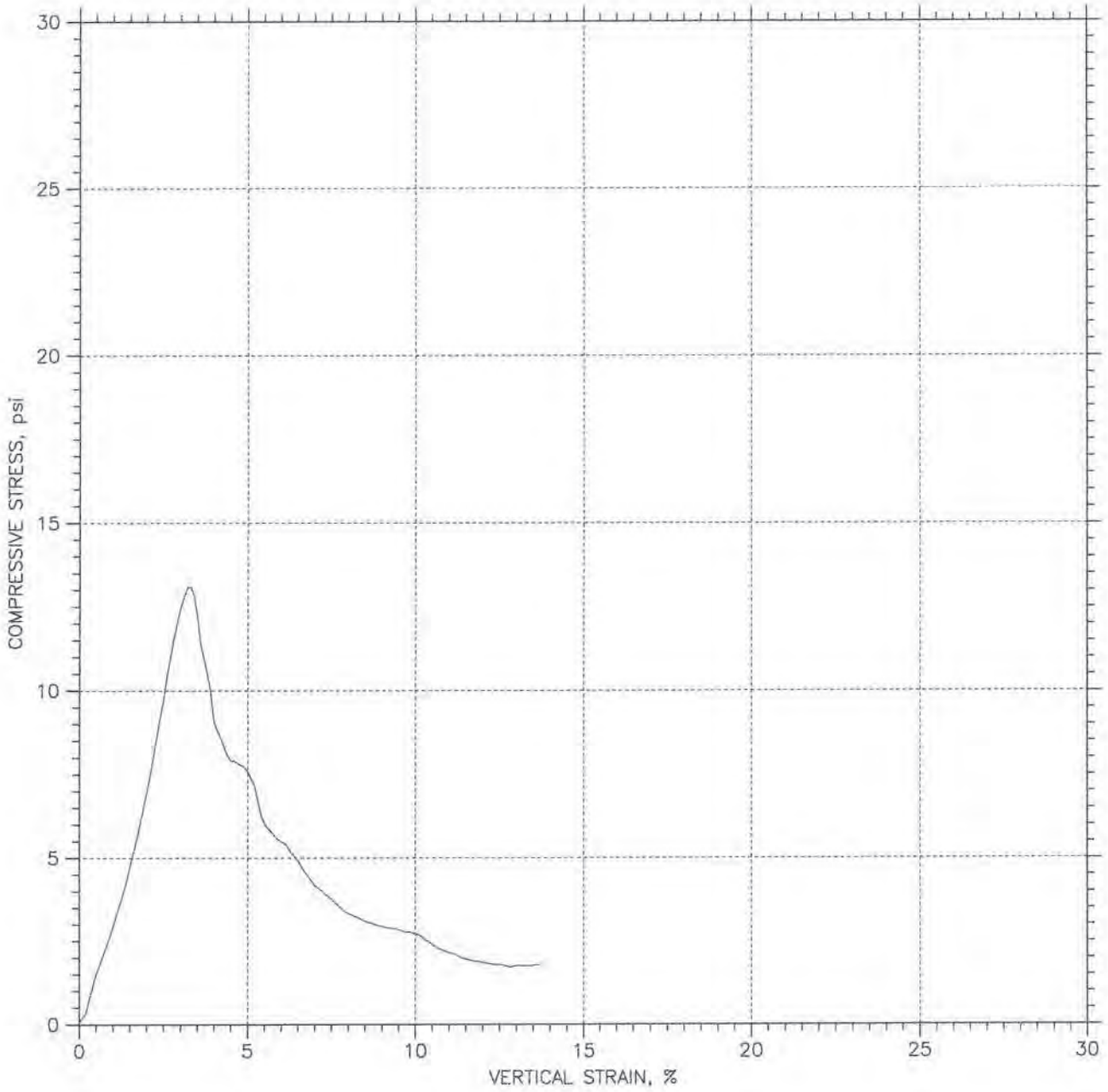
UNCONFINED COMPRESSION TEST REPORT



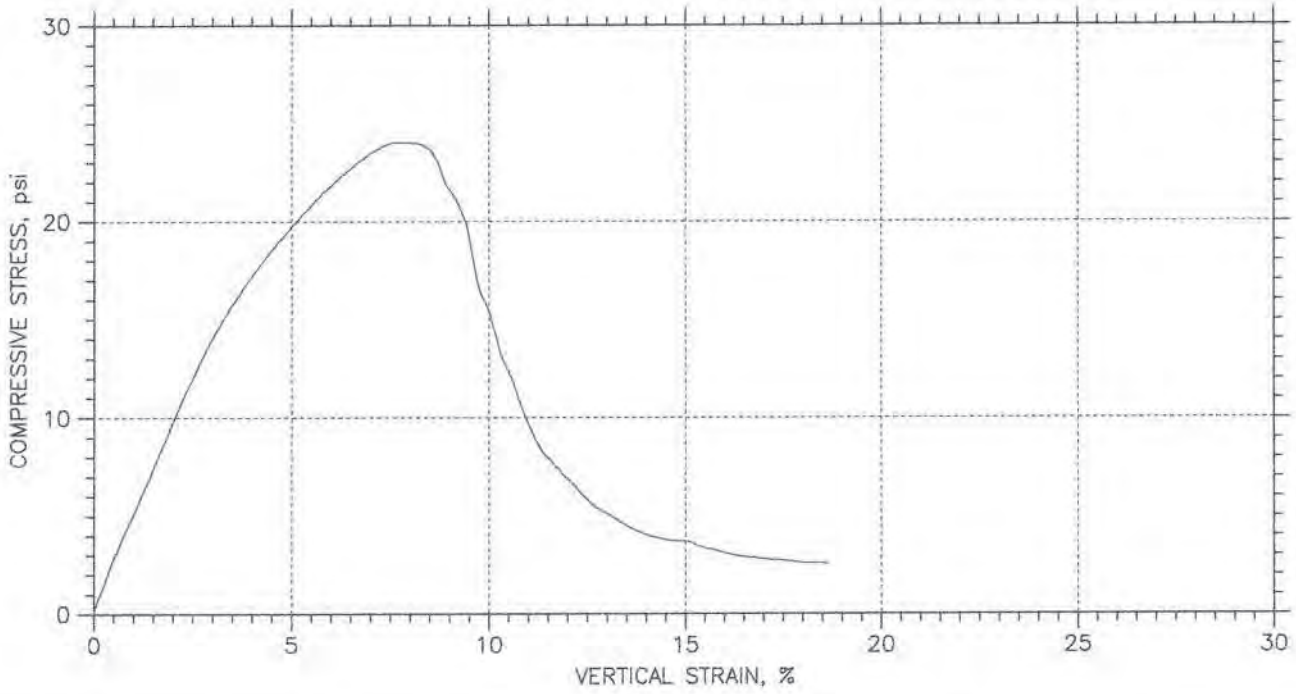
	Project: ser-5-094-093-031	Location:	Project No.:
	Boring No.: 13	Tested By: DT	Checked By: SS
	Sample No.: SS-488-13	Test Date: 10/21/2013	Depth: 5.0 - 7.0
	Test No.: UC-50-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &		
	Remarks: organics Hard iron oxide 2" in dia.		

FIG. B-55
Sheet 2 of 2

ue, 22-OCT-2013 07:01:31

55-488-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-51-13			
Initial	Diameter, in	2.799			
	Height, in	5.564			
	Water Content, %	27.11			
	Dry Density, pcf	99.36			
	Saturation, %	108.04			
	Void Ratio	0.665			
Unconfined Compressive Strength, psi		24.02			
Undrained Shear Strength, psi		12.01			
Time to Failure, min		7.4608			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 13

Sample Type: Undisturbed

Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &

Remarks: organics Hard iron oxide 2" in dia.

FIG. B-56

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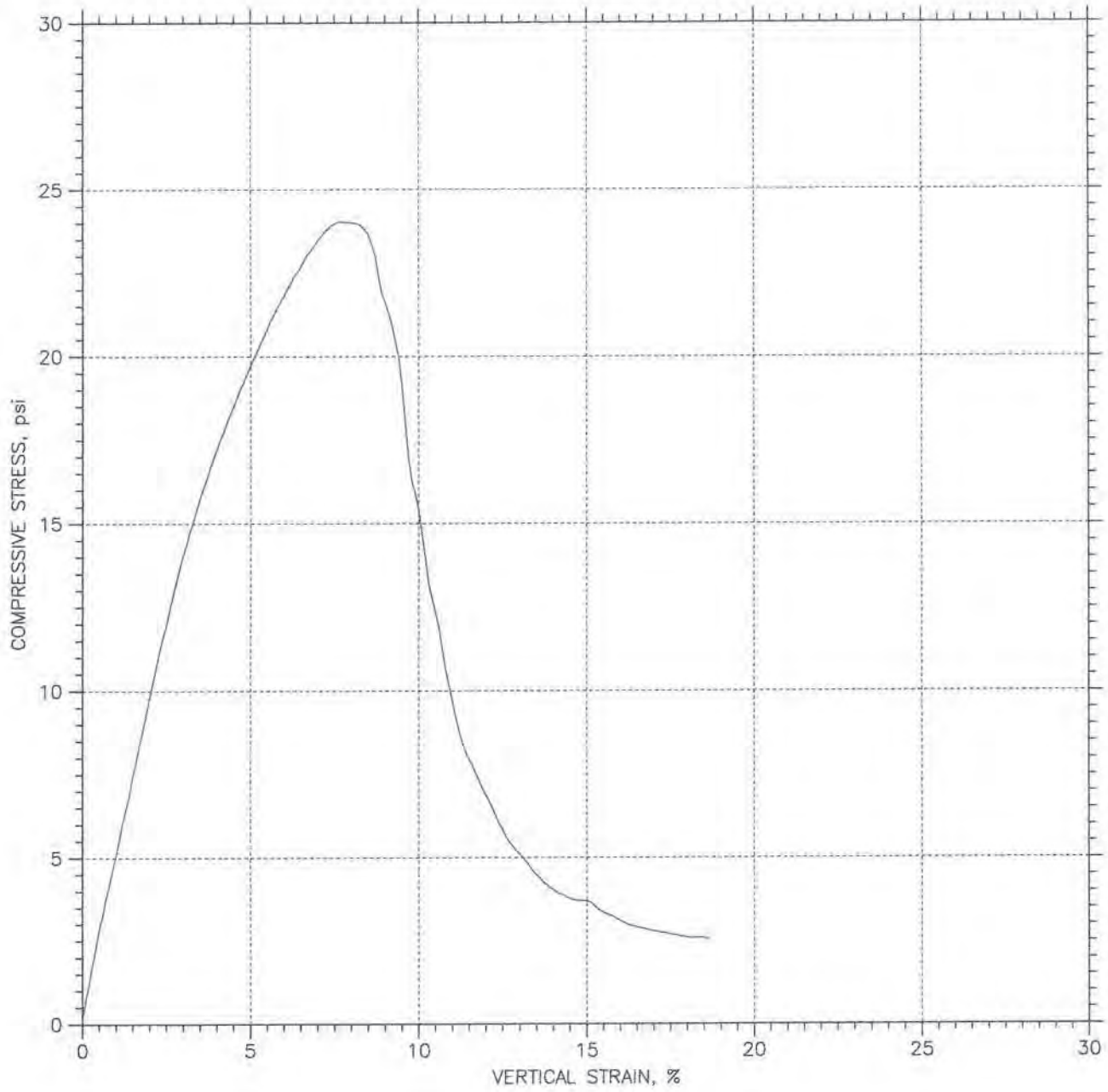
UNCONFINED COMPRESSION TEST REPORT



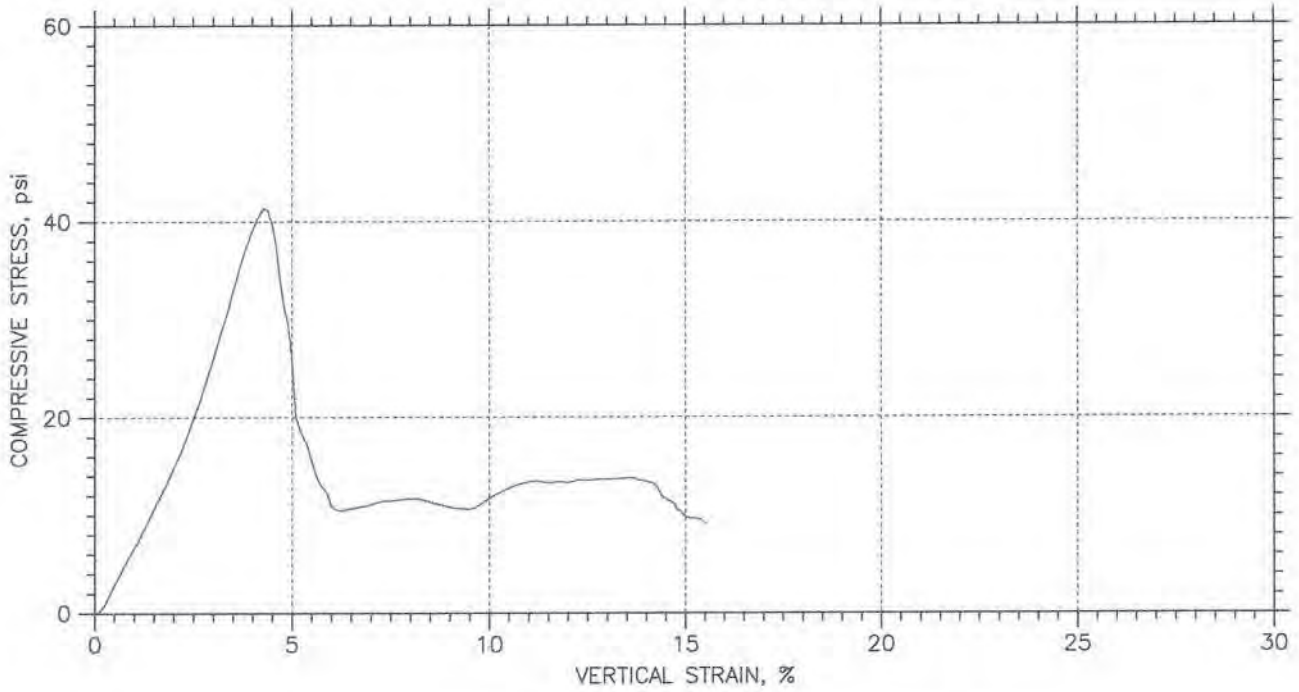
	Project: ser-5-094-093-031	Location:	Project No.:
	Boring No.: 13	Tested By: DT	Checked By: SS
	Sample No.: SS-488-13	Test Date: 10/21/2013	Depth: 5.0 - 7.0
	Test No.: UC-51-13	Sample Type: Undisturbed	Elevation:
	Description: Total length 22" with 2.5" disturbed / Gry Brn silty loam w/ iron oxide &		
	Remarks: organics Hard iron oxide 2" in dia.		

FIG. B-56
Sheet 2 of 2

ue, 22-OCT-2013 07:05:25

SS-492-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-52-13			
Initial	Diameter, in	2.856			
	Height, in	5.602			
	Water Content, %	22.72			
	Dry Density, pcf	102.2			
	Saturation, %	97.33			
	Void Ratio	0.619			
Unconfined Compressive Strength, psi		41.32			
Undrained Shear Strength, psi		20.66			
Time to Failure, min		4.128			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 13

Sample Type: Undisturbed

Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes

Remarks: to Gry clay

FIG. B-57
Sheet 1 of 2

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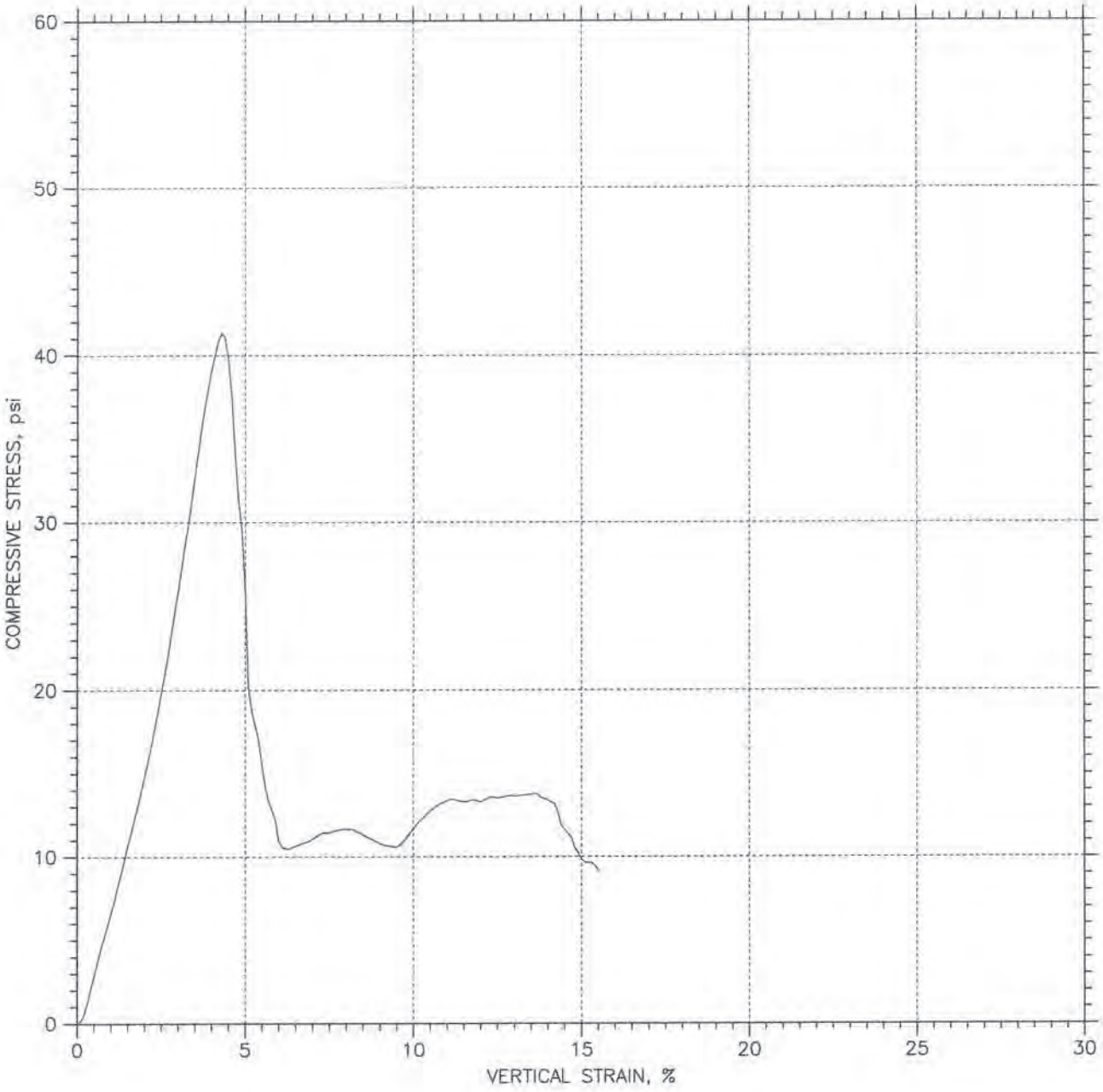
SS-492-13

UNCONFINED COMPRESSION TEST REPORT



Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-492-13	Test Date: 10/22/2013	Depth: 15.0 - 17.0
Test No.: UC-52-13	Sample Type: Undisturbed	Elevation:
Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes		
Remarks: to Gry clay		

FIG. B-57
Sheet 2 of 2

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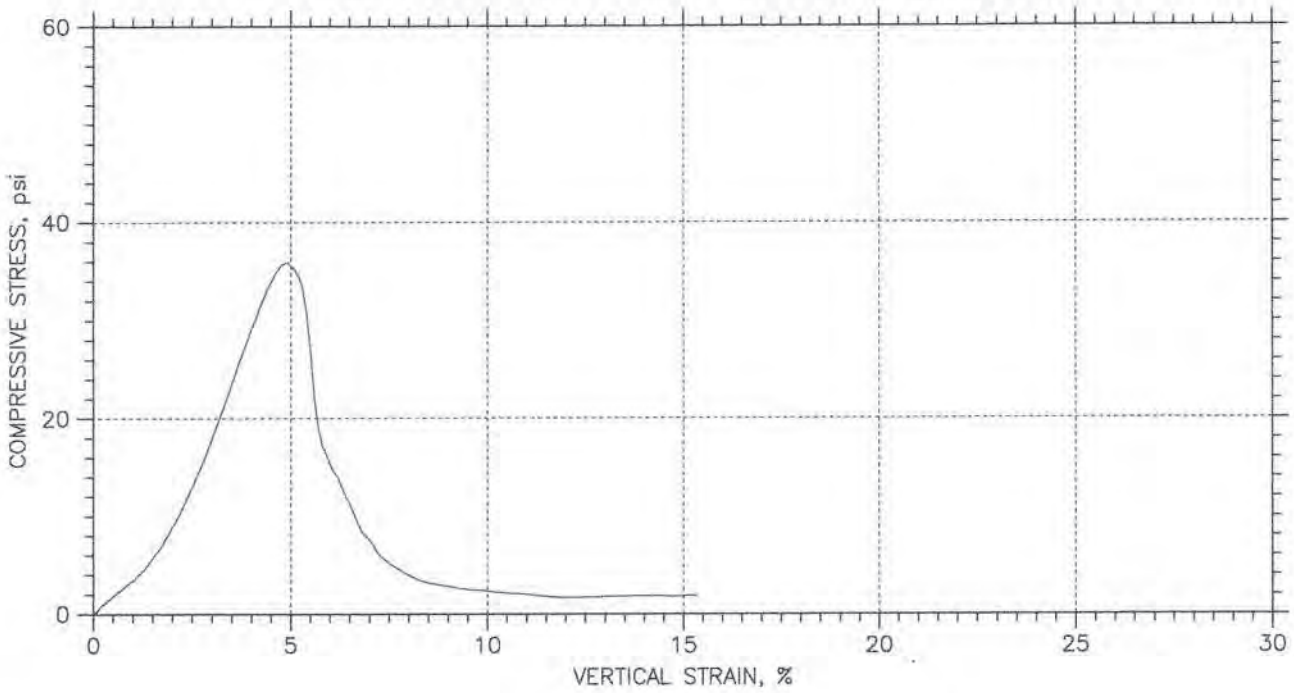
55-492-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-53-13			
Initial	Diameter, in	2.855			
	Height, in	5.625			
	Water Content, %	22.85			
	Dry Density, pcf	104.8			
	Saturation, %	104.69			
	Void Ratio	0.578			
Unconfined Compressive Strength, psi		35.93			
Undrained Shear Strength, psi		17.96			
Time to Failure, min		4.7691			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

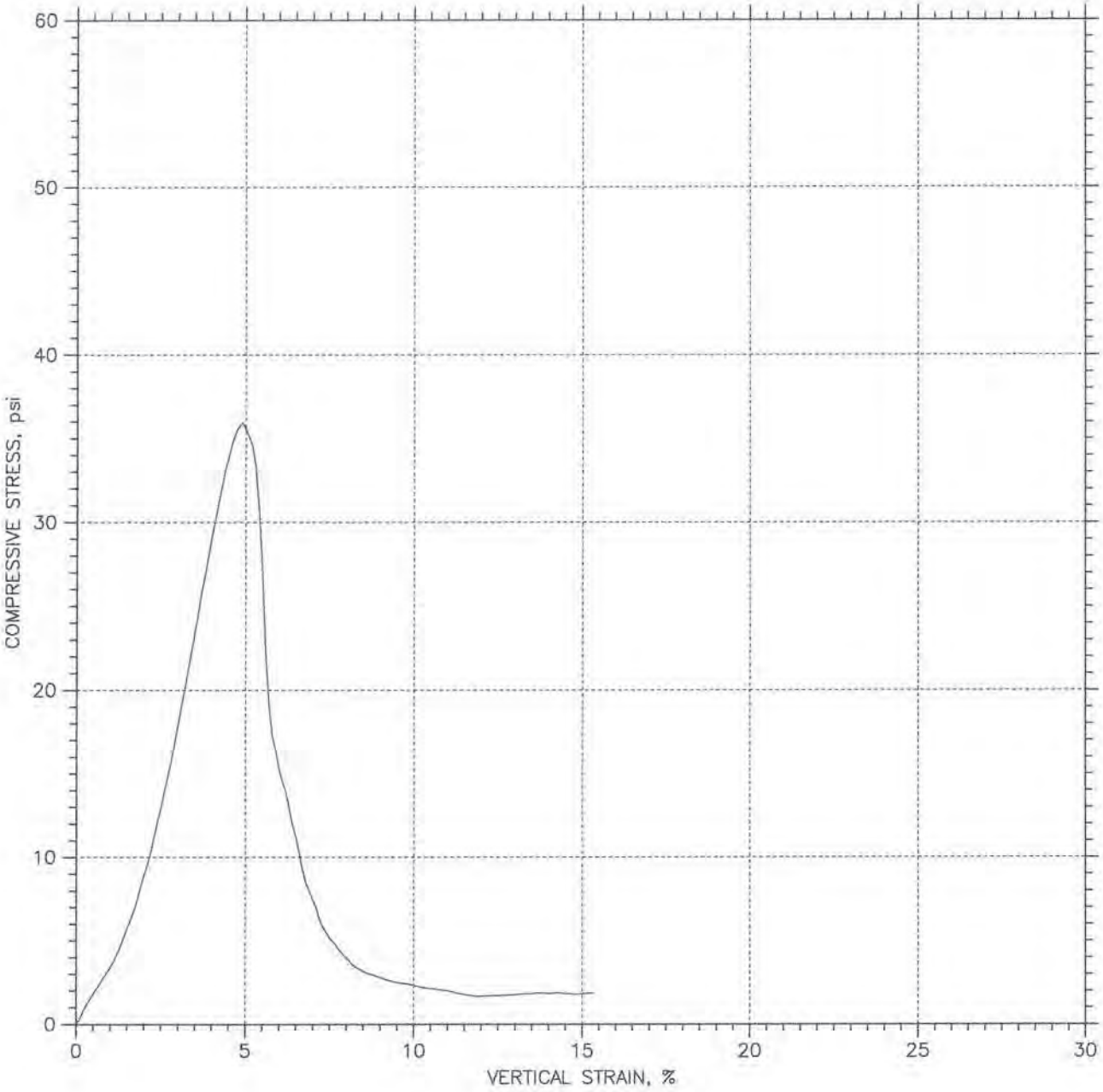
Project: ser-5-094-093-031
Location:
Project No.:
Boring No.: 13
Sample Type: Undisturbed
Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes
Remarks: to Gry clay

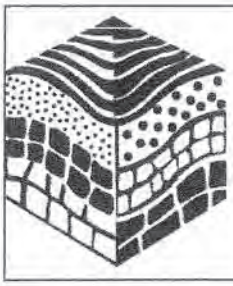
FIG. B-58
Sheet 1 of 2

Wed, 23-OCT-2013 07:30:29

SS-492-13

UNCONFINED COMPRESSION TEST REPORT





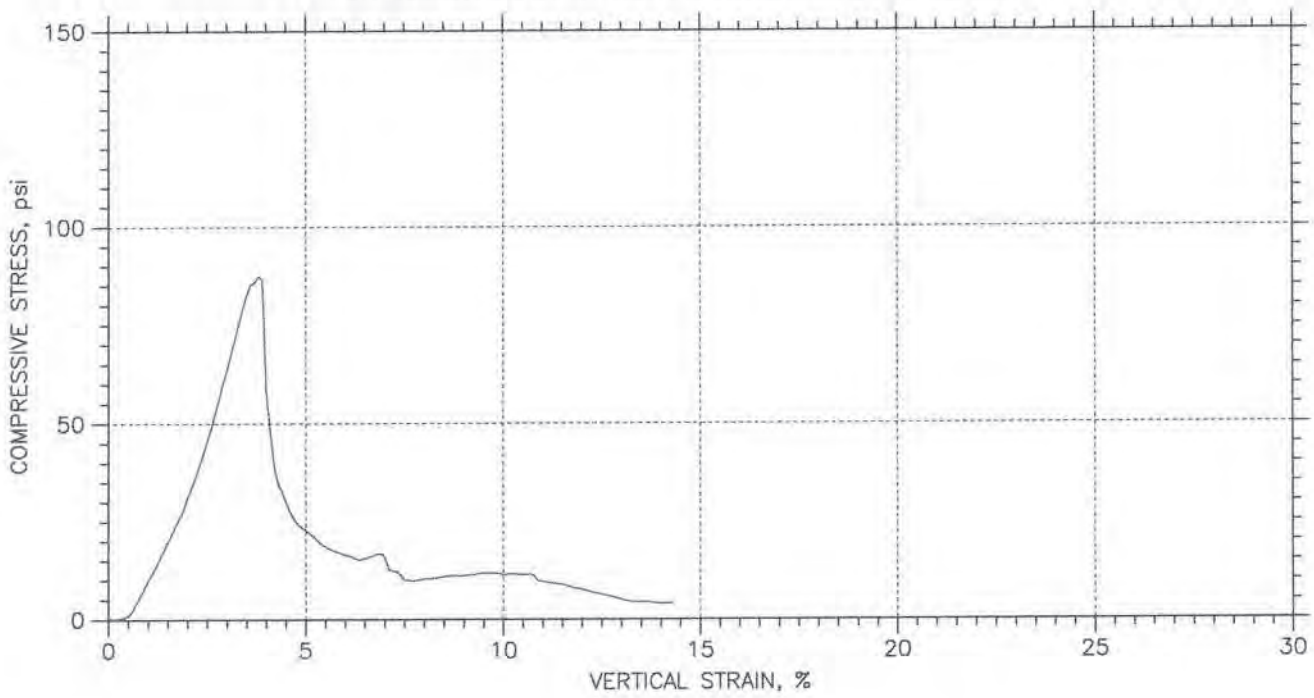
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-492-13	Test Date: 10/22/2013	Depth: 15.0 - 17.0
Test No.: UC-53-13	Sample Type: Undisturbed	Elevation:
Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes		
Remarks: to Gry clay		

FIG. B-58
Sheet 2 of 2

Wed, 23-OCT-2013 07:30:29

SS-492-13

UNCONFINED COMPRESSION TEST REPORT



Symbol					
Test No.		UC-54-13			
Initial	Diameter, in	2.853			
	Height, in	5.618			
	Water Content, %	22.77			
	Dry Density, pcf	104.6			
	Saturation, %	103.72			
	Void Ratio	0.582			
Unconfined Compressive Strength, psi		87.33			
Undrained Shear Strength, psi		43.66			
Time to Failure, min		3.7657			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031

Location:

Project No.:

Boring No.: 13

Sample Type: Undisturbed

Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes

Remarks: to Gry clay

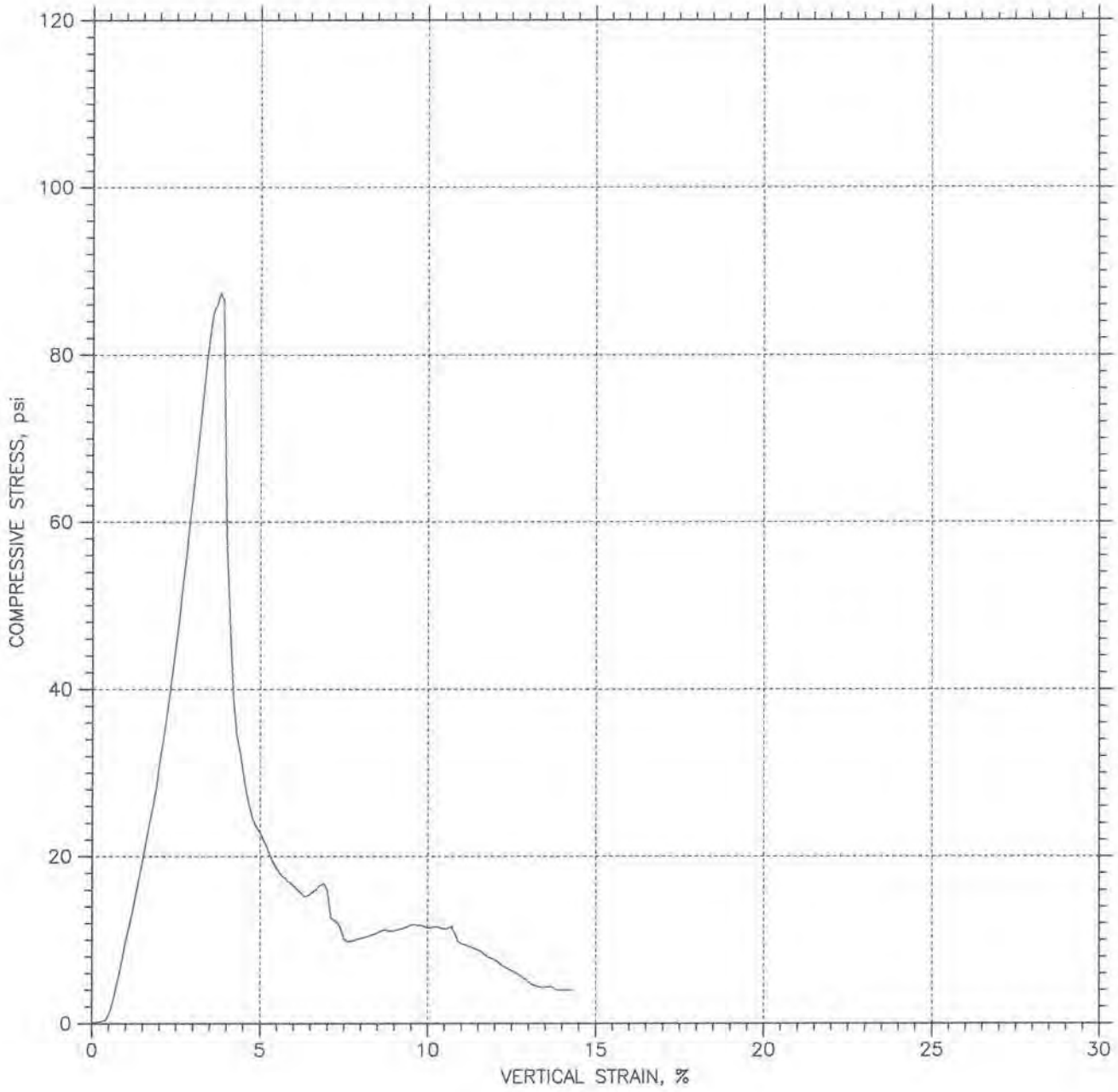
FIG. B-59

Sheet 1 of 2

Wed, 23-OCT-2013 07:32:31

SS-492-13

UNCONFINED COMPRESSION TEST REPORT



Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-492-13	Test Date: 10/22/2013	Depth: 15.0 - 17.0
Test No.: UC-54-13	Sample Type: Undisturbed	Elevation:
Description: Total length 25.5" Gry to Gry Brn silty clay loam. Bottom 4" changes		
Remarks: to Gry clay		

FIG. B-59
Sheet 2 of 2

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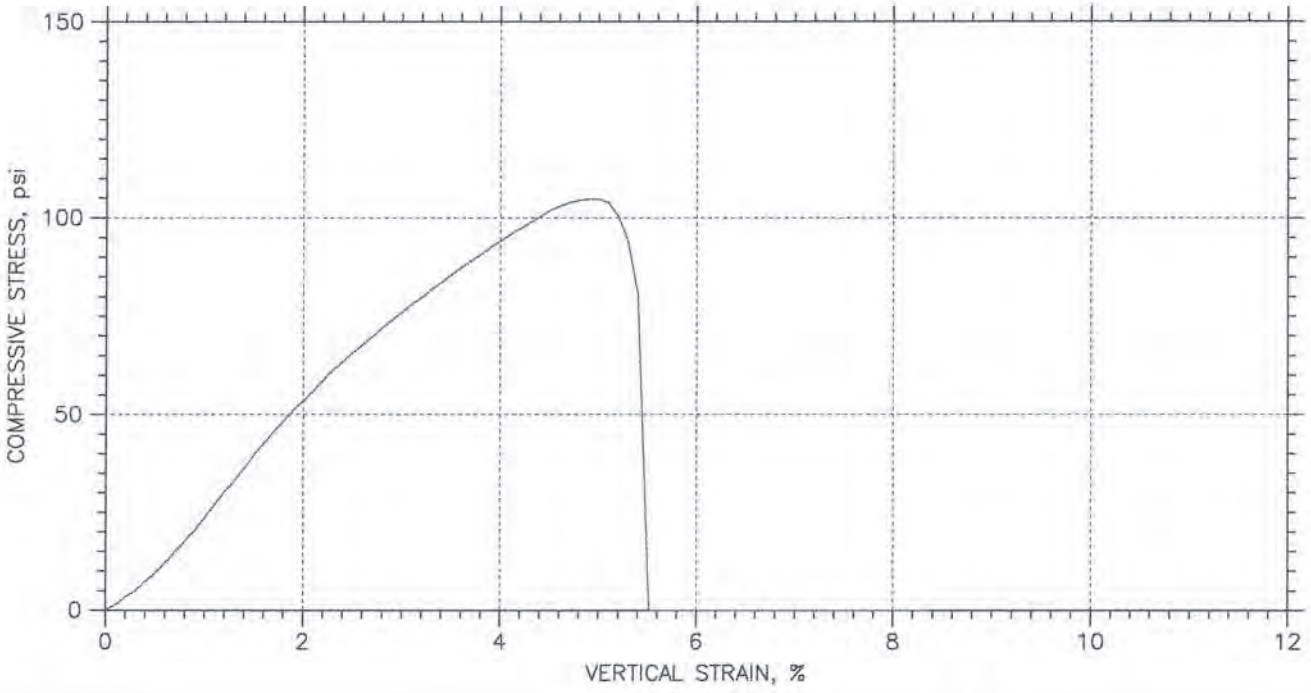
SS-498-13

UNCONFINED COMPRESSION TEST REPORT

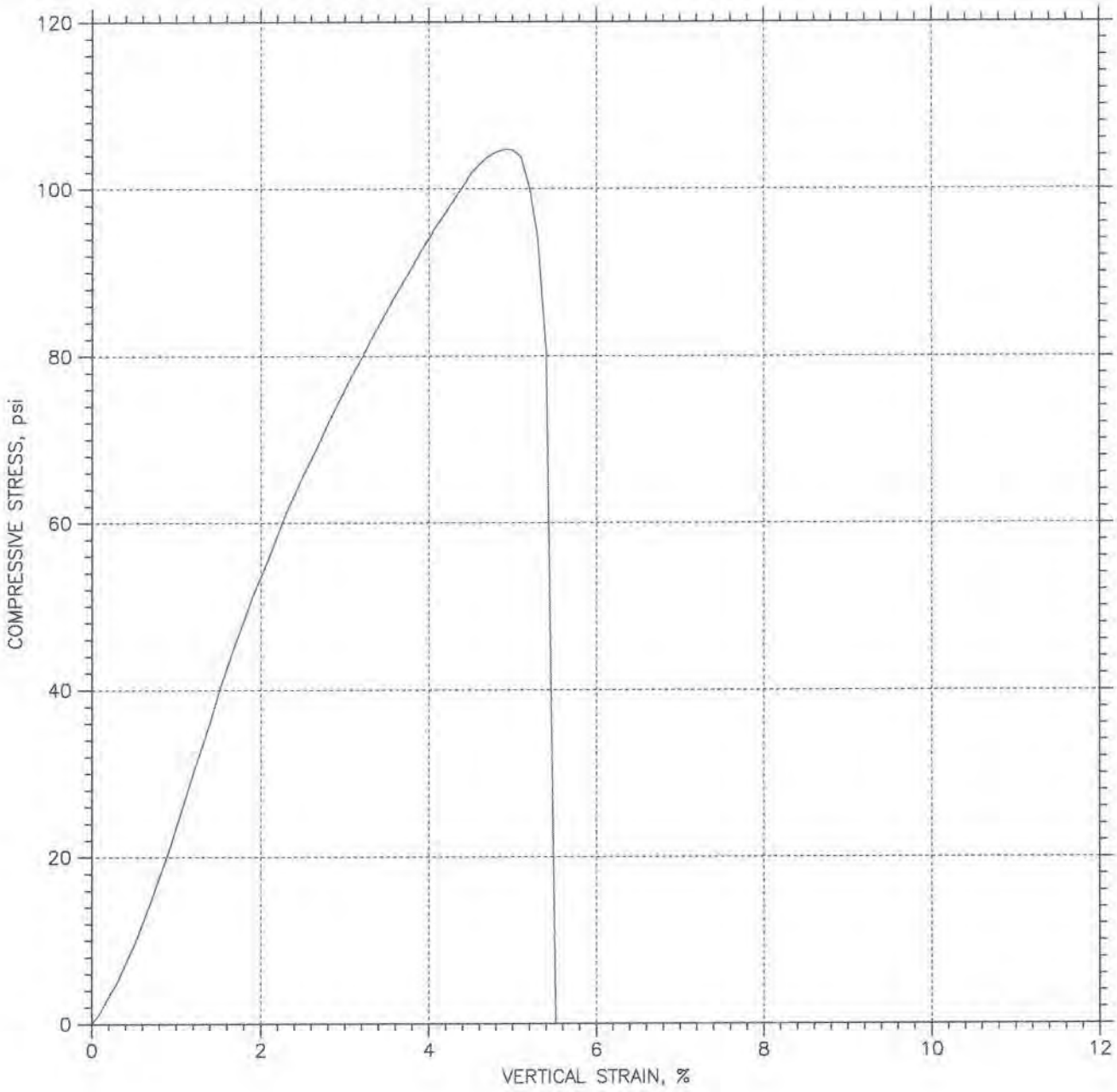


Symbol					
Test No.		UC-55-13			
Initial	Diameter, in	2.852			
	Height, in	5.553			
	Water Content, %	27.26			
	Dry Density, pcf	97.1			
	Saturation, %	102.66			
	Void Ratio	0.704			
Unconfined Compressive Strength, psi		104.7			
Undrained Shear Strength, psi		52.35			
Time to Failure, min		4.7335			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031
Location:
Project No.:
Boring No.: 13
Sample Type: Undisturbed
Description: Total length 24 " Gry Clay, Bottom 2" of Tube Coal. Ran UC on middle
Remarks: portion due to sample broken in several areas of the tube.

FIG. B-60
Sheet 1 of 2

UNCONFINED COMPRESSION TEST REPORT



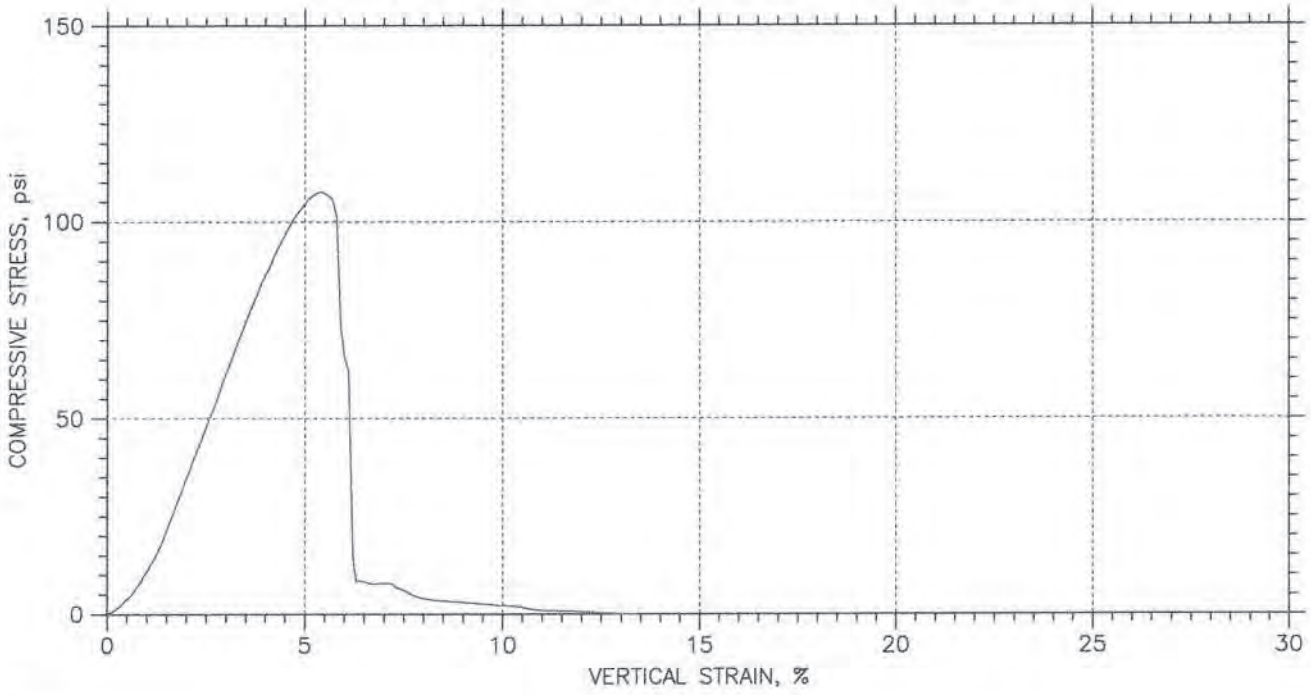
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-498-13	Test Date: 10/23/2013	Depth: 30.0 - 32.0
Test No.: UC-55-13	Sample Type: Undisturbed	Elevation:
Description: Total length 24 " Gry Clay, Bottom 2" of Tube Coal. Ran UC on middle		
Remarks: portion due to sample broken in several areas of the tube.		

FIG. B-60
Sheet 2 of 2

hu, 24-OCT-2013 07:12:35

SS-506-13

UNCONFINED COMPRESSION TEST REPORT

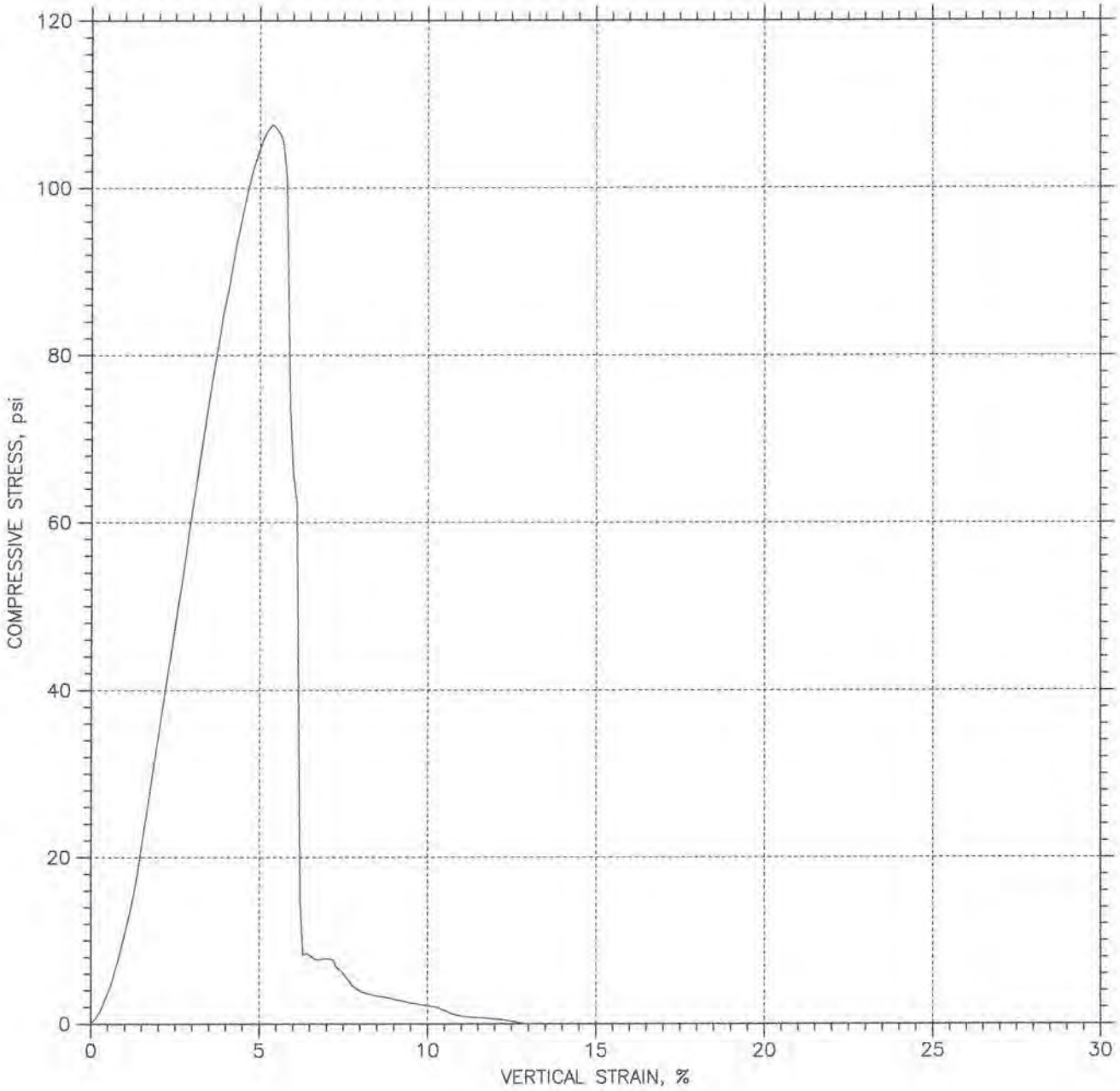


Symbol					
Test No.		UC-56-13			
Initial	Diameter, in	2.854			
	Height, in	5.555			
	Water Content, %	25.30			
	Dry Density, pcf	102.2			
	Saturation, %	108.44			
	Void Ratio	0.618			
Unconfined Compressive Strength, psi		107.5			
Undrained Shear Strength, psi		53.77			
Time to Failure, min		5.2773			
Strain Rate, %/min		1			
Measured Specific Gravity		2.65			
Liquid Limit		0			
Plastic Limit		0			
Plasticity Index		0			
Failure Sketch					

Project: ser-5-094-093-031
Location:
Project No.:
Boring No.: 13
Sample Type: Undisturbed
Description: Total length 25 " Gry Clay Trace Coal Materal was fractrued in
Remarks: various areas. Slickebn - sided

FIG. B-61

UNCONFINED COMPRESSION TEST REPORT



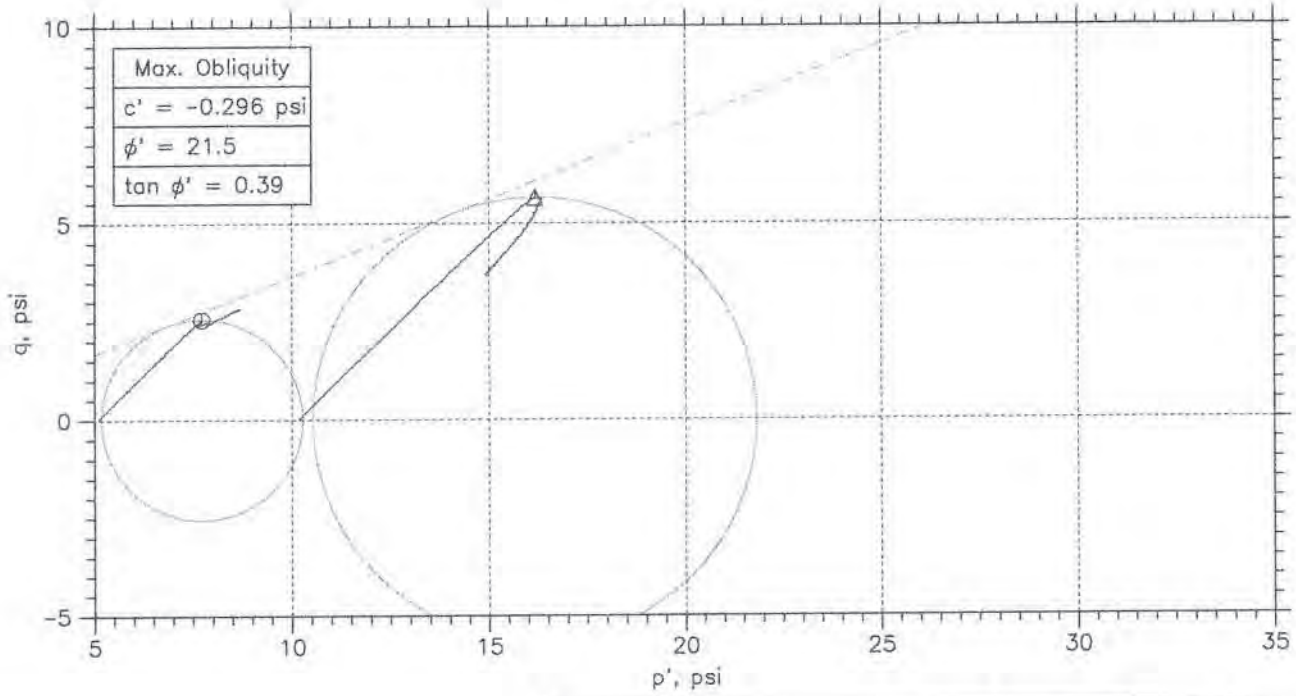
Project: ser-5-094-093-031	Location:	Project No.:
Boring No.: 13	Tested By: DT	Checked By: SS
Sample No.: SS-506-13	Test Date: 10/23/2013	Depth: 50.0 - 52.0
Test No.: UC-56-13	Sample Type: Undisturbed	Elevation:
Description: Total length 25 " Gry Clay Trace Coal Materal was fractrued in		
Remarks: various areas. Slickebn - sided		

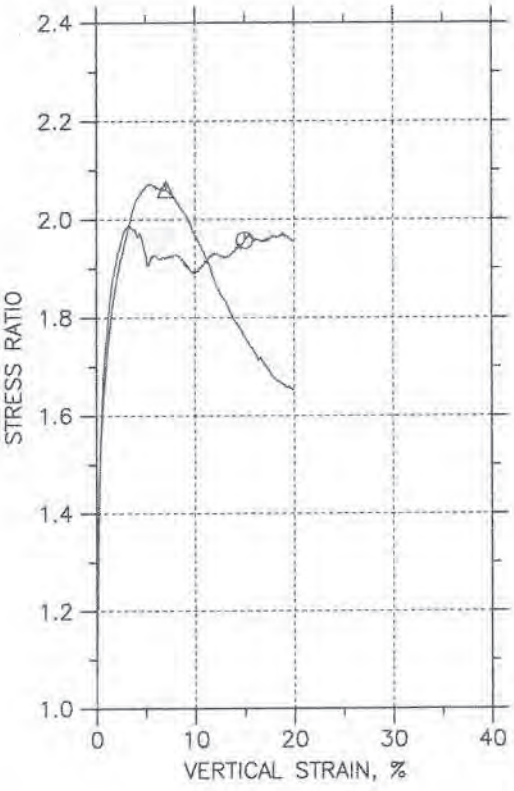
FIG. B-61
Sheet 2 of 2

hu, 24-OCT-2013 07:15:08

SS-490-13

Test File





Symbol		⊙	△		
Sample No.		SS-490-13	SS-490-13		
Test No.		UU-83-13	UU-84-13		
Depth		10.0 - 12.0	10.0 - 12.0		
Initial	Diameter, in	2.71	2.734		
	Height, in	5.619	5.646		
	Water Content, %	39.7	34.4		
	Dry Density, pcf	79.1	83.75		
	Saturation, %	96.4	93.5		
	Void Ratio	1.09	0.975		
Before Shear	Water Content, %	39.7	34.4		
	Dry Density, pcf	79.11	83.74		
	Saturation*, %	96.4	93.4		
	Void Ratio	1.09	0.976		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		5.086	10.16		
Shear Strength, psi		2.74	5.651		
Strain at Failure, %		15	7.07		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031

Location:

Project No.:

Boring No.: B13

Sample Type:

Description: Total length 17' Top 5" brn silty clay - Disturbed, remaining sample

Remarks: Blk, Dark Brn clay.

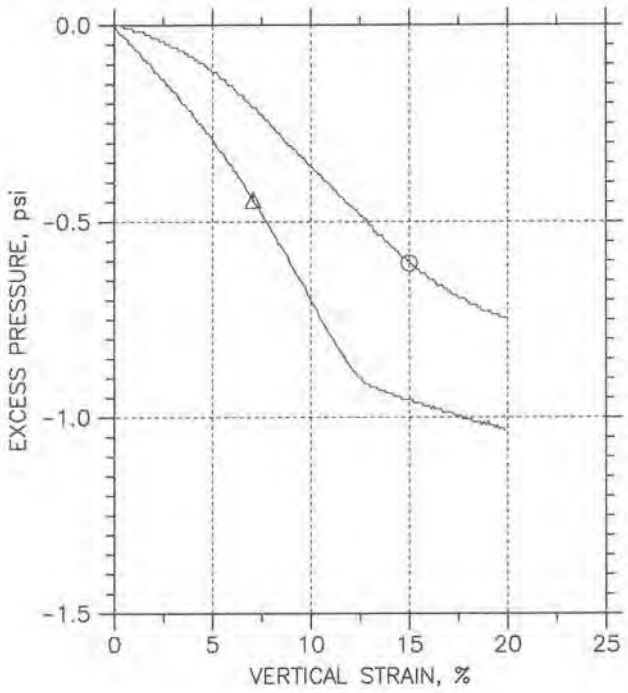
Phase calculations based on start and end of test.

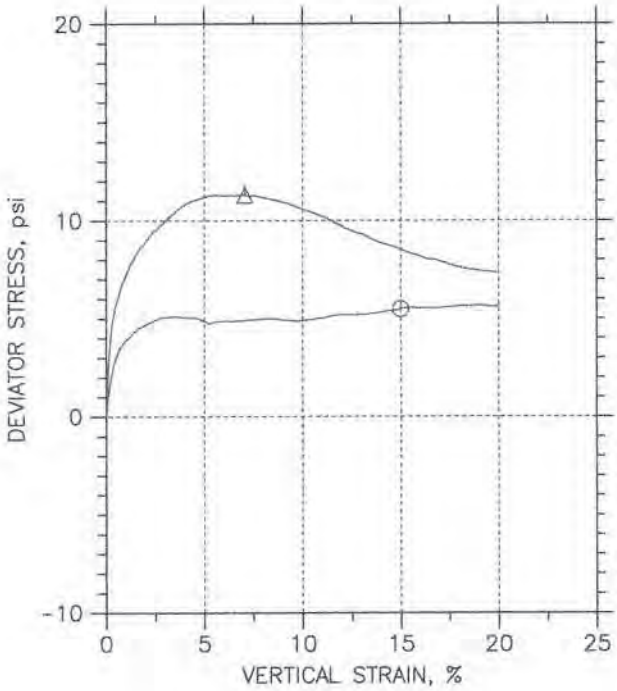
* Saturation is set to 100% for phase calculations.

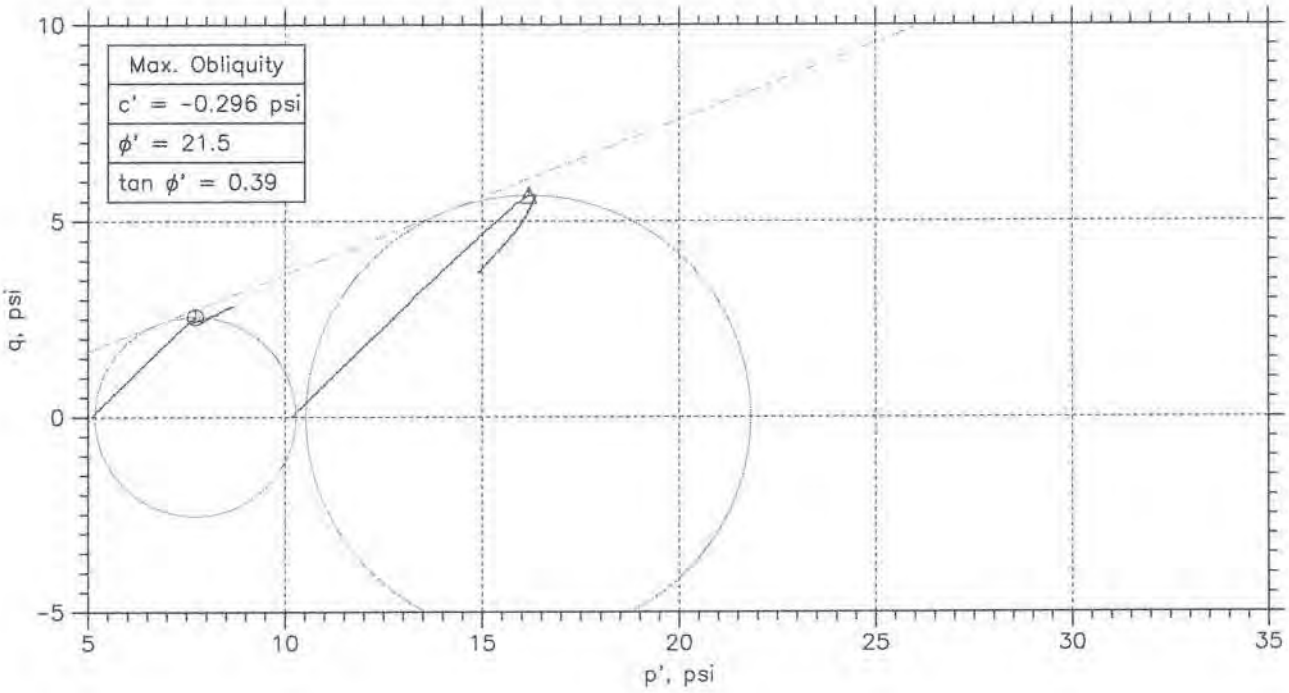
Tue, 22-OCT-2013 07:19:52

FIG. B-62

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-490-13	UU-83-13	10.0 - 12.0	DT	10/21/13	SS		UU-83-2013.dat
△	SS-490-13	UU-84-13	10.0 - 12.0	DT	10/21/13	SS		UU-84-2013.dat

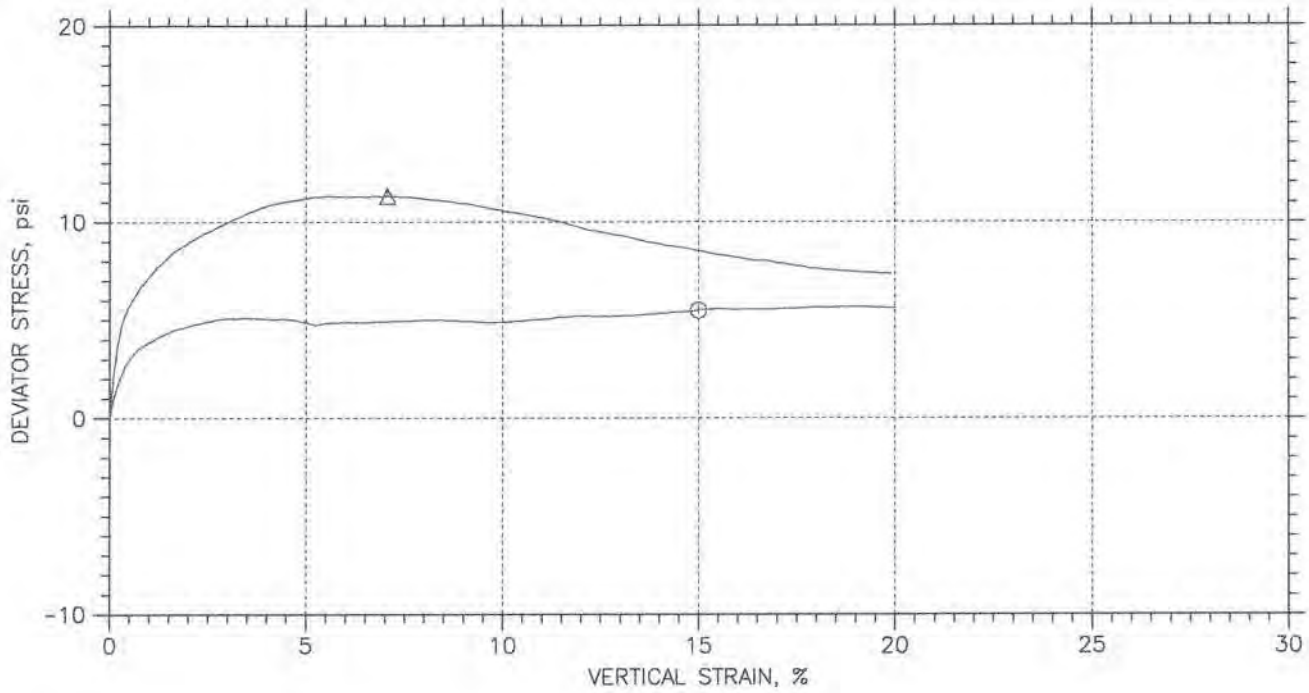
NDDOT North Dakota Department of Transportation

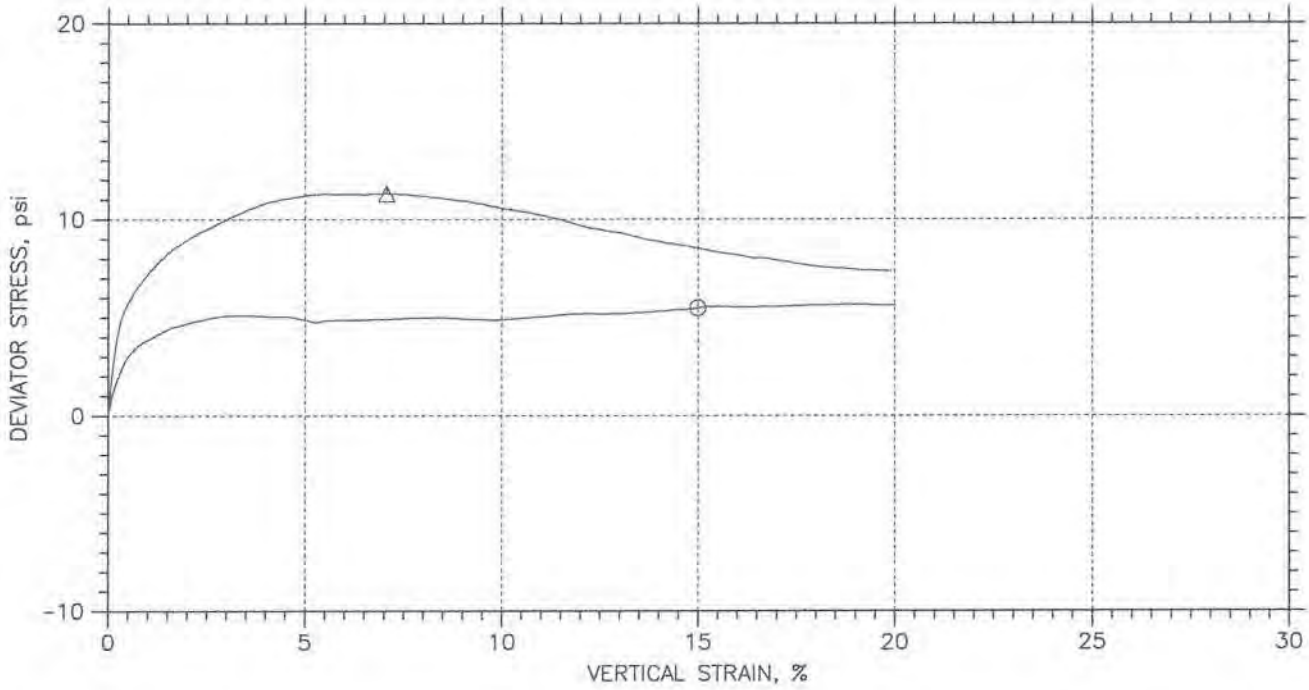
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 17' Top 5" brn silty clay - Disturbed, remaining sample		
Remarks: Blk, Dark Brn clay.		

FIG. B-62

Tue, 22-OCT-2013 07:19:52

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	SS-490-13	UU-83-13	10.0 - 12.0	DT	10/21/13	SS		UU-83-2013.dat
△	SS-490-13	UU-84-13	10.0 - 12.0	DT	10/21/13	SS		UU-84-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 17' Top 5'' brn silty clay - Disturbed, remaining sample		
Remarks: Blk, Dark Brn clay.		

FIG. B-62

Tue, 22-OCT-2013 07:19:52

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B13
Sample No.: SS-490-13
Test No.: UU-83-13

Location:
Tested By: DT
Test Date: 10/21/13
Sample Type:

Project No.:
Checked By: SS
Depth: 10.0 - 12.0
Elevation:

Soil Description: Total length 17' Top 5'' brn silty clay - Disturbed, remaining sample
Remarks: Blk, Dark Brn clay.

Specimen Height: 5.62 in
Specimen Area: 5.77 in^2
Specimen Volume: 531.12 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Estimated Specific Gravity: 2.65

Liquid Limit: ---

Plastic Limit: ---

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s27	---		0
Wt. Container + Wet Soil, gm	60.59	---	---	0
Wt. Container + Dry Soil, gm	48.19	---	---	0
Wt. Container, gm	16.96	---	---	0
Wt. Wet Soil, gm	43.63	940.18	672.97	0
Wt. Dry Soil, gm	31.23	672.97	672.97	0
Wt. Water, gm	12.4	267.21	0	0.00
Water Content, %	39.71	39.71	0.00	---
Void Ratio	---	1.09	1.09	---
Degree of Saturation, %	---	96.41	0.00	---
Dry Unit Weight, pcf	---	79.102	79.106	---

Initial

Height: 5.619 in
Area: 5.768 in^2
Volume: 531.12 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.102 pcf
Saturation: 96.41 %

End of Initialization
Time: 6.9218 min
Total Vertical Stress: 5.0864 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 5.0864 psi
Effective Horizontal Stress: 5.094 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 0 cc

Height: 5.6189 in
Area: 5.768 in^2
Volume: 531.09 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 96.42 %

End of Consolidation/A
Time: 6.9218 min
Total Vertical Stress: 5.0864 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 5.0864 psi
Effective Horizontal Stress: 5.094 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 0 cc

Height: 5.6189 in
Area: 5.768 in^2
Volume: 531.09 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 96.42 %

End of Saturation
Time: 6.9218 min
Total Vertical Stress: 5.0864 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 5.0864 psi
Effective Horizontal Stress: 5.094 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 0 cc

Height: 5.6189 in
Area: 5.768 in^2
Volume: 531.09 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 96.42 %

End of Consolidation/B
Time: 6.9218 min
Total Vertical Stress: 5.0864 psi
Total Horizontal Stress: 5.094 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 5.0864 psi
Effective Horizontal Stress: 5.094 psi

Height Change: 9.2444e-005 in
Area Change: 0 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 0 cc

Height: 5.6189 in
Area: 5.768 in^2
Volume: 531.09 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 96.42 %

End of Shear
Time: 27.145 min
Total Vertical Stress: 10.733 psi
Total Horizontal Stress: 5.1262 psi
Pore Pressure: -0.74471 psi
Effective Vertical Stress: 11.478 psi
Effective Horizontal Stress: 5.871 psi

Height Change: 1.1242 in
Area Change: -1.4423 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 267.21 cc

Height: 4.4948 in
Area: 7.2104 in^2
Volume: 531.09 cc

Moisture: 0.00 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 0.00 %

At Failure
Time: 22.062 min
Total Vertical Stress: 10.599 psi
Total Horizontal Stress: 5.1185 psi
Pore Pressure: -0.60679 psi
Effective Vertical Stress: 11.206 psi
Effective Horizontal Stress: 5.7253 psi

Height Change: 0.84293 in
Area Change: -1.018 in^2
Volume Change: 0.026214 cc
Water Change: 0.0010726 cc
Correction: 0 cc

Height: 4.7761 in
Area: 6.786 in^2
Volume: 531.09 cc

Moisture: 39.71 %
Void Ratio: 1.09
Dry Unit Weight: 79.106 pcf
Saturation: 96.42 %

FIG. B-62
Sheet 4 of 5

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B13
Sample No.: SS-490-13
Test No.: UU-84-13

Location:
Tested By: DT
Test Date: 10/21/13
Sample Type:

Project No.:
Checked By: SS
Depth: 10.0 - 12.0
Elevation:

Soil Description: Total length 17' Top 5'' brn silty clay - Disturbed, remaining sample
Remarks: Blk, Dark Brn clay. Trace organic

Specimen Height: 5.65 in
Specimen Area: 5.87 in^2
Specimen Volume: 543.16 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s3	---		
Wt. Container + Wet Soil, gm	56.64	---	---	0
Wt. Container + Dry Soil, gm	46.6	---	---	0
Wt. Container, gm	17.41	---	---	0
Wt. Wet Soil, gm	39.23	979.35	728.71	0
Wt. Dry Soil, gm	29.19	728.71	728.71	0
Wt. Water, gm	10.04	250.64	0	0
Water Content, %	34.40	34.40	0.00	0.00
Void Ratio	---	0.98	0.98	---
Degree of Saturation, %	---	93.46	0.00	---
Dry Unit Weight, pcf	---	83.754	83.735	---

Initial

Height: 5.646 in
Area: 5.8707 in^2
Volume: 543.16 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.754 pcf
Saturation: 93.46 %

End of Initialization
Time: 8.8488 min
Total Vertical Stress: 10.163 psi
Total Horizontal Stress: 10.164 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.163 psi
Effective Horizontal Stress: 10.164 psi

Height Change: -0.000416 in
Area Change: 0 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 0 cc

Height: 5.6464 in
Area: 5.8707 in^2
Volume: 543.28 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 93.43 %

End of Consolidation/A
Time: 8.8488 min
Total Vertical Stress: 10.163 psi
Total Horizontal Stress: 10.164 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.163 psi
Effective Horizontal Stress: 10.164 psi

Height Change: -0.000416 in
Area Change: 0 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 0 cc

Height: 5.6464 in
Area: 5.8707 in^2
Volume: 543.28 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 93.43 %

End of Saturation
Time: 8.8488 min
Total Vertical Stress: 10.163 psi
Total Horizontal Stress: 10.164 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.163 psi
Effective Horizontal Stress: 10.164 psi

Height Change: -0.000416 in
Area Change: 0 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 0 cc

Height: 5.6464 in
Area: 5.8707 in^2
Volume: 543.28 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 93.43 %

End of Consolidation/B
Time: 8.8488 min
Total Vertical Stress: 10.163 psi
Total Horizontal Stress: 10.164 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 10.163 psi
Effective Horizontal Stress: 10.164 psi

Height Change: -0.000416 in
Area Change: 0 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 0 cc

Height: 5.6464 in
Area: 5.8707 in^2
Volume: 543.28 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 93.43 %

End of Shear
Time: 29.05 min
Total Vertical Stress: 17.584 psi
Total Horizontal Stress: 10.236 psi
Pore Pressure: -1.0361 psi
Effective Vertical Stress: 18.62 psi
Effective Horizontal Stress: 11.272 psi

Height Change: 1.1238 in
Area Change: -1.4604 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 250.66 cc

Height: 4.5222 in
Area: 7.3311 in^2
Volume: 543.28 cc

Moisture: 0.00 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 0.00 %

At Failure
Time: 16.042 min
Total Vertical Stress: 21.506 psi
Total Horizontal Stress: 10.204 psi
Pore Pressure: -0.4452 psi
Effective Vertical Stress: 21.951 psi
Effective Horizontal Stress: 10.649 psi

Height Change: 0.39876 in
Area Change: -0.44633 in^2
Volume Change: -0.12006 cc
Water Change: -0.016625 cc
Correction: 0 cc

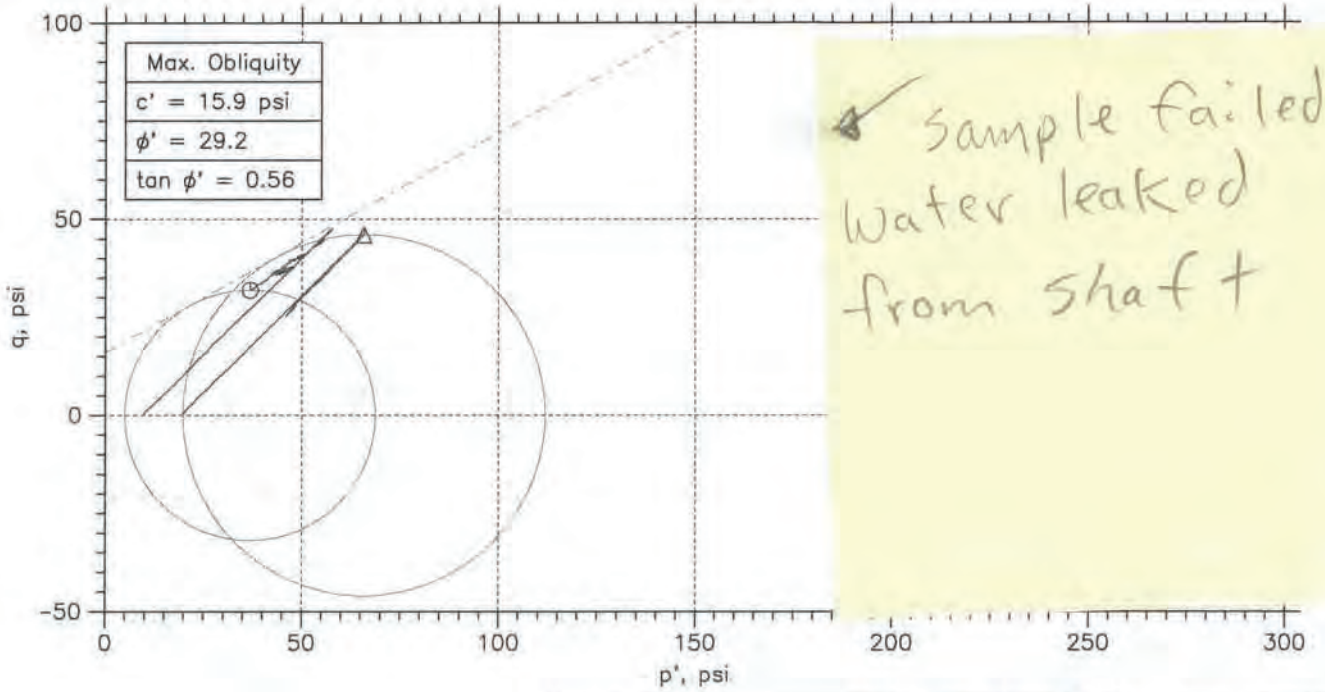
Height: 5.2472 in
Area: 6.317 in^2
Volume: 543.28 cc

Moisture: 34.40 %
Void Ratio: 0.98
Dry Unit Weight: 83.735 pcf
Saturation: 93.43 %

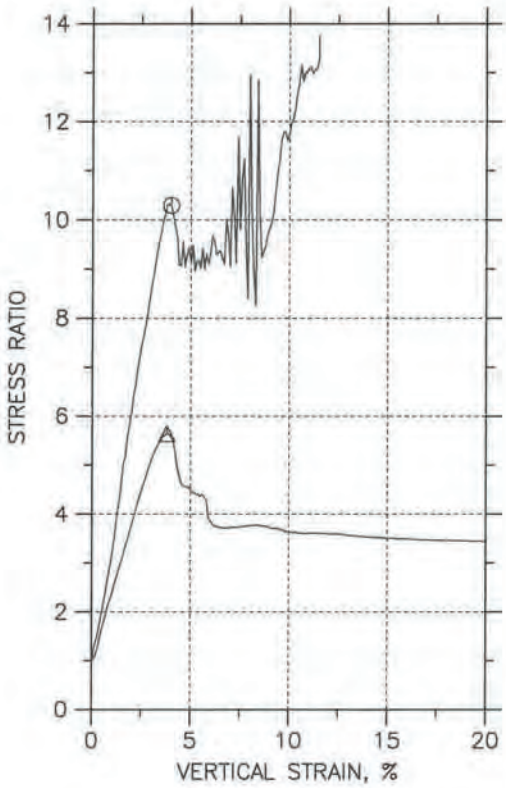
FIG. B-62
Sheet 5 of 5

SS-494-13

Test File



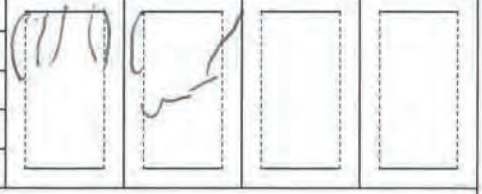
Sample failed
Water leaked
from shaft



Symbol		⊙	△		
Sample No.		SS-494-13	SS-494-13		
Test No.		UU-85-13	UU-86-13		
Depth		20.0 - 22.0	20.0 - 22.0		
Initial	Diameter, in	2.845	2.834		
	Height, in	5.632	5.572		
	Water Content, %	18.7	25.5		
	Dry Density, pcf	111.9	101.3		
	Saturation, %	103.7	106.7		
	Void Ratio	0.479	0.632		
Before Shear	Water Content, %	17.9	23.8		
	Dry Density, pcf	112.2	101.4		
	Saturation*, %	100.0	100.0		
	Void Ratio	0.475	0.631		
	Back Press., psi	.0	.0		
Ver. Eff. Cons. Stress, psi		9.673	19.43		
Shear Strength, psi		47.63	46.04		
Strain at Failure, %		4	3.8		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031
Location:
Project No.:
Boring No.: B13
Sample Type:
Description: Total length 26" Gry Clay Trace pebbles
Remarks:



Phase calculations based on start and end of test.
* Saturation is set to 100% for phase calculations.

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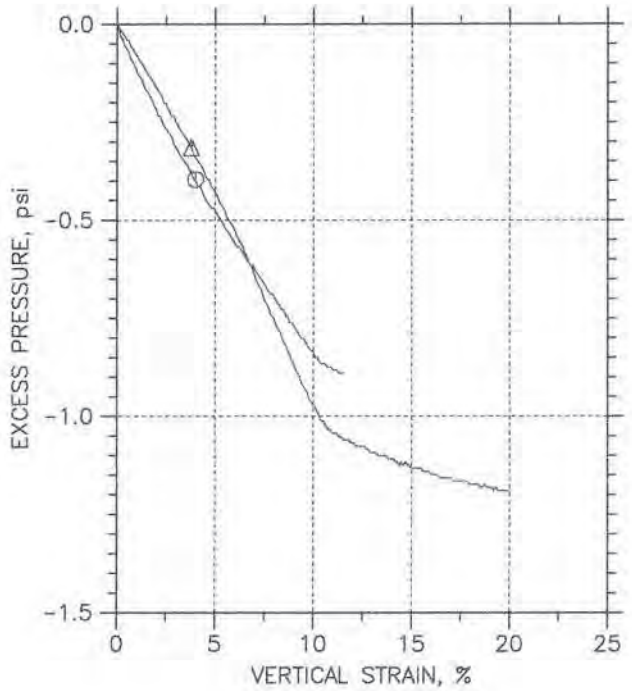
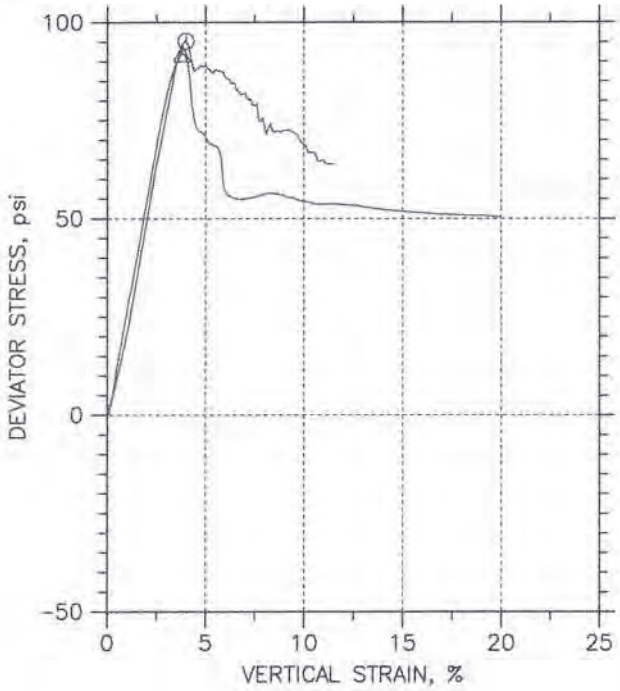
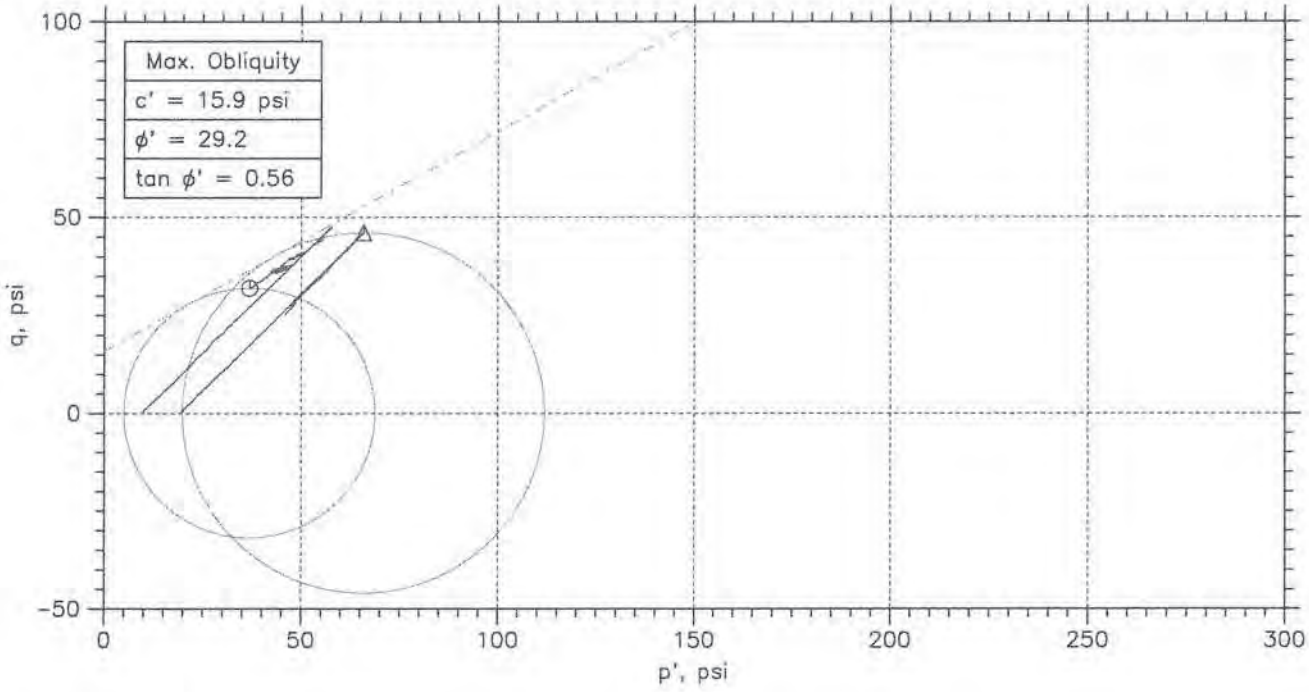
FIG. B-63
Sheet 1 of 5

SS-494-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-494-13	UU-85-13	20.0 - 22.0	DT	10/22/13	SS		UU-85-2013.dat
△	SS-494-13	UU-86-13	20.0 - 22.0	DT	10/22/13	SS		UU-86-2013.dat

NDDOT
North Dakota Department of Transportation

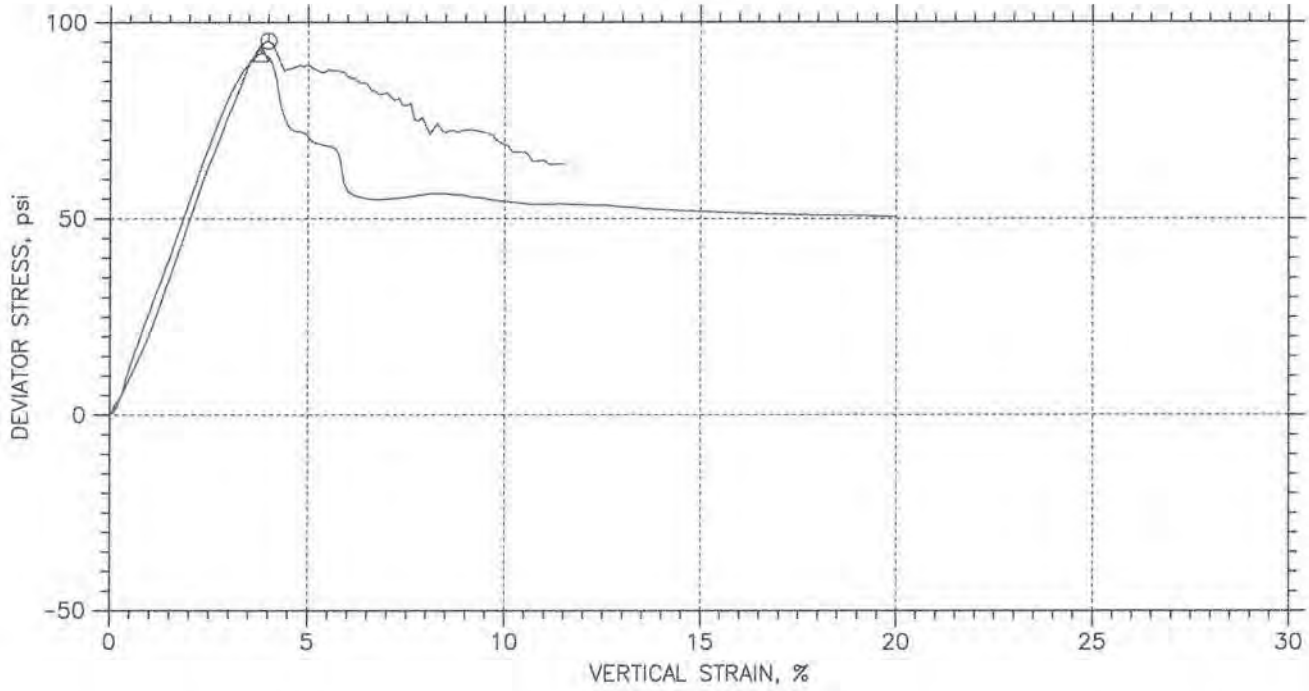
Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 26" Gry Clay Trace pebbles		
Remarks:		

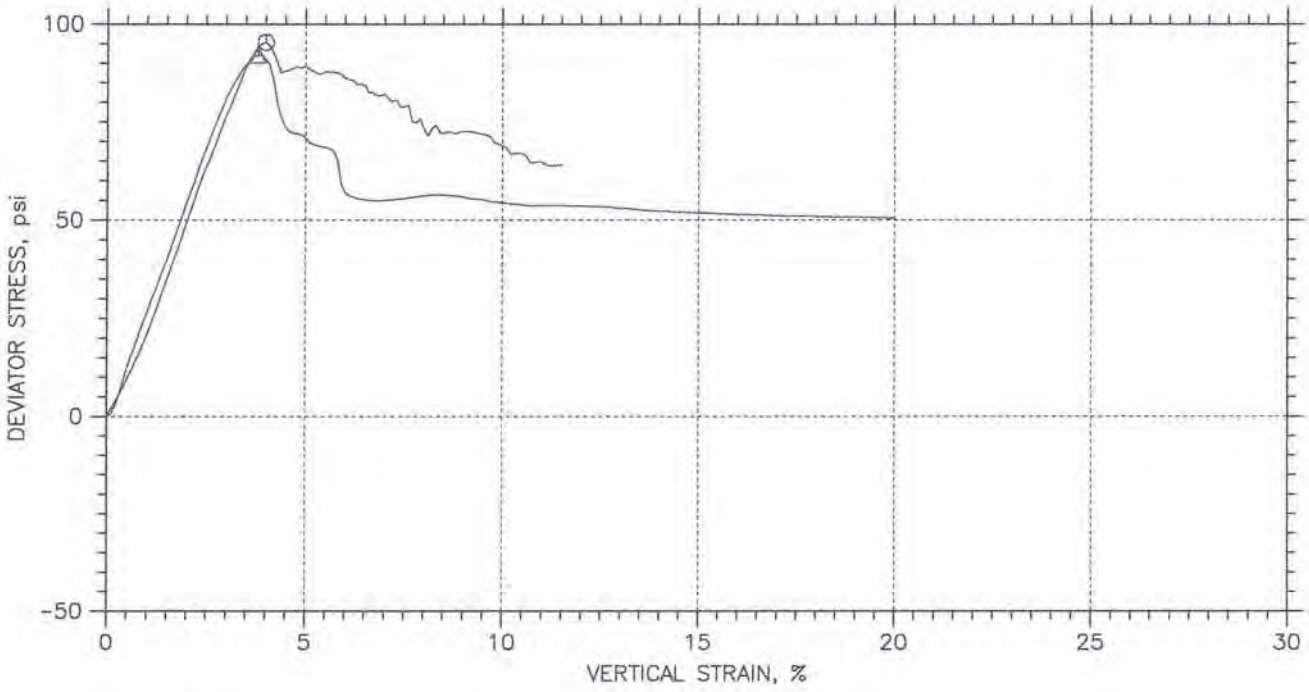
FIG. B-63
Sheet 2 of 5

Wed, 23-OCT-2013 07:39:34

SS-494-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-494-13	UU-85-13	20.0 - 22.0	DT	10/22/13	SS		UU-85-2013.dat
△	SS-494-13	UU-86-13	20.0 - 22.0	DT	10/22/13	SS		UU-86-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 26" Gry Clay Trace pebbles		
Remarks:		

FIG. B-63
Sheet 3 of 5

Wed, 23-OCT-2013 07:39:34

SS-494-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B13
Sample No.: SS-494-13
Test No.: UU-85-13

Location:
Tested By: DT
Test Date: 10/22/13
Sample Type:

Project No.:
Checked By: SS
Depth: 20.0 - 22.0
Elevation:

Soil Description: Total length 26" Gry Clay Trace pebbles
Remarks:

Specimen Height: 5.63 in
Specimen Area: 6.36 in^2
Specimen Volume: 586.70 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s3	---		
Wt. Container + Wet Soil, gm	61.14	---	---	0
Wt. Container + Dry Soil, gm	54.24	---	---	0
Wt. Container, gm	17.41	---	---	0
Wt. Wet Soil, gm	43.73	1248.4	1051.4	0
Wt. Dry Soil, gm	36.83	1051.4	1051.4	0
Wt. Water, gm	6.9	196.98	0	0
Water Content, %	18.73	18.73	0.00	0.00
Void Ratio	---	0.48	0.47	---
Degree of Saturation, %	---	103.71	0.00	---
Dry Unit Weight, pcf	---	111.88	112.17	---

Initial

Height: 5.632 in
Area: 6.357 in^2
Volume: 586.7 cc

Moisture: 18.73 %
Void Ratio: 0.48
Dry Unit Weight: 111.88 pcf
Saturation: 103.71 %

End of Initialization
Time: 4.5837 min
Total Vertical Stress: 9.6734 psi
Total Horizontal Stress: 9.6793 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 9.6734 psi
Effective Horizontal Stress: 9.6793 psi

Height Change: 0.0048996 in
Area Change: 0 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 8.5993 cc

Height: 5.6271 in
Area: 6.357 in^2
Volume: 585.17 cc

Moisture: 17.92 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 4.5837 min
Total Vertical Stress: 9.6734 psi
Total Horizontal Stress: 9.6793 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 9.6734 psi
Effective Horizontal Stress: 9.6793 psi

Height Change: 0.0048996 in
Area Change: 0 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 8.5993 cc

Height: 5.6271 in
Area: 6.357 in^2
Volume: 585.17 cc

Moisture: 17.92 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 100.00 %

End of Saturation
Time: 4.5837 min
Total Vertical Stress: 9.6734 psi
Total Horizontal Stress: 9.6793 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 9.6734 psi
Effective Horizontal Stress: 9.6793 psi

Height Change: 0.0048996 in
Area Change: 0 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 8.5993 cc

Height: 5.6271 in
Area: 6.357 in^2
Volume: 585.17 cc

Moisture: 17.92 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 4.5837 min
Total Vertical Stress: 9.6734 psi
Total Horizontal Stress: 9.6793 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 9.6734 psi
Effective Horizontal Stress: 9.6793 psi

Height Change: 0.0048996 in
Area Change: 0 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 8.5993 cc

Height: 5.6271 in
Area: 6.357 in^2
Volume: 585.17 cc

Moisture: 17.92 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 100.00 %

End of Shear
Time: 16.324 min
Total Vertical Stress: 68.078 psi
Total Horizontal Stress: 4.1171 psi
Pore Pressure: -0.88231 psi
Effective Vertical Stress: 68.96 psi
Effective Horizontal Stress: 4.9995 psi

Height Change: 0.65363 in
Area Change: -0.01587 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 197.01 cc

Height: 4.9784 in
Area: 7.1729 in^2
Volume: 585.17 cc

Moisture: 0.00 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 0.00 %

At Failure
Time: 8.6599 min
Total Vertical Stress: 105.12 psi
Total Horizontal Stress: 9.865 psi
Pore Pressure: -0.38854 psi
Effective Vertical Stress: 105.51 psi
Effective Horizontal Stress: 10.254 psi

Height Change: 0.23 in
Area Change: -0.27093 in^2
Volume Change: 1.5312 cc
Water Change: -0.023597 cc
Correction: 0 cc

Height: 5.402 in
Area: 6.628 in^2
Volume: 585.17 cc

Moisture: 17.92 %
Void Ratio: 0.47
Dry Unit Weight: 112.17 pcf
Saturation: 100.00 %

FIG. B-63
Sheet 4 of 5

SS-494-13

TRIAXIAL TEST

Project: SER-5-094(093)031
Boring No.: B13
Sample No.: SS-494-13
Test No.: UU-86-13

Location:
Tested By: DT
Test Date: 10/22/13
Sample Type:

Project No.:
Checked By: SS
Depth: 20.0 - 22.0
Elevation:

Soil Description: Total length 26" Gry Clay Trace pebbles
Remarks:

Specimen Height: 5.57 in
Specimen Area: 6.31 in^2
Specimen Volume: 575.97 cc

Piston Area: 0.16 in^2
Piston Friction: 0.00 lb
Piston Weight: 0.00 lb

Filter Strip Correction: 0.00 psi
Membrane Correction: 4.20 lb/in
Correction Type: Uniform

Liquid Limit: ---

Plastic Limit: ---

Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s4	---		
Wt. Container + Wet Soil, gm	55.85	---	---	0
Wt. Container + Dry Soil, gm	47.99	---	---	0
Wt. Container, gm	17.11	---	---	0
Wt. Wet Soil, gm	38.74	1173.1	935.06	0
Wt. Dry Soil, gm	30.88	935.06	935.06	0
Wt. Water, gm	7.86	238.01	0	0
Water Content, %	25.45	25.45	0.00	0.00
Void Ratio	---	0.63	0.63	---
Degree of Saturation, %	---	106.67	0.00	---
Dry Unit Weight, pcf	---	101.35	101.42	---

Initial

Height: 5.572 in
Area: 6.308 in^2
Volume: 575.97 cc

Moisture: 25.45 %
Void Ratio: 0.63
Dry Unit Weight: 101.35 pcf
Saturation: 106.67 %

End of Initialization
Time: 11.028 min
Total Vertical Stress: 19.426 psi
Total Horizontal Stress: 19.431 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 19.426 psi
Effective Horizontal Stress: 19.431 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 15.352 cc

Height: 5.5706 in
Area: 6.308 in^2
Volume: 575.54 cc

Moisture: 23.82 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 100.00 %

End of Consolidation/A
Time: 11.028 min
Total Vertical Stress: 19.426 psi
Total Horizontal Stress: 19.431 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 19.426 psi
Effective Horizontal Stress: 19.431 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 15.352 cc

Height: 5.5706 in
Area: 6.308 in^2
Volume: 575.54 cc

Moisture: 23.82 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 100.00 %

End of Saturation
Time: 11.028 min
Total Vertical Stress: 19.426 psi
Total Horizontal Stress: 19.431 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 19.426 psi
Effective Horizontal Stress: 19.431 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 15.352 cc

Height: 5.5706 in
Area: 6.308 in^2
Volume: 575.54 cc

Moisture: 23.82 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 100.00 %

End of Consolidation/B
Time: 11.028 min
Total Vertical Stress: 19.426 psi
Total Horizontal Stress: 19.431 psi
Pore Pressure: 0 psi
Effective Vertical Stress: 19.426 psi
Effective Horizontal Stress: 19.431 psi

Height Change: 0.0013867 in
Area Change: 0 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 15.352 cc

Height: 5.5706 in
Area: 6.308 in^2
Volume: 575.54 cc

Moisture: 23.82 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 100.00 %

End of Shear
Time: 31.264 min
Total Vertical Stress: 70.042 psi
Total Horizontal Stress: 19.552 psi
Pore Pressure: -1.1899 psi
Effective Vertical Stress: 71.232 psi
Effective Horizontal Stress: 20.742 psi

Height Change: 1.1155 in
Area Change: -1.5731 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 238.04 cc

Height: 4.4565 in
Area: 7.8811 in^2
Volume: 575.54 cc

Moisture: 0.00 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 0.00 %

At Failure
Time: 14.928 min
Total Vertical Stress: 111.58 psi
Total Horizontal Stress: 19.512 psi
Pore Pressure: -0.31569 psi
Effective Vertical Stress: 111.9 psi
Effective Horizontal Stress: 19.828 psi

Height Change: 0.21318 in
Area Change: -0.25133 in^2
Volume Change: 0.43002 cc
Water Change: -0.034323 cc
Correction: 0 cc

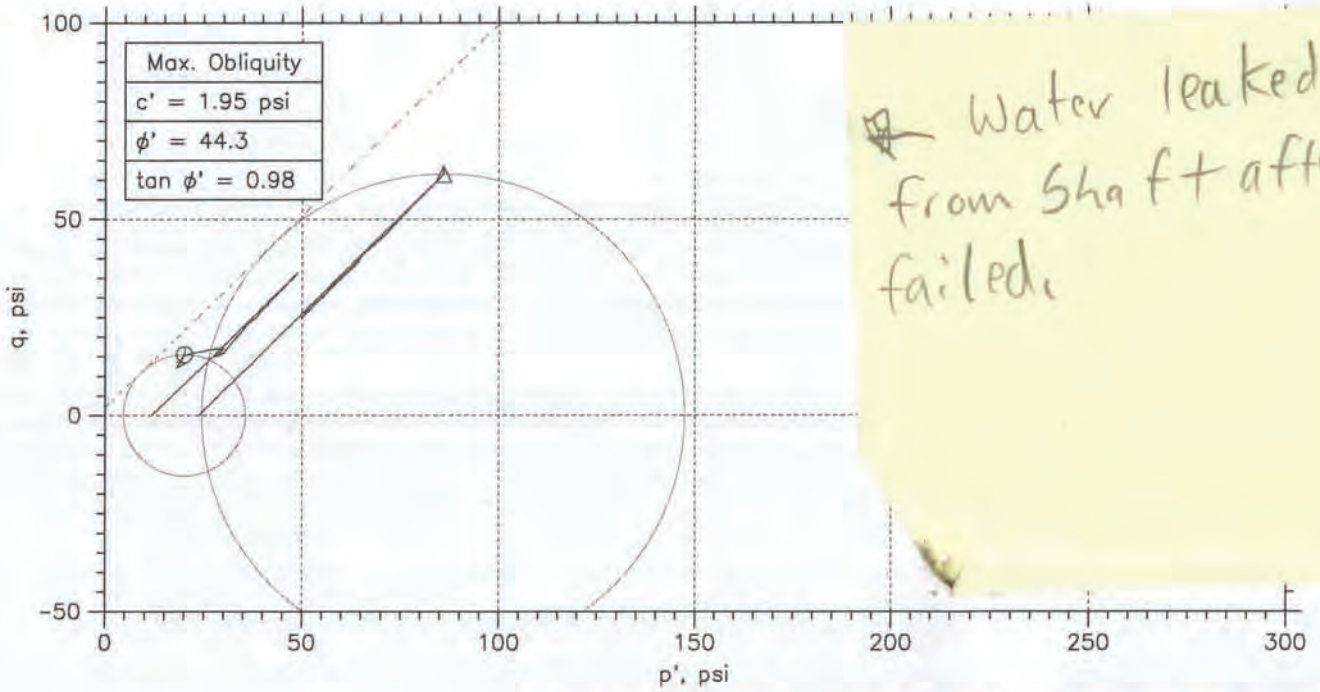
Height: 5.3588 in
Area: 6.5593 in^2
Volume: 575.54 cc

Moisture: 23.82 %
Void Ratio: 0.63
Dry Unit Weight: 101.42 pcf
Saturation: 100.00 %

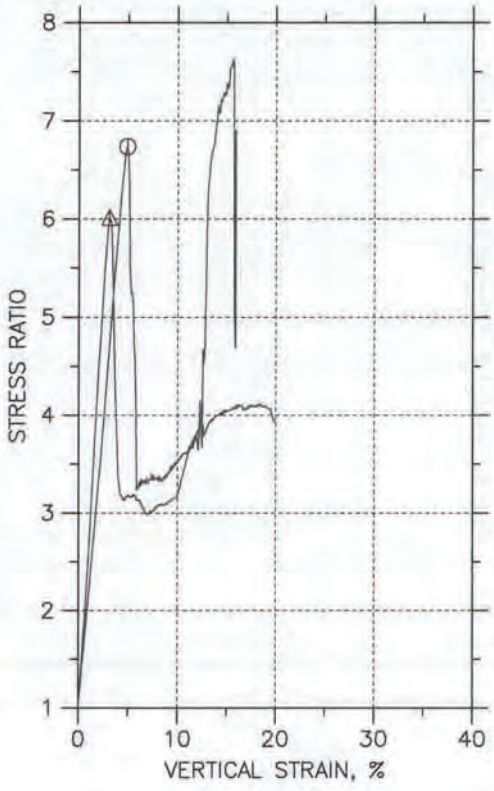
FIG. B-63
Sheet 5 of 5

SS-496-13

Test File



* Water leaked from Shaft after failed.



Symbol		⊙	△		
Sample No.		SS-496-13	SS-496-13		
Test No.		UU-87-13	UU-88-13		
Depth		25.0 - 27.0	25.0 - 27.0		
Initial	Diameter, in	2.843	2.827		
	Height, in	5.542	5.587		
	Water Content, %	24.7	24.9		
	Dry Density, pcf	99.54	101.5		
	Saturation, %	99.0	104.7		
	Void Ratio	0.662	0.63		
Before Shear	Water Content, %	24.7	23.4		
	Dry Density, pcf	99.6	102.1		
	Saturation*, %	99.2	100.0		
	Void Ratio	0.661	0.62		
	Back Press., psi	.0	-.008095		
Ver. Eff. Cons. Stress, psi		11.98	24.01		
Shear Strength, psi		36.32	61.46		
Strain at Failure, %		4.9	3.1		
Strain Rate, %/min		1	1		
B-Value		---	---		
Estimated Specific Gravity		2.65	2.65		
Liquid Limit		---	---		
Plastic Limit		---	---		

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Project: SER-5-094(093)031

Location:

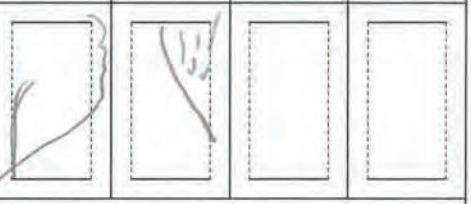
Project No.:

Boring No.: B13

Sample Type:

Description: Total length 25" w/ 2" Disturbed Gry Clay Fractured in many areas

Remarks:



Phase calculations based on start and end of test.

* Saturation is set to 100% for phase calculations.

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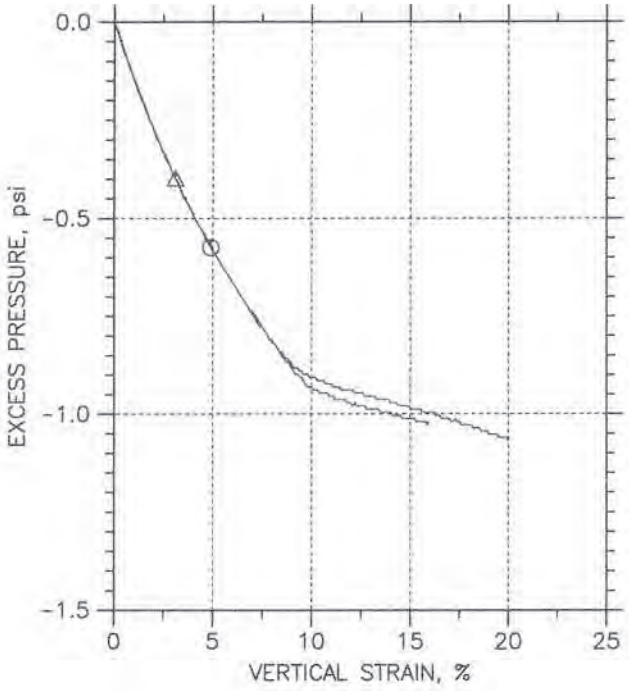
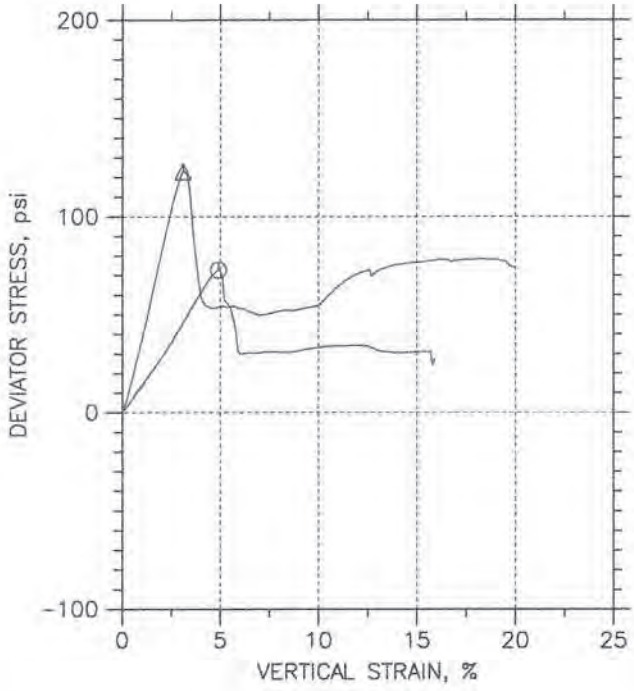
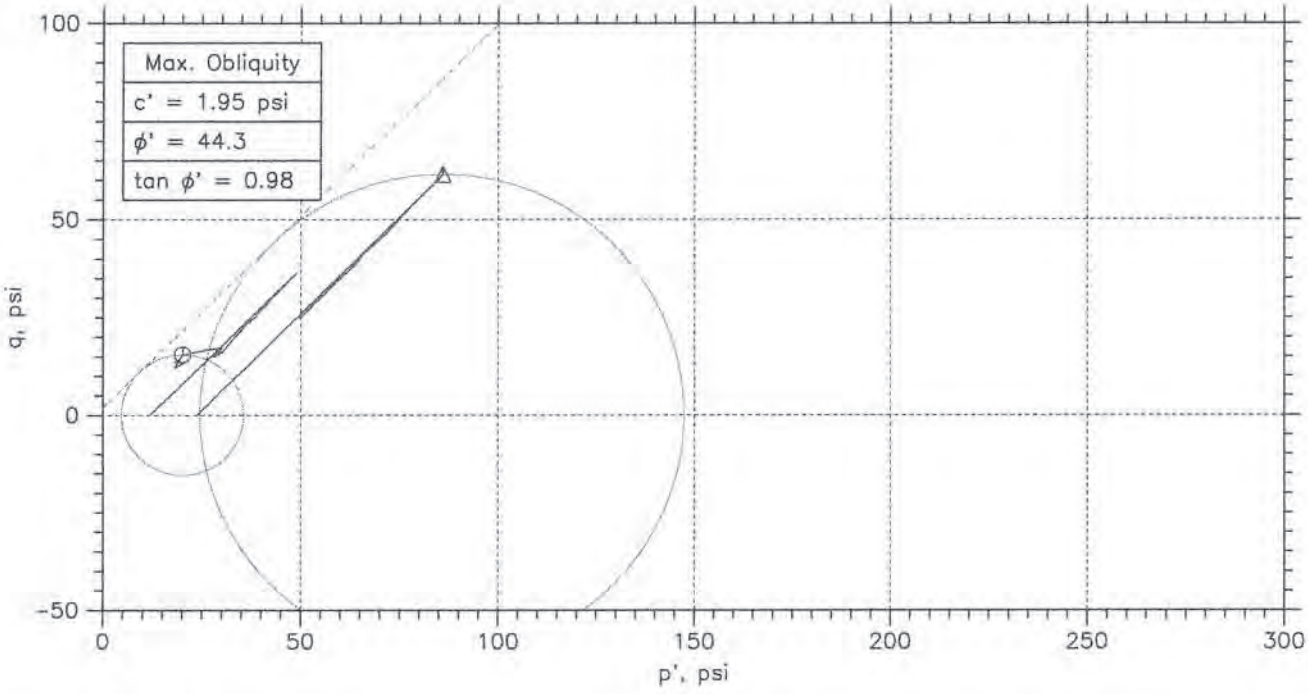
FIG. B-64

SS-496-13

Test File







	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊙	SS-496-13	UU-87-13	25.0 - 27.0	DT	10/22/13	SS		UU-87-2013.dat
△	SS-496-13	UU-88-13	25.0 - 27.0	DT	10/22/13	SS		UU-88-2013.dat

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Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 25" w/ 2" Disturbed Gry Clay Fractured in many areas		
Remarks:		

FIG. B-64
Sheet 2 of 5

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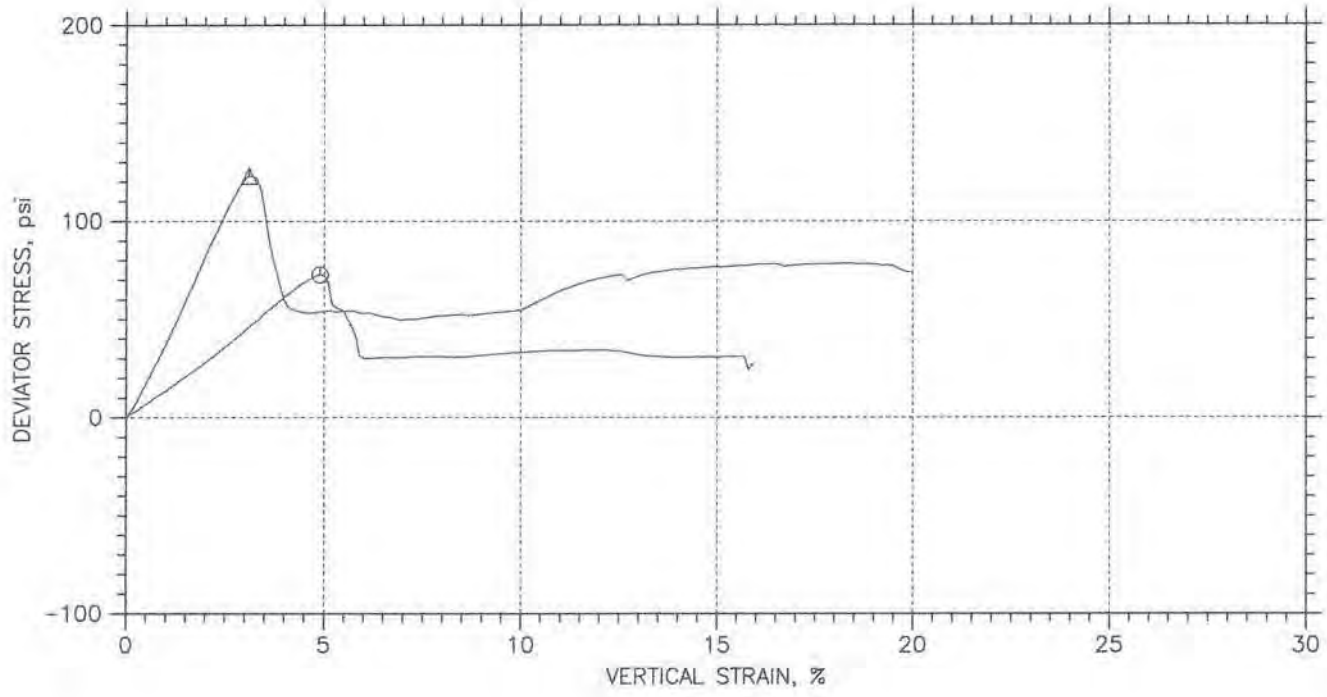
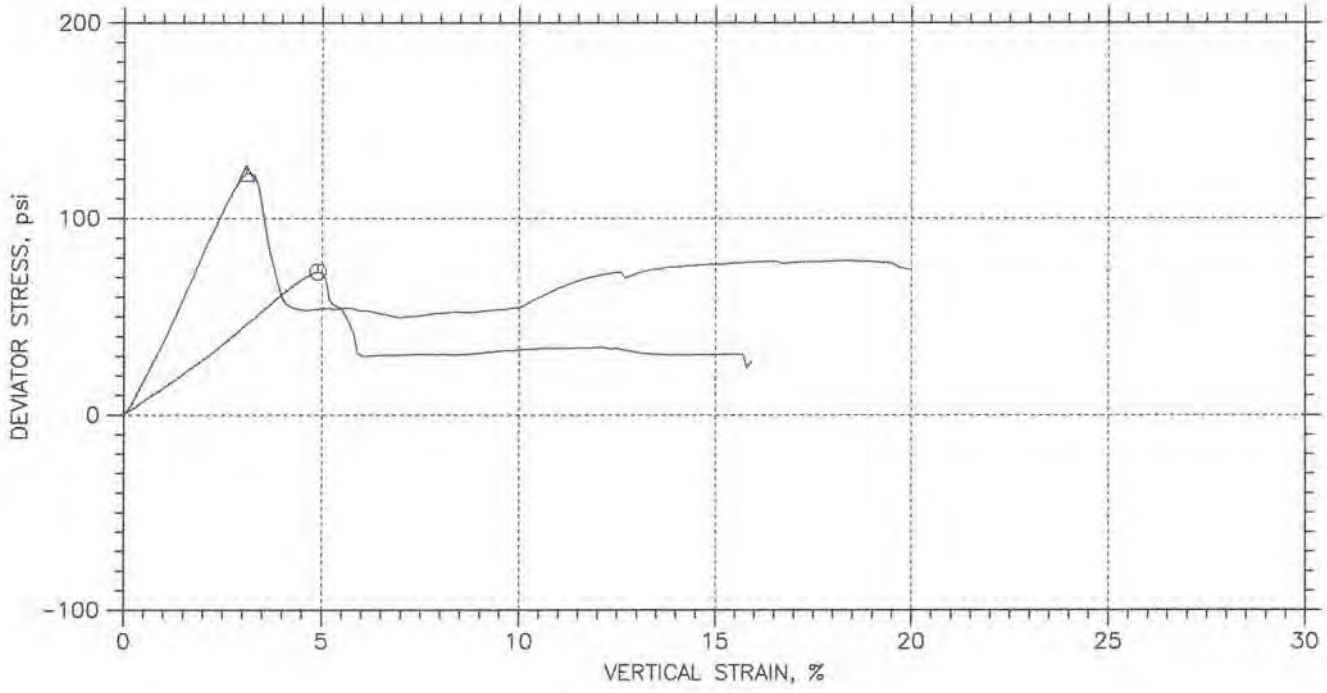
SS-496-13

Test File





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⏲	SS-496-13	UU-87-13	25.0 - 27.0	DT	10/22/13	SS		UU-87-2013.dat
△	SS-496-13	UU-88-13	25.0 - 27.0	DT	10/22/13	SS		UU-88-2013.dat

NDDOT North Dakota Department of Transportation

Project: SER-5-094(093)031	Location:	Project No.:
Boring No.: B13	Sample Type:	
Description: Total length 25" w/ 2" Disturbed Gry Clay Fractured in many areas		
Remarks:		

FIG. B-64

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SS-496-13

TRIAXIAL TEST

Project: SER-5-094(093)031 | Location: | Project No.:
Boring No.: B13 | Tested By: DT | Checked By: SS
Sample No.: SS-496-13 | Test Date: 10/22/13 | Depth: 25.0 - 27.0
Test No.: UU-87-13 | Sample Type: | Elevation:

Soil Description: Total length 25'' w/ 2'' Disturbed Gry Clay Fractured in many areas
Remarks:

Specimen Height: 5.54 in | Piston Area: 0.16 in^2 | Filter Strip Correction: 0.00 psi
Specimen Area: 6.35 in^2 | Piston Friction: 0.00 lb | Membrane Correction: 4.20 lb/in
Specimen Volume: 576.52 cc | Piston Weight: 0.00 lb | Correction Type: Uniform

Liquid Limit: --- | Plastic Limit: --- | Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s42	---		
Wt. Container + Wet Soil, gm	53.64	---	---	0
Wt. Container + Dry Soil, gm	46.38	---	---	0
Wt. Container, gm	17.04	---	---	0
Wt. Wet Soil, gm	36.6	1146.7	919.22	0
Wt. Dry Soil, gm	29.34	919.22	919.22	0
Wt. Water, gm	7.26	227.45	-1.1642e-013	0
Water Content, %	24.74	24.74	-0.00	0.00
Void Ratio	---	0.66	0.66	---
Degree of Saturation, %	---	99.05	-0.00	---
Dry Unit Weight, pcf	---	99.537	99.604	---

Initial
Height: 5.542 in | Moisture: 24.74 %
Area: 6.3481 in^2 | Void Ratio: 0.66
Volume: 576.52 cc | Dry Unit Weight: 99.537 pcf
Saturation: 99.05 %

End of Initialization
Time: 1.892 min
Total Vertical Stress: 11.977 psi | Height Change: 0.001248 in | Height: 5.5408 in | Moisture: 24.75 %
Total Horizontal Stress: 11.988 psi | Area Change: 0 in^2 | Area: 6.3481 in^2 | Void Ratio: 0.66
Pore Pressure: 0 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 11.977 psi | Water Change: -0.0091171 cc | Saturation: 99.22 %
Effective Horizontal Stress: 11.988 psi | Correction: 0 cc

End of Consolidation/A
Time: 1.892 min
Total Vertical Stress: 11.977 psi | Height Change: 0.001248 in | Height: 5.5408 in | Moisture: 24.75 %
Total Horizontal Stress: 11.988 psi | Area Change: 0 in^2 | Area: 6.3481 in^2 | Void Ratio: 0.66
Pore Pressure: 0 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 11.977 psi | Water Change: -0.0091171 cc | Saturation: 99.22 %
Effective Horizontal Stress: 11.988 psi | Correction: 0 cc

End of Saturation
Time: 1.892 min
Total Vertical Stress: 11.977 psi | Height Change: 0.001248 in | Height: 5.5408 in | Moisture: 24.75 %
Total Horizontal Stress: 11.988 psi | Area Change: 0 in^2 | Area: 6.3481 in^2 | Void Ratio: 0.66
Pore Pressure: 0 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 11.977 psi | Water Change: -0.0091171 cc | Saturation: 99.22 %
Effective Horizontal Stress: 11.988 psi | Correction: 0 cc

End of Consolidation/B
Time: 1.892 min
Total Vertical Stress: 11.977 psi | Height Change: 0.001248 in | Height: 5.5408 in | Moisture: 24.75 %
Total Horizontal Stress: 11.988 psi | Area Change: 0 in^2 | Area: 6.3481 in^2 | Void Ratio: 0.66
Pore Pressure: 0 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 11.977 psi | Water Change: -0.0091171 cc | Saturation: 99.22 %
Effective Horizontal Stress: 11.988 psi | Correction: 0 cc

End of Shear
Time: 18.635 min
Total Vertical Stress: 30.816 psi | Height Change: 0.88446 in | Height: 4.6575 in | Moisture: -0.00 %
Total Horizontal Stress: 3.5924 psi | Area Change: -1.2004 in^2 | Area: 7.5485 in^2 | Void Ratio: 0.66
Pore Pressure: -1.0199 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 31.836 psi | Water Change: -0.0091171 cc | Saturation: -0.00 %
Effective Horizontal Stress: 4.6123 psi | Correction: 227.46 cc

At Failure
Time: 6.9141 min
Total Vertical Stress: 84.717 psi | Height Change: 0.2728 in | Height: 5.2692 in | Moisture: 24.75 %
Total Horizontal Stress: 12.085 psi | Area Change: -0.32877 in^2 | Area: 6.6769 in^2 | Void Ratio: 0.66
Pore Pressure: -0.57472 psi | Volume Change: 0.38948 cc | Volume: 576.13 cc | Dry Unit Weight: 99.604 pcf
Effective Vertical Stress: 85.292 psi | Water Change: -0.0091171 cc | Saturation: 99.22 %
Effective Horizontal Stress: 12.66 psi | Correction: 0 cc

FIG. B-64
Sheet 4 of 5

SS-496-13

TRIAXIAL TEST

Project: SER-5-094(093)031 | Location: | Project No.:
Boring No.: B13 | Tested By: DT | Checked By: SS
Sample No.: SS-496-13 | Test Date: 10/22/13 | Depth: 25.0 - 27.0
Test No.: UU-88-13 | Sample Type: | Elevation:

Soil Description: Total length 25'' w/ 2'' Disturbed Gry Clay Fractured in many areas
Remarks:

Specimen Height: 5.59 in | Piston Area: 0.16 in^2 | Filter Strip Correction: 0.00 psi
Specimen Area: 6.28 in^2 | Piston Friction: 0.00 lb | Membrane Correction: 4.20 lb/in
Specimen Volume: 574.67 cc | Piston Weight: 0.00 lb | Correction Type: Uniform

Liquid Limit: --- | Plastic Limit: --- | Estimated Specific Gravity: 2.65

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	s54	---		
Wt. Container + Wet Soil, gm	54.6	---	---	0
Wt. Container + Dry Soil, gm	47.11	---	---	0
Wt. Container, gm	17.02	---	---	0
Wt. Wet Soil, gm	37.58	1166.8	934.25	0
Wt. Dry Soil, gm	30.09	934.25	934.25	0
Wt. Water, gm	7.49	232.55	1.1642e-013	0
Water Content, %	24.89	24.89	0.00	0.00
Void Ratio	---	0.63	0.62	---
Degree of Saturation, %	---	104.69	0.00	---
Dry Unit Weight, pcf	---	101.49	102.14	---

Initial
Height: 5.587 in | Moisture: 24.89 %
Area: 6.2768 in^2 | Void Ratio: 0.63
Volume: 574.67 cc | Dry Unit Weight: 101.49 pcf
Saturation: 104.69 %

End of Initialization
Time: 1.7992 min
Total Vertical Stress: 24.006 psi | Height Change: 0.011833 in | Height: 5.5752 in | Moisture: 23.39 %
Total Horizontal Stress: 24.041 psi | Area Change: 0 in^2 | Area: 6.2768 in^2 | Void Ratio: 0.62
Pore Pressure: -0.0080946 psi | Volume Change: 3.6514 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 24.014 psi | Water Change: -0.0080445 cc | Saturation: 100.00 %
Effective Horizontal Stress: 24.049 psi | Correction: 14.085 cc

End of Consolidation/A
Time: 1.7992 min
Total Vertical Stress: 24.006 psi | Height Change: 0.011833 in | Height: 5.5752 in | Moisture: 23.39 %
Total Horizontal Stress: 24.041 psi | Area Change: 0 in^2 | Area: 6.2768 in^2 | Void Ratio: 0.62
Pore Pressure: -0.0080946 psi | Volume Change: 3.6514 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 24.014 psi | Water Change: -0.0080445 cc | Saturation: 100.00 %
Effective Horizontal Stress: 24.049 psi | Correction: 14.085 cc

End of Saturation
Time: 1.7992 min
Total Vertical Stress: 24.006 psi | Height Change: 0.011833 in | Height: 5.5752 in | Moisture: 23.39 %
Total Horizontal Stress: 24.041 psi | Area Change: 0 in^2 | Area: 6.2768 in^2 | Void Ratio: 0.62
Pore Pressure: -0.0080946 psi | Volume Change: 3.6514 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 24.014 psi | Water Change: -0.0080445 cc | Saturation: 100.00 %
Effective Horizontal Stress: 24.049 psi | Correction: 14.085 cc

End of Consolidation/B
Time: 1.7992 min
Total Vertical Stress: 24.006 psi | Height Change: 0.011833 in | Height: 5.5752 in | Moisture: 23.39 %
Total Horizontal Stress: 24.041 psi | Area Change: 0 in^2 | Area: 6.2768 in^2 | Void Ratio: 0.62
Pore Pressure: -0.0080946 psi | Volume Change: 3.6514 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 24.014 psi | Water Change: -0.0080445 cc | Saturation: 100.00 %
Effective Horizontal Stress: 24.049 psi | Correction: 14.085 cc

End of Shear
Time: 22.048 min
Total Vertical Stress: 98.664 psi | Height Change: 1.1269 in | Height: 4.4601 in | Moisture: 0.00 %
Total Horizontal Stress: 24.218 psi | Area Change: -1.536 in^2 | Area: 7.8128 in^2 | Void Ratio: 0.62
Pore Pressure: -1.0604 psi | Volume Change: 3.6508 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 99.725 psi | Water Change: -0.0085808 cc | Saturation: 0.00 %
Effective Horizontal Stress: 25.279 psi | Correction: 232.56 cc

At Failure
Time: 5.0003 min
Total Vertical Stress: 147.04 psi | Height Change: 0.18475 in | Height: 5.4022 in | Moisture: 23.39 %
Total Horizontal Stress: 24.114 psi | Area Change: -0.21476 in^2 | Area: 6.4916 in^2 | Void Ratio: 0.62
Pore Pressure: -0.38854 psi | Volume Change: 3.6519 cc | Volume: 571.02 cc | Dry Unit Weight: 102.14 pcf
Effective Vertical Stress: 147.43 psi | Water Change: -0.0085808 cc | Saturation: 100.00 %
Effective Horizontal Stress: 24.502 psi | Correction: 0 cc

FIG. B-64
Sheet 5 of 5

APPENDIX C

INSTRUMENTATION REPORTS

APPENDIX C

INSTRUMENTATION REPORTS

LETTER REPORTS

Shannon & Wilson (2014a)
September 2014 Instrumentation Data Evaluation Letter (41 pages)

Shannon & Wilson (2014b)
March 2014 Instrumentation Data Evaluation Letter (54 pages)

REFERENCES

Shannon & Wilson, Inc., (Shannon & Wilson), 2014a, September 2014 Instrumentation Data Evaluation, I-94 Painted Canyon Installations, Project No. PE-5-094(107), PCN 20549, Billings County, North Dakota prepared by Shannon & Wilson, Inc., Denver, CO, 23-1-01447-200, for North Dakota Department of Transportation, October 6.

Shannon & Wilson, 2014b, March 2014 Instrumentation Data Evaluation, I-94 Painted Canyon Installations, North Dakota prepared by Shannon & Wilson, Inc., Denver, CO, 23-1-01400-100, for North Dakota Department of Transportation, April 18.

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON
WISCONSIN

October 6, 2014

North Dakota Department of Transportation
608 East Boulevard Avenue
Bismarck, North Dakota 58505

Attn: Mr. Matt Kurle

RE: SEPTEMBER 2014 INSTRUMENTATION DATA EVALUATION, I-94 PAINTED CANYON INSTALLATIONS, PROJECT PE-5-094 (107) 030, PCN 20549, BILLINGS COUNTY, NORTH DAKOTA

This letter report presents our recent evaluation of the geotechnical instrumentation that was installed in the area of the Painted Canyon along I-94 near Medora, North Dakota. The instrumentation data was provided to us by the North Dakota Department of Transportation (NDDOT) Materials and Research Department on September 23, 2014.

This evaluation was performed in conjunction with the landslide mitigation design that was initiated in September 2014 by Shannon & Wilson for NDDOT.

PROJECT DESCRIPTION

The project site has a history of landslides and ground deformations that have been observed since the 1970s along the area downslope of the westbound lanes of I-94. In the area of the subject landslide, an inclinometer casing was installed in late 2001 to evaluate depths of shear zones and rates of movement. Since then, additional inclinometer casings have been installed to delineate the extent of the ground movement and to replace casings that became inoperable due to excessive deformation.

Through early 2014, twelve inclinometer casings were operational and being monitored by NDDOT on an approximate monthly schedule. NDDOT is also measuring the water levels inside the inclinometer casings to evaluate changes in groundwater elevations.

1321 BANNOCK STREET, SUITE 200
DENVER, COLORADO 80204-4077
303-825-3800 FAX: 303-825-3801
TDD 1-800-833-6388
www.shannonwilson.com

In March 2014, two borings (SW-01 and SW-02) were drilled to provide additional subsurface information. Within each of these boreholes, an inclinometer casing was installed to supplement the existing instrumentation program. Three levels of vibrating wire piezometers (VWP) were attached to the exterior of the new inclinometer casings and the annulus of the assemblies was backfilled with grout to the ground surface. An additional boring, SW-01A, was drilled next to boring SW-01 for installation of a VWP in a sand-filled monitoring zone.

A site plan of the previous and new instrument installations is presented in Figure 1. In the following sections, an evaluation of the existing instrumentation data and monitoring program is provided.

PIEZOMETERS

The water levels measured inside the inclinometer casings reflect long term seepage in or out of the casing. For this summary, we did not include evaluation of the water levels in the inclinometer casings.

The two new boreholes, SW-01 and SW-02, have the VWP signal leads routed to the top of the boreholes and then connected into battery-powered 4-channel stand-alone dataloggers. The three leads from boring SW-02 go into one datalogger, and the three from boring SW-01 and the one from boring SW-01A go into the other logger. The loggers were programmed to calculate and store values of piezometric head above the tip of the VWP.

Figure 2 presents a plot of the pore pressure readings for borings SW-01 and SW-01A piezometers between March 14 and September 17, 2014. In boring SW-01, VWP1 is the shallow installation and VWP3 is the deepest, as shown on the plot. VWP4 (in boring SW-01A) is at approximately the same elevation as VWP2 in boring SW-01. In the grouted borehole SW-01, the upper piezometer (VWP1) has been dry since installation. The middle piezometer (VWP2) has displayed a steady decreasing trend in pore pressure since installation (an overall decrease of 3 feet), with a slight increase of about 1 foot earlier in September. The lowest piezometer (VWP3) has shown relatively stable pore pressure measurements over the last couple of months (26 feet above the piezometer). In the adjacent boring SW-01A, the piezometer installed in sand backfill at El. 2,746 has been showing a steady increase (3.5 feet) in pore pressure since installation.

For comparison purposes, the two instruments installed at approximately the same elevation (VWP2 at approximately 2,746 feet and VWP4 at approximately 2,747 feet) in adjacent boreholes, are currently exhibiting slightly varying trends in measured piezometric pressures. VWP4, installed in a sand back-filled filter zone, continues to exhibit a slow rise since installation. This instrument is currently indicating a pore pressure approximately 4 feet higher than VWP2, which was grouted into the borehole.

Figure 3 presents a plot of the pore pressure readings for boring SW-02 piezometers between March 14 and September 17, 2014. As with boring SW-01, the designations for the VWPs increase with depth. In boring SW-02, the upper two piezometers (VWP1 and VWP2) indicated a slight rise in pore pressure (+ 3 feet) during the first month, and have since shown a slight decrease in pore pressure (-2 feet). The lower piezometer (VWP3) indicated a decrease in pore pressure over the first two months (-4 feet), and has since indicated a rise in pore pressure (+ 4 feet).

It appears that these ground water measurements are seasonal in nature, but long-term monitoring will provide a better determination of that.

INCLINOMETER CASINGS

Fourteen inclinometer casings were available for monitoring subsurface deformations in this area earlier this year, including the two new casings installed in March 2014. Based on data provided by NDDOT, three of these casings have deformed enough to prevent passage of the inclinometer probe and obtain reliable measurements. These three casings include Casing 3A, Casing 13, and the new Casing SW-01.

In January of this year, NDDOT switched their inclinometer monitoring equipment from Slope Indicator's Classic system to Slope Indicator's AT system. The monitoring procedures and principles are similar, but the differences in the probe outputs create discrepancies in correctly evaluating the continuing trends of displacement from old system to new system. Accordingly, the inclinometer evaluations presented herein reflect measurements with respect to the initial reading obtained with the new equipment in January 2014.

In general, most of the casings that are exhibiting continued movement are following similar trends of displacement. Slight positive rates of displacement occurred between the end of January and the end of April of this year. This was followed by significant increases in the displacement rates (up to 2.8-inches per month for Casing 10) through the middle of June. In general, the rates of displacement since then have decreased to the rates observed earlier in the year, or to slightly above those rates.

Table 1 presents a summary of the available inclinometer casing measurement information, including direction of resultant casing deformation, depths of observed shear zones, rates of displacement, and magnitudes of casing displacement (since January 29, 2014). This table was updated from the April 2014 summary document, to include revisions in magnitudes and directions of displacement.

On Figure 1, the area observed to have the highest rates of casing displacement have been outlined. Also indicated on this figure are the casings that are no longer measurable due to excess deformation. Figures 4 through 17 display plots of cumulative and time displacement for the A and B directions for each casing, and where applicable, since January 29, 2014.

Summarized below is a review and evaluation of each of the inclinometer casings at the project site. This reflects an update on the evaluation provided in April 2014.

Casing SW-01

Boring SW-01 is located on the east shoulder of westbound I-94 in the upper portion of the identified current slide area. Casing SW-01 is about 112 feet deep. Figure 4a presents the cumulative displacement plot of Casing SW-01 since installation in March 2014. As indicated on the figure, one shear zone has been identified at a depth of 42 to 44 feet below the top of the casing. Figure 4b shows the measured displacement versus time since installation. The last complete measurement of this casing was obtained on August 7, 2014. Subsequent attempts to perform complete inclinometer surveys have been unsuccessful due to the magnitude of displacement of the casing over the relatively thin shear zone.

In addition to the observed shear movements of the casing, Figure 4a suggests rotational movement of the top of the casing as well.

Continued measurements of this casing will not provide data that is directly comparable to the initial measurement set. Because the top of the casing and the shear zone continues to move, there is no fixed reference point for the measurements of this casing anymore. If reliable surveys have been obtained for a repeatable point on the top of the casing, subsequent casing measurements above the shear zone could be referenced to the top of the casing.

Casing SW-02

Boring SW-02 is located downslope near the Park fence, in the middle of the existing slide zone. The casing is approximately 102 feet in depth. Measured deformations of up to 4.5-inches at the top of the casing in the resultant direction have been observed since installation in March 2014. As shown on Figure 5a, casing deformation is occurring primarily in a zone 8 to 12 feet below the top of the casing. The shape of the cumulative displacement plot suggests that the movement is primarily translational in this observed shear zone. Figure 5b presents the plotted measured displacement near the top of the casing versus time.

Casing 1A

Casing 1A was installed in August 2013, replacing the adjacent Casings 1 and 2, which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 1A is about 50 feet deep.

Plotted cumulative displacement values since January 29, 2014 are presented on Figure 6a. As shown, displacements are occurring in both the A0 and B180 direction, with the resultant displacement direction between approximately N35E and N50E. Two distinct shear zones are identified with the measurements, and current displacements at these zones and the top of the casing continue at a relatively steady rate, as shown on the Figure 6b displacement versus time plot. Similar to Casing SW-01, the upper displacement zone of Casing 1A suggests rotational movement of the top of the casing as well as translational movement.

Casing 3A

Casing 3A was installed in August 2013, replacing the adjacent Casing 3 (installed in July 2011) which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 3A is about 50 feet deep.

Cumulative displacement values from measurements obtained since January 29, 2014 are plotted on Figure 7a. Two distinct shear zones are identified in this casing, at depths of 16 to 20 feet and at depths of 26 to 30 feet. The last complete measurement of this casing was obtained on May 28, 2014. Subsequent attempts to perform complete inclinometer surveys have resulted in questionable data or blockage of the casing. The casing has deformed enough in the lower shear zone to prevent passage of the inclinometer probe.

As indicated in the displacement versus time plot, on Figure 7b, the rate of displacement increased significantly up to the last available consistent data set on May 28.

Continued measurements of this casing will not provide data that is directly comparable to the initial measurement set. Because the top of the casing and the shear zone continues to move, there is no fixed reference point for the measurements of this casing anymore. If reliable surveys have been obtained for a repeatable point on the top of the casing, subsequent casing measurements above the blocked zone could be referenced to the top of the casing.

Casing 4

Casing 4 was installed in September 2011 to assist with determining the extent of ground movement in this area. Casing 4 is about 50 feet deep.

Plotted cumulative displacement values obtained since January 29, 2014 are presented on Figure 8a. One deep distinct shear zone, at depths between 38 and 40 feet, is identified in this casing, and current displacements at this zone and the top of the casing continue at a relatively steady rate with some apparent seasonal fluctuations, as shown on the Figure 8b displacement versus time plot.

Casing 5A

Casing 5A was installed in August 2013, replacing the adjacent Casing 5 (installed in September 2011) which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 5A is about 40 feet deep.

Plotted cumulative displacement values obtained since January 29, 2014 are presented on Figure 9a. One distinct shear zone, between depths of 10 and 14 feet, is identified in this replacement casing; however, casing measurements prior to 2014 (in an earlier casing with previous monitoring equipment) suggested potential movement occurring in the lower 2 to 3 feet of the casing (depths of 37 to 40 ft). This lower zone is currently not apparent in the replacement Casing 5A. Current measured displacements in the upper identified zone and the top of the casing continue at a relatively steady rate with some apparent seasonal fluctuations, as shown on the Figure 9b displacement versus time plot.

Casing 6

Casing 6 was installed in September 2011, upslope of Casings 1, 2, and 1A and along the north edge of westbound I-94. Casing 6 is about 48 feet deep.

Casing measurements obtained since January 29, 2014 have indicated no distinct shear zones along the depth of the casing. An evaluation of the incremental output for this casing's measurements suggest that bottom of the casing may not be fixed. A plot of incremental displacement along the depth of the casing, since January 2014, is presented in Figure 10. This plot displays an incremental increase in angular rotation of the bottom measurement point in the casing, suggesting slight potential movement at the tip of the casing. This is consistent with measurements observed in this casing prior to this year.

Casing 7

Casing 7 was installed in September 2011, south of Casing 6 and along the north edge of westbound I-94. Casing 7 is about 50 feet deep.

Cumulative displacement values obtained since January 29, 2014 are plotted on Figure 11a. One distinct shear zone between approximate depths of 16 and 20 feet is observed on the plots for this casing. Slight changes in incremental displacements were observed in previous years at depths of approximately 35 and 45 feet, suggesting possible deeper shear zones; however, data obtained in 2014 have not indicated similar displacements.

Displacements in the upper shear zone and the top of the casing over the last couple of months continue to increase at a relatively consistent rate, as indicated on the displacement versus time plot shown on Figure 11b. Rates of displacement, as discussed earlier, are time dependent and appear to increase temporarily in late spring.

Casing 8

Casing 8 was installed in September 2011, in the median between eastbound and westbound I-94. Casing 8 is about 60 feet deep.

Casing measurements obtained since January 29, 2014 have indicated no observable shear zones or measurable displacements, as shown on Figure 12.

Casing 9

Casing 9 was installed in September 2011, in the south edge of eastbound I-94. Casing 9 is about 50 feet deep.

Casing measurements obtained since January 29, 2014 have indicated no observable shear zones, as shown on Figure 13. Slight fluctuations have been observed in the upper couple feet of the casing, but there is no distinct trend in the observed displacements.

Casing 10

Casing 10 was installed within the Park area in July 2013. Casing 10 is about 60 feet deep.

Cumulative displacement values obtained since January 29, 2014 are plotted on Figure 14a. Measurements indicate a distinct shear zone 12 to 16 feet below the top of the casing. Displacements at this zone and the top of the casing increased at a significant rate of about 2.8-inches per month between April 28 and May 28 of this year, as shown on the displacement versus time plot on Figure 14b. Displacement rates since June 16 have reduced, but continue currently at approximately 0.65 inch per month.

Casing 11

Casing 11 was installed within the Park area in July 2013. Casing 11 is about 50 feet deep.

Cumulative displacement values obtained since January 29, 2014 are plotted on Figure 15a. Measurements of this casing indicate a distinct shear zone 28 to 30 feet below the top of the casing. Displacements at this zone and the top of the casing have increased at a relatively steady rate during the early part of summer, but have since then been relatively stable, as shown on the displacement versus time plot on Figure 15b.

Casing 12

Casing 12 was installed within the Park area in July 2013. Measurements for Casing 12 extend to depth of about 40 feet deep.

Cumulative displacement values obtained since January 29, 2014 are plotted on Figure 16a. Measurements of this casing indicate a shear zone between depths of 22 and 26 feet below the top of the casing. An increase in the rate of displacement was observed in this casing between the early August and early September measurements, as shown on the displacement versus time Figure 16b. The current rates of displacement have decreased to match those observed just prior to August.

Casing 13

Casing 13 was installed within the Park area in July 2013. Measurements for Casing 13 extend to depth of about 60 feet deep.

Cumulative displacement values obtained since January 29, 2014 are plotted on Figure 17a. Measurements of this casing indicate a distinct shear zone between 10 and 14 feet below the top of the casing. The last complete measurement of this casing was obtained on April 28, 2014. The casing has deformed enough to prevent passage of the inclinometer probe past the measurement depth of 8 feet below the top of the casing.

A time versus displacement plot for the resultant direction is presented on Figure 17b, indicating accelerated movement from early April to the end of April.

Continued measurements of this casing will not provide data that is directly comparable to the initial measurement set. Because the top of the casing and the shear zone continues to move, there is no fixed reference point for the measurements of this casing anymore. If reliable surveys have been obtained for a repeatable point on the top of the casing, subsequent casing measurements above the blocked zone could be referenced to the top of the casing.

SUMMARY

The approximate current rate of displacement and direction of top of casing movement is tabulated and presented in Table 1, and displayed on Figure 1. As shown, the direction of the displacements is typically downslope, and this is relatively consistent amongst each of the casings. Three casings are no longer measureable due to significant deformation. These are Casings 3A, 13, and SW-01.

Of the casings that were still measurable as of September 17, inclinometer Casing 10 exhibits the largest amount of lateral displacement (approximately 5.5 inches) since installation. This is considering the magnitude of displacement measured with the previous monitoring system in addition to this year's measurements. Likewise, Casings 7 and SW-02 have displaced up to 4.4 and 4.2 inches, respectively, since installation. Based on the magnitude of total displacement for these casings, it is possible the deformed casings may restrict passage of the monitoring probe through the identified shear zones if the rate of displacement continues.

CLOSURE

The information provided to you in this letter report is an evaluation of the monitoring data developed at this site since January 2014. Continued monitoring of the instrumentation will be useful for evaluating conditions at the site, determining rates of movement, and monitoring the effectiveness of the horizontal drains.

This document was prepared for the exclusive use of the NDDOT. The evaluations contained in this document are based on the measurements and data provided by NDDOT.

Within the limitations of the scope, schedule, availability of data and budget, the evaluations presented in this letter report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice at the time this letter report was prepared. We make no other warranty, either expressed or implied.

If you have any questions or comments regarding the enclosed information, please contact us.

Sincerely,

SHANNON & WILSON, INC.

Rob Clark
Associate

10/6/14

Gregory R. Fischer, P.E.
Sr. Vice President

RC:GRF/rc

Enc: Table 1 – Inclinometer Casing Displacements
Figure 1 – Site and Exploration Plan
Figure 2 – Boring SW-01 Piezometer Levels
Figure 3 – Boring SW-02 Piezometer Levels
Figure 4a – Casing SW-01 Inclinometer Cumulative Displacement
Figure 4b – Casing SW-01 Inclinometer Resultant Time Displacement
Figure 5a – Casing SW-02 Inclinometer Cumulative Displacement
Figure 5b – Casing SW-02 Inclinometer Resultant Time Displacement
Figure 6a – Casing 1A Inclinometer Cumulative Displacement
Figure 6b – Casing 1A Inclinometer Resultant Time Displacement
Figure 7a – Casing 3A Inclinometer Cumulative Displacement
Figure 7b – Casing 3A Inclinometer Resultant Time Displacement
Figure 8a – Casing 4 Inclinometer Cumulative Displacement
Figure 8b – Casing 4 Inclinometer Resultant Time Displacement
Figure 9a – Casing 5A Inclinometer Cumulative Displacement
Figure 9b – Casing 5A Inclinometer Resultant Time Displacement
Figure 10 – Casing 6 Inclinometer Incremental Displacement
Figure 11a – Casing 7 Inclinometer Cumulative Displacement
Figure 11b – Casing 7 Inclinometer Resultant Time Displacement
Figure 12 – Casing 8 Inclinometer Cumulative Displacement
Figure 13 – Casing 9 Inclinometer Cumulative Displacement
Figure 14a – Casing 10 Inclinometer Cumulative Displacement
Figure 14b – Casing 10 Inclinometer Resultant Time Displacement

Figure 15a – Casing 11 Inclinometer Cumulative Displacement
Figure 15b – Casing 11 Inclinometer Resultant Time Displacement
Figure 16a – Casing 12 Inclinometer Cumulative Displacement
Figure 16b – Casing 12 Inclinometer Resultant Time Displacement
Figure 17a – Casing 13 Inclinometer Cumulative Displacement
Figure 17b – Casing 13 Inclinometer Resultant Time Displacement

TABLE 1
INCLINOMETER CASING DISPLACEMENTS

Casing	Casing Elev.[1]	A0 Direction[2]	Resultant Direction[3]	Approximate Shear or Measurement Zones		Current Incremental Rate of Displacement, inch/month (as of 9/17/14)[4]	Overall Rates of Displacement, inch/month (since 1/29/14)[5]	Top of Casing Resultant Displacement, inches (since 1/29/14)[6]
				Depths, ft	Elev., ft.			
SW-01[7]	2797	N 68 E	N 60 E N 53 E	Top of Casing 42 - 44	2797 2755 - 2753	N/A	0.2 0.3	1.0
SW-02	2752	N 75 E	N 40 E N 40 E	Top of Casing 8 - 12	2752 2744 - 2740	0.22	0.7	4.2
1A	2775	N 80 E	N 50 E N 50 E N 35 E	Top of Casing 22 - 26 30 - 34	2775 2753 - 2749 2745 - 2741	0.19 0.2 0.06	0.3 0.3 0.2	2.0
3A[8]	2773	N 63 E	N 48 E N 43 E N 43 E	Top of Casing 16 - 20 26 - 30	2773 2757 -2753 2747 - 2743	N/A	0.6 0.7 0.4	2.2
4	2777.2	N 71 E	N 56 E N 61 E	Top of Casing 38 - 42	2777 2739 - 2735	0.07 0.06	0.1 0.1	0.6
5A	2777	N 74 E	N 14 E N 19 E	Top of Casing 12 - 14	2777 2765 - 2763	0.11 0.08	0.2 0.1	1.3
6[9]	2794.4	N 58 E		Bottom of Casing (not fixed?)	2748			
7	2797.2	N 63 E	N 43 E N 63 E	Top of Casing 17 - 21	2797 2780 - 2776	0.11 0.08	0.1 0.1	1.0
8	2799.1	N 70 E		n/a				
9	2812.6	N 68 E		n/a				
10	2736.9	N 57 E	N 62 E N 62 E	Top of Casing 12 - 16	2737 2725 - 2721	0.65 0.63	0.2 0.2	5.3
11	2713.3	N 84 E	N 59 E N 59 E	Top of Casing 28-30	2713 2685 - 2683	0.09 0.07	0.2 0.2	1.8
12	2684.7	N 50 E	N 75 E N 70 E	Top of Casing 23 - 25	2685 2665 - 2663	0.06 0.04	0.1 0.1	1.0
13[10]	2737.3	N 88 E	N 45 E N 45 E	Top of Casing 12 - 14	2737 2725 - 2723	N/A	0.4 0.4	1.3

Notes:

1 Ground surface for Casings 1 through 13, and assumed approximate top of casing. Top of casing elevation for Casings SW-01 and SW-02.

2 Alignment of A-direction grooves, as measured and provided by NDDOT.

3 Interpreted direction, based on A and B axis displacements, at top of casing and depths indicated in adjacent "Approximate Shear or Measurement Zones" column.

4 Rate of displacement calculated based on displacement measured between last two reading sets.

5 Rate of displacement calculated based on total displacement since 1/29/2014.

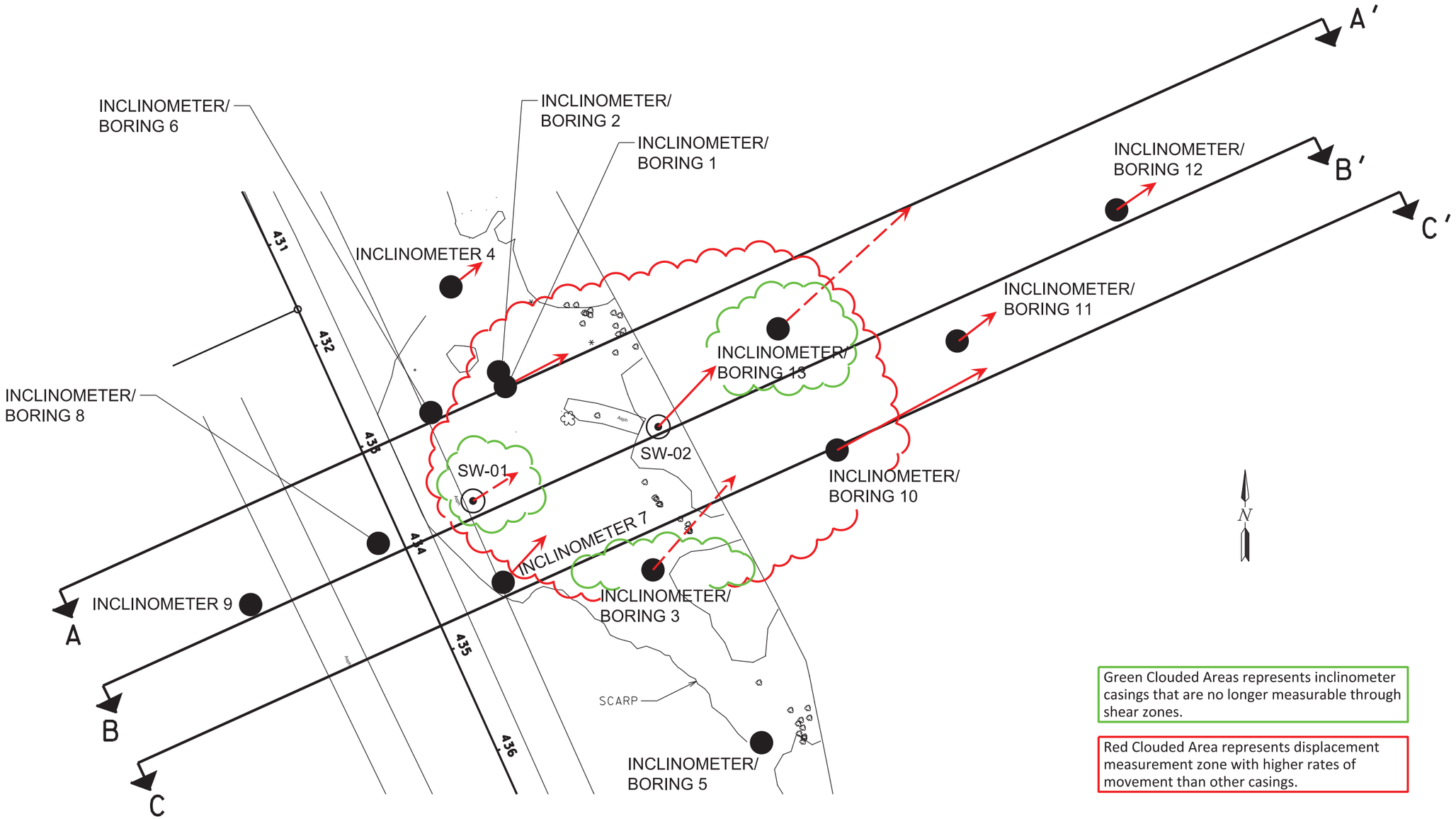
6 Total displacement based on top of casing measurements since 1/29/2014 .

7 Values shown represent last measured data set from 8/7/2014. Casing deformed beyond measurable range.

8 Values shown represent last measured data set from 5/28/2014. Casing deformed beyond measurable range.

9 Only bottom of casing deformations observed since installation for this casing.

10 Values shown represent last measured data set from 4/28/2014. Casing deformed beyond measurable range.



Green Clouded Areas represents inclinometer casings that are no longer measurable through shear zones.

Red Clouded Area represents displacement measurement zone with higher rates of movement than other casings.

LEGEND

INCLINOMETER/ BORING 13 — Previous NDDOT Inclinometer/Boring Designation and Approximate Location

SW-01 — Current Shannon & Wilson Inclinometer/Boring Designation and Approximate Location

Direction and rate of top of casing displacement.

Direction and Rate of Top of Casing Displacement prior to Casing Becoming Inoperable

0 — 0.5 — 1

Rate of Displacement, Inches per Month

0 — 100 — 200

Scale in Feet

NOTES

1. Site plan adapted from NDDOT file *175SB_001_Layout_11-20-13.dgn.*

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

SITE AND EXPLORATION PLAN

October 2014 — 23-1-01447-001

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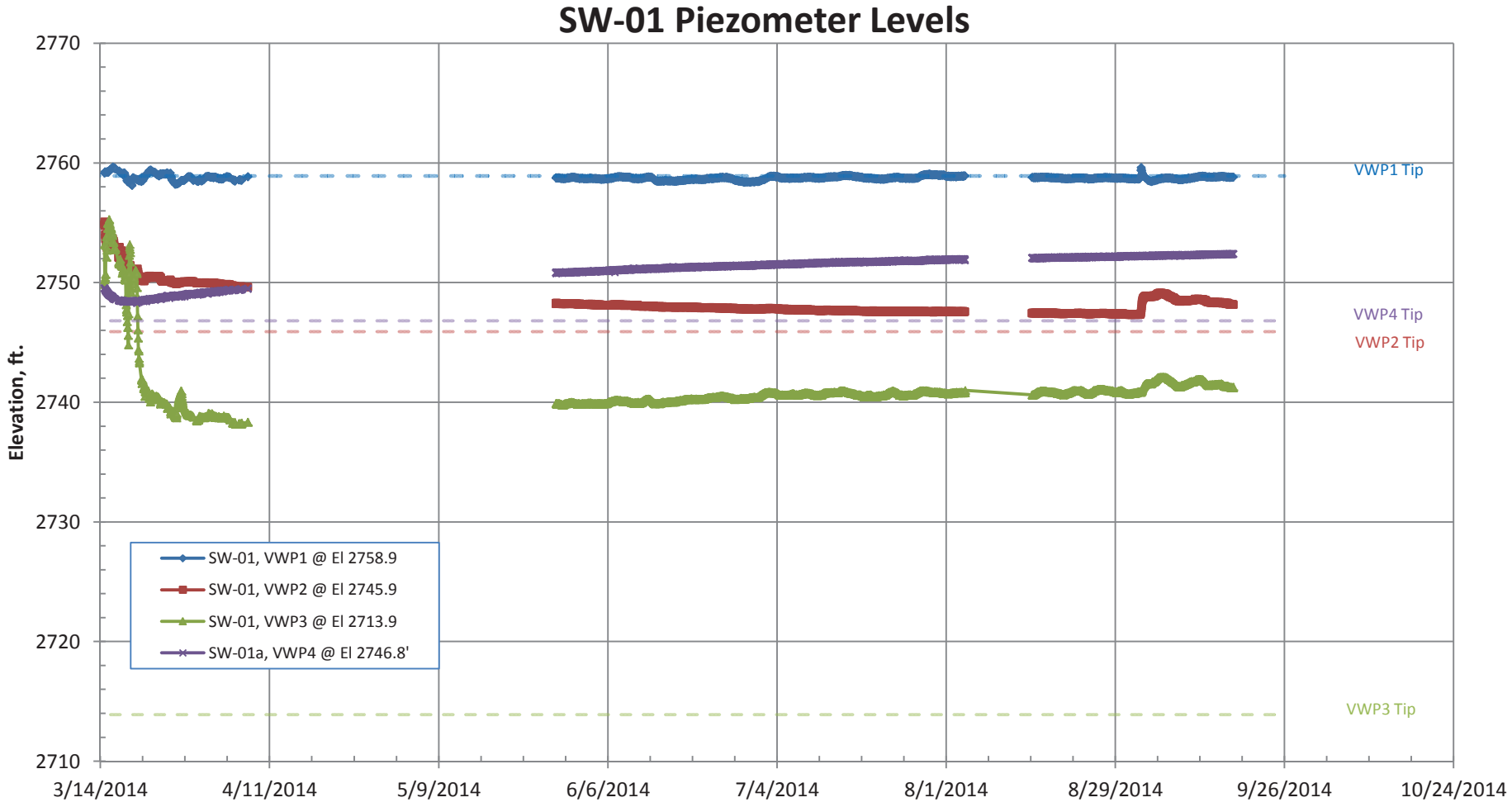
FIG. 1

FILE: J:\23\01447-300\SW Plan_Inst.dgn



Notes:

1. SW-01 instruments (VWP1 through VWP3) backfilled with grout.
2. SW-01a, VWP4 installed in sand backfilled borehole adjacent to grouted VWP1 through VWP3.

FIG. 2

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

BORING SW-01
PIEZOMETER LEVELS

October 2014 21-1-01447-200

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Geotechnical and Environmental Consultants

FIG. 2

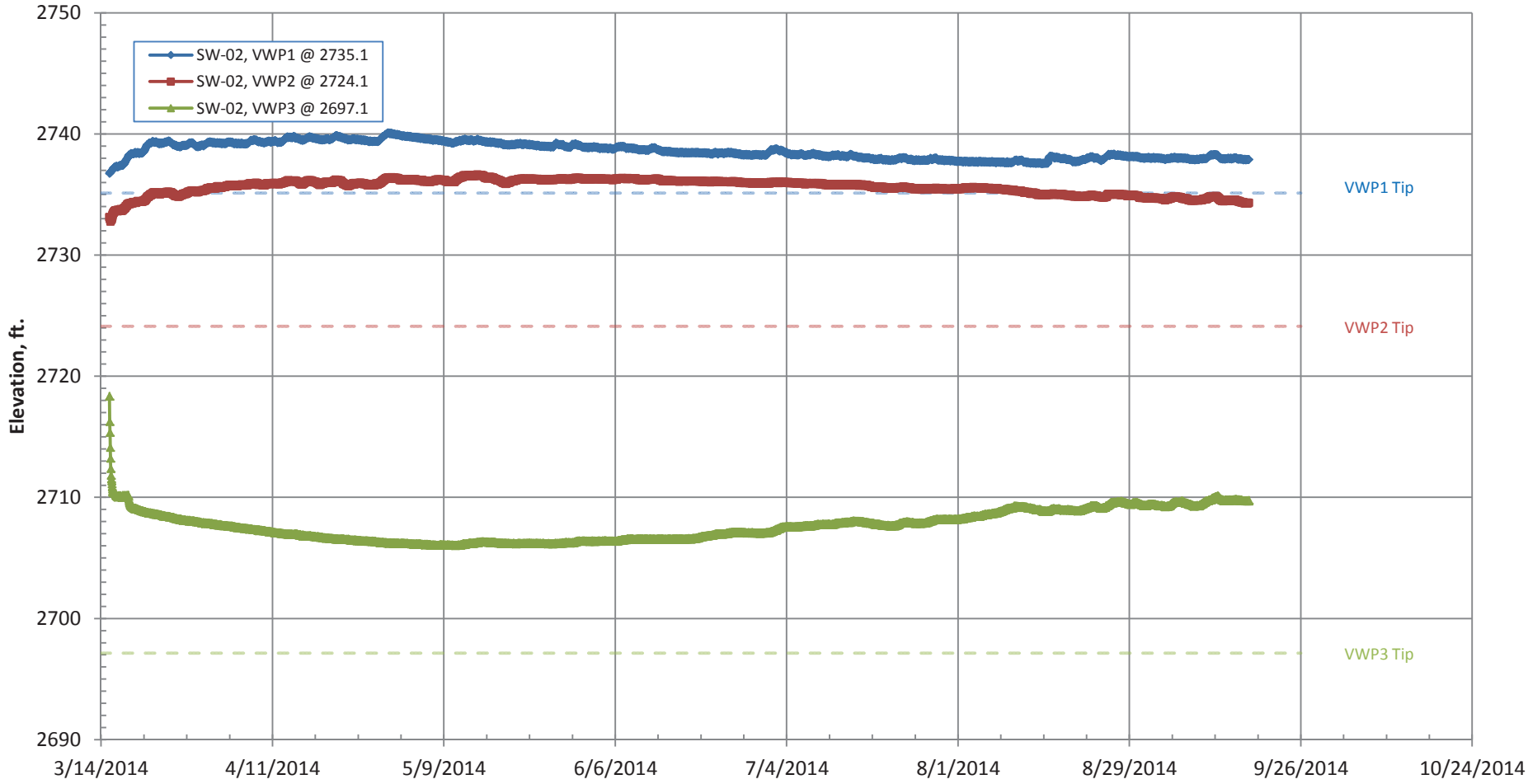

FIG. 3

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

BORING SW-02
PIEZOMETER LEVELS

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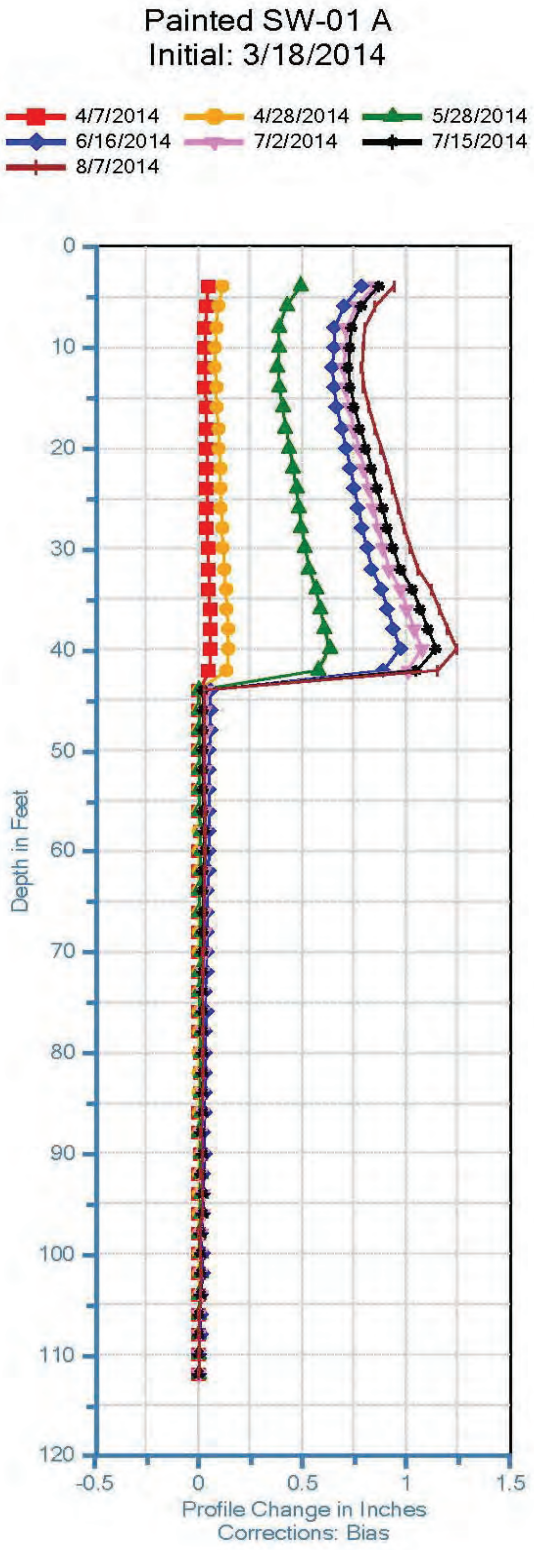
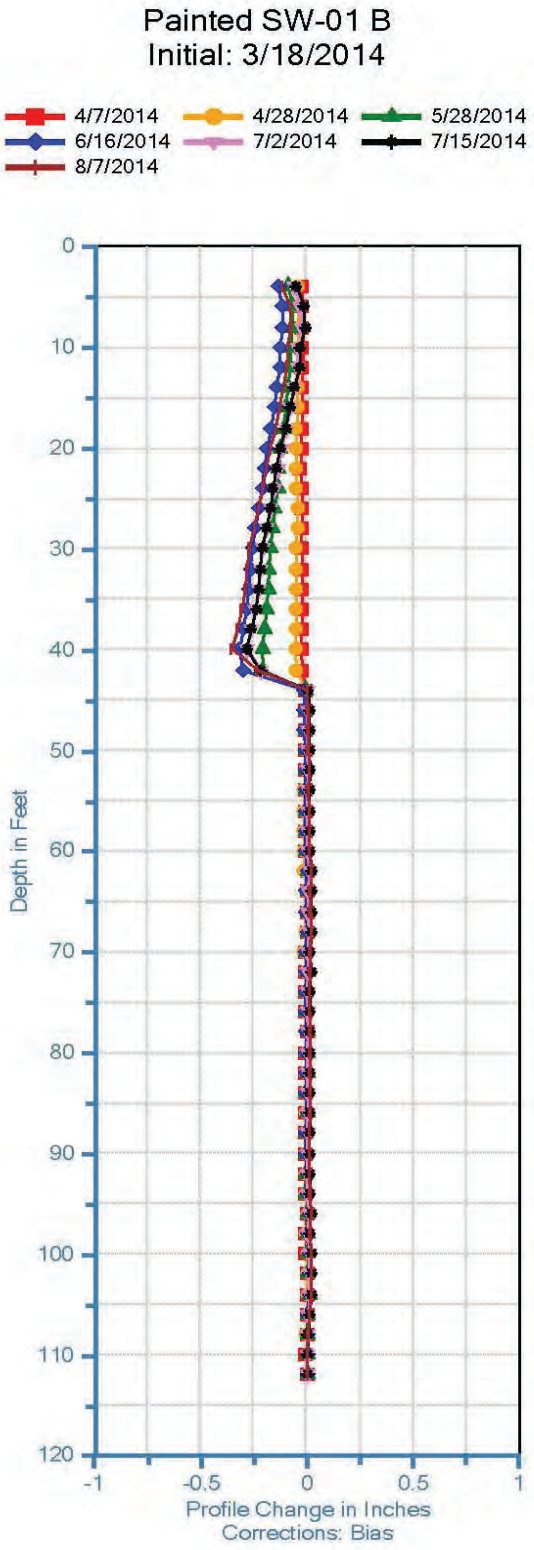
FIG. 3





Note: Unable to read past depth of 40 feet in one pass of probe on 9/3/14, and both passes on 9/17/14.

I-94 Painted Canyon Landslide
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CASING SW-01 INCLINOMETER CUMULATIVE DISPLACEMENT

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FIG. 4a

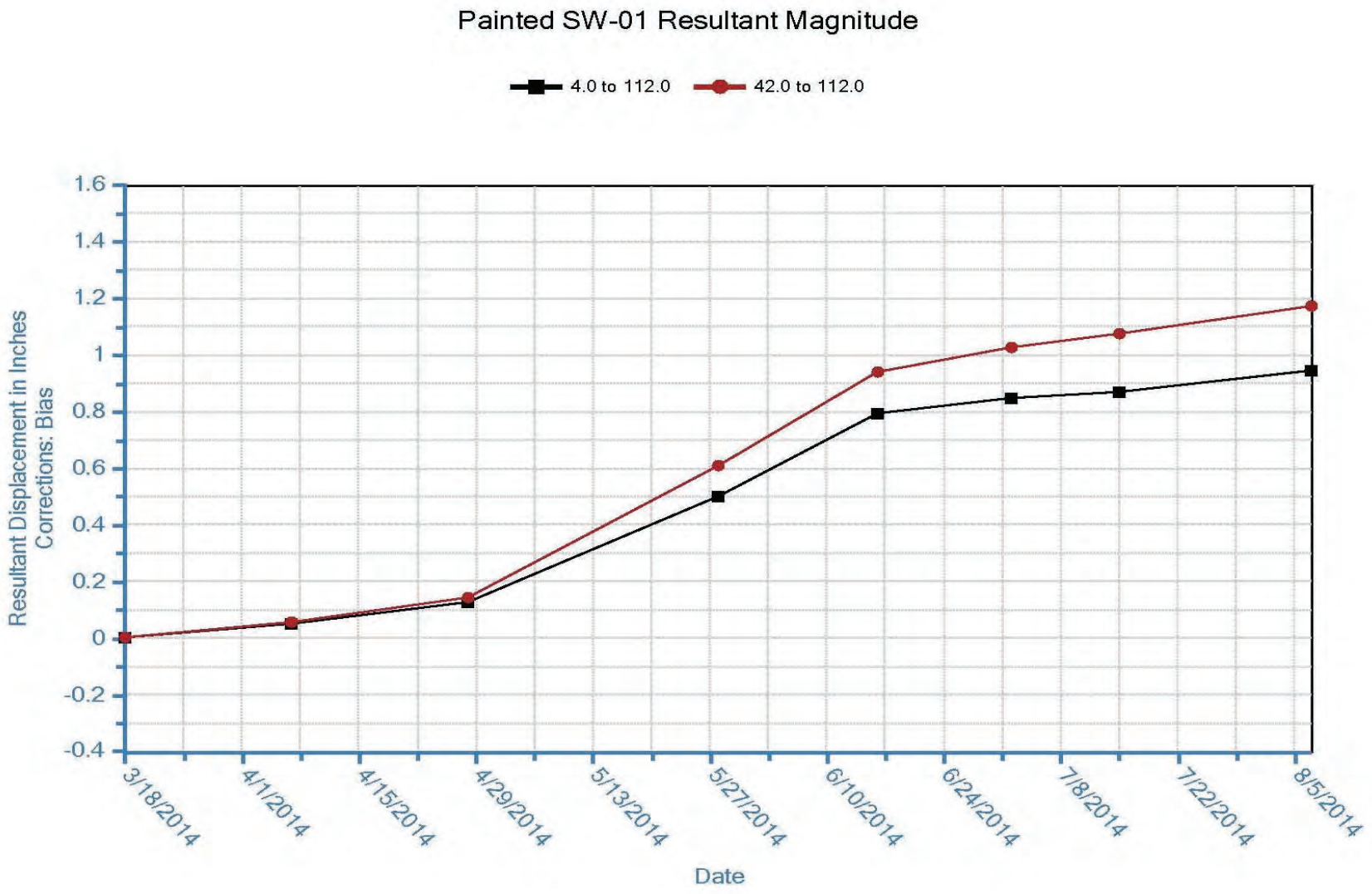

FIG. 4b

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING SW-01 INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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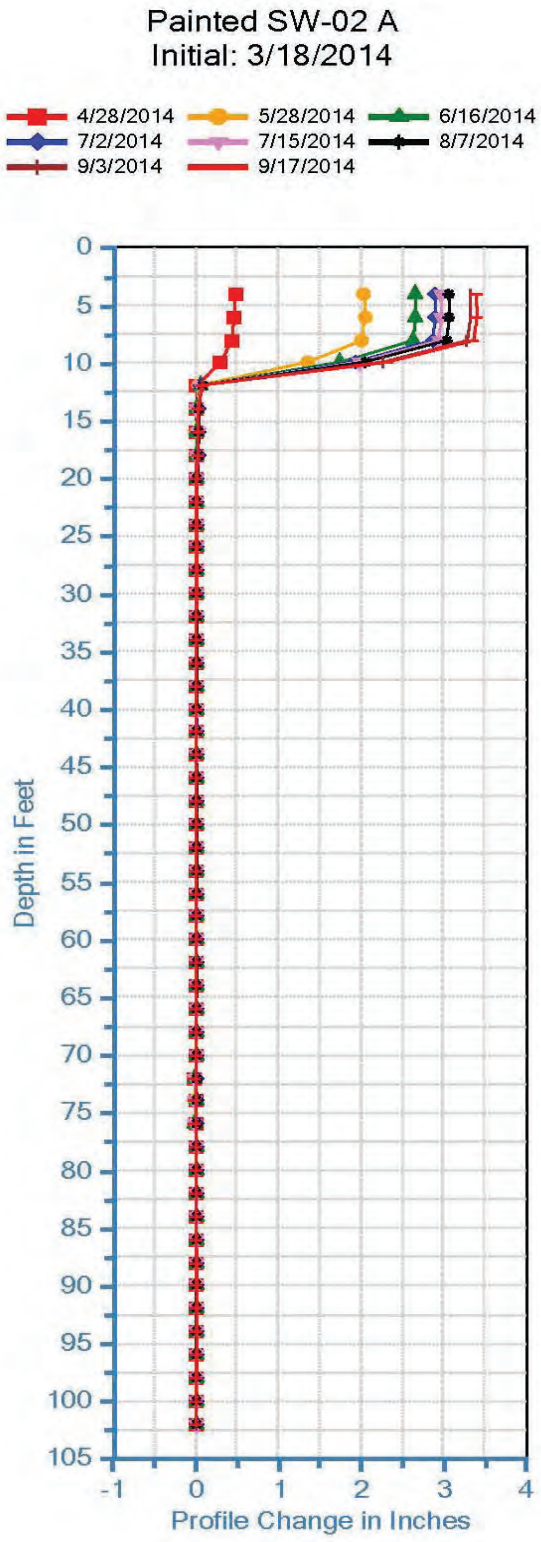
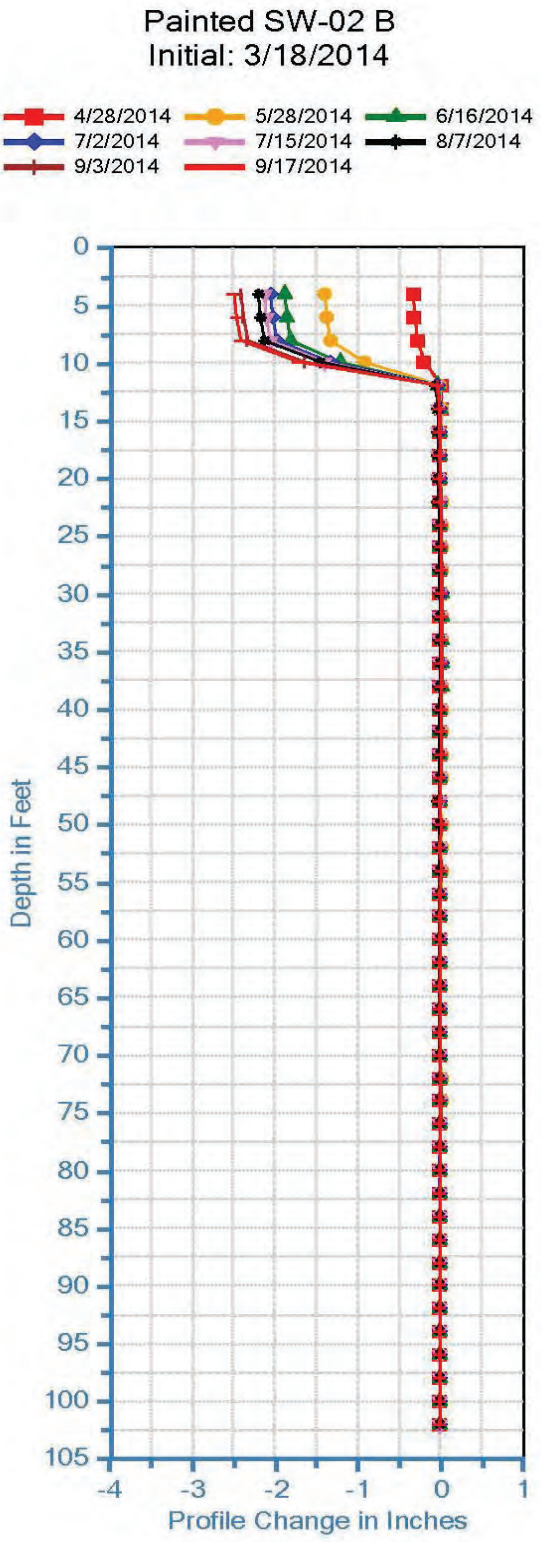
FIG. 4b





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING SW-02 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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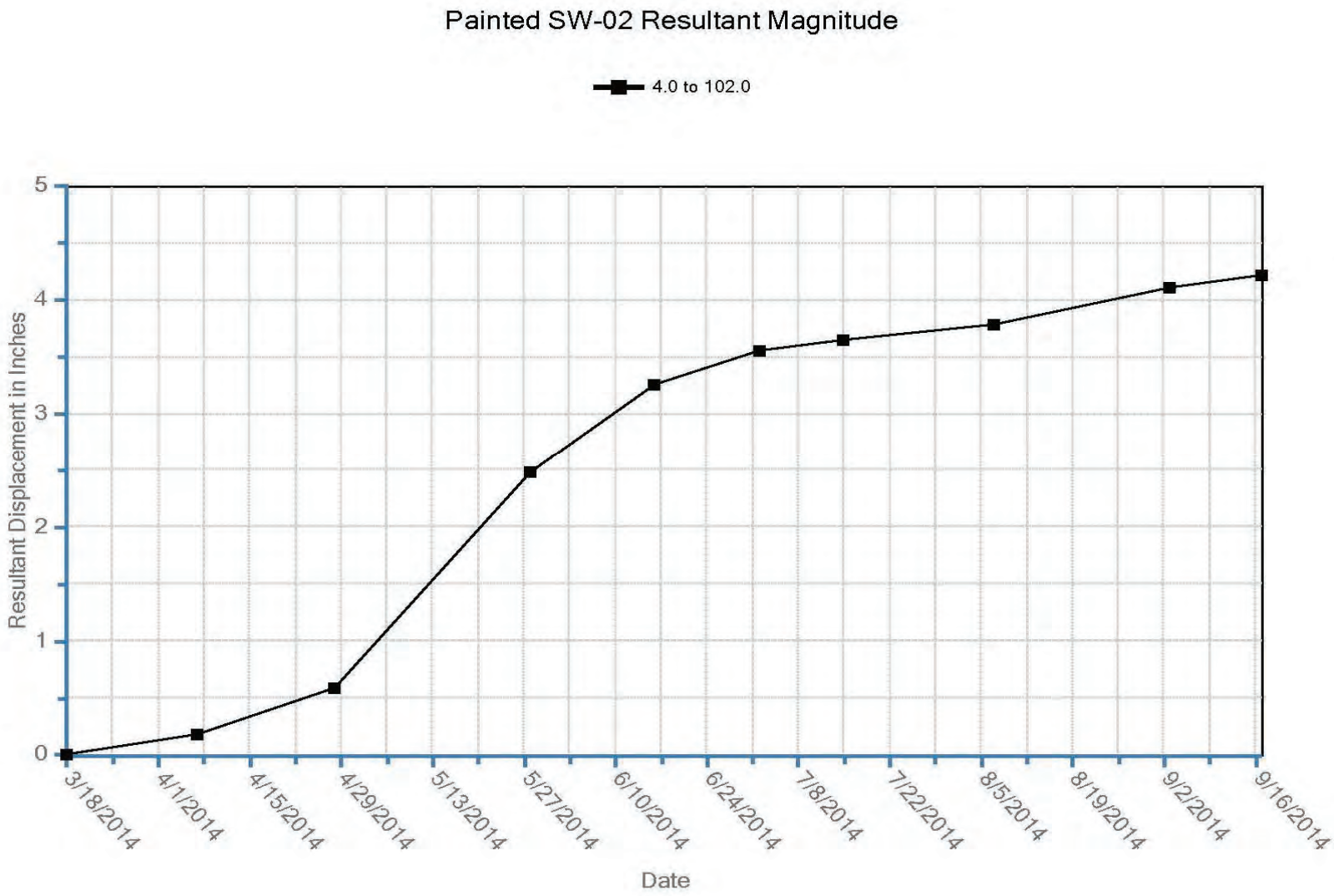
FIG. 5a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING SW-02 INCLINOMETER RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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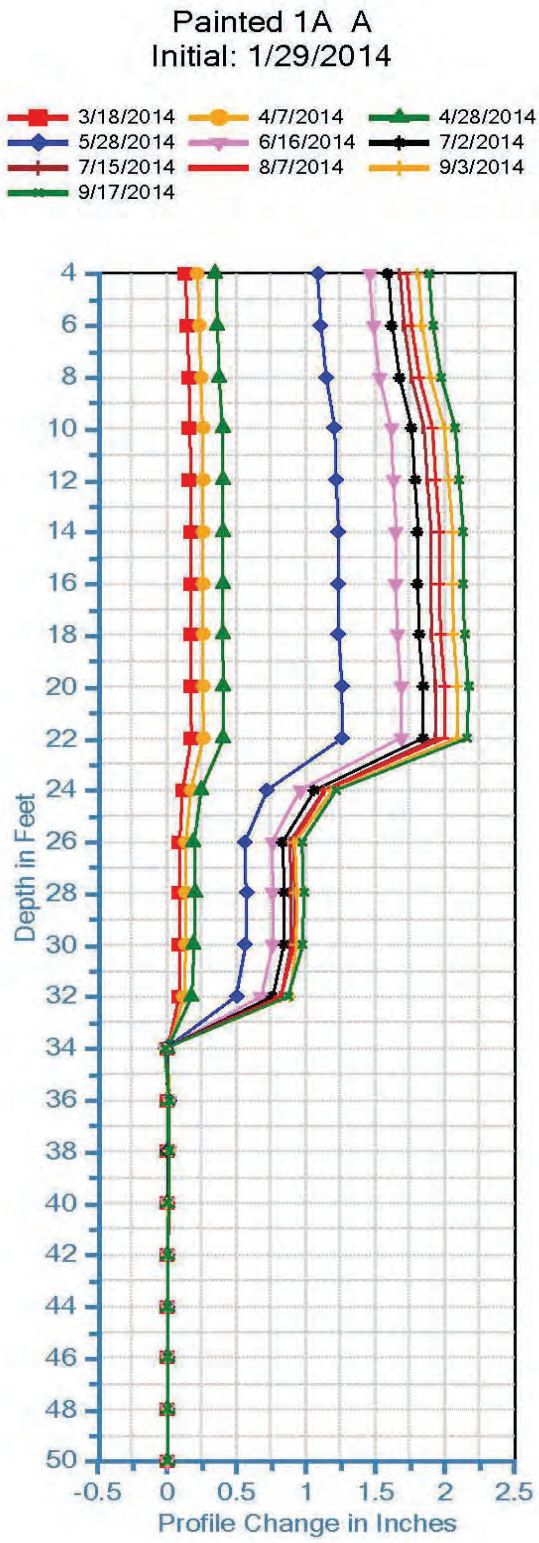
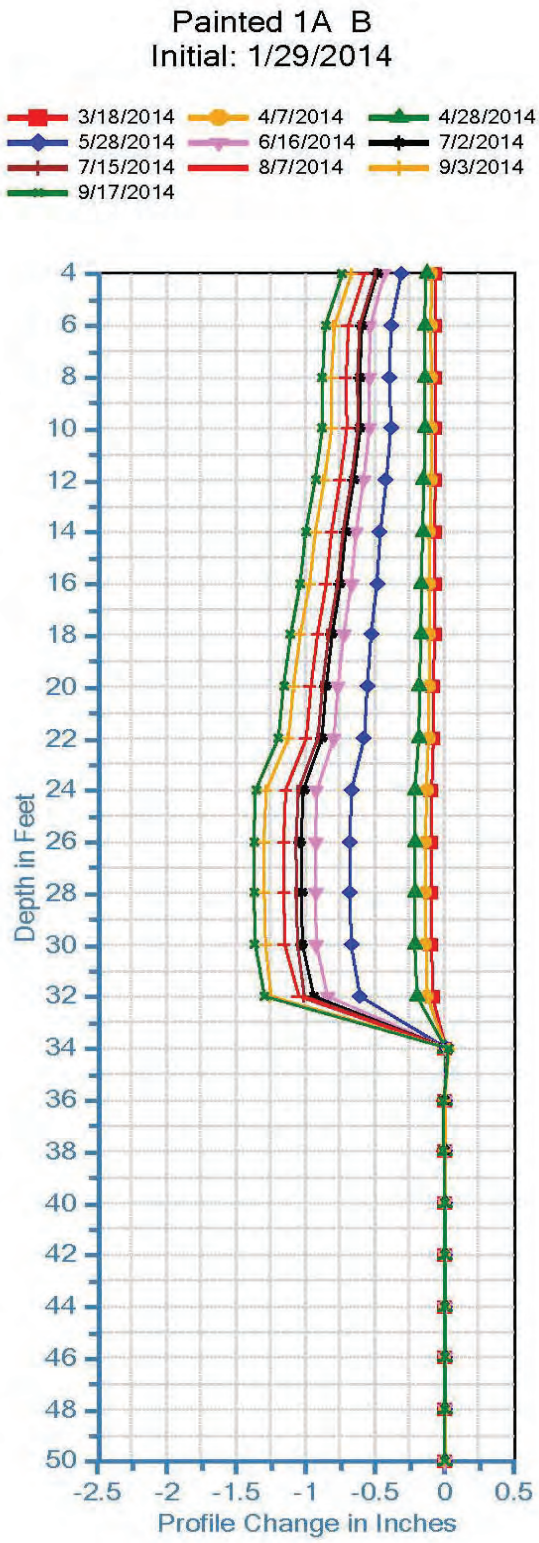
FIG. 5b

FIG. 5b





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 1A INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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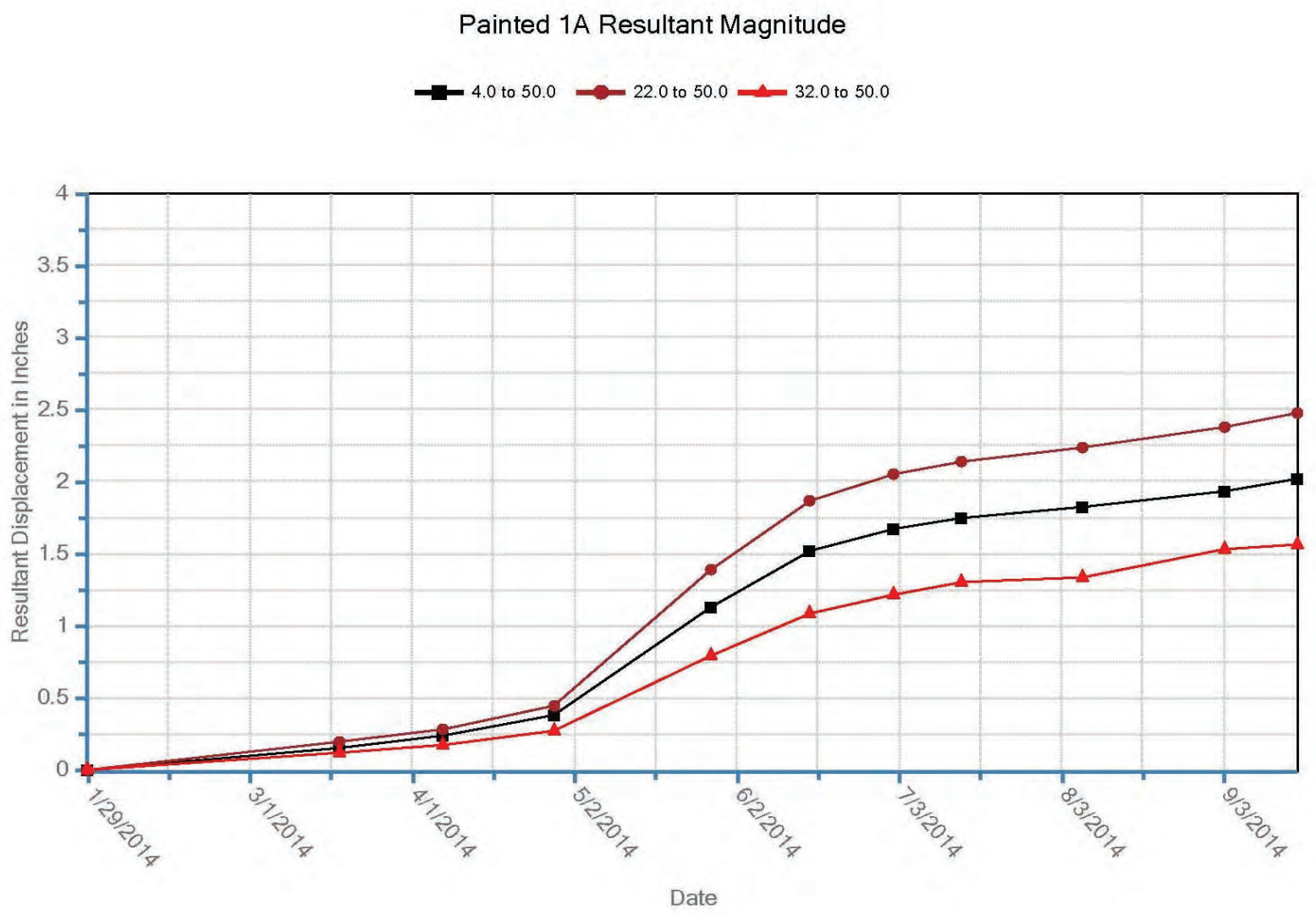
FIG. 6a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 1A INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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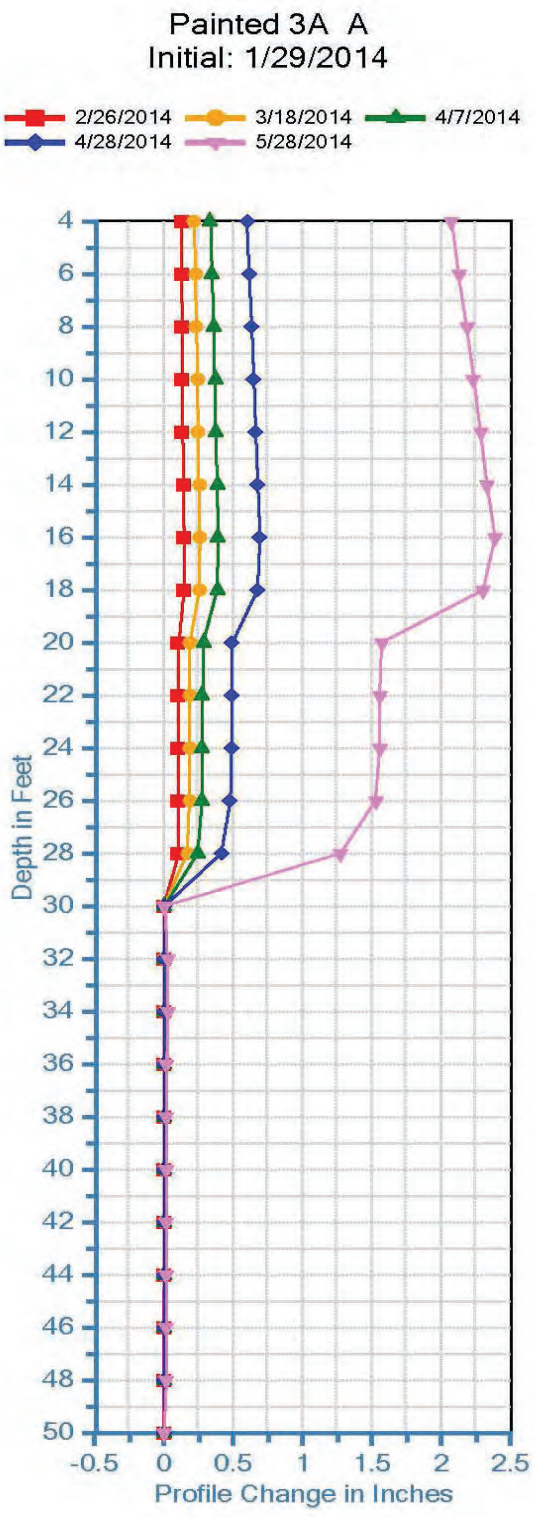
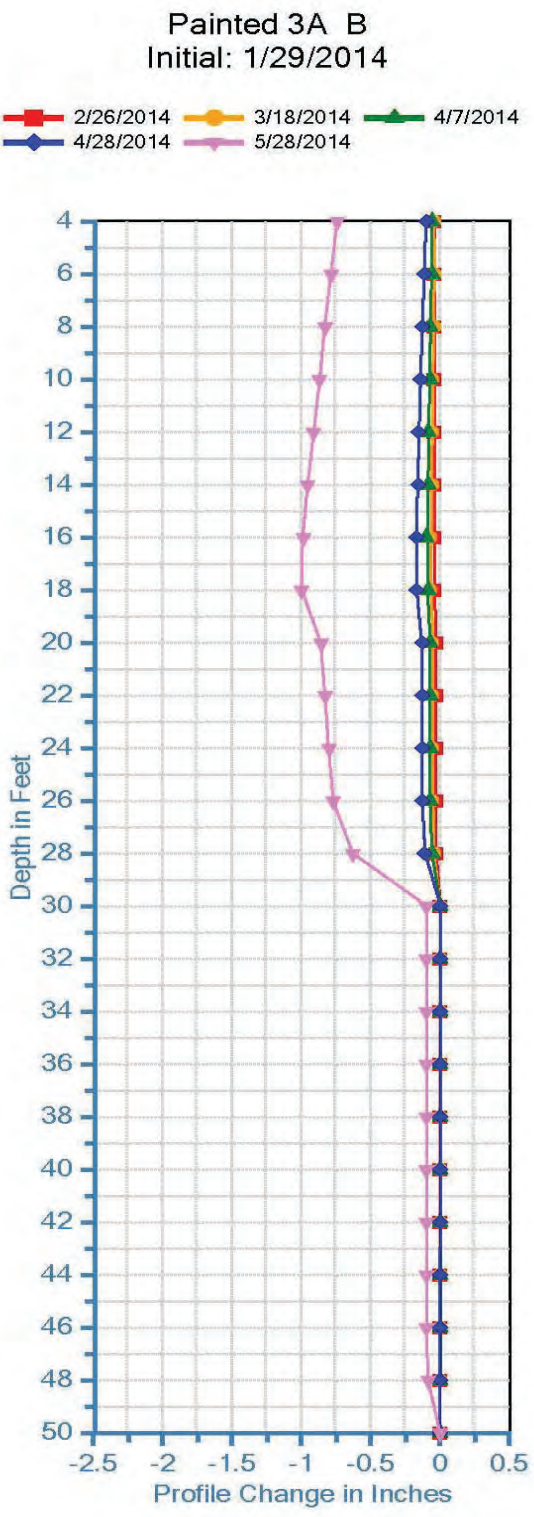
FIG. 6b

FIG. 6b





Note: Unable to read accurately past depth of 26 feet in one pass of probe after 5/28/14, and both passes on 8/7/14.

I-94 Painted Canyon Landslide
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CASING 3A INCLINOMETER CUMULATIVE DISPLACEMENT

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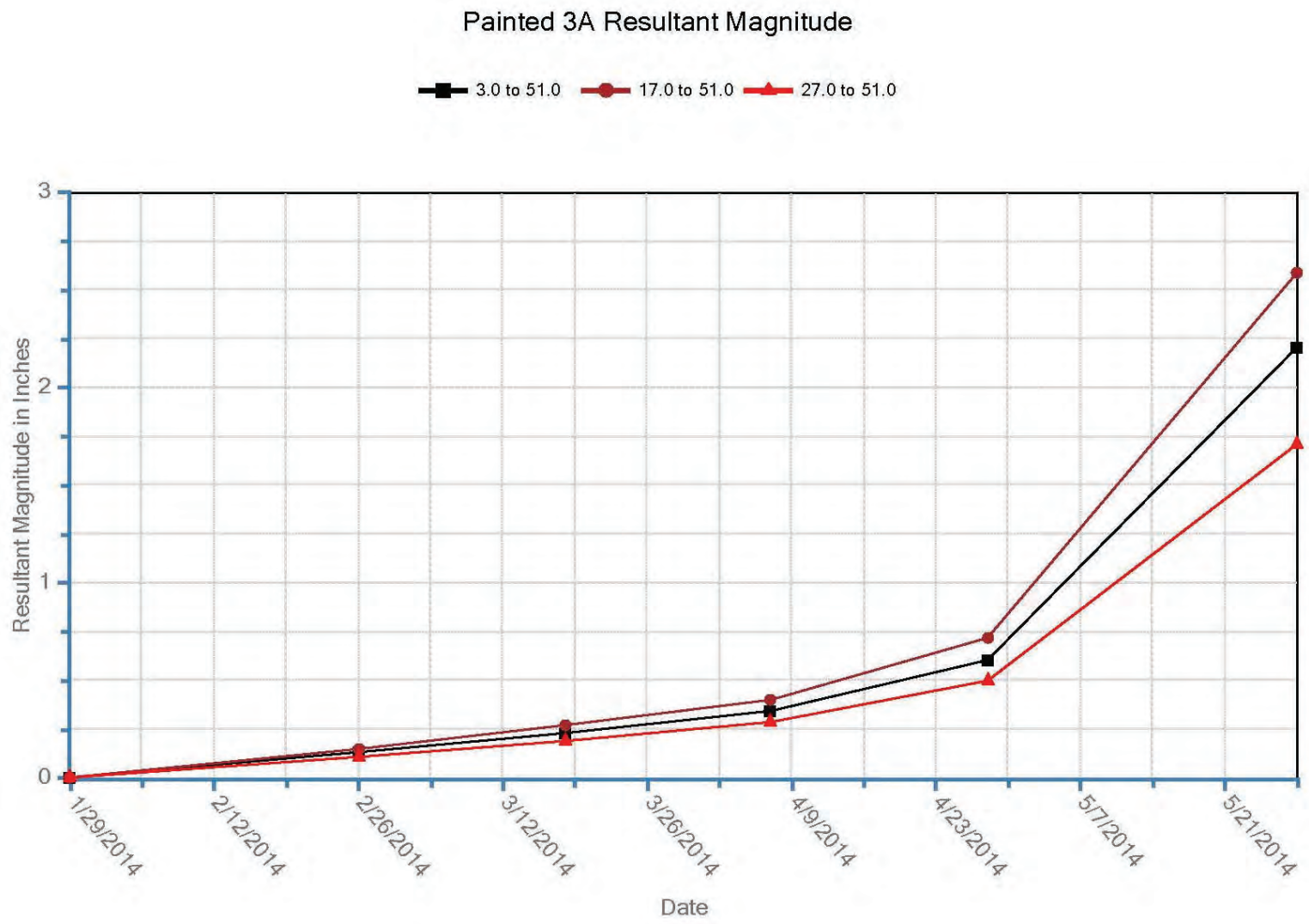
FIG. 7a



I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 3A INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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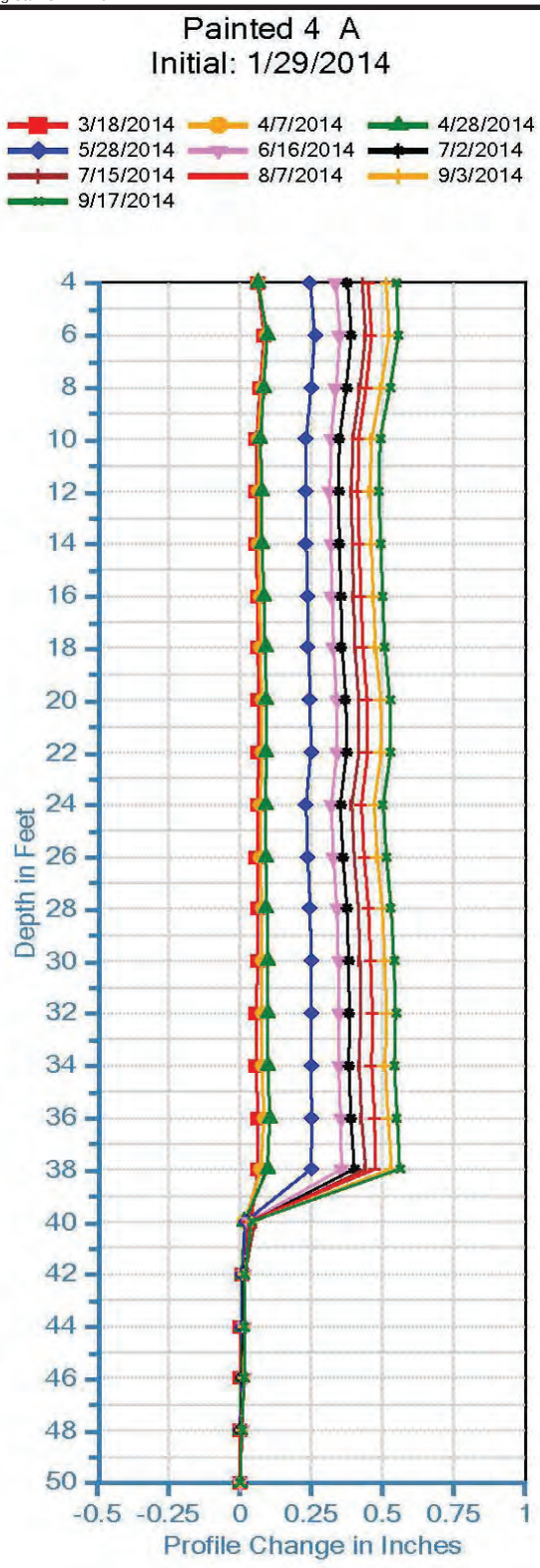
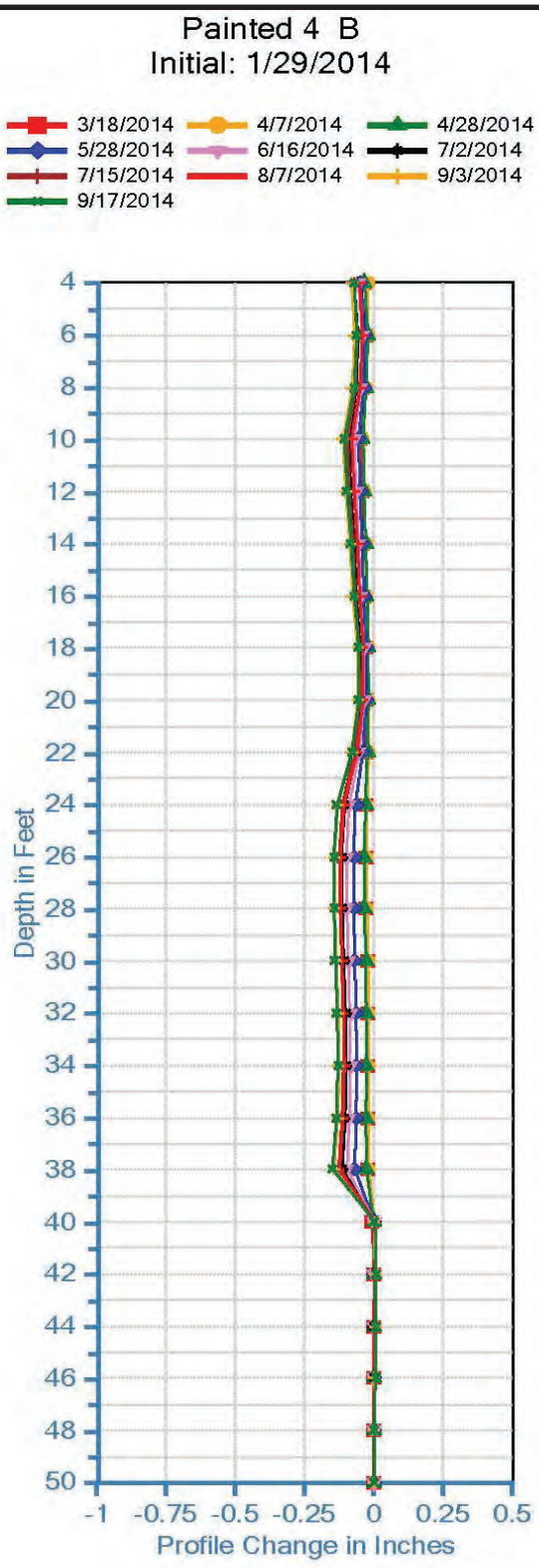
FIG. 7b

FIG. 7b





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 4 INCLINOMETER
CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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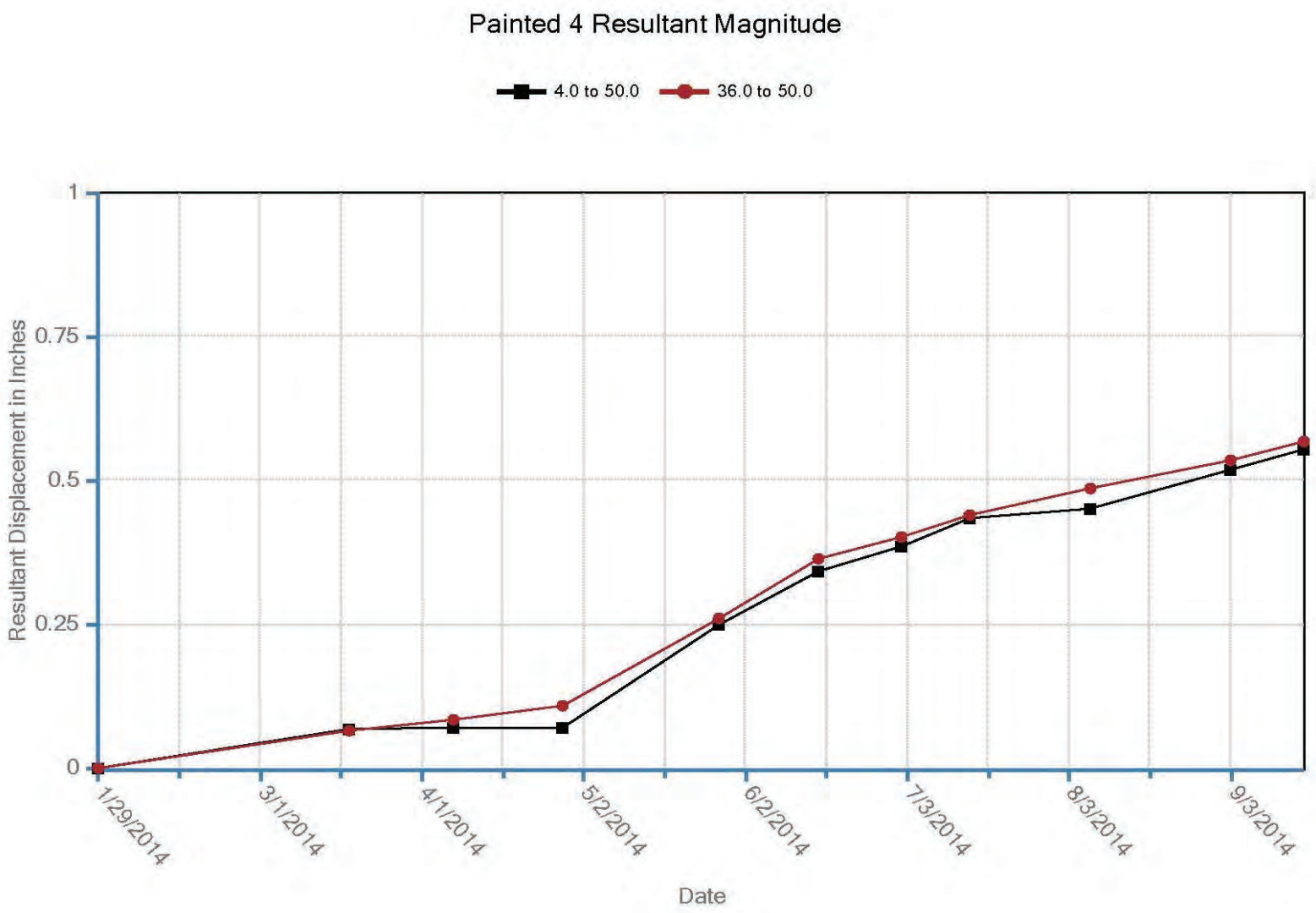
FIG. 8a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 4 INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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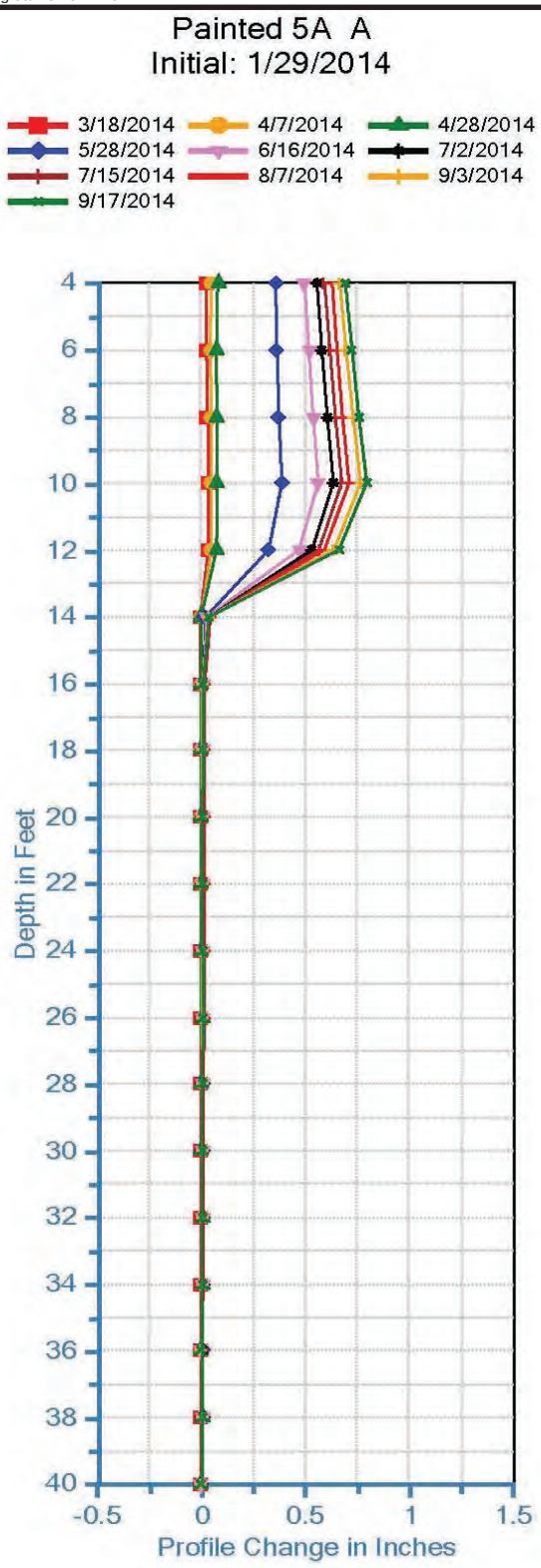
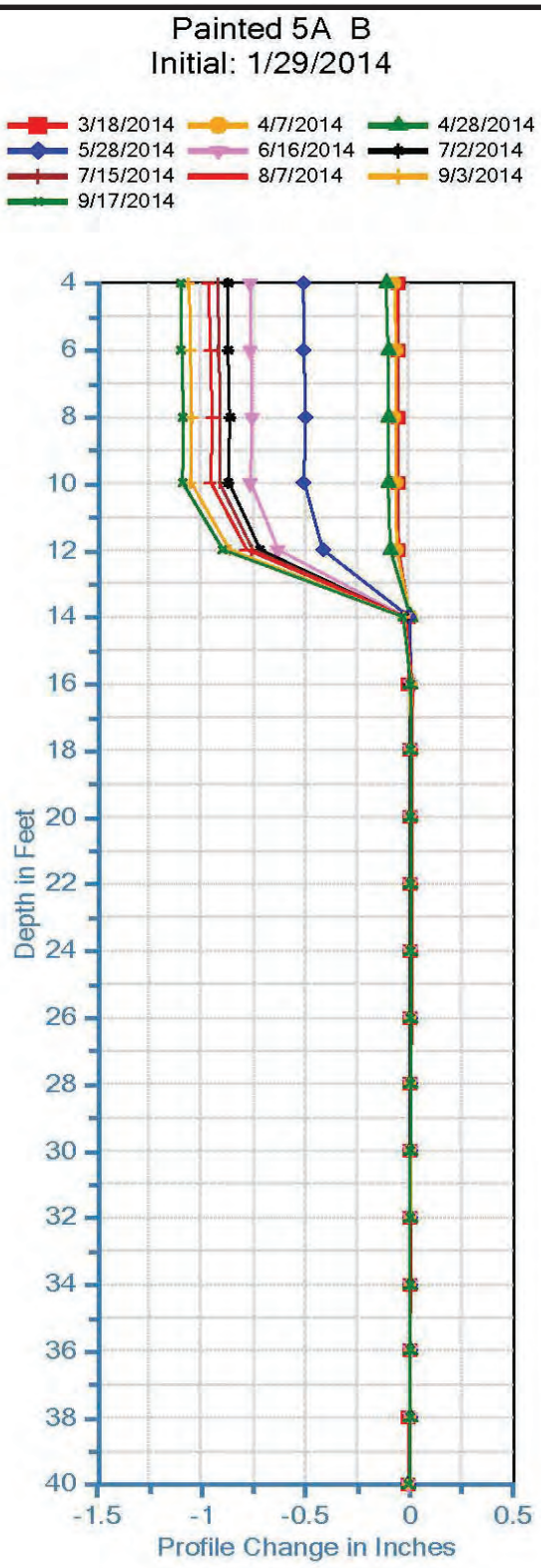
FIG. 8b

FIG. 8b





I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 5A INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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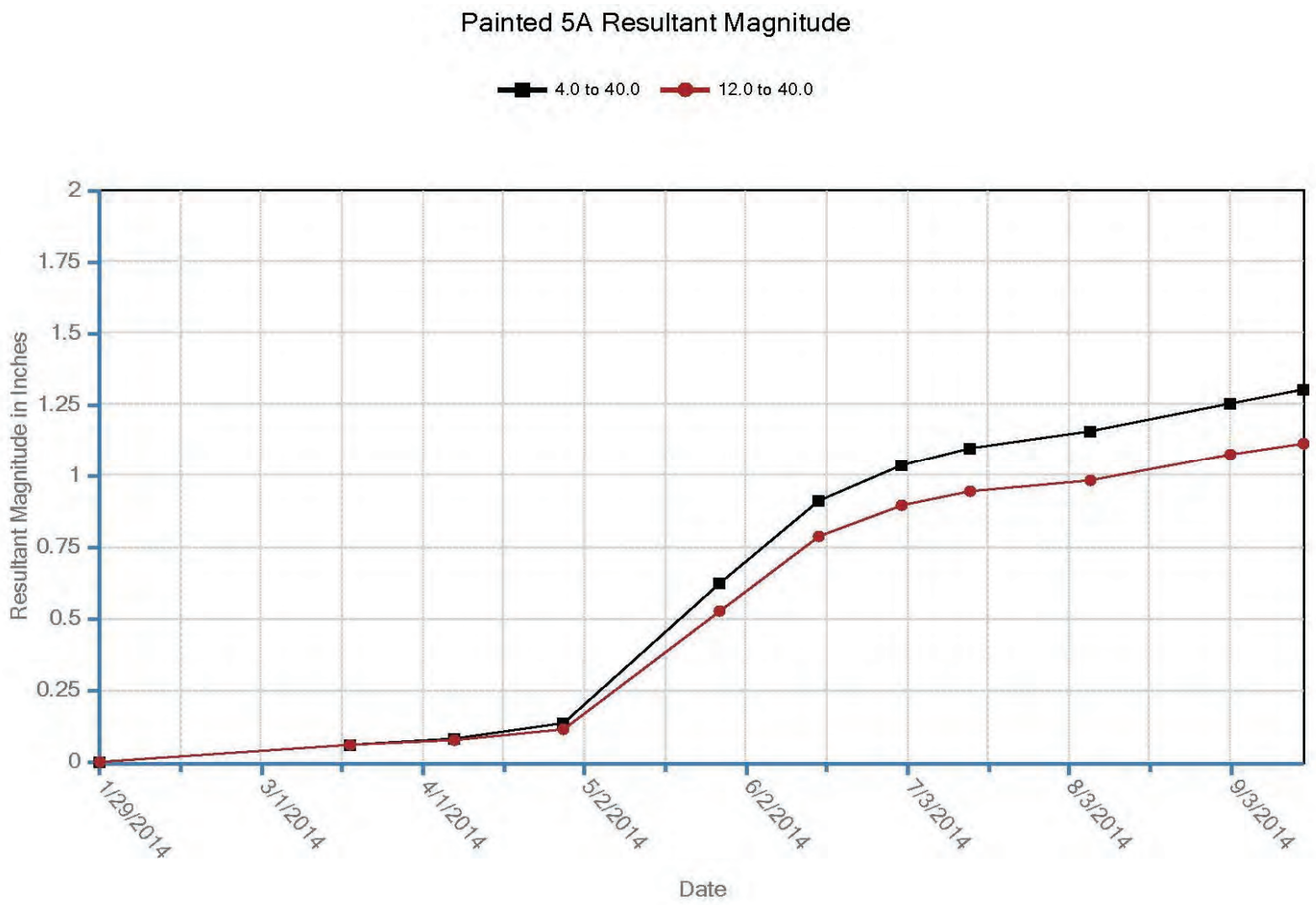
FIG. 9a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 5A INCLINOMETER
RESULTANT TIME DISPLACEMENT

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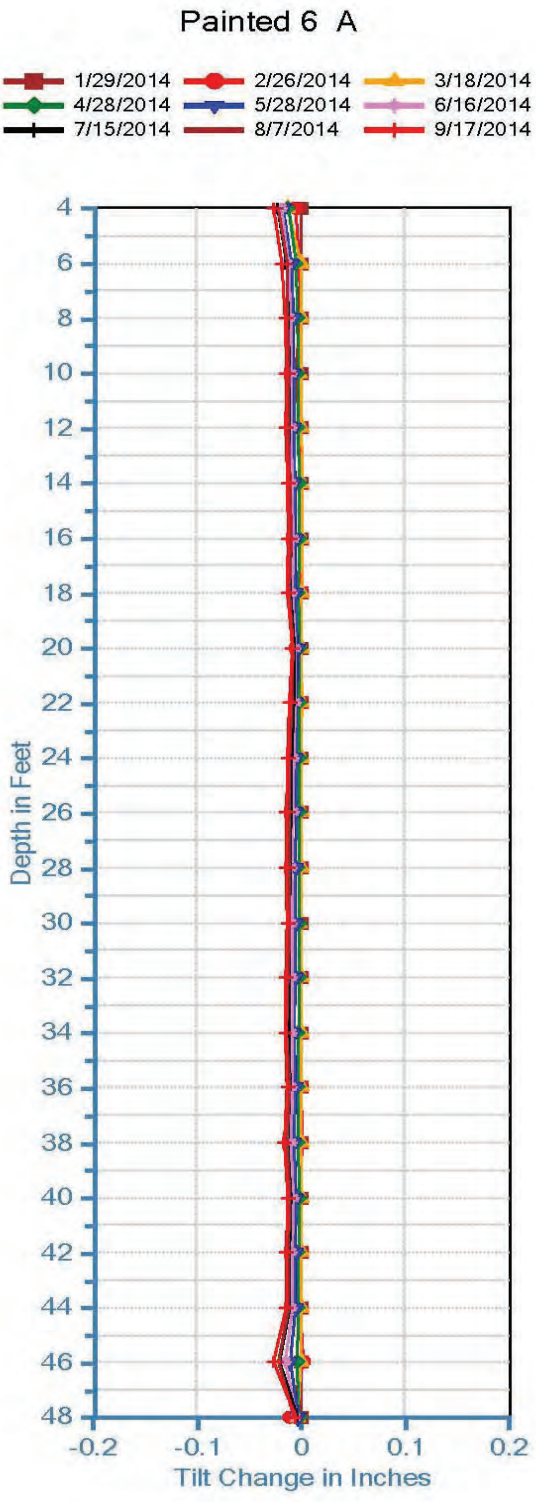
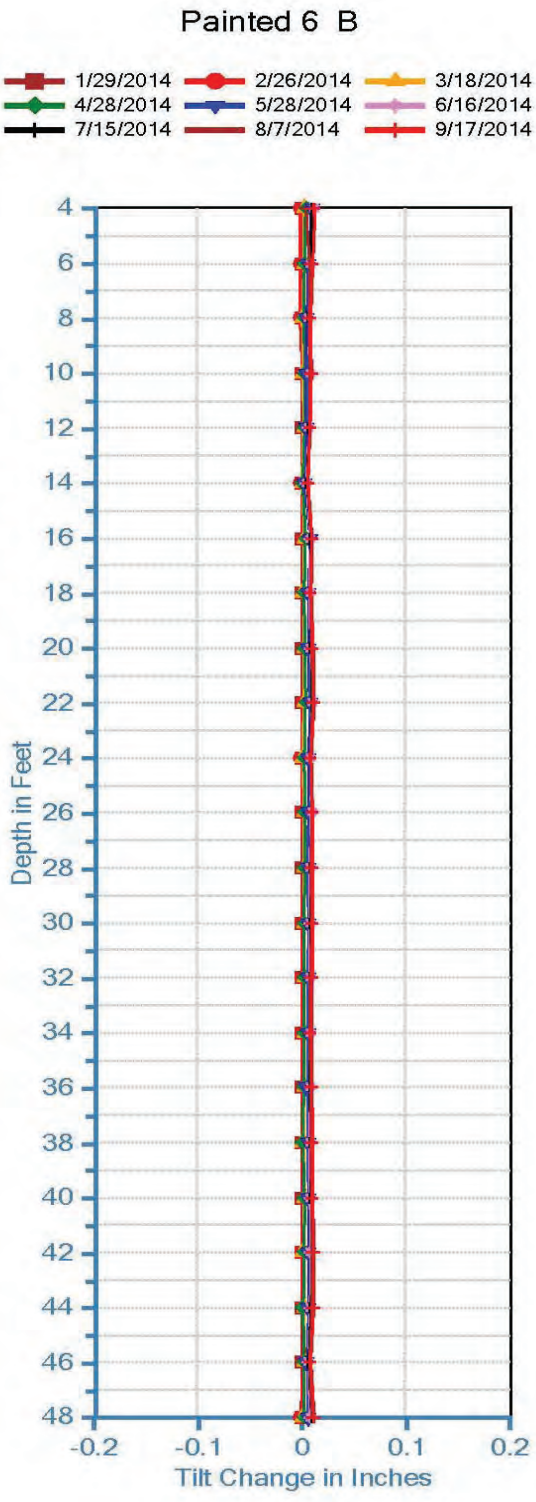
FIG. 9b

FIG. 9b





Note: This plot represents incremental changes in tilt along length of casing, and not cumulative displacements (like all other presented plots). This is plotted in this manner as the bottom of the casing does not appear to be fixed.

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
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CASING 6 INCLINOMETER INCREMENTAL DISPLACEMENT

October 2014 21-1-01447-200

SHANNON & WILSON, INC.
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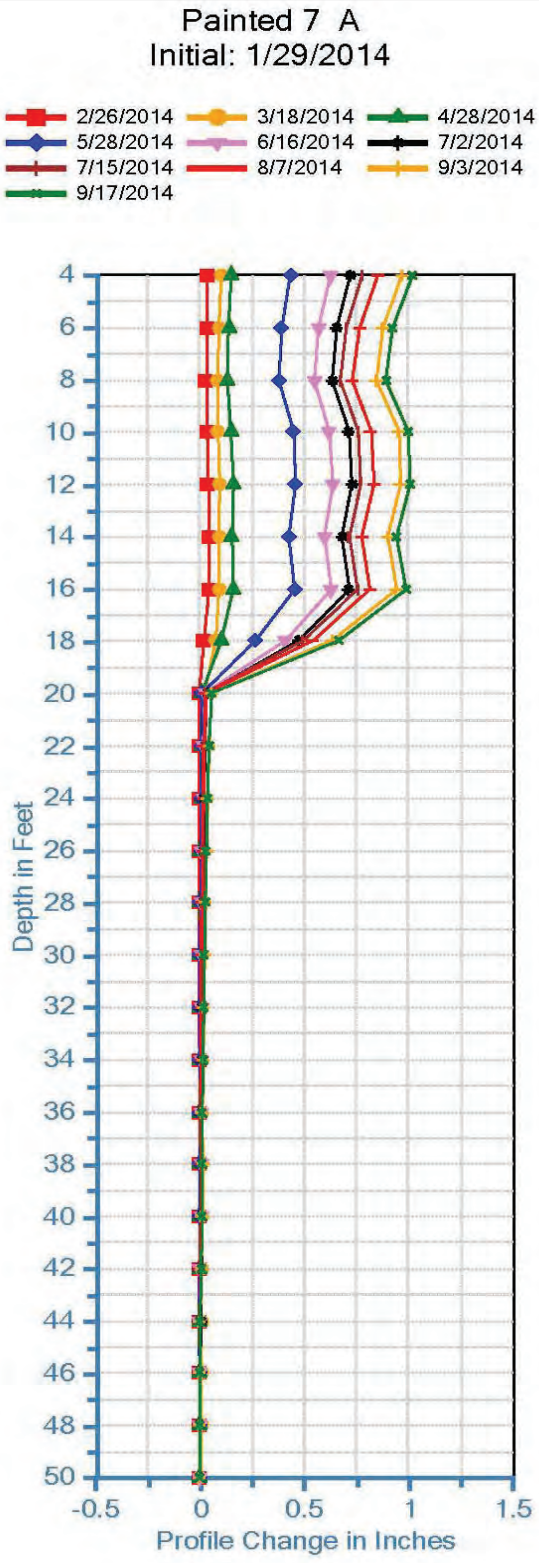
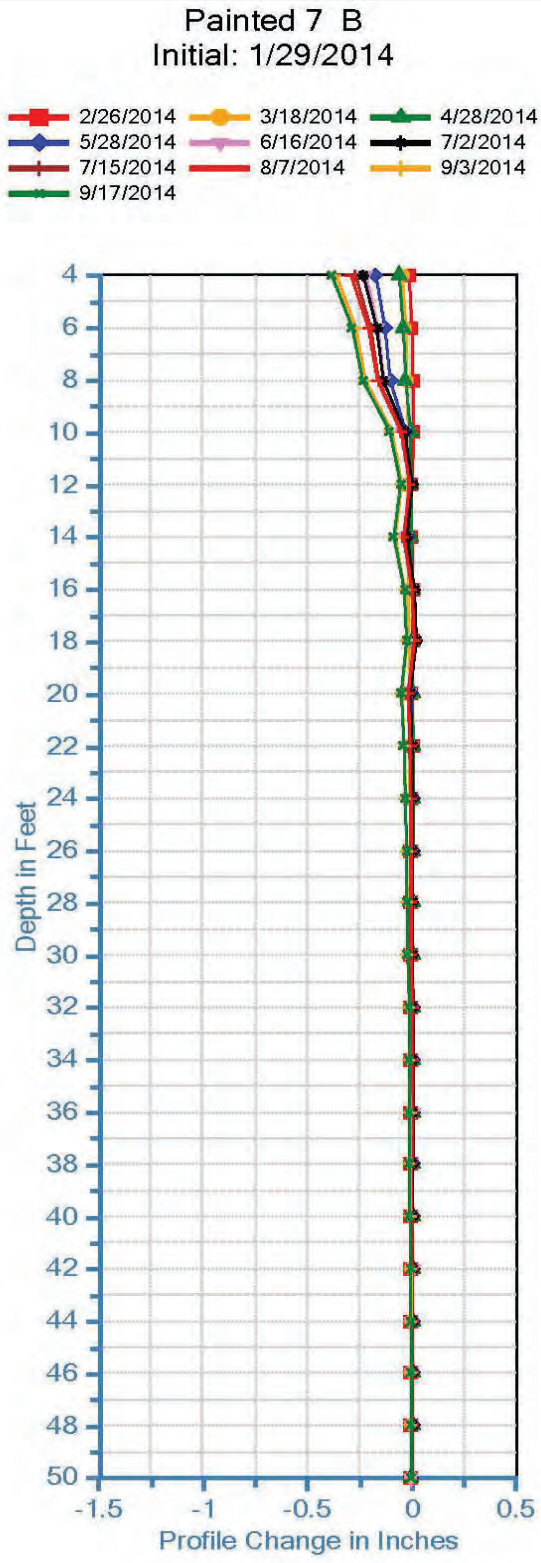
FIG. 10





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 7 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

SHANNON & WILSON, INC.
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FIG. 11a

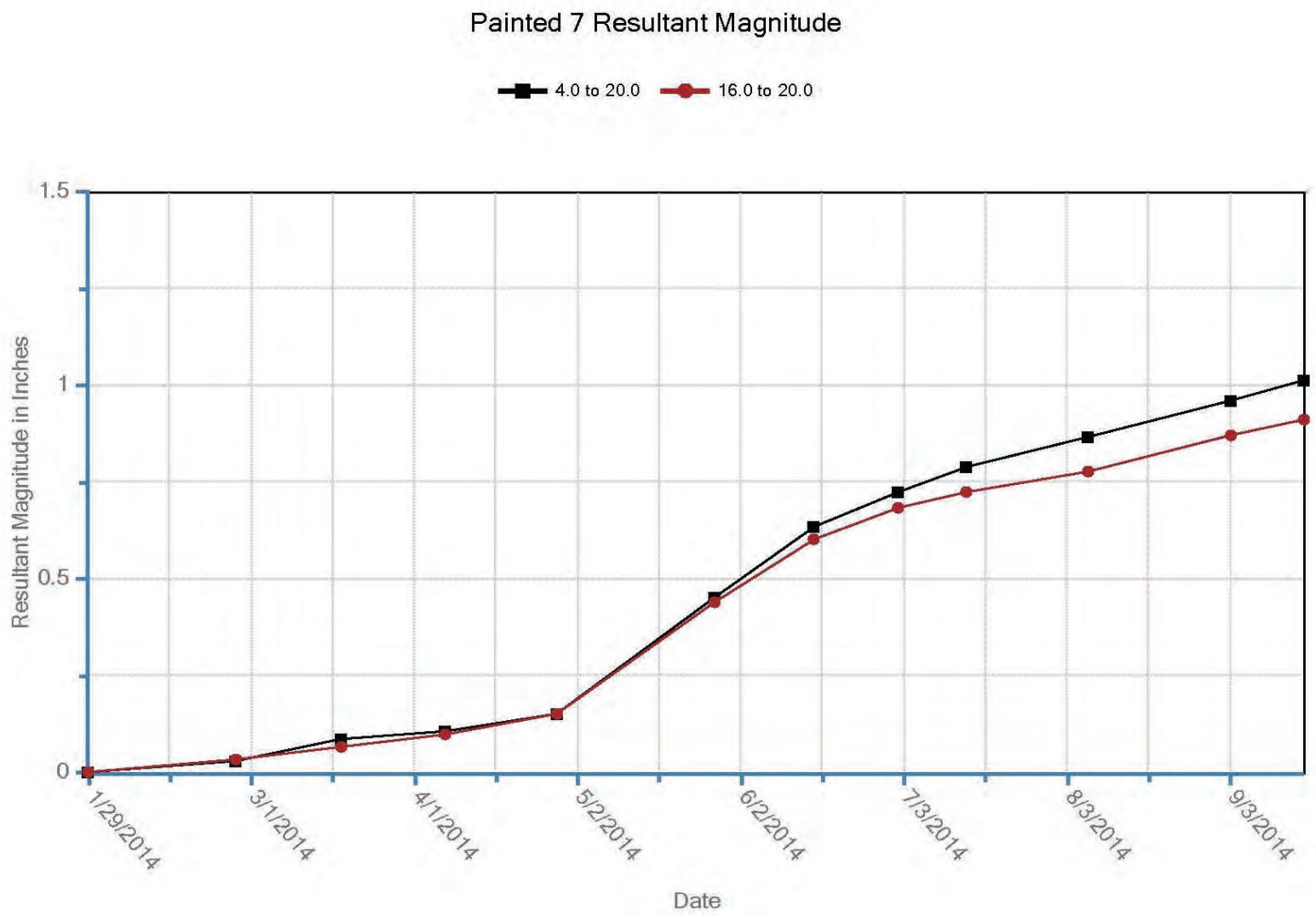

FIG. 11b

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
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CASING 7 INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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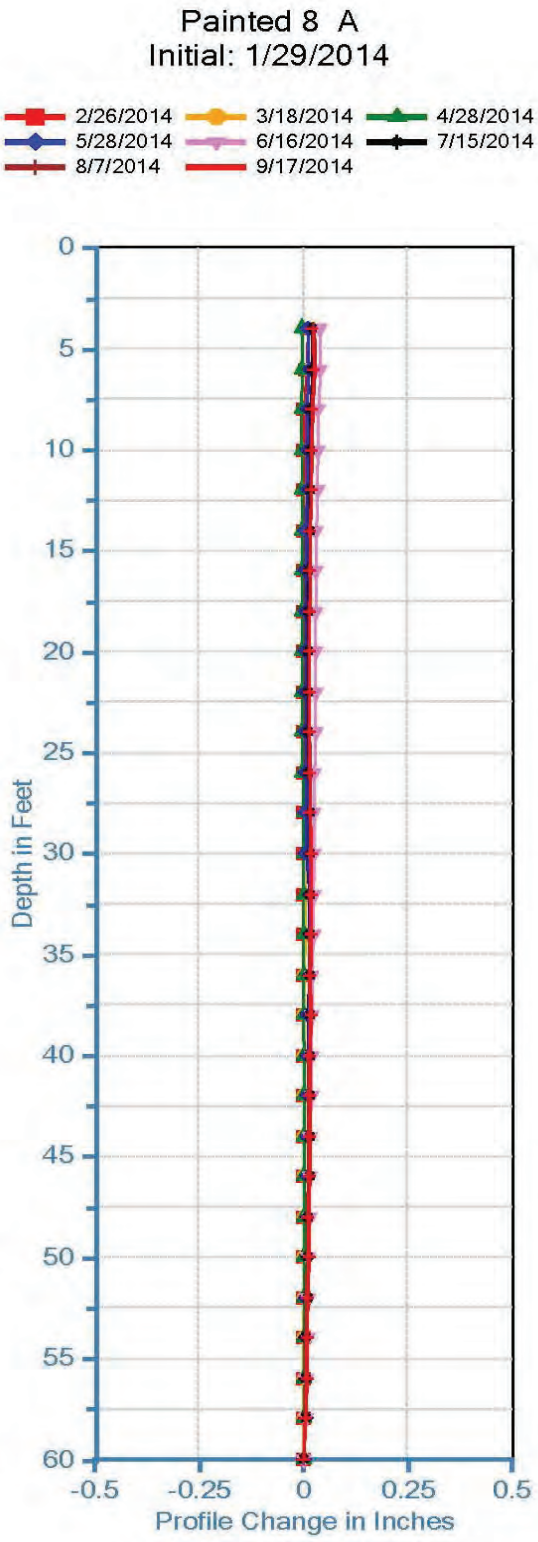
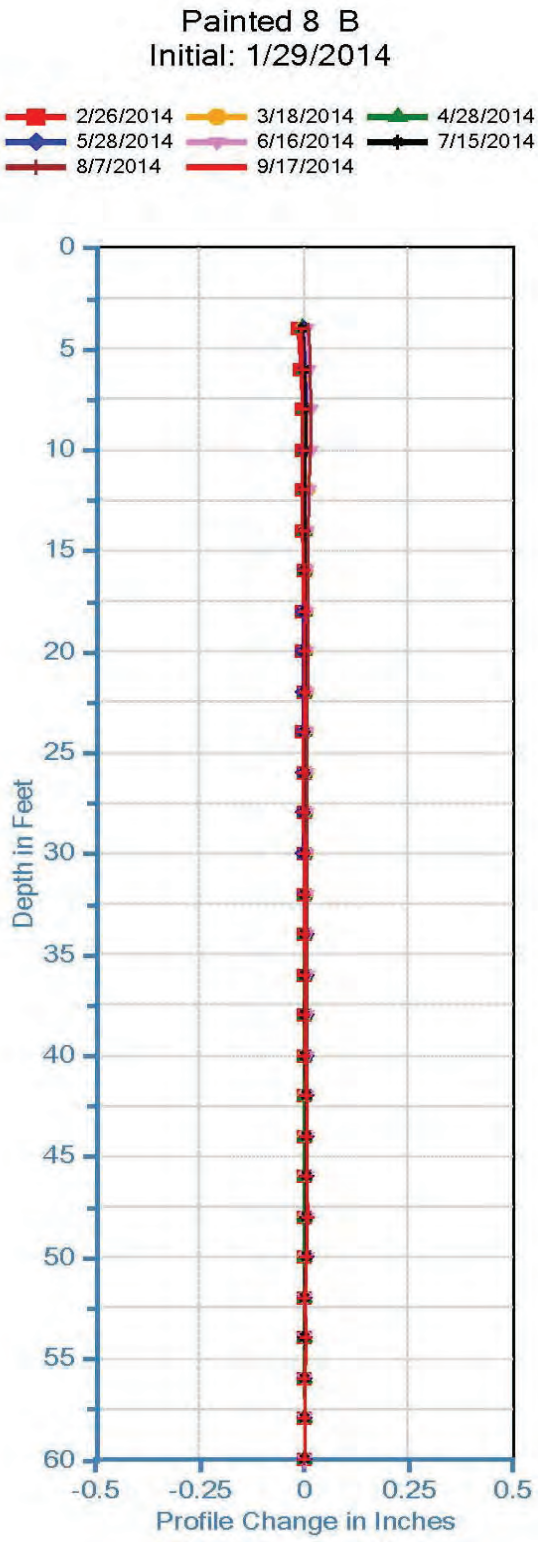
FIG. 11b





I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 8 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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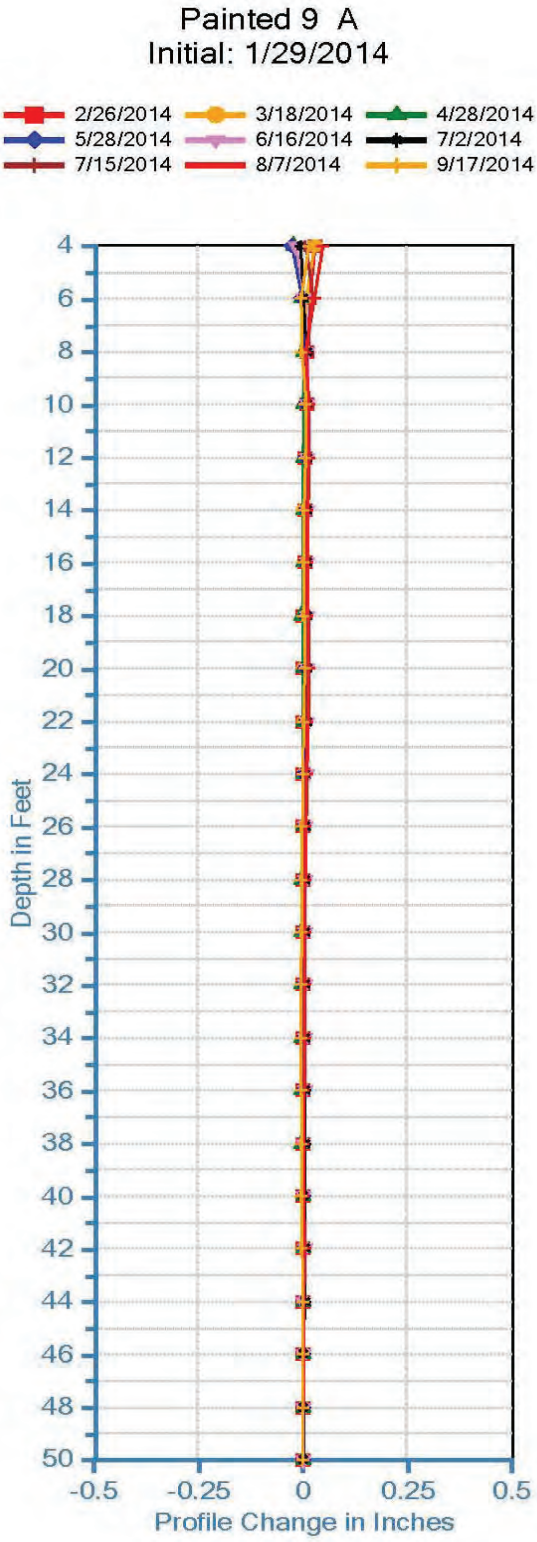
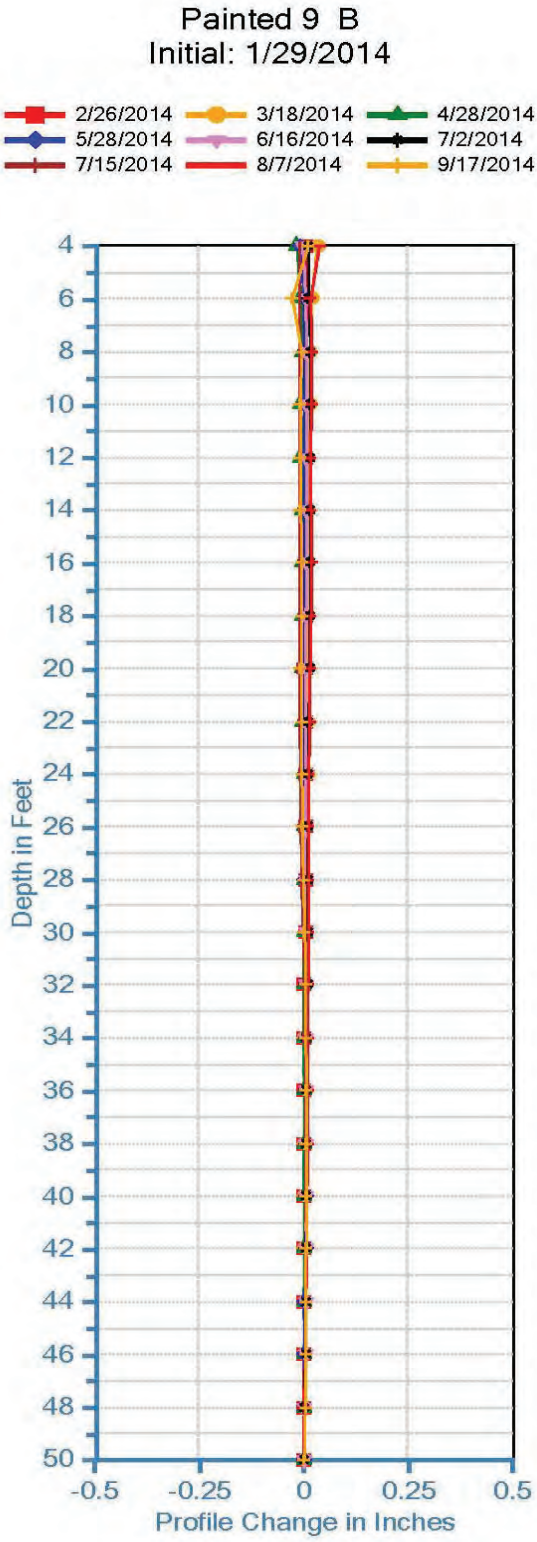
FIG. 12





I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 9 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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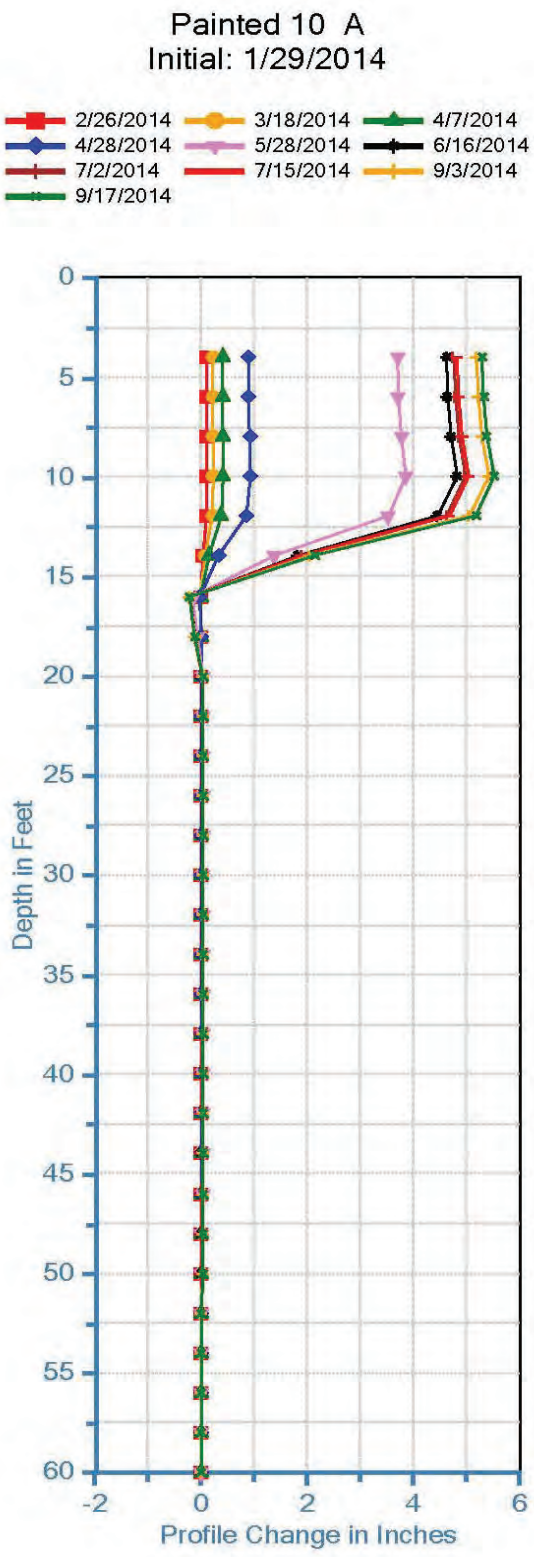
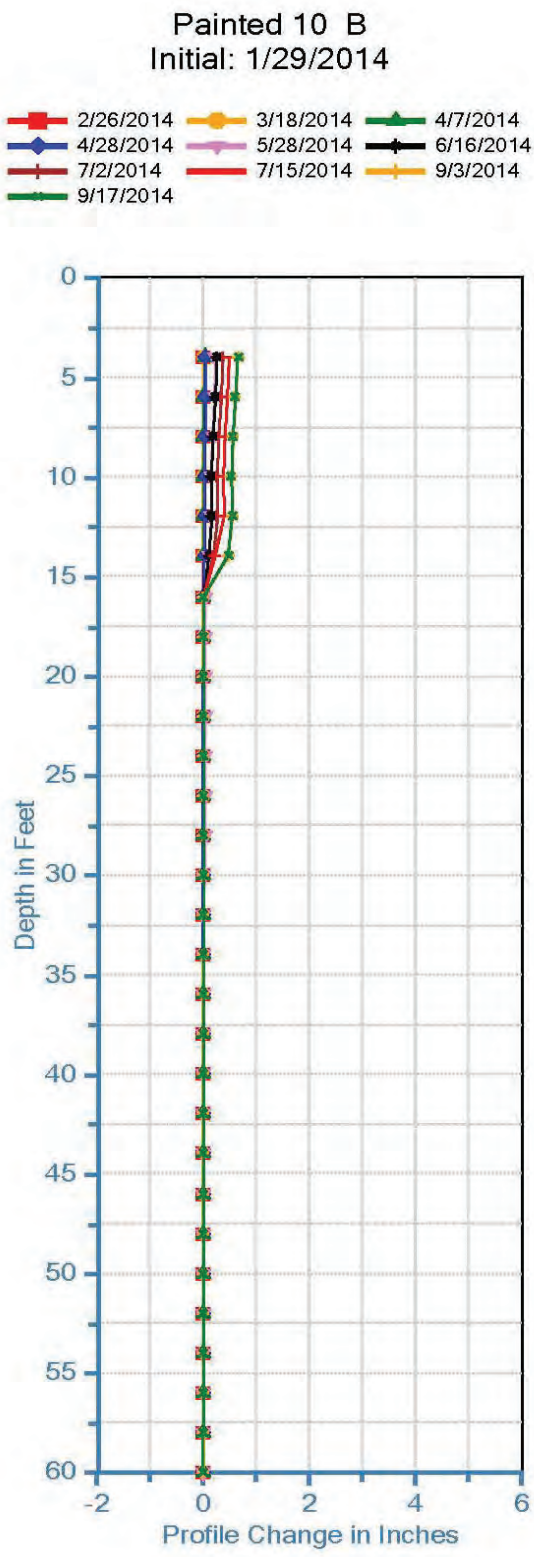
FIG. 13





I-94 Painted Canyon Landslide
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CASING 10 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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FIG. 14a

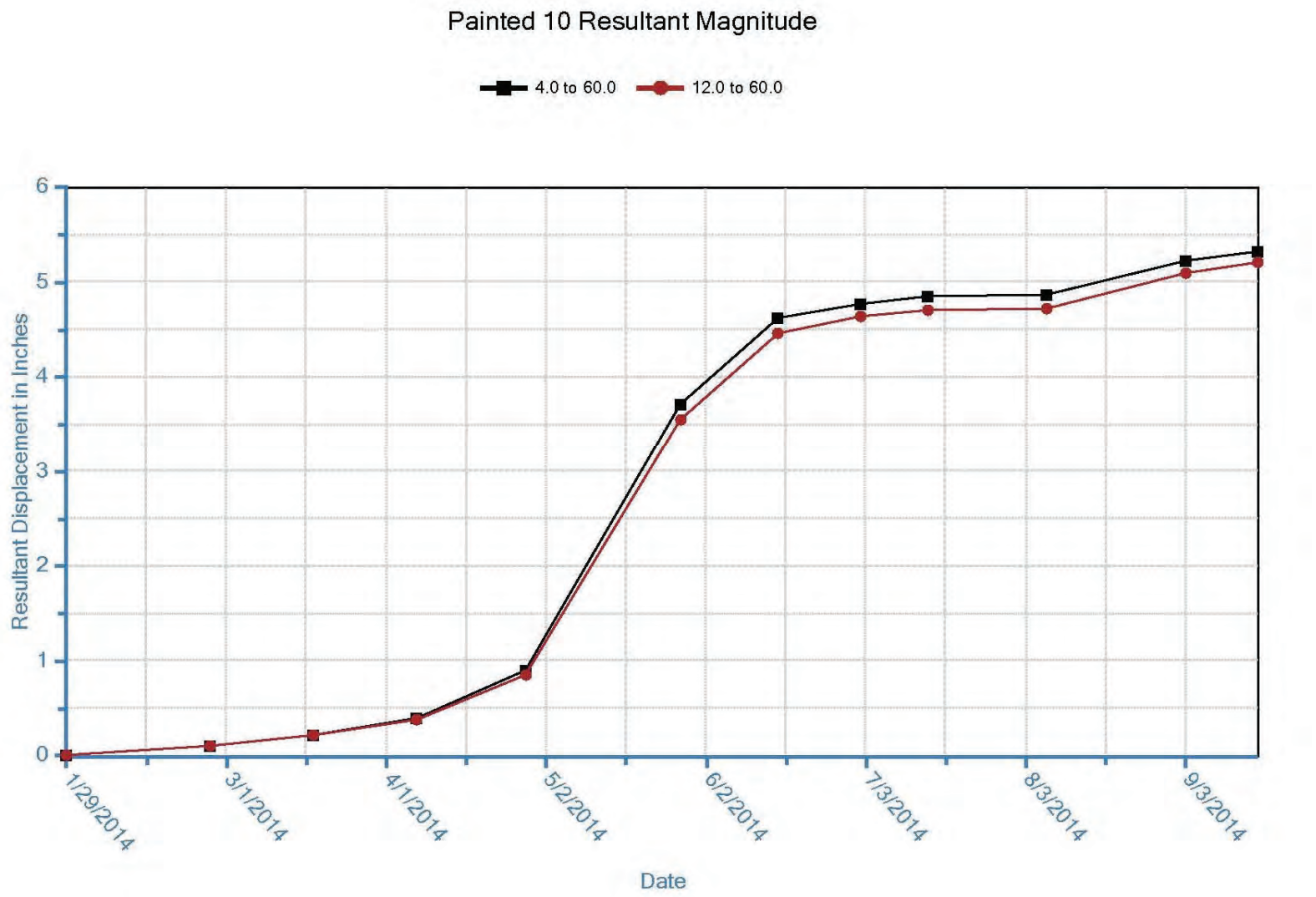


FIG. 14b

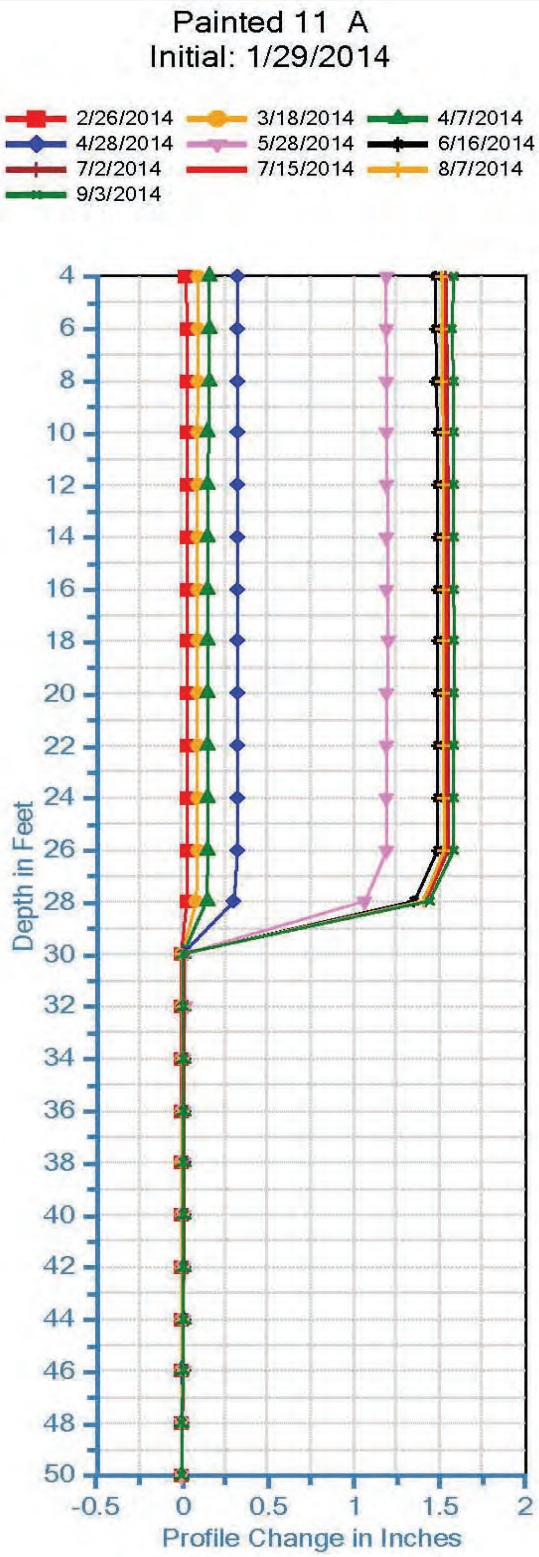
I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

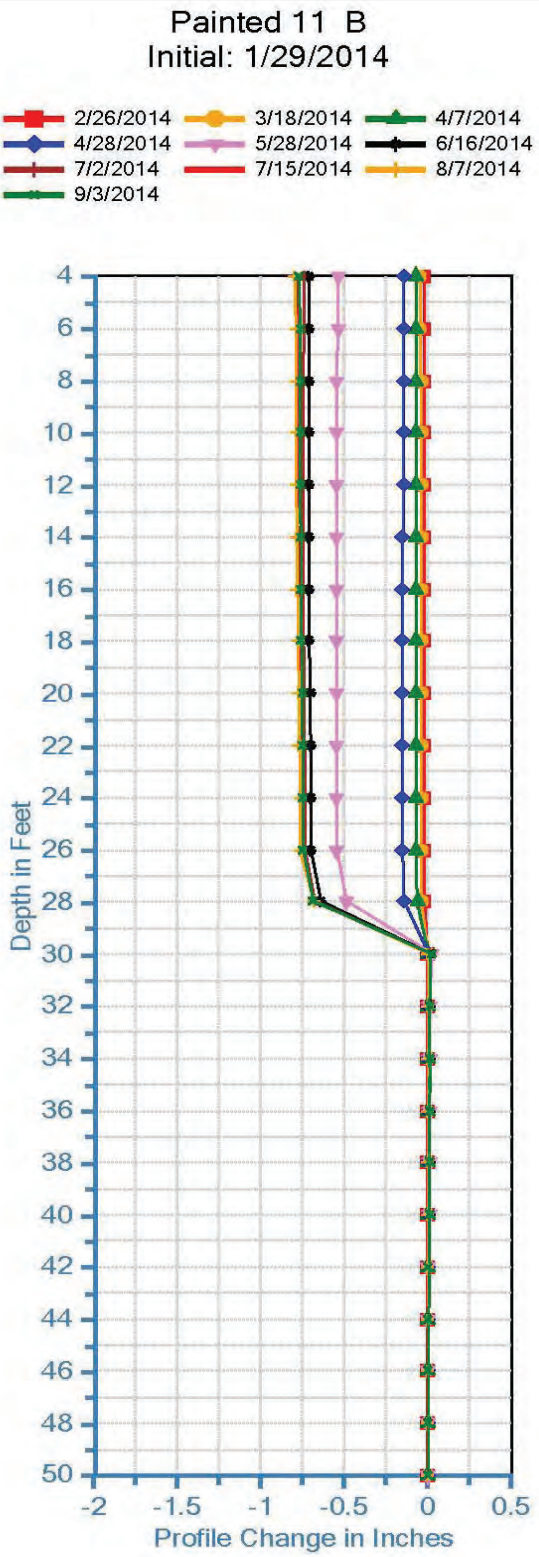
CASING 10 INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 14b





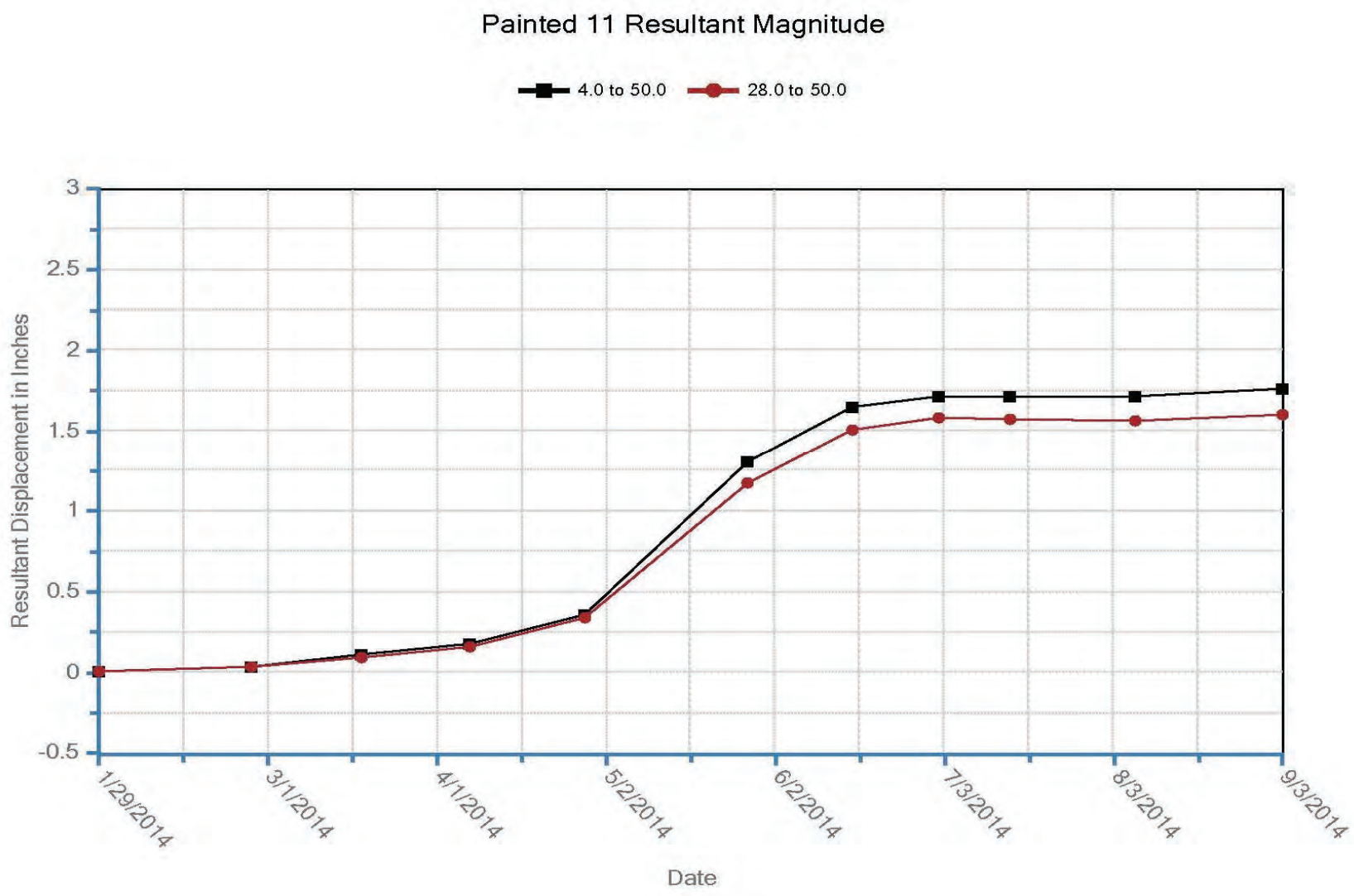
I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 11 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 15a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 11 INCLINOMETER
RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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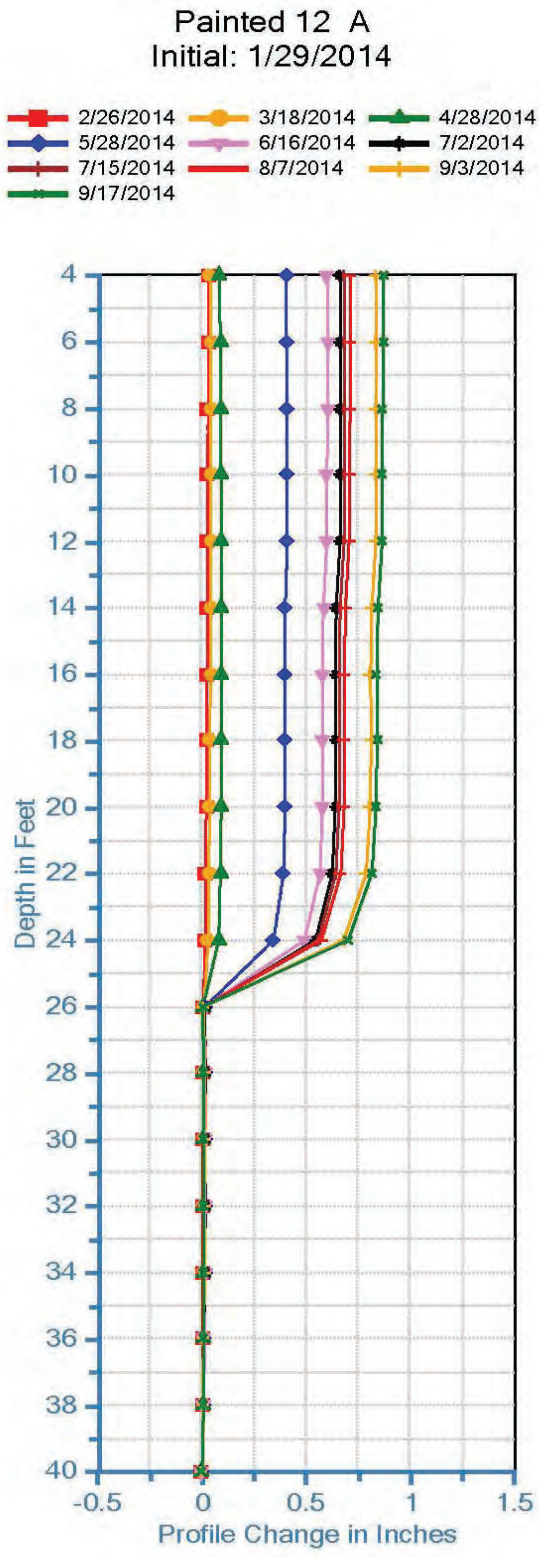
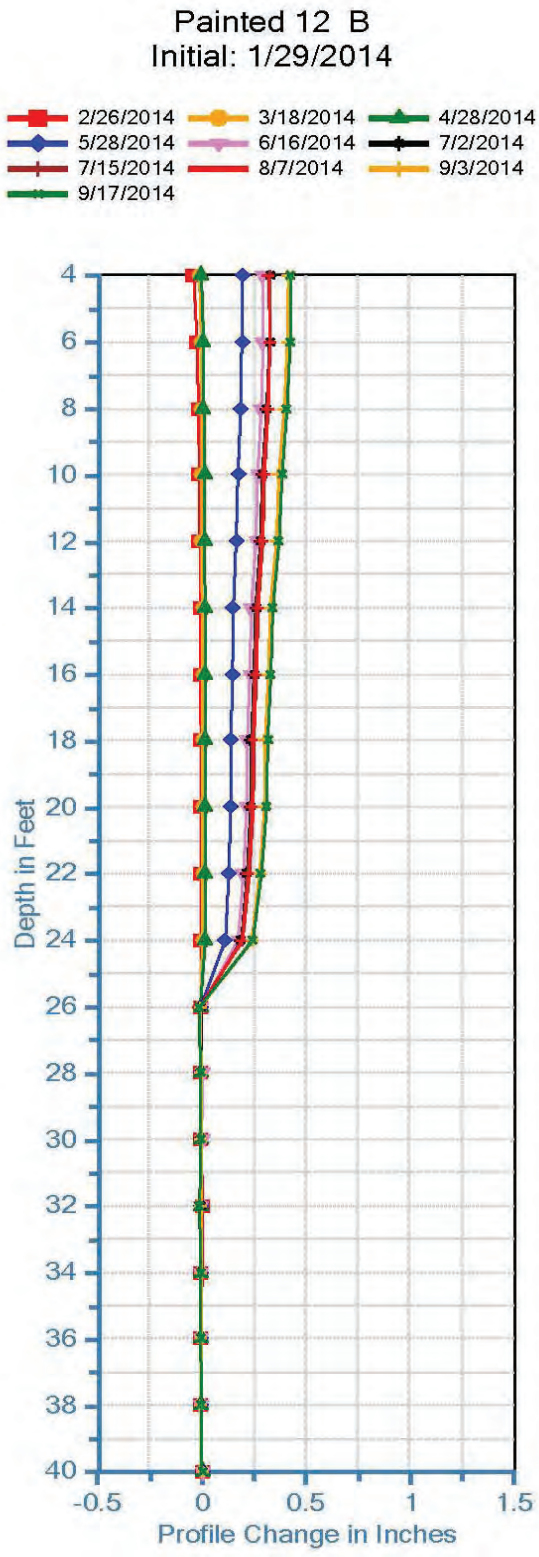
FIG. 15b

FIG. 15b





I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 12 INCLINOMETER CUMULATIVE DISPLACEMENT

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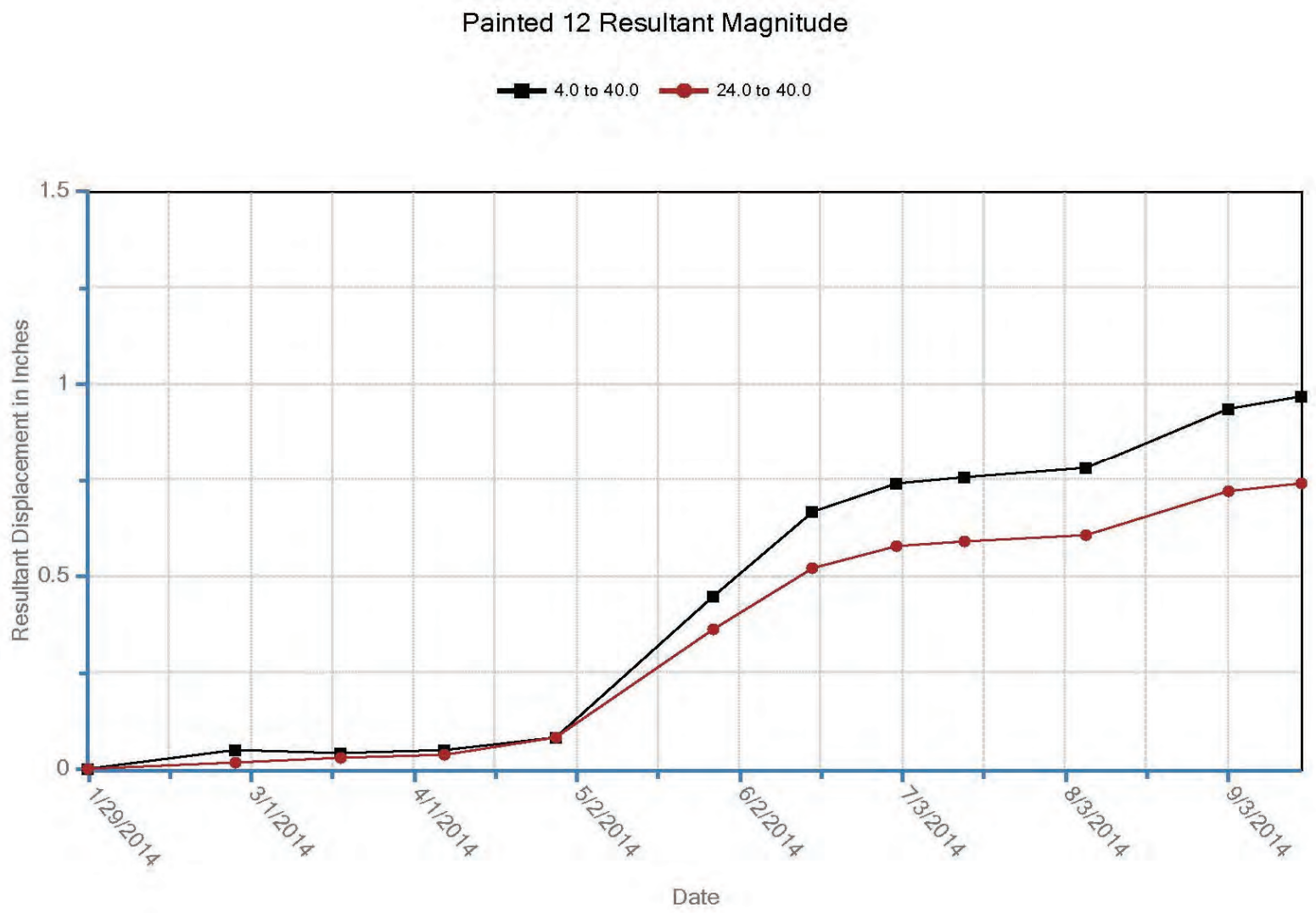
FIG. 16a



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 12 INCLINOMETER RESULTANT TIME DISPLACEMENT

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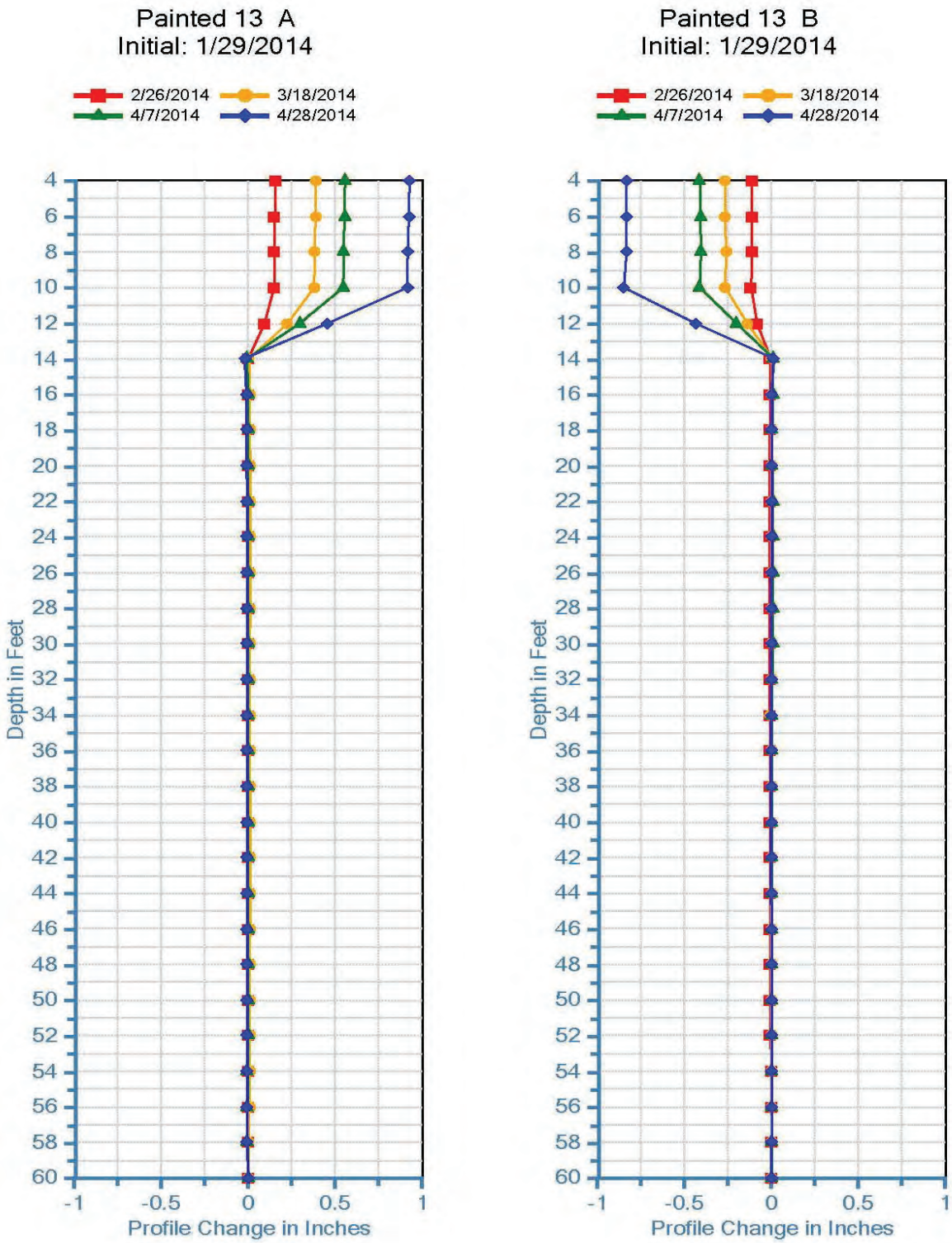
FIG. 16b

FIG. 16b



I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 13 INCLINOMETER CUMULATIVE DISPLACEMENT

October 2014 21-1-01447-200

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FIG. 17a

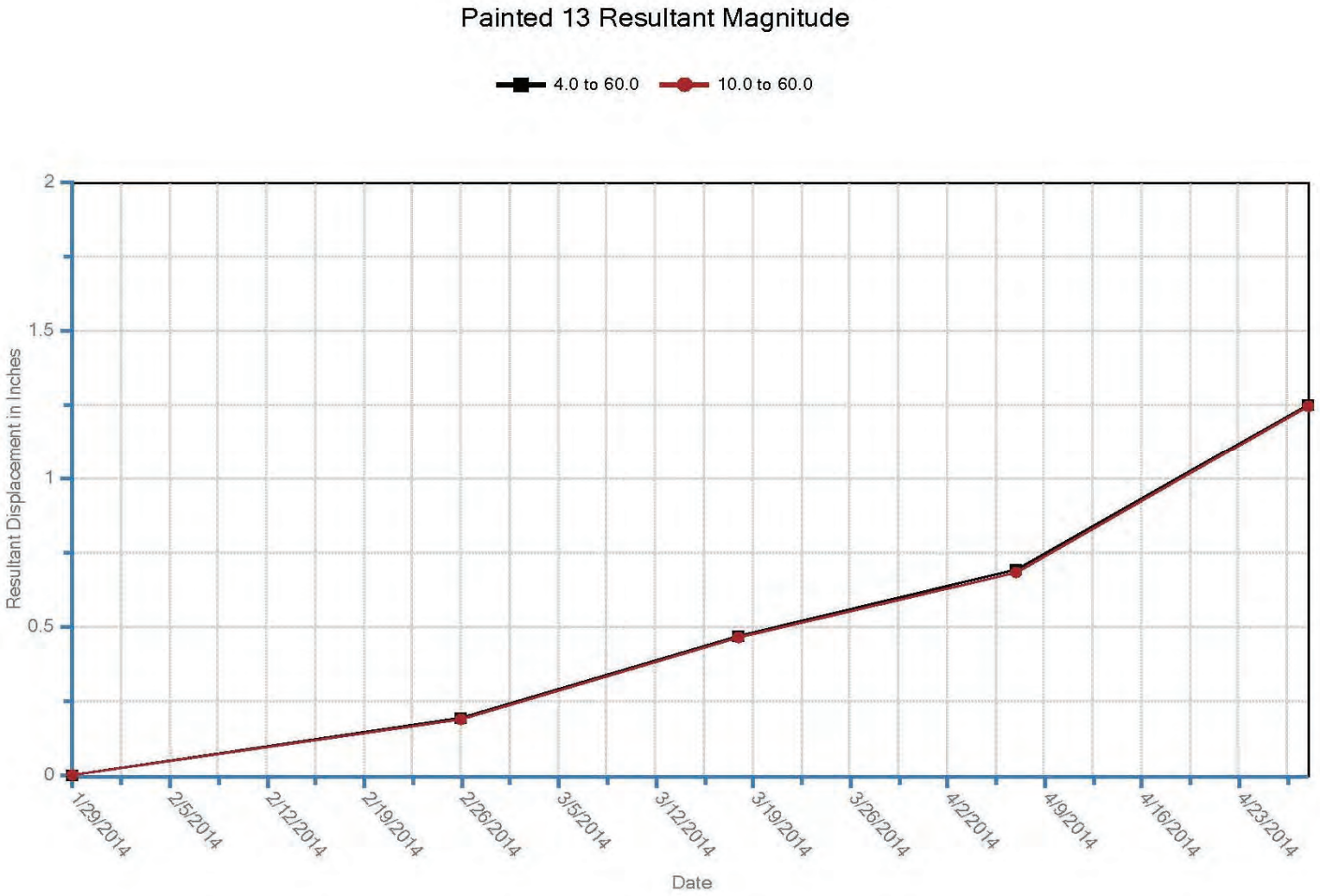

FIG. 17b

I-94 Painted Canyon Landslide
Project No. PE-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 13 INCLINOMETER RESULTANT TIME DISPLACEMENT

October 2014 21-1-01447-200

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FIG. 17b

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ALASKA
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April 18, 2014

North Dakota Department of Transportation
608 East Boulevard Avenue
Bismarck, North Dakota 58505

Attn: Mr. Jeff Jirava

RE: MARCH 2014 INSTRUMENTATION DATA EVALUATION, I-94 PAINTED CANYON INSTALLATIONS, NORTH DAKOTA

Dear Mr. Jirava:

This letter report presents our recent evaluation of the geotechnical instrumentation that was installed in the area of the Painted Canyon along I-94 near Medora, North Dakota. The instrumentation data was provided to us from the North Dakota Department of Transportation (NDDOT) Materials and Research department on March 19, 2014.

This evaluation was performed in conjunction with the exploration and new instrumentation installation program that was completed in March 2014 by Shannon & Wilson and NDDOT.

PROJECT DESCRIPTION

The project site has a history of landslides and ground deformations that have been observed since the 1970s along the downslope area of the westbound lanes of I-94. In the area of the subject landslide, an inclinometer casing was installed in late 2001 to evaluate depths of shear zones and rates of movement. Since then, additional inclinometer casings have been installed to delineate the extent of the ground movement and to replace casings that became inoperable due to excessive deformation.

Through 2013, twelve inclinometer casings are operational and being monitored by NDDOT on an approximate monthly schedule. NDDOT is also measuring the water levels inside the inclinometer casings to evaluate changes in groundwater elevations.

1321 BANNOCK STREET, SUITE 200
DENVER, COLORADO 80204-4077
303-825-3800 FAX: 303-825-3801
TDD 1-800-833-6388
www.shannonwilson.com

In March 2014, two borings (SW-01 and SW-02) were drilled to provide additional subsurface information. Within each of these boreholes, an inclinometer casing was installed to supplement the existing instrumentation program. Three levels of vibrating wire piezometers (VWP) were attached to the exterior of the new inclinometer casings and the annulus of the assemblies was backfilled with grout up to the ground surface. An additional boring, SW-01A, was drilled next to boring SW-01 for installation of a VWP in a sand-filled monitoring zone.

A site plan of the previous and new instrument installations is presented in Figure 1. In the following sections, an evaluation of the existing instrumentation data and monitoring program is provided.

PIEZOMETERS

The water levels measured inside the inclinometer casings reflect long term seepage in or out of the casing. Unless the inclinometer casings are slotted and a specific monitoring zone is established, determination of where the water is seeping through the casing is difficult and the source of ground water could be any point along the depth of the casing. Responsiveness of the water levels within the casing will tend to be significantly slower than a typical well, as the joints of the inclinometer casing are generally sealed with glue or an O-ring connection. Use of the casings for long term water level readings is reasonable, as long as NDDOT understands the limitations.

The two new boreholes, SW-01 and SW-02, have the VWP signal leads routed to the top of the boreholes and then connected into battery-powered 4-channel stand-alone dataloggers. The three leads from boring SW-02 go into one datalogger, and the three from boring SW-01 and the one from boring SW-01A go into the other logger. The loggers were programmed to calculate and store values of piezometric head above the tip of the VWP. While this simplifies the data reduction process somewhat, it limits the capabilities for evaluation of the data and instrument performance. This method also results in more effort to correct the recorded pore pressure values if an incorrect formula or entry is used in the logger program. If future datalogger and piezometers are installed, we would suggest recording just the raw data and using spreadsheets for determining the piezometer water levels.

Figure 2 presents a plot of the pore pressure readings for borings SW-01 and SW-01A piezometers between March 14 and April 7, 2014. In boring SW-01, VWP1 is the shallow installation and VWP3 is the deepest, as shown on the plot. VWP4 (in boring SW-01A) is at approximately the same elevation as VWP2 in boring SW-01. Over the monitoring period shown, the data from the gages indicate relatively stable readings, except for instrument VWP3. As indicated in Figure 2, VWP3 initially indicated a slight decreasing trend in pore pressure, with a temporary drop of about 5 feet of head. Over several hours early on March 20, this instrument indicated a 10 foot drop in head, with an additional 2 foot drop over the next week. In the last week and a half, measurements have indicated relative stability. VWP1 has indicated no piezometeric head above the gage since installation.

For comparison purposes, the two instruments installed at approximately the same elevation (VWP2 at approximately 2,746 ft and VWP4 at approximately 2,747 ft), are currently exhibiting the same pore pressure elevation. VWP4, installed in a sand back-filled filter zone, has had a slow rise over the last month to stabilize at approximately the same elevation as VWP2, which was grouted into the borehole and has a slight decrease in measured pore pressures over the last month.

Figure 3 presents a plot of the pore pressure readings for boring SW-02 piezometers between March 14 and April 7, 2014. As with boring SW-01, the designations for the VWPs increase with depth. The approximate three weeks of monitoring indicate relative stability in the upper VWP, a slight rise in pore pressure of the middle VWP, and a slight trend of decreasing pore pressure in the lowest VWP after an initial drop.

NEW INCLINOMETER CASINGS

Inclinometer casings were installed to depths of 110 and 100 feet, for borings SW-01 and SW-02, respectively. The 3.34-inch-outside-diameter casings were installed with the internal grooves aligned in the general direction of anticipated ground movement. The casings extend a couple feet above ground surface. Boring SW-01 is located on the east shoulder of westbound I-94 and boring SW-02 is located downslope near the park fence.

Two sets of inclinometer readings were performed on March 18, 2014 to establish baseline readings for each new casing. One set of readings was done in the grooves aligned in the downslope direction (A-direction), and the other set was done in the perpendicular grooves (B-direction). Subsequent casings measurements need only be performed within the A-direction grooves of the casing. The inclinometer probe is biaxial and measures both the A0 and B0 values in one pass, and then measures A180 and B180 values in the second pass when the probe is turned around. The casings were measured using the new Slope Indicator AT monitoring system, which is discussed below in its comparison to the old monitoring system.

A subsequent data set was obtained for each casing on April 4, 2014. Figure 4 presents the displacement plot of Casing SW-01, in comparison to the baseline measurements. In the three week duration, one shear zone has been identified at a depth of 42 to 44 feet below the top of the casing.

Based on current measurements, deformation of Casing SW-02 is only observed in the top 12 feet of the casing, as shown on Figure 5. In the three week duration, the top of the casing has displaced approximately 0.2-inch, when considering the vector direction movement.

Checksum values for the baseline readings of each casing were relatively consistent in both the A and B directions. A checksum value is the sum of the A0 and A180 readings at the same depth. The initial top reading depth of Casing SW-02 had larger than normal checksum values, suggesting that the top of the casing may not be secured against lateral deformations, or an erroneous value was recorded. The grout backfill in the upper part of this casing may have settled out leaving the casing unsupported.

PREVIOUS INCLINOMETER CASINGS

Included in the following discussion is a review and evaluation of the measurements performed on the previously installed inclinometer casings. Through October 2013, NDDOT performed the measurements approximately monthly with the Slope Indicator Classic inclinometer system to monitor movement of the slide area. Based on our review of the data, trends in distinct and faster moving shear zones were easier to identify and evaluate. Additional zones of possible shear movement were observed in the analysis; however the relatively small apparent displacements were within the level of accuracy of the measurement sets provided and therefore not considered reliable zones of movement for evaluation.

A new inclinometer monitoring system was implemented by NDDOT this year (Slope Indicator AT system), replacing the older Classic system. Measurements with this new system started January 29, 2014. NDDOT adjusted the procedures for monitoring with the new system to correlate reading depths from one system to the next. To some extent, the old and new data sets are comparable; however, bias-shift and rotation error corrections to the new data sets were necessary to facilitate the comparison to the previous data sets for some of the casing sets. For some casings, the comparisons could not correctly be performed. The differences in the probe outputs create some discrepancies in correctly evaluating the continuing trends of displacement from old probe to new probe.

It is our opinion that the new AT system will provide more repeatable results with the casing measurements, and a higher level of accuracy than was observed with the Classic system. Based on our evaluation of the data, it would be preferable to establish the readings obtained on January 29, 2014, as a new baseline, and compare all subsequent reading sets done with the AT system to it. For future reference, it would be desirable to take readings with the old probe on the same day as the new probe to assist in matching up output from the two probes.

Table 1 presents a summary of identified shear zones and approximate rates of displacements observed, based on inclinometer casing measurements. On Figure 1, the area observed to have the highest rates of casing displacement have been outlined. This area includes the new inclinometer casings, and subsequent measurements should indicate rates of displacement for them. Figures 6 through 17 present plots of cumulative displacement for the A and B directions of both the old and new probe measurements of each casing, unless otherwise indicated. Cumulative displacement sums the incremental displacements of each measurement interval from the bottom of the casing up toward the top. With slight fluctuations in measurements from one depth to the next, or from one reading set to the next, the errors in the accuracy compound and make interpretation of trends in displacement more difficult. Summarized below is a discussion of the measurements and interpreted displacements for each casing.

Casing 1A

Casing 1A was installed in August 2013, replacing the adjacent Casings 1 and 2, which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 1A is about 50 feet deep with the A-direction internal grooves oriented downslope.

Plotted cumulative displacement values from the new AT system (2014 measurements) and the old Classic system are presented on Figure 6a. As shown, displacements are occurring in both the A0 and B180 direction, with the resultant displacement direction between approximately N35E and N50E. Two distinct shear zones are identified with the measurements, and displacements at these zones and the top of the casing continue at a steady rate, as shown on the Figure 6b displacement versus time plot. The two systems compare adequately for this casing, but long term monitoring should rely on the AT system data, as discussed above. Measured cumulative displacements with just the new system are presented on Figure 6c.

Casing 3A

Casing 3A was installed in August 2013, replacing the adjacent Casing 3 (installed July 2011) which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 3A is about 50 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 7a and 7b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. Two distinct shear zones are identified in this casing, with the upper shear zone more identifiable with the current measurements than previously. Displacements at these two zones and the top of the casing continue at a steady rate, as indicated on the displacement versus time plots for the two systems, in Figure 7c.

Casing 4

Casing 4 was installed in September 2011 to assist with determining the extent of ground movement in this area. Casing 4 is about 50 feet deep with the A-direction internal grooves oriented downslope.

Plotted cumulative displacement values from the new AT system (2014 measurements) and the old Classic system are presented on Figure 8a. One deep distinct shear zones is identified in this casing, and displacements at this zone and the top of the casing continue at a relatively steady rate with some apparent seasonal fluctuations, as shown on the Figure 8b displacement versus time plot. The two systems compare adequately for this casing, but long

term monitoring should rely on the AT system data, as discussed above. Measured cumulative displacements with just the new system are presented on Figure 8c.

Casing 5A

Casing 5A was installed in August 2013, replacing the adjacent Casing 5 (installed September 2011) which had deformed enough to restrict continued monitoring with the inclinometer probe. Casing 5A is about 40 feet deep with the A-direction internal grooves oriented downslope.

Plotted cumulative displacement values from the new AT system (2014 measurements) and the old Classic system are presented on Figure 9a. One distinct shear zones is identified in the upper third of this replacement casing, however the original casing measurements also suggested potential movement occurring in the lower 2 to 3 feet of the casing (depths of 37 to 40 ft). This lower zone is currently not apparent in the replacement Casing 5A. Measured displacements in the upper identified zone and the top of the casing continue at a relatively steady rate with some apparent seasonal fluctuations, as shown on the Figure 9b displacement versus time plot. This plot represents the time plot for the resultant direction, or combination of both the A and B directions, for the Classic system (top plot) and the AT system (lower plot).

The two systems compare adequately for this casing, but long term monitoring should rely on the AT system data, as discussed above. Measured cumulative displacements from the new system are presented on Figure 9c.

Casing 6

Casing 6 was installed in September 2011, upslope of Casings 1, 2, and 1A and along the north edge of westbound I-94. Casing 6 is about 50 feet deep with the A-direction internal grooves oriented downslope.

Casing measurements with the Classic monitoring system indicated no distinct shear zones along the depth of the casing. The standard displacement plot for this casing suggested that bottom of the casing may not be fixed. A plot of incremental displacement along the depth of the casing, up through October 2013, is presented in Figure 10a. This plot displays an incremental increase in angular rotation of the bottom measurement point in the casing, suggesting that movement could be occurring at the tip of the casing. An incremental plot for the

new probe system is presented in Figure 10b; however no indications of displacement have been observed in this casing with new probe measurements through April 2014.

Casing 7

Casing 7 was installed in September 2011, south of Casing 6 and along the north edge of westbound I-94. Casing 7 is about 52 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 11a and 11b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. One distinct shear zone between approximate depths of 17 to 21 feet is observed on the plots for this casing. Slight changes in incremental displacements were observed in the Classic measurement data at depths of approximately 35 and 45 feet, suggesting possible deeper shear zones; however, recent data from the AT system have not indicated similar displacements. Displacements at the upper shear zone and the top of the casing continue to increase at a slower rate than in past years, with some seasonal fluctuations, as indicated on the displacement versus time plot shown on Figure 11c. The upper plot on this figure displays the resultant displacement versus time for the Classic monitoring system, while the lower plot represents new AT monitoring system measurements.

Casing 8

Casing 8 was installed in September 2011, in the median between eastbound and westbound I-94. Casing 8 is about 62 feet deep with the A-direction internal grooves oriented downslope (toward the northeast).

Casing measurements with the Classic monitoring system suggested the bottom of the casing may not have been stable in the first several months of monitoring, resulting in plotted data that was questionable when it is assumed that the bottom is fixed, as shown on Figure 12a. If an initial measurement set from February 2012 is used for comparison of subsequent sets using the Classic system measurements, then slight possible shear zones at depths of approximately 36 and 46 feet in the casing were observed; however, measurements with the new AT monitoring system do not indicate any displacements at any depths in the casing, as shown on Figure 12b.

Casing 9

Casing 9 was installed in September 2011, in the south edge of eastbound I-94. Casing 9 is about 50 feet deep with the A-direction internal grooves oriented toward the northeast.

Casing measurements with the Classic monitoring system indicated slight displacement of the top of the casing up the hillside (toward the southwest), in addition to slight apparent deformation along the length of the casing also toward the upslope side, as shown on Figure 13a. These apparent displacements are questionable, considering the direction and depth of movement. Measurements with the new monitoring system do not indicate any displacement along the depth of the casing, however slight downslope (easterly) displacements are observed at top of the casing, as shown on Figure 13b.

Casing 10

Casing 10 was installed within the Park area in July 2013. Casing 10 is about 50 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 14a and 14b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. Measurements with the Classic system indicated fluctuations along the length of the casing that were difficult to associate with displacements during that time period. Measurements from the new AT system, however, did display more precise readings with a distinct shear zone 12 to 16 feet below the top of the casing. Displacements at this zone and the top of the casing have increased at a relatively steady rate since the start of this year, as shown on the lower plot of Figure 14c. This figure presents displacement versus time plots for the Classic system (on top) and the new AT system.

Casing 11

Casing 11 was installed within the Park area in July 2013. Casing 11 is about 50 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 15a and 15b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. Similar to

Casing 10, the measurements with the Classic system indicated fluctuations along the length of the casing that were difficult to associate with displacements. Measurements prior to 2014 also suggest that the bottom of the casing was not fixed as shown on Figure 15a, so it is difficult to determine definitive indications of displacement during that time interval. Measurements from the new AT system, however, did display more precise readings with a distinct shear zone 28 to 30 feet below the top of the casing and the bottom appeared to be fixed. Displacements at this zone and the top of the casing have increased at a relatively steady rate since the start of this year, as shown on the lower plot of Figure 15c. This figure presents displacement versus time plots for the Classic system (on top) and the new AT system.

Casing 12

Casing 12 was installed within the Park area in July 2013. Measurements for Casing 12 extend to depth of about 40 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 16a and 16b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. Measurements prior to 2014 display slight fluctuations along the depth of the casing, but a distinct shear zone between 23 and 25 feet below ground surface is identifiable. Measurements from the new AT system appeared to provide more precision along the length of the casing, also indicating the same shear zone location. Displacements at the shear zone and the top of the casing are increasing slightly since the start of this year, as shown on the lower plot of Figure 16c. This figure presents displacement versus time plots for the Classic system (on top) and the new AT system.

Casing 13

Casing 13 was installed within the Park area in July 2013. Measurements for Casing 13 extend to depth of about 60 feet deep with the A-direction internal grooves oriented downslope.

Cumulative displacement values from the two monitoring systems are plotted on Figures 17a and 17b, for the old Classic system and the new AT system, respectively, as the data sets from the two systems did not correlate sufficient enough for direct comparison. Measurements prior to 2014 display slight fluctuations along the depth of the casing, but a distinct shear zone

between 11 and 13 feet below ground surface is identifiable. Measurements from the new AT system appeared to provide more precision along the length of the casing, also indicating the same shear zone location. A time versus displacement plot for the resultant direction of both monitoring systems, is presented on Figure 17c, with the Classic system on top and the new AT system on the bottom.

SUMMARY

The approximate current rate of displacement and direction of top of casing movement is tabulated and presented in Table 1, and displayed on Figure 1. As shown, the direction of the displacements is typically downslope, and this is relatively consistent amongst each of the casings. Based on current data sets (April 2014), the top of casing measurements with the highest current incremental rate of movement are as follows:

- Casing 13 0.9-inch / month
- Casing 10 0.27-inch / month
- Casing SW-02 0.24-inch / month
- Casing 3A 0.17-inch / month
- Casing 1A 0.14-inch / month

Of the casings that have not been replaced, inclinometer Casing 7 currently exhibits the largest amount of lateral displacement (approximately 3.6-inches); however the current rate of movement at this casing is less than most other casings at the site. Based on the magnitude of total displacement for this casing, it is possible the deformed casing may restrict passage of the monitoring probe through the identified shear zone when the rate of displacement increases again.

RECOMMENDATIONS

The instrumentation that has been installed and monitored at this site have and will continue to provide useful information regarding piezometric pressures, identification of shear zones, and rates of movements associated with those shear zones. To provide consistent and reliable instrumentation data, we recommend the following for continued monitoring:

- Piezometers
    - Data should be downloaded monthly from dataloggers, at a minimum.
    - Batteries and desiccants, inside dataloggers, should be changed every six months.
    - Instrument cable serial numbers should be verified with datalogger connection channels. Confirm that the serial number in program is same as connected cable.
    - Perform another set of manual readings, if possible, to check connections and data reduction formulas. Manual readings from March 14, showed output for VWP2 and VWP3, of boring SW-01, different from those recording in the datalogger. These may have been transposed or switched.
    - Confirm the zero reading for Channel 1 (VWP1) of the datalogger at boring SW-02. Shannon & Wilson field notes indicate an initial reading of 8998.88, but the screen shots of the datalogger setup indicate an initial reading of 8898.88. We suspect that the value entered into the datalogger is correct, but this should be verified.
    - The dataloggers are configured to calculate and record head of water above gage installation. Because they are already operating in this configuration, it is unnecessary to change. For future installations, it is recommended to record only raw data through the data loggers. This reduces possible errors or questions regarding data reduction, and simplifies second party data evaluation.
    - Monitoring frequency can be reduced to every 4 or 6 hours on dataloggers. Volume of data will become overwhelming eventually for long term monitoring, and the hourly measurements are not necessary for analysis.
- Inclinometers
    - All inclinometer casings should now be monitored with the Slope Indicator AT system.
    - Measurements should be performed on a monthly basis.
    - Inclinometer Casings 1A through 13 (previous casings) should be monitored with the same procedures established in January 2014, for consistency in the readings.
    - Subsequent measurements of Casings 1A through 13 should be compared to the new baseline readings obtained in January 2014 for accurate data evaluation. The previous data sets (with the Classic probe) can be used for determination of casing deformation up to October 2013, but some caution should be exercised for comparison of old sets to the new sets.

- New inclinometer Casings SW-01 and SW-02 need only be measured in the A-direction grooves.
- Subsequent measurements for Casing SW-01 should be compared to the set obtained at 3/18/2014 12:34 p.m., for determination of casing displacement.
- Subsequent measurements for Casing SW-02 should be compared to the set obtained at 3/18/2014 11:22 p.m., for determination of casing displacement.
- The top reading depth of Casing SW-02 (4 feet) was unstable in the initial measurements. It is possible that this upper portion of the casing was not restrained against lateral movement (grout settled out?). Subsequent measurements do not indicate offset values at this depth, so either this portion of the casing became fixed or one of the measurement values was erroneous. The fixity of the top portion of the casing should be confirmed in the field, and resolved if it's not secure.

CLOSURE

The information provided to you in this letter report is an evaluation of the monitoring data developed at this site over the last several years. Continued monitoring of the instrumentation will be useful for evaluating conditions at the site, determining rates of movement, and monitoring the effectiveness of the horizontal drains.

This document was prepared for the exclusive use of the NDDOT. The analyses, conclusions, and recommendations contained in this document are based on the measurements and data provided by NDDOT.

Within the limitations of the scope, schedule, availability of data, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice at the time this report was prepared. We make no other warranty, either expressed or implied.

If you have any questions or comments regarding the enclosed information, please contact us.

Sincerely,

SHANNON & WILSON, INC.

Rob Clark by GRF

Rob Clark
Associate

GREGORY ROBERT FISCHER REGISTERED PROFESSIONAL PE 4324 ENGINEER NORTH DAKOTA 4/19/14

Gregory R. Fischer, P.E.
Sr. Vice President

RC:GRF/rc

Enc: Table 1 – Inclinometer Casing Displacements
Figure 1 – Site Plan
Figure 2 – SW-01 Piezometer Levels
Figure 3 – SW-02 Piezometer Levels
Figure 4 – SW-01 Inclinometer Casing Cumulative Displacement
Figure 5 – SW-02 Inclinometer Casing Cumulative Displacement
Figure 6a – Casing 1a Inclinometer Casing Cumulative Displacement
Figure 6b – Casing 1a Inclinometer Casing Resultant Time Displacement
Figure 6c – Casing 1a Inclinometer Casing New Probe Cumulative Displacement
Figure 7a – Casing 3a Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 7b – Casing 3a Inclinometer Casing Cumulative Displacement, 2014
Figure 7c – Casing 3a Inclinometer Casing Resultant Time Displacement
Figure 8a – Casing 4 Inclinometer Casing Cumulative Displacement
Figure 8b – Casing 4 Inclinometer Casing Resultant Time Displacement
Figure 8c – Casing 4 Inclinometer Casing New Probe Cumulative Displacement
Figure 9a – Casing 5a Inclinometer Casing Cumulative Displacement
Figure 9b – Casing 5a Inclinometer Casing Resultant Time Displacement
Figure 9c – Casing 5a Inclinometer Casing New Probe Cumulative Displacement
Figure 10a – Casing 6 Inclinometer Casing Incremental Displacement, through 10/21/13
Figure 10b – Casing 6 Inclinometer Casing Incremental Displacement, 2014
Figure 11a – Casing 7 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 11b – Casing 7 Inclinometer Casing Cumulative Displacement, 2014
Figure 11c – Casing 7 Inclinometer Casing Resultant Time Displacement
Figure 12a – Casing 8 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 12b – Casing 8 Inclinometer Casing Cumulative Displacement, 2014
Figure 13a – Casing 9 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 13b – Casing 9 Inclinometer Casing Cumulative Displacement, 2014

Figure 14a – Casing 10 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 14b – Casing 10 Inclinometer Casing Cumulative Displacement, 2014
Figure 14c – Casing 10 Inclinometer Casing Resultant Time Displacement
Figure 15a – Casing 11 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 15b – Casing 11 Inclinometer Casing Cumulative Displacement, 2014
Figure 15c – Casing 11 Inclinometer Casing Resultant Time Displacement
Figure 16a – Casing 12 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 16b – Casing 12 Inclinometer Casing Cumulative Displacement, 2014
Figure 16c – Casing 12 Inclinometer Casing Resultant Time Displacement
Figure 17a – Casing 13 Inclinometer Casing Cumulative Displacement, through 10/21/13
Figure 17b – Casing 13 Inclinometer Casing Cumulative Displacement, 2014
Figure 17c – Casing 13 Inclinometer Casing Resultant Time Displacement

TABLE 1
INCLINOMETER CASING DISPLACEMENTS

Casing	Casing Elev.[1]	A0 Direction[2]	Resultant Direction[3]	Approximate Shear or Measurement Zones		Current Incremental Rate of Displacement (as of 4/7/14)	Overall Rates of Displacement (up through 4/7/14)[4]	Top of Casing Resultant Displacement (up through 4/7/14)[5]
				Depths, ft	Elev., ft.			
1A	2775	N 80 E	N 50 E	Top of Casing	2775	0.14"/month	0.11"/month	0.87 inches
			N 50 E	22 - 26	2753 - 2749	0.14"/month	0.14"/month	(offset between probes?)
			N 35 E	30 - 34	2745 - 2741	0.09"/month	0.10"/month	
3A	2773	N 63 E	N 58 E	Top of Casing	2773	0.17"/month	0.17"/month	0.61 inches
			N 58 E	16 - 20	2757 -2753	0.20"/month	0.20"/month	
			N 53 E	26 - 30	2747 - 2743	0.14"/month	0.15"/month	
4	2777.2	N 71 E	N 56 E	Top of Casing	2777	0.01"/month	0.08"/month	1.64 inches
			N 61 E	38 - 42	2739 - 2735	0.03"/month	0.07"/month	
5A	2777	N 74 E	N 14 E	Top of Casing	2777	0.04"/month	0.08"/month	0.24 inches
			N 14 E	12 - 14	2765 - 2763	0.02"/month	0.05"/month	
6[6]	2794.4	N 58 E		Bottom of Casing (not fixed?)	2748			
7	2797.2	N 63 E	N 38 E	Top of Casing	2797	< 0.01"/month	0.11"/month	3.58 inches
			N 63 E	17 - 21	2780 - 2776	0.02"/month	0.10"/month	
			N 23 E	35 - 37	2762 - 2760	-0.01"/month	0.01"/month	
			N 23 E	43 - 45	2754 - 2752	< 0.01"/month	< 0.01"/month	
8[7]	2799.1	N 70 E		n/a				
9[8]	2812.6	N 68 E		n/a				
10	2736.9	N 57 E	N 57 E	Top of Casing	2737	0.27"/month	0.17"/month	0.74 inches
			N 57 E	12 - 16	2725 - 2721	0.26"/month	0.17"/month (based on 2014 readings)	
11	2713.3	N 84 E	N 59 E	Top of Casing	2713	0.11"/month	0.08"/month	0.29 inches
			N 59 E	28-30	2685 - 2683	0.10"/month	0.07"/month (based on 2014 readings)	
12	2684.7	N 50 E	N 50 E	Top of Casing	2685	0.02"/month	0.02"/month	0.12 inches
			N 50 E	23 - 25	2665 - 2663	0.01"/month	0.02"/month (based on 2014 readings)	
13	2737.3	N 88 E	N 53 E	Top of Casing	2737	0.90"/month	0.47"/month	1.68 inches
			N 53 E	12 - 14	2725 - 2723	0.86"/month	0.46"/month	
SW-01	2797	N 68 E	N 48 E	Top of Casing	2797	0.09"/month	0.09"/month	0.07 inches
			N 48 E	42 - 44	2755 - 2753	0.09"/month	0.09"/month	(new probe only)
SW-02	2752	N 75 E	N 48 E	Top of Casing	2752	0.24"/month	0.24"/month	0.18 inches
			N 48 E	8 - 12	2744 - 2740			(new probe only)

Notes:

1 Ground surface for Casings 1 through 13, and assumed approximate top of casing. Top of casing elevation for Casings SW-01 and SW-02.

2 Alignment of A-direction grooves, as measured and provided by NDDOT.

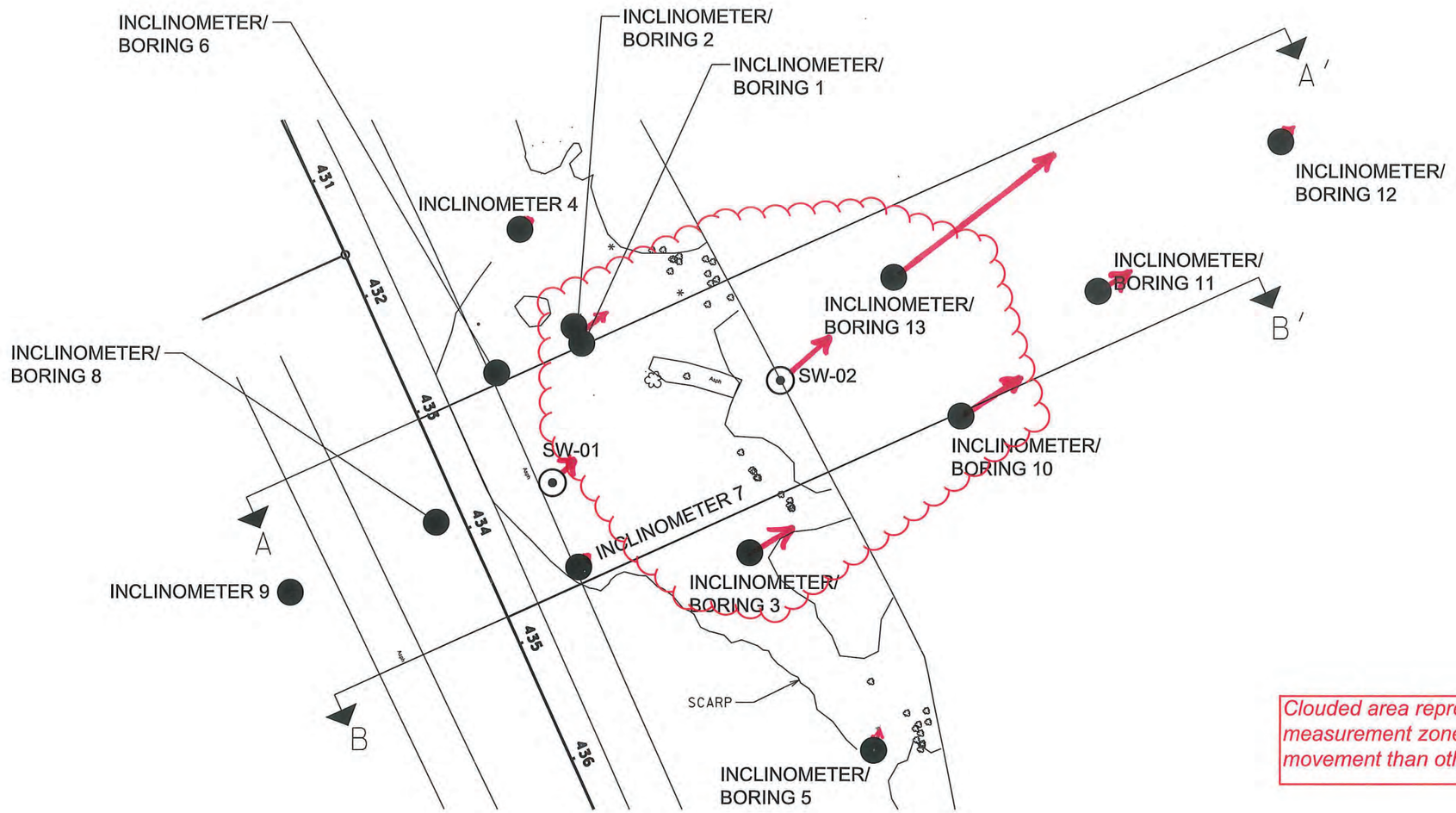
3 Interpreted direction, based on A and B axis displacements, at top of casing and depths indicated in adjacent "Shear or Measurement Zone" column.

4 Rate of displacement calculated based on total displacement since initial reading, unless indicated otherwise.

5 Total displacement based on top of casing measurements through 10/21/2013 (with Classic system) added to the current top of casing displacements (from the AT system).

6 Only bottom of casing deformations observed since installation for this casing with Classic monitoring system. New AT monitoring system measurements have not indicated similar deformations.

7 Determination of shear zones difficult, as Classic measurements indicated bottom of casing movements. New AT monitoring system measurements have not indicated similar deformations.



Clouded area represents displacement measurement zone with higher rates of movement than other casings.

LEGEND

INCLINOMETER/ BORING 13	Existing NDDOT Inclinometer/Boring Designation and Approximate Location
SW-01	Proposed Shannon & Wilson Inclinometer/Boring Designation and Approximate Location
	Direction and rate of top of casing displacement

NOTES

1. Site plan adapted from NDDOT file *175SB_001_Layout_11-20-13.dgn.*

I-94 Painted Canyon Landslide
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SITE AND EXPLORATION PLAN

January 2014 23-1-01400-001

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FIG. 1

FILE: $file$

4/15/2014-SW-01_Piezos.xlsx-Title Block Plot-rwc

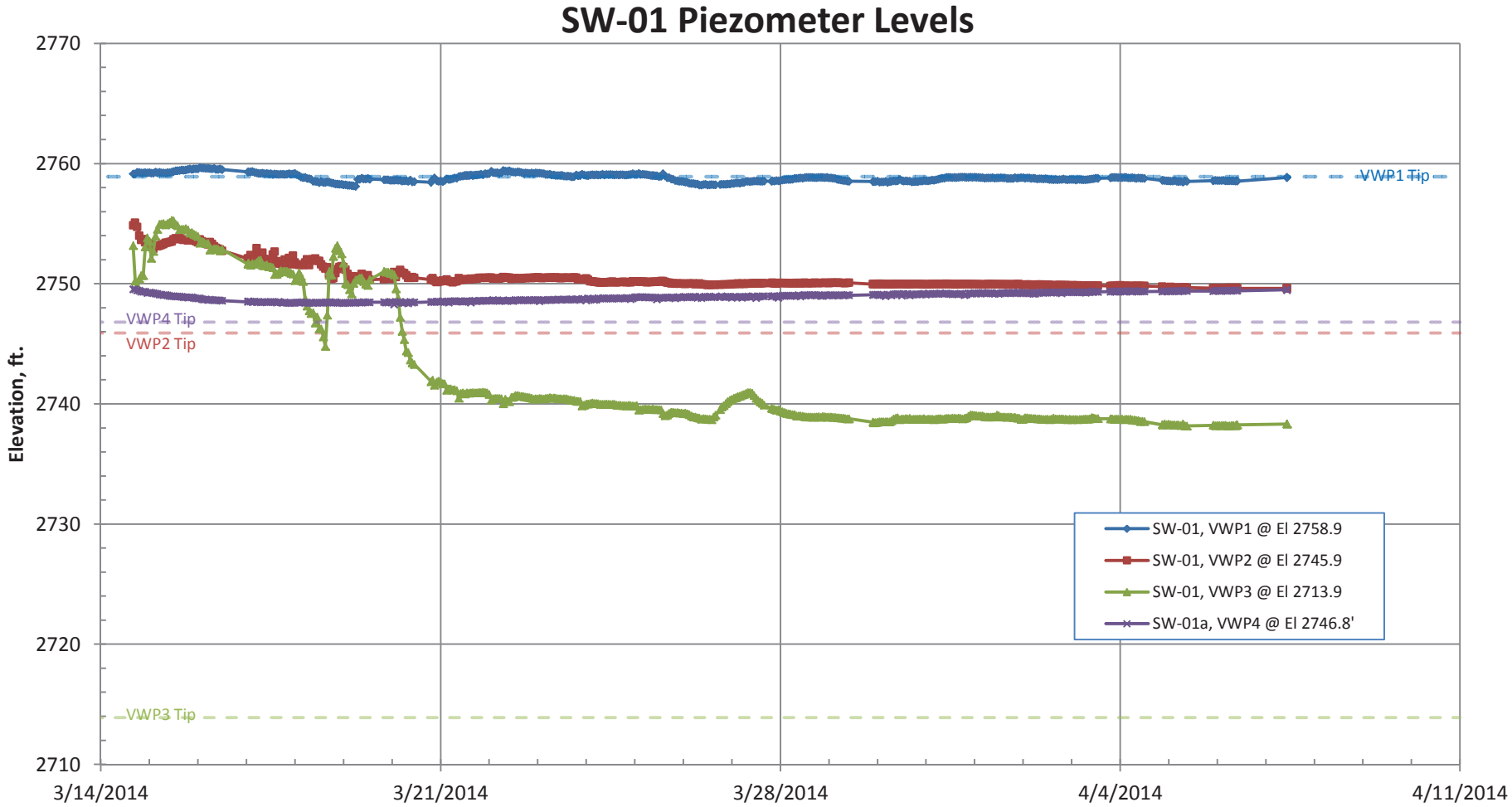

FIG. 2

I-94 Painted Canyon Landslide
Project No. SER-5-094(107)030, PCN 20549
Billings County, North Dakota

BORING SW-01
PIEZOMETER LEVELS

April 2014 21-1-01400-001

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FIG. 2

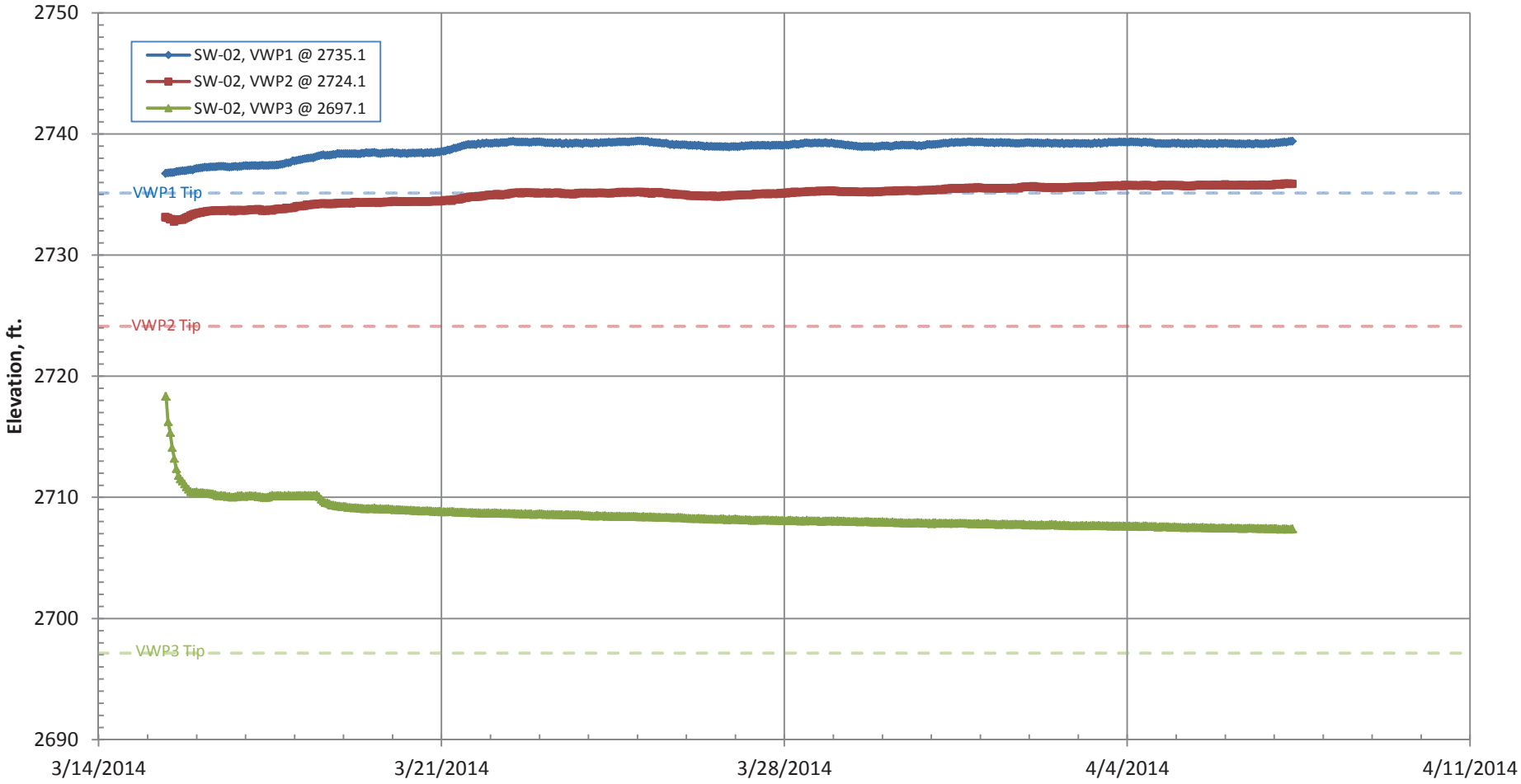

FIG. 3

I-94 Painted Canyon Landslide
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BORING SW-02
PIEZOMETER LEVELS

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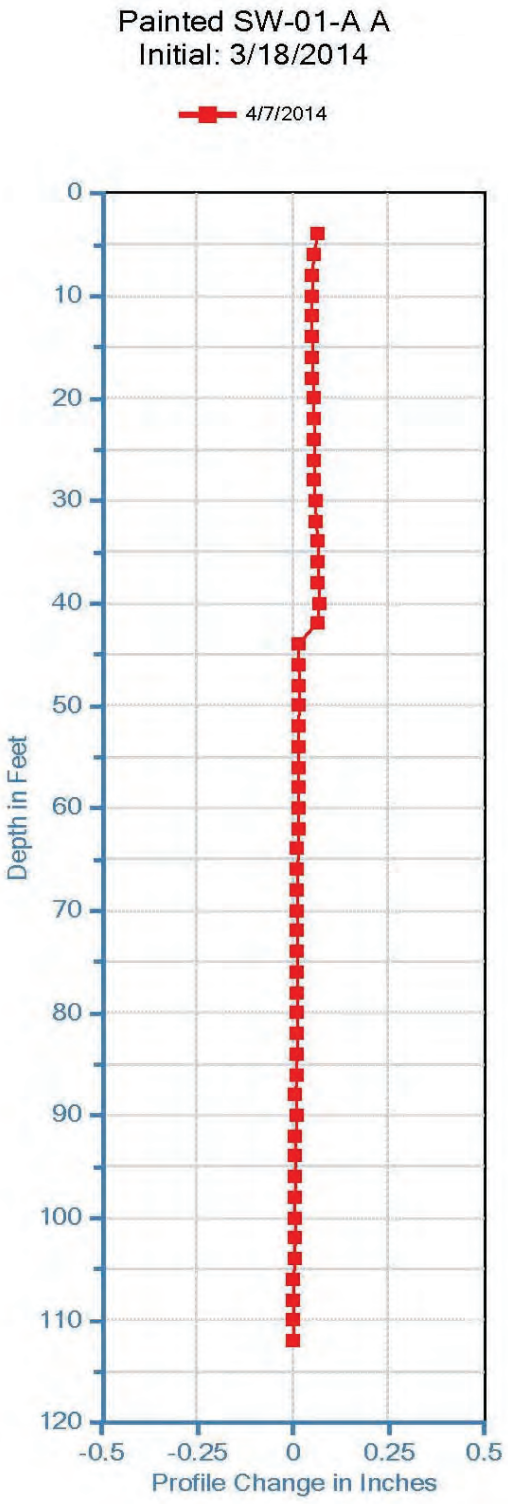
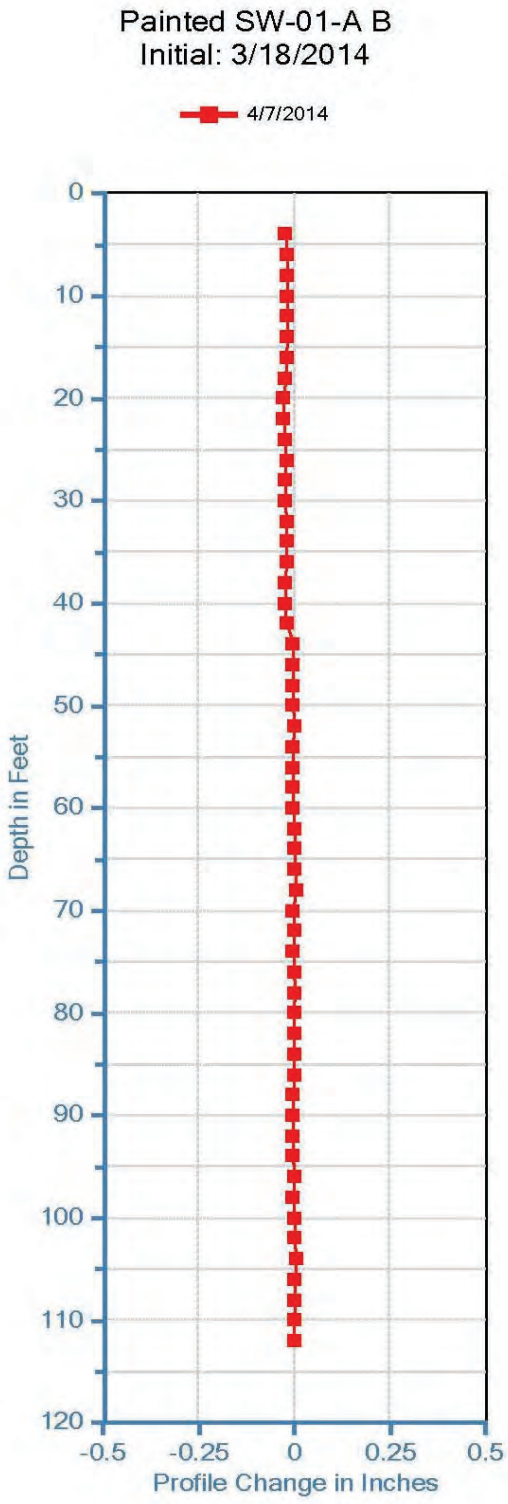
FIG. 3





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Billings County, North Dakota

CASING SW-01 INCLINOMETER CUMULATIVE DISPLACEMENT

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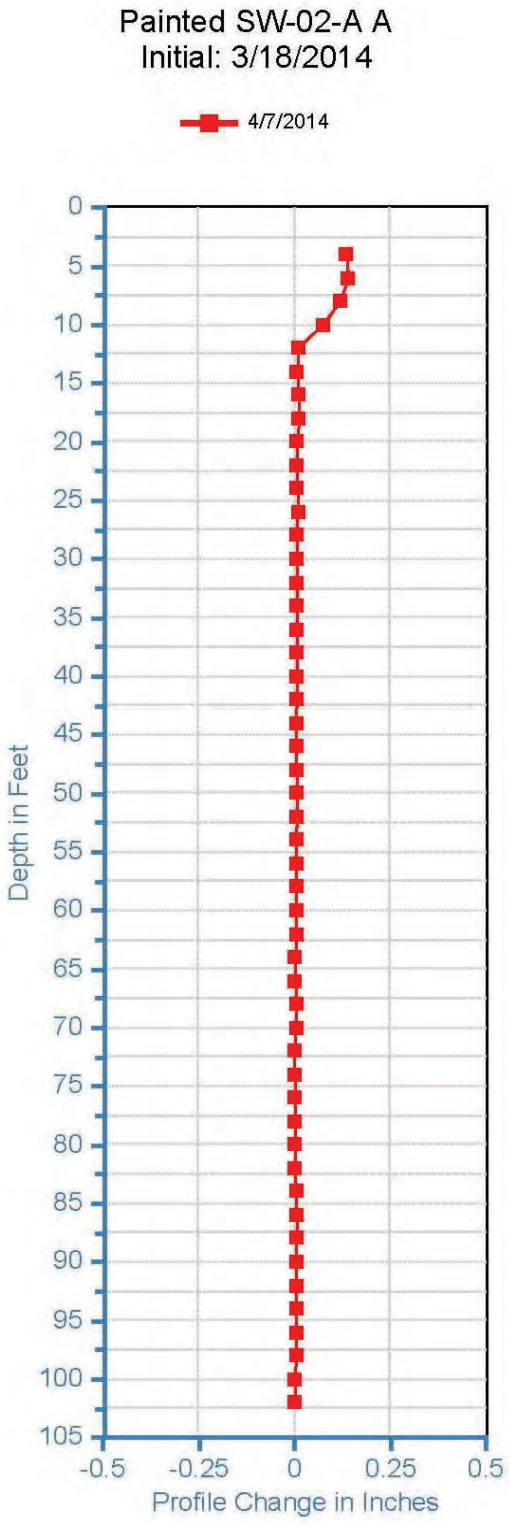
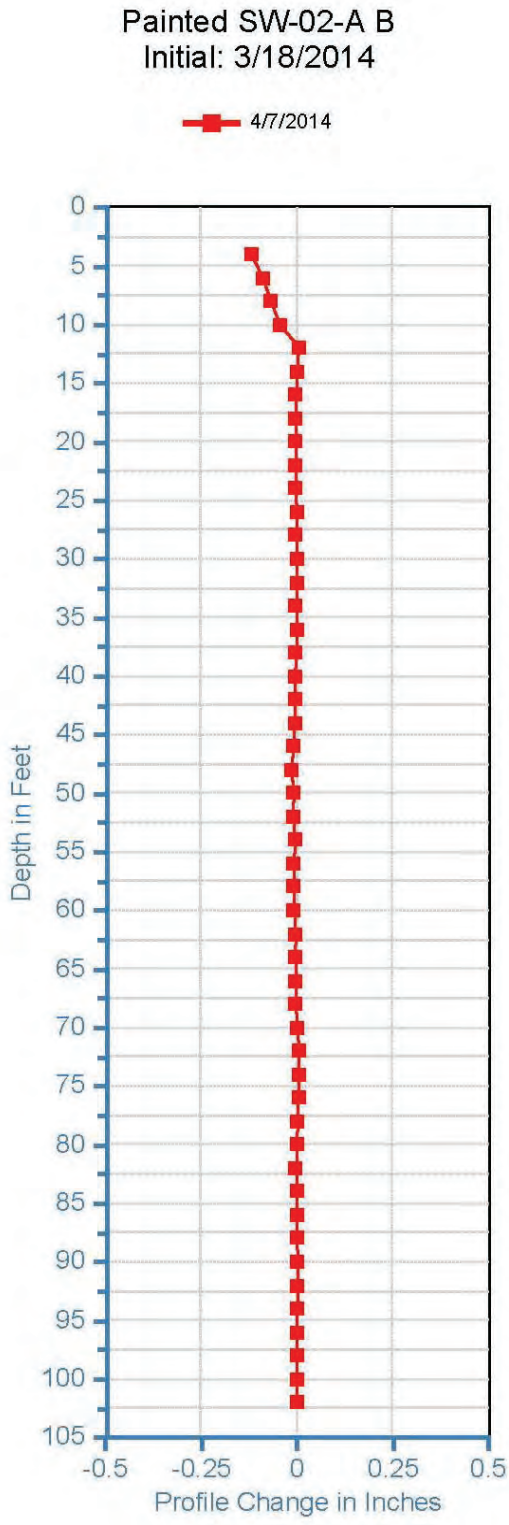
FIG. 4





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CASING SW-02 INCLINOMETER CUMULATIVE DISPLACEMENT

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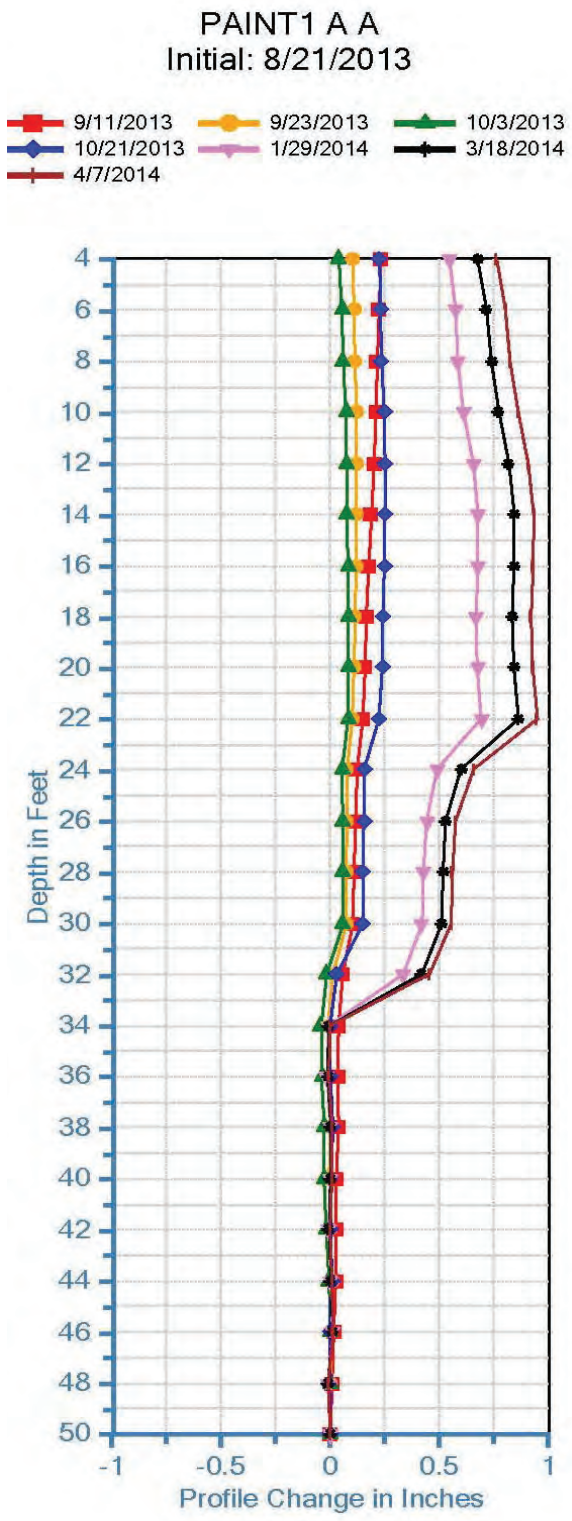
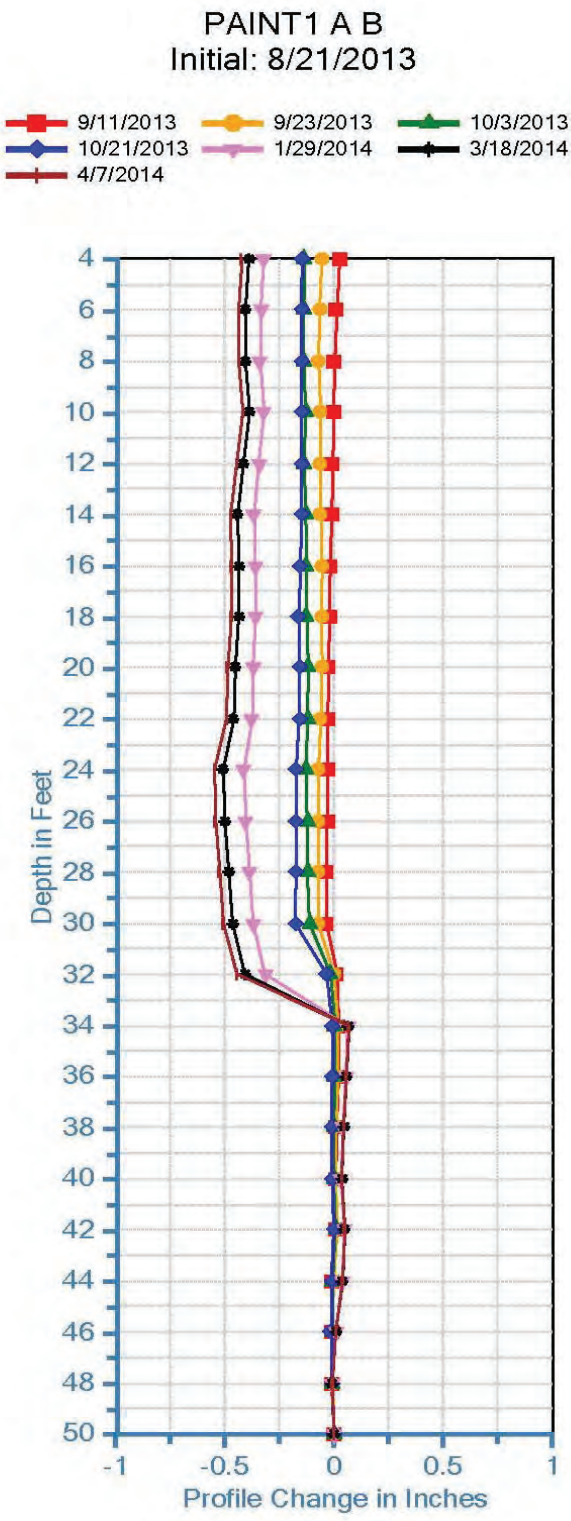
FIG. 5





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 1A INCLINOMETER
CUMULATIVE DISPLACEMENT

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FIG. 6a

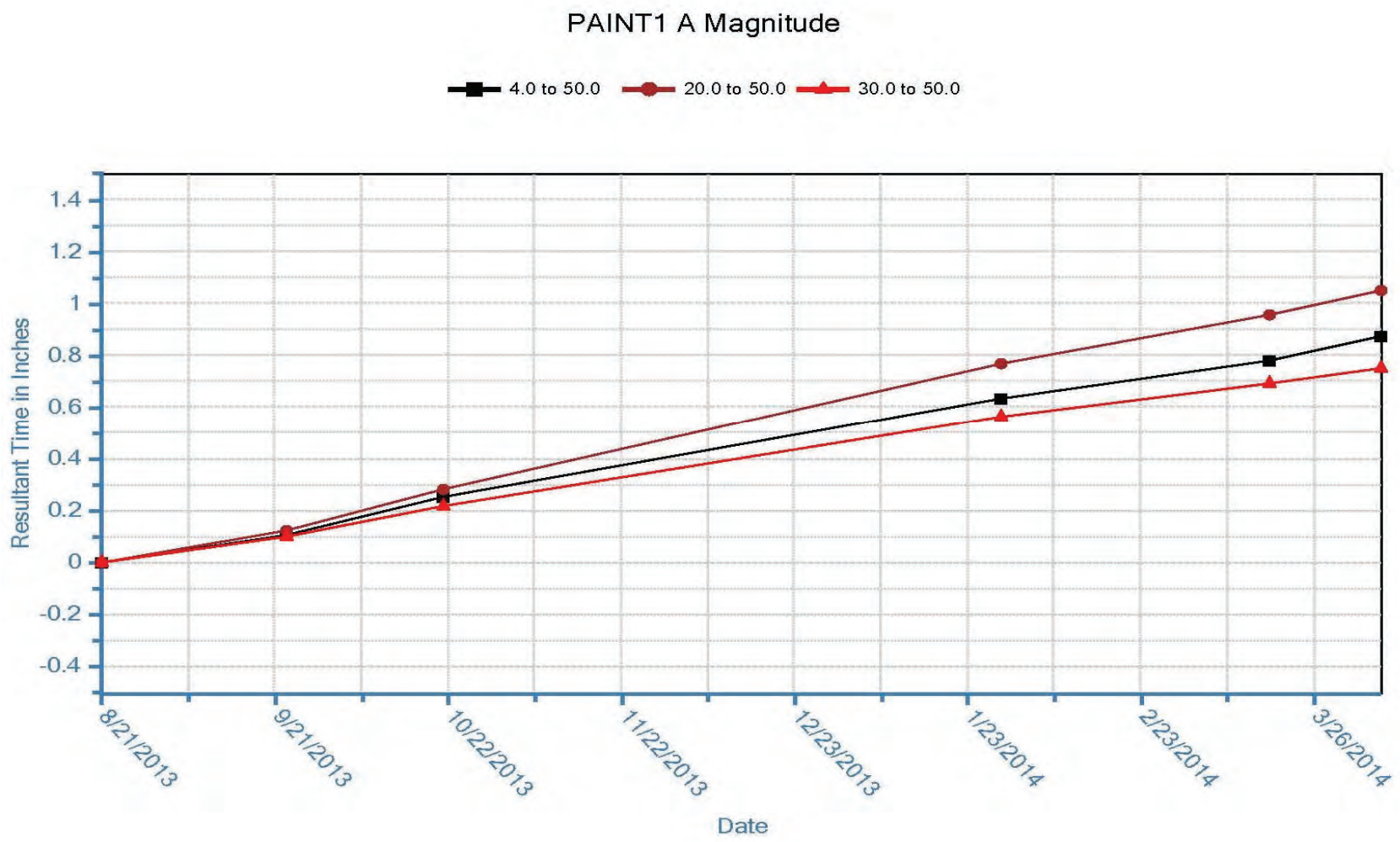

FIG. 6b

I-94 Painted Canyon Landslide
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CASING 1A INCLINOMETER
RESULTANT TIME DISPLACEMENT

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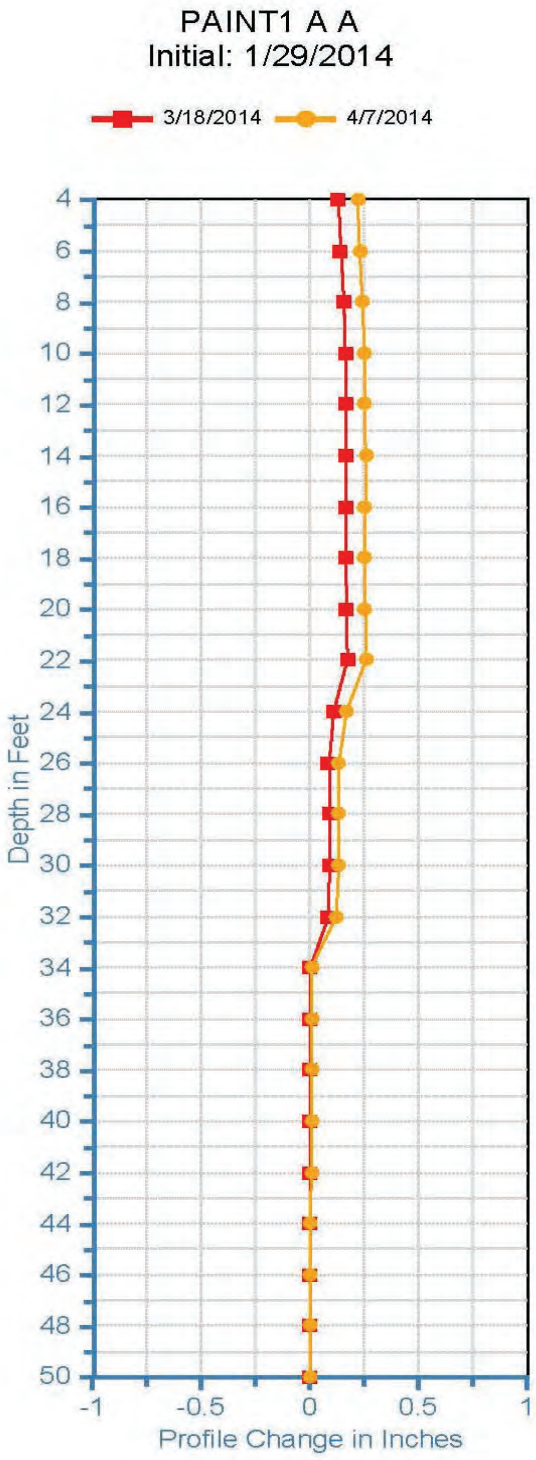
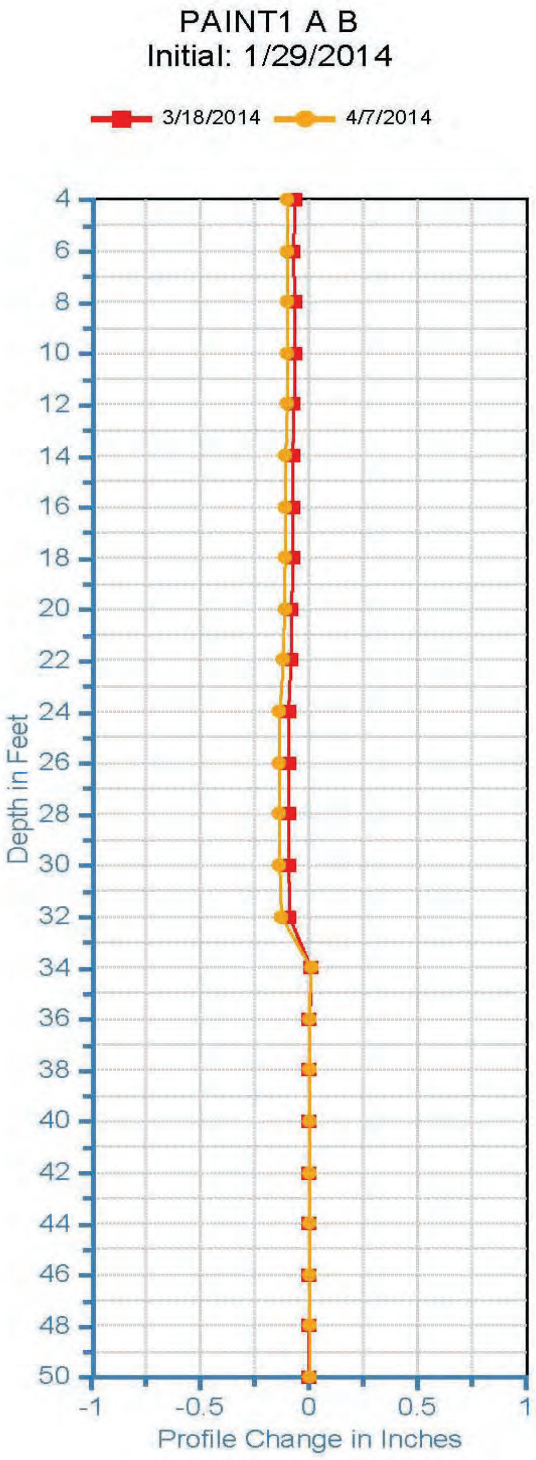
FIG. 6b





I-94 Painted Canyon Landslide
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CASING 1A INCLINOMETER
CUMULATIVE DISPLACEMENT
NEW PROBE ONLY

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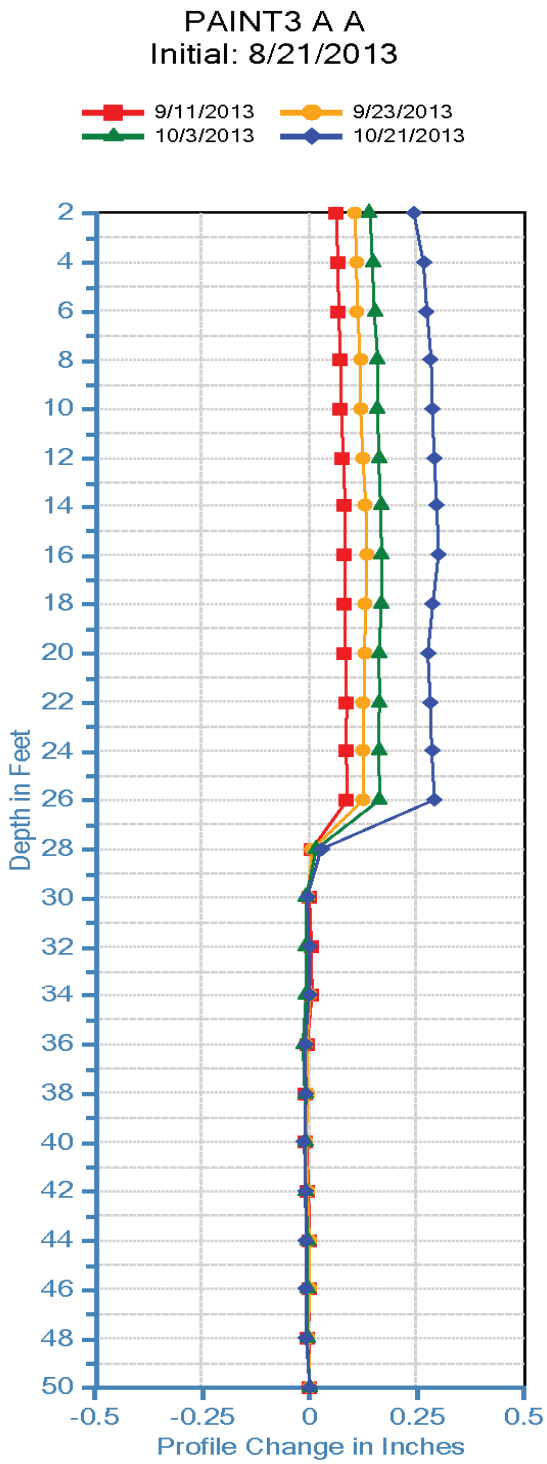
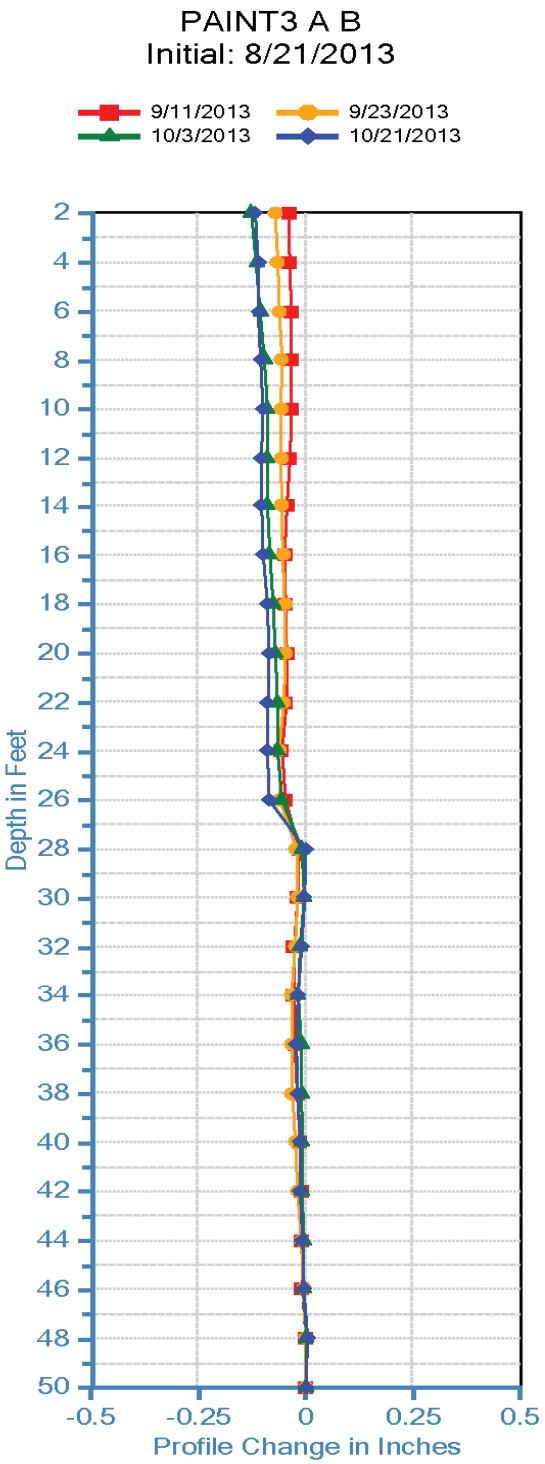
FIG. 6c





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 3A INCLINOMETER
CUMULATIVE DISPLACEMENT
OLD PROBE ONLY

April 2014 21-1-01400-001

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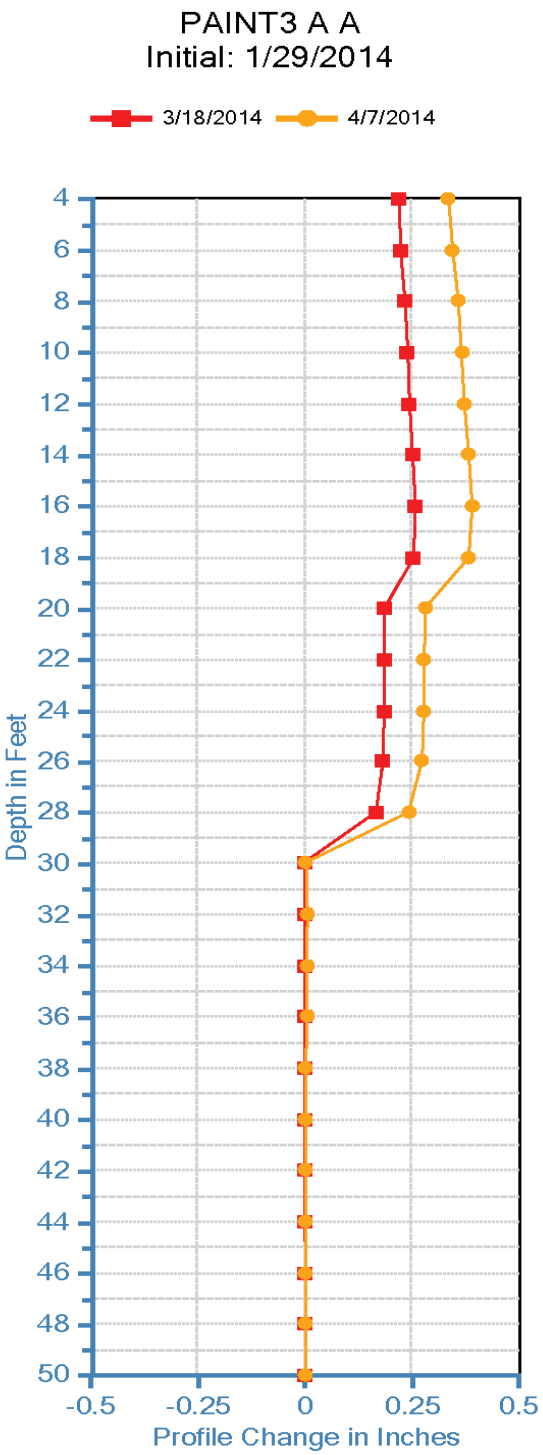
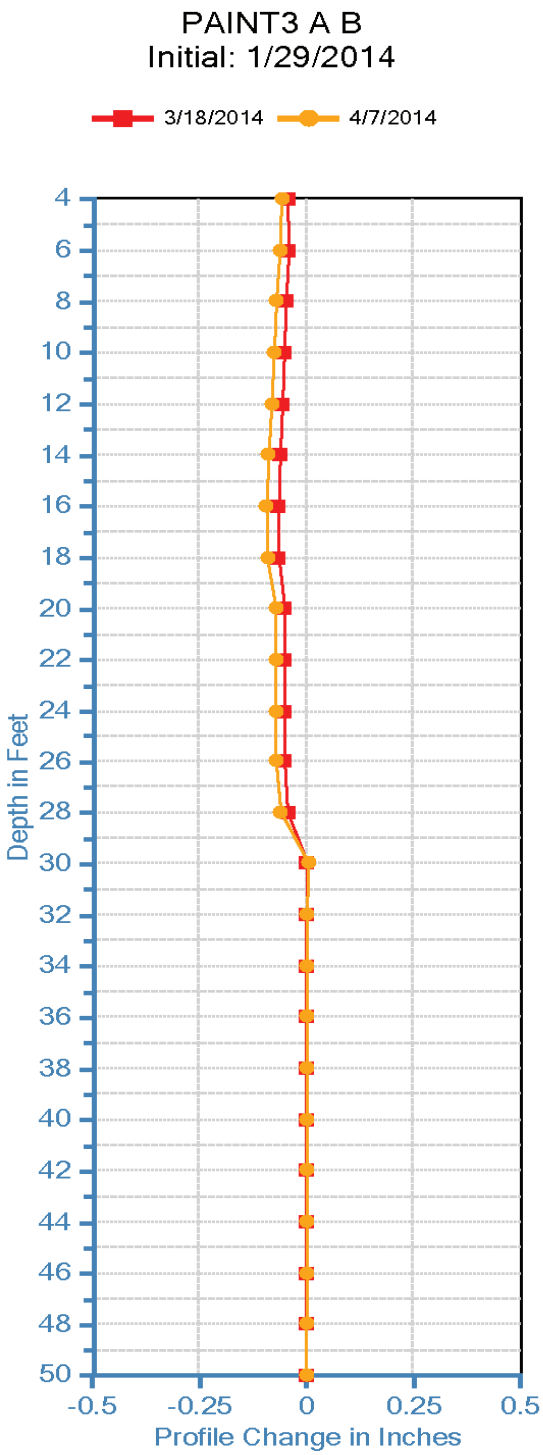
FIG. 7a





I-94 Painted Canyon Landslide
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CASING 3A INCLINOMETER
CUMULATIVE DISPLACEMENT
NEW PROBE ONLY

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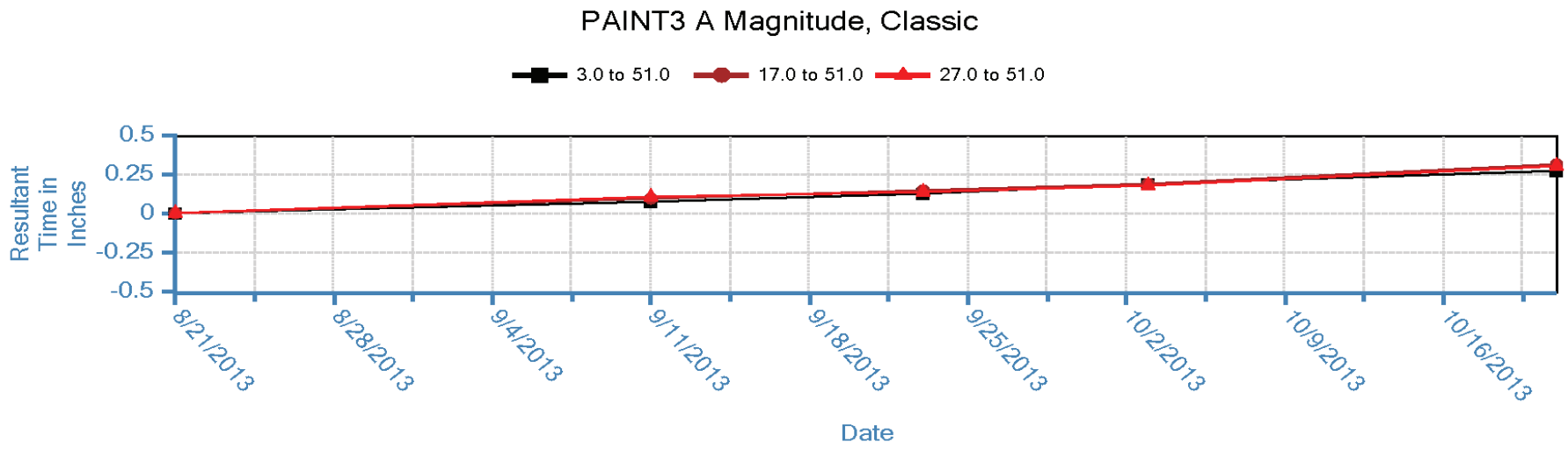
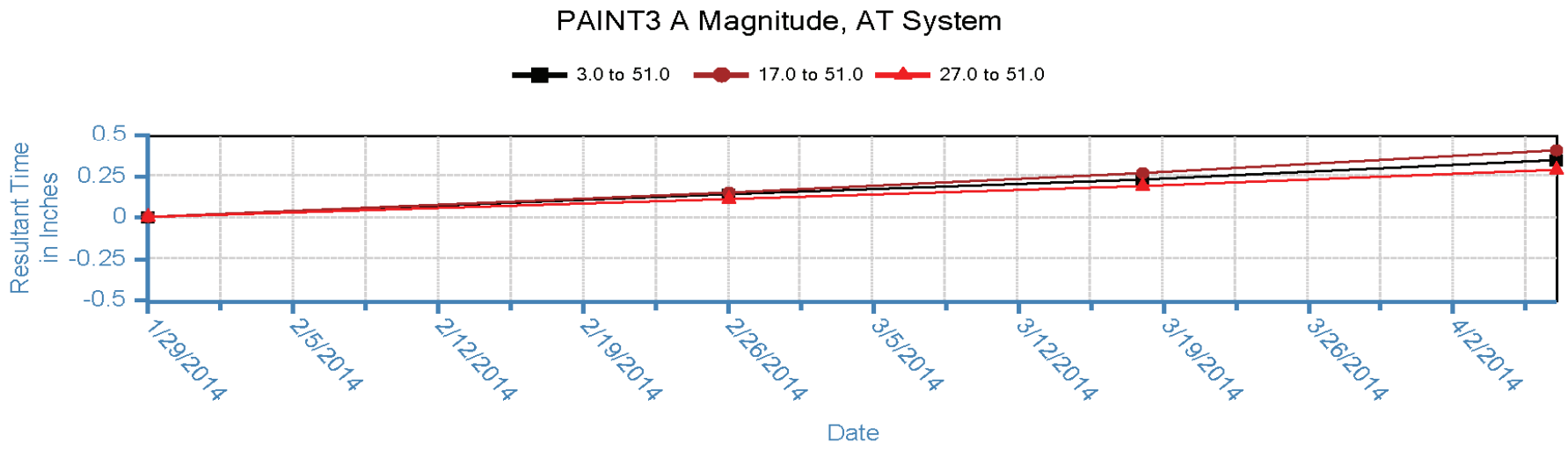
FIG. 7b





I-94 Painted Canyon Landslide
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Billings County, North Dakota

CASING 3A INCLINOMETER
RESULTANT TIME DISPLACEMENT

April 2014 21-1-01400-001

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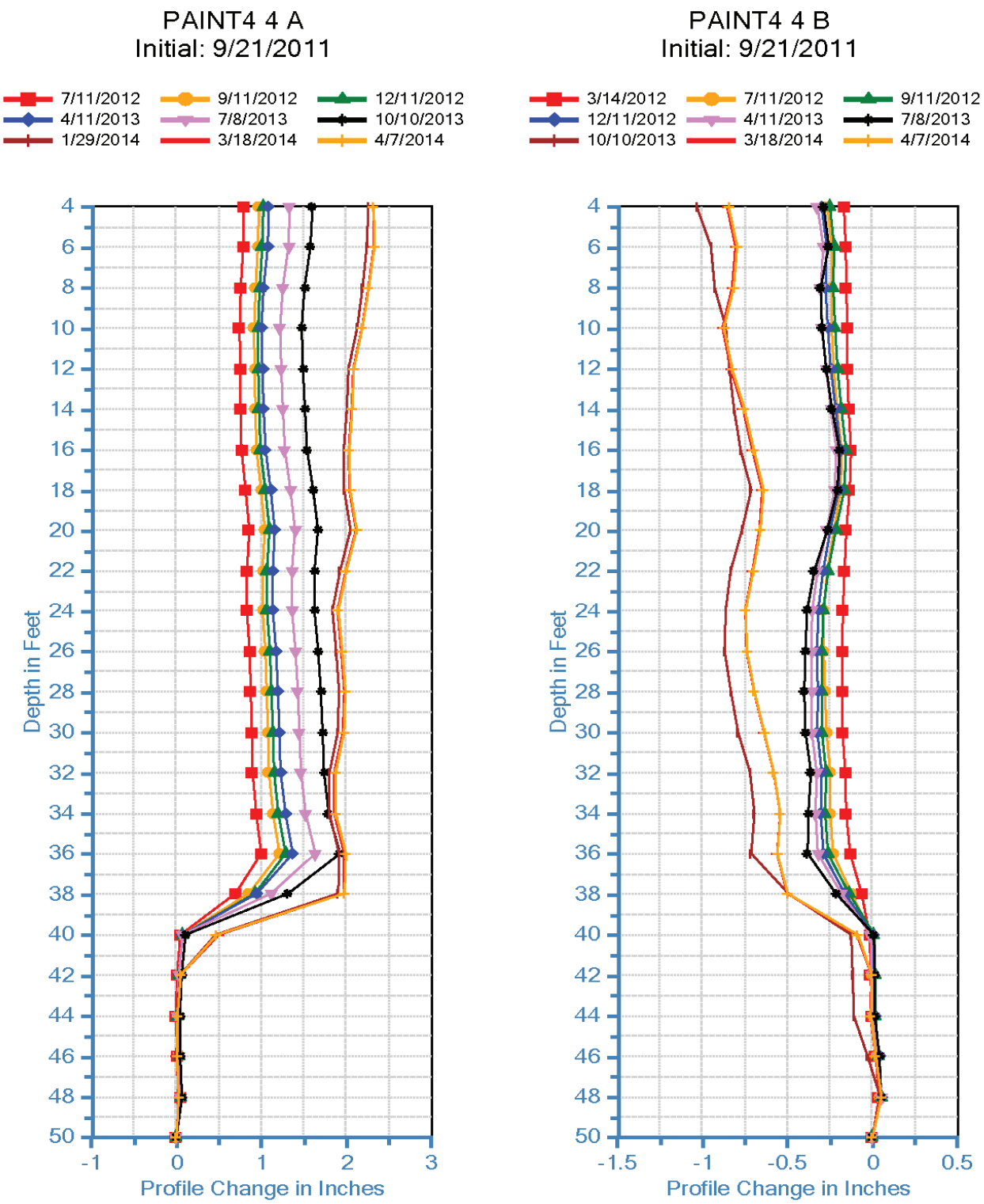
FIG. 7c

FIG. 7c



I-94 Painted Canyon Landslide
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CASING 4 INCLINOMETER
CUMULATIVE DISPLACEMENT

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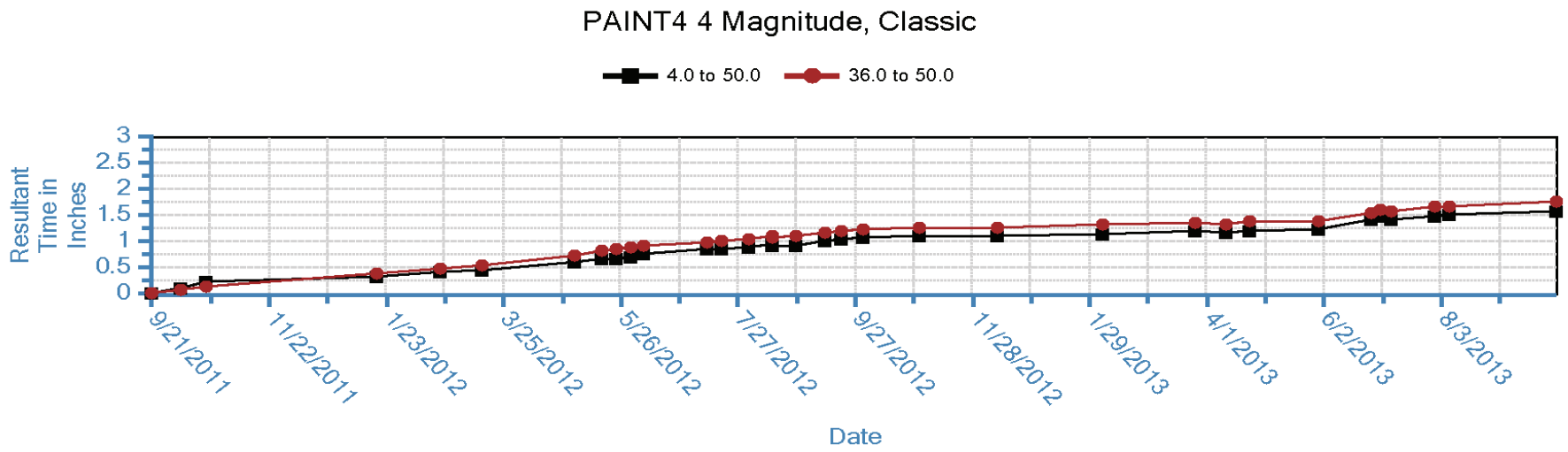
FIG. 8a



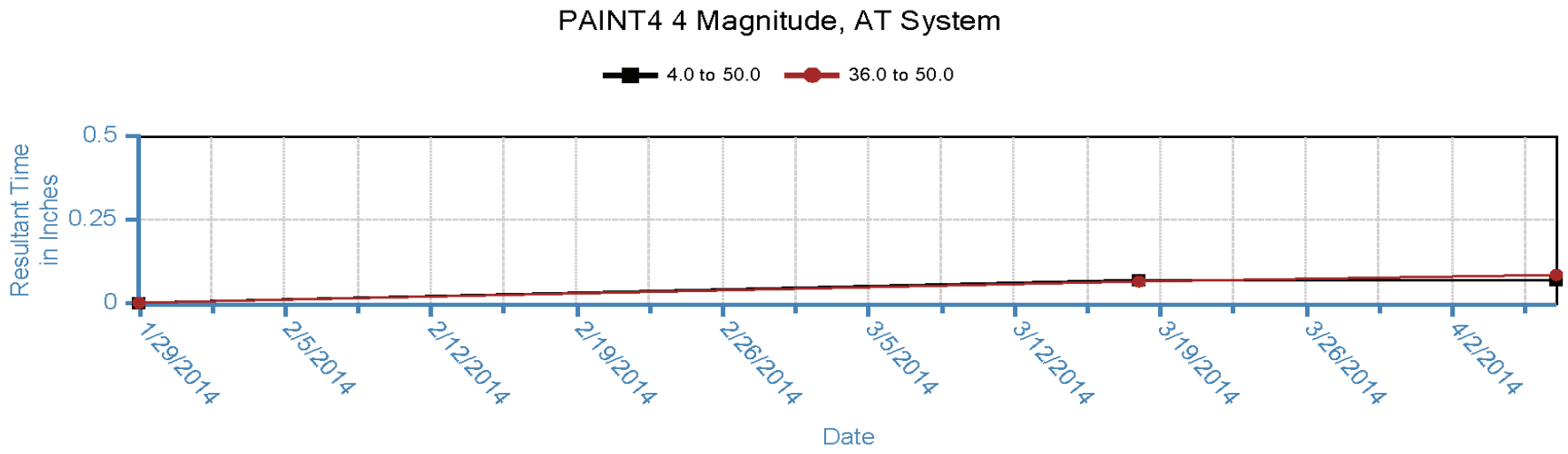


FIG. 8b

I-94 Painted Canyon Landslide
Project No. SER-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 4 INCLINOMETER
RESULTANT TIME DISPLACEMENT

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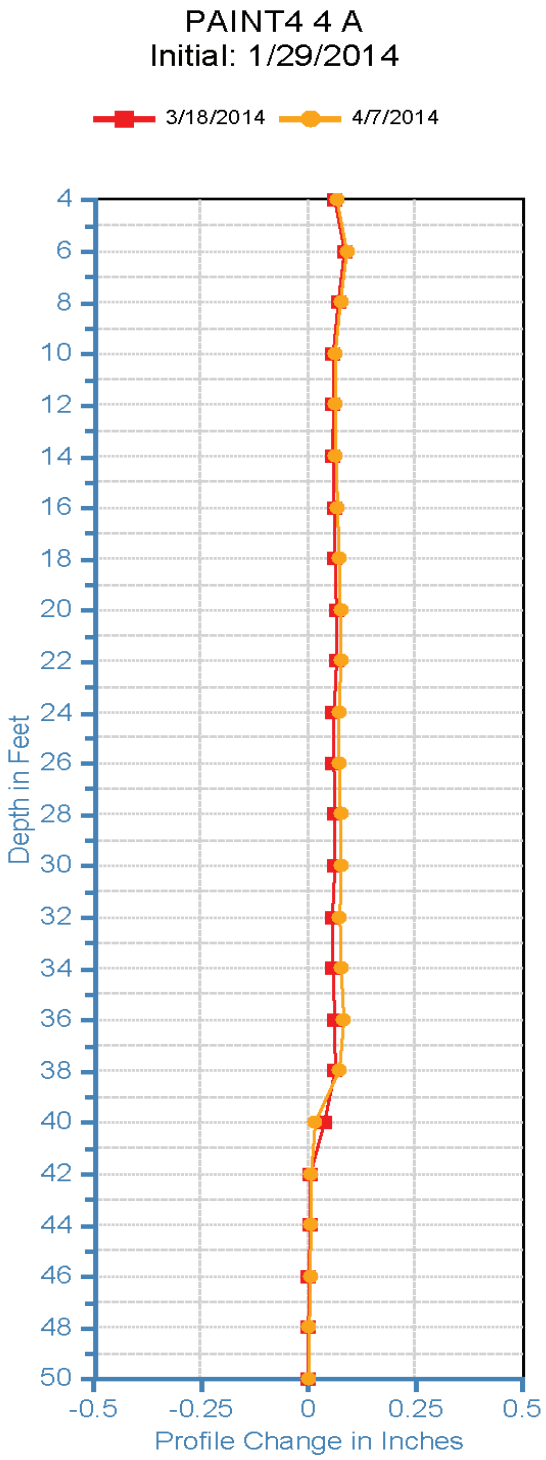
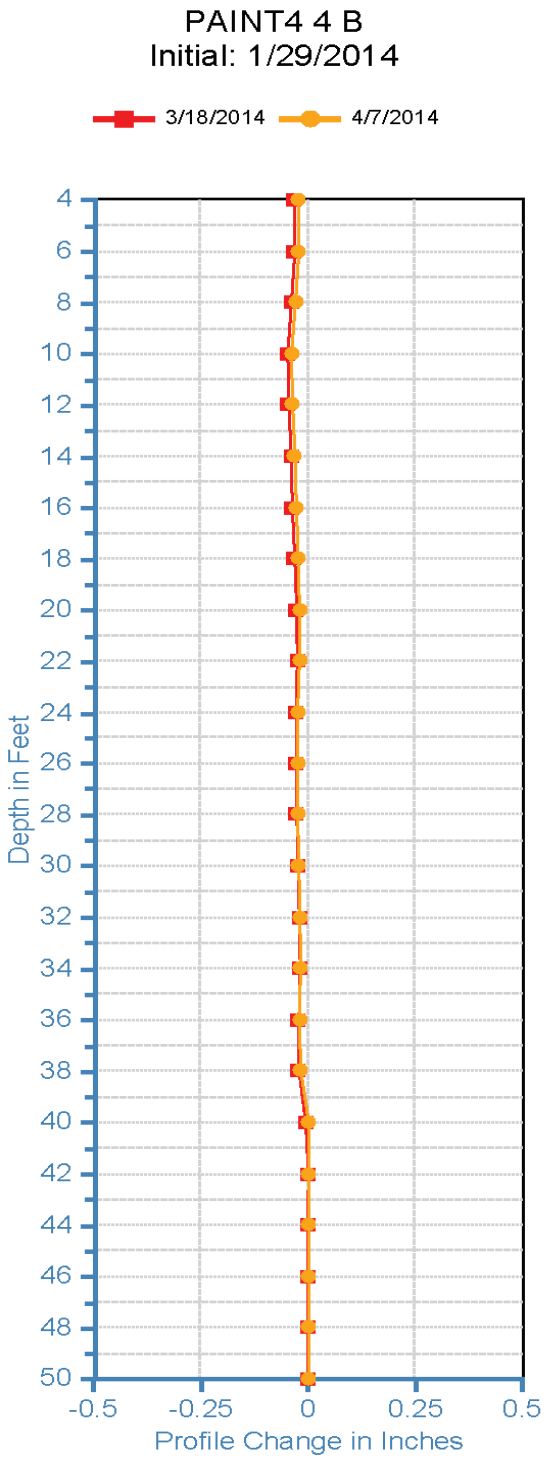
FIG. 8b





I-94 Painted Canyon Landslide
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CASING 4 INCLINOMETER
CUMULATIVE DISPLACEMENT
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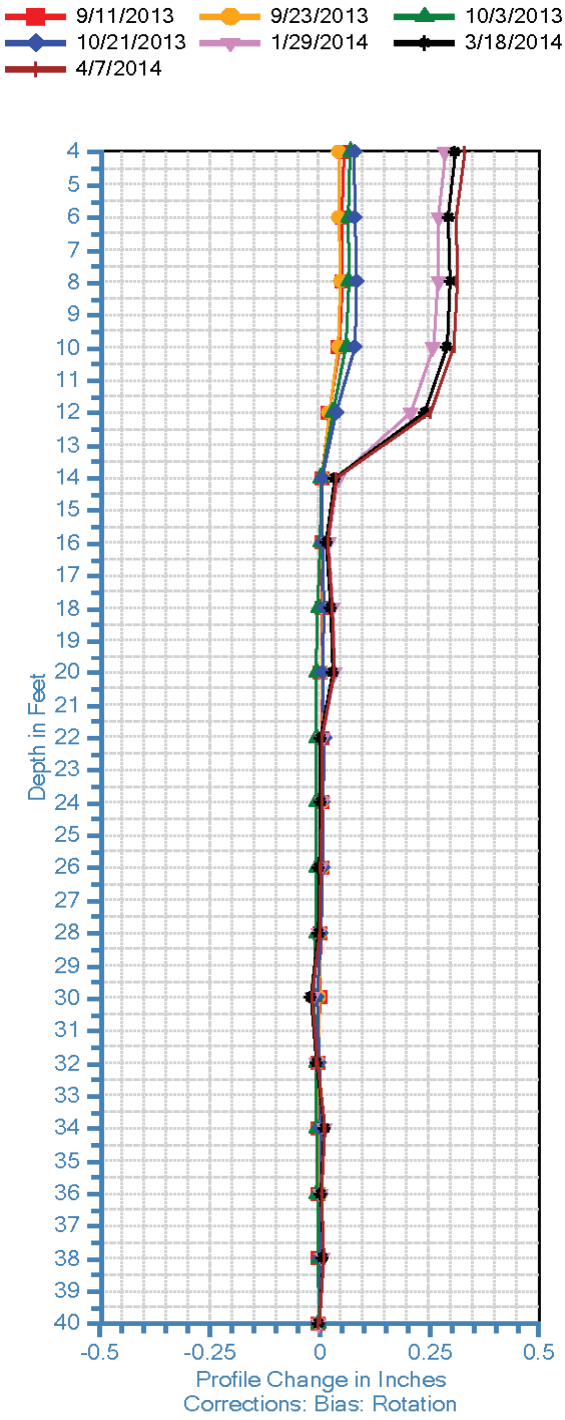
FIG. 8c

PAINT5 A A
Initial: 8/21/2013



PAINT5 A B
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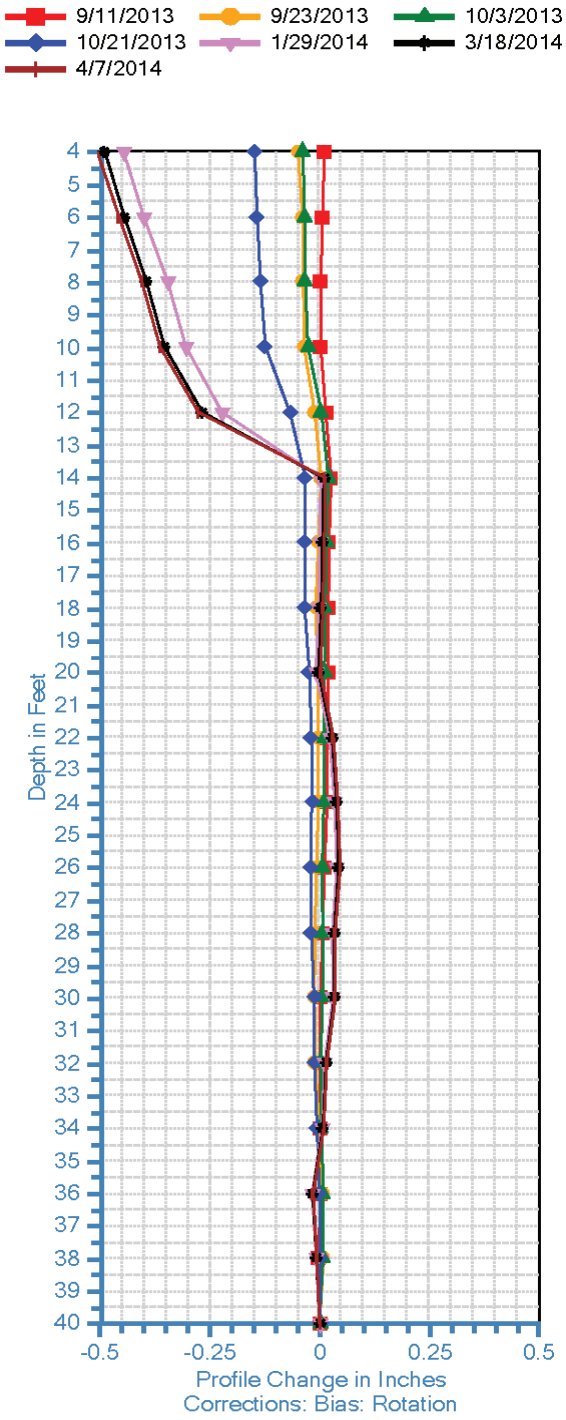

I-94 Painted Canyon Landslide
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CASING 5A INCLINOMETER
CUMULATIVE DISPLACEMENT

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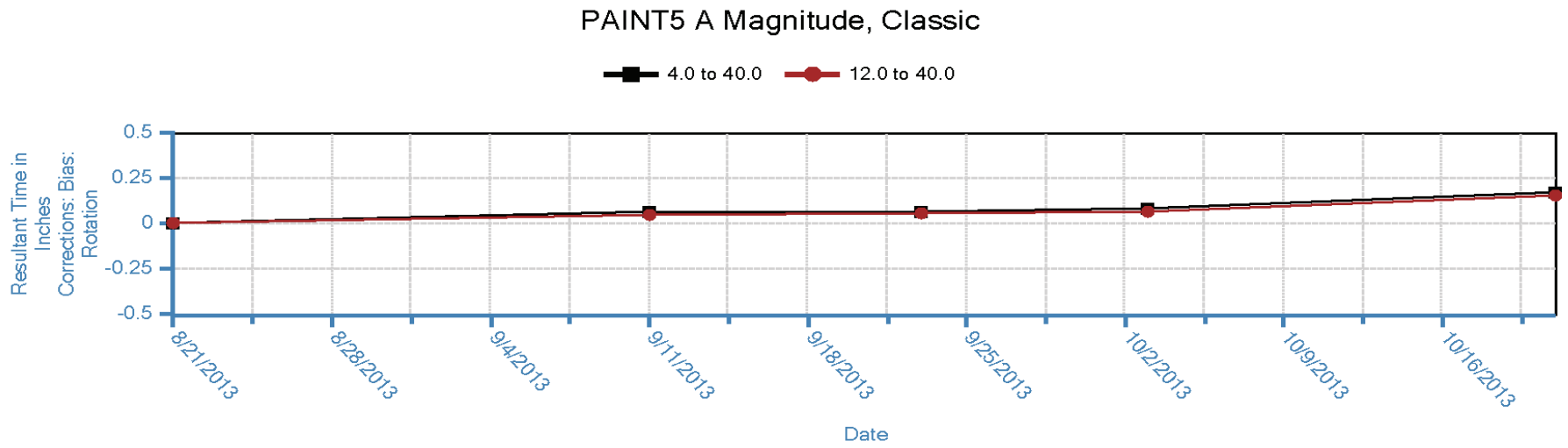
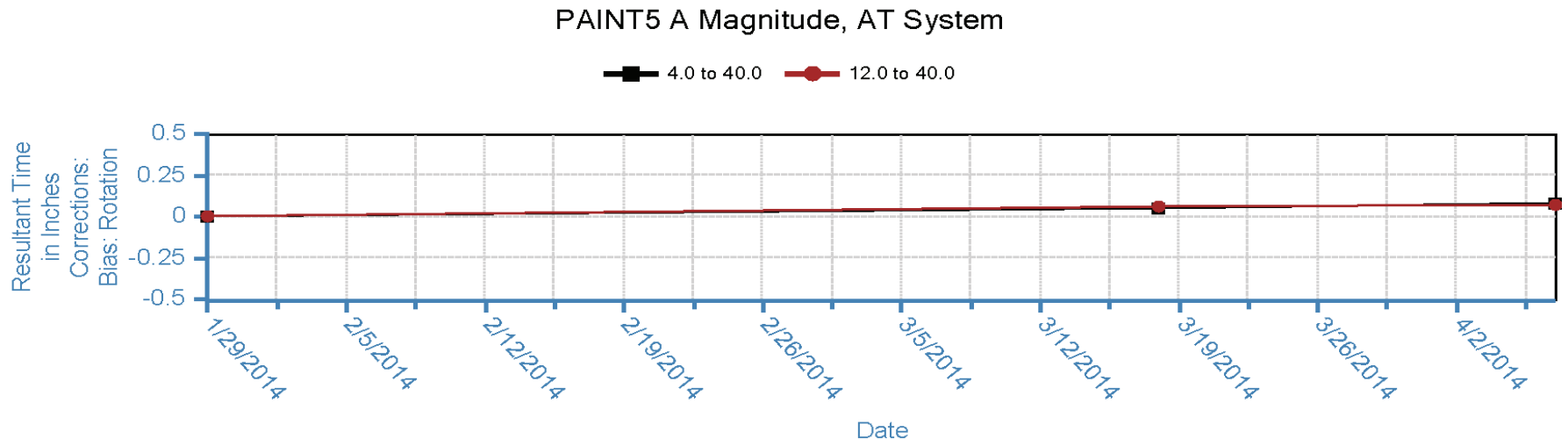
FIG. 9a





I-94 Painted Canyon Landslide
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CASING 5A INCLINOMETER
RESULTANT TIME DISPLACEMENT

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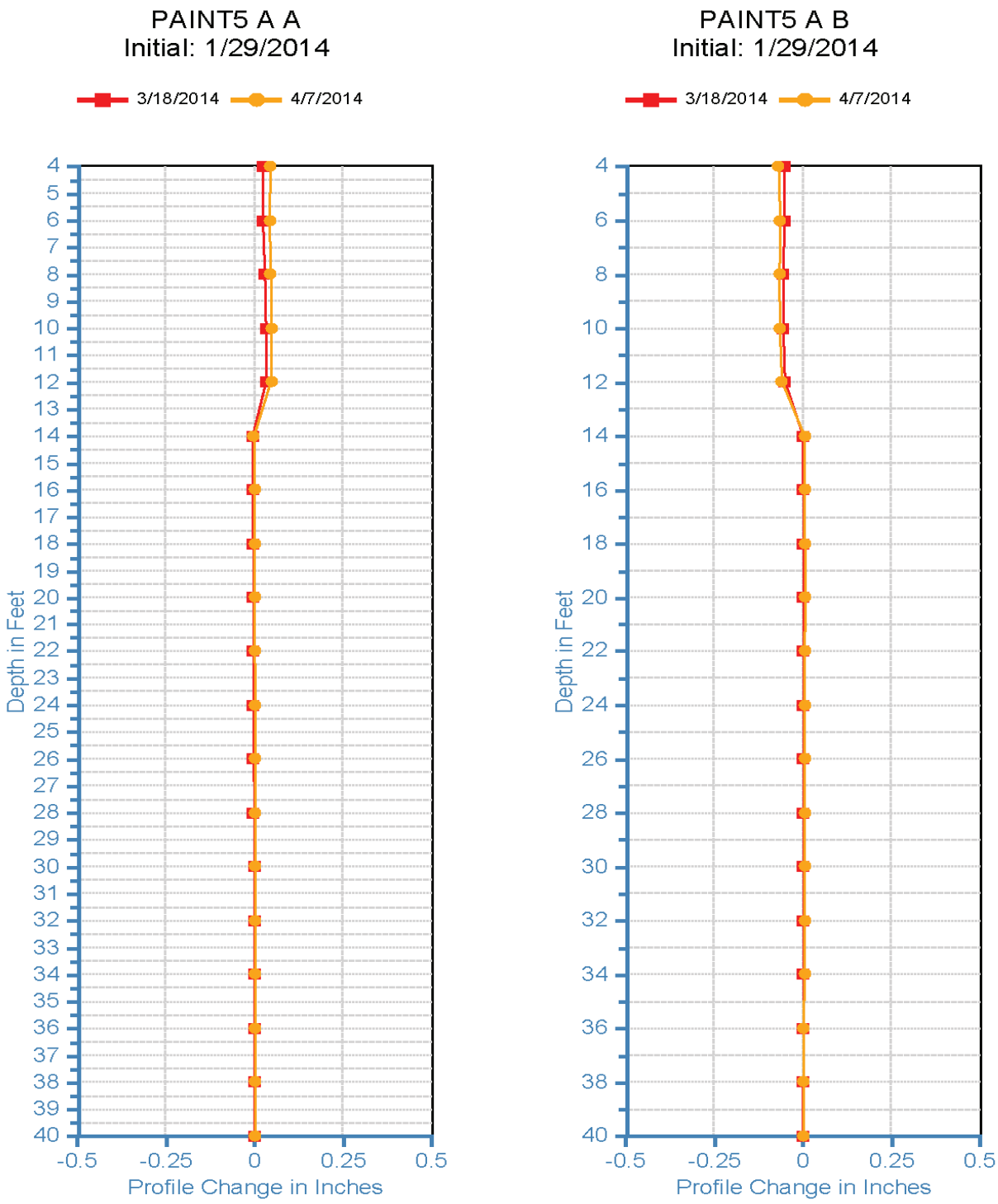
FIG. 9b

FIG. 9b



I-94 Painted Canyon Landslide
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CASING 5A INCLINOMETER
CUMULATIVE DISPLACEMENT
NEW PROBE ONLY

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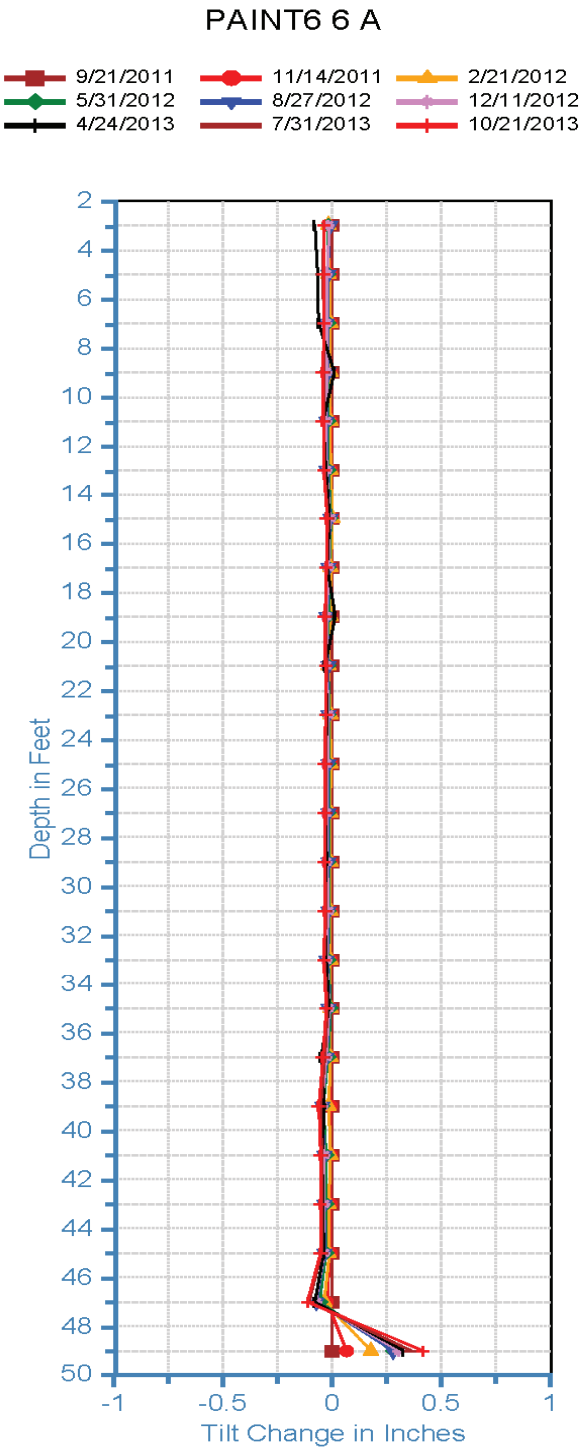
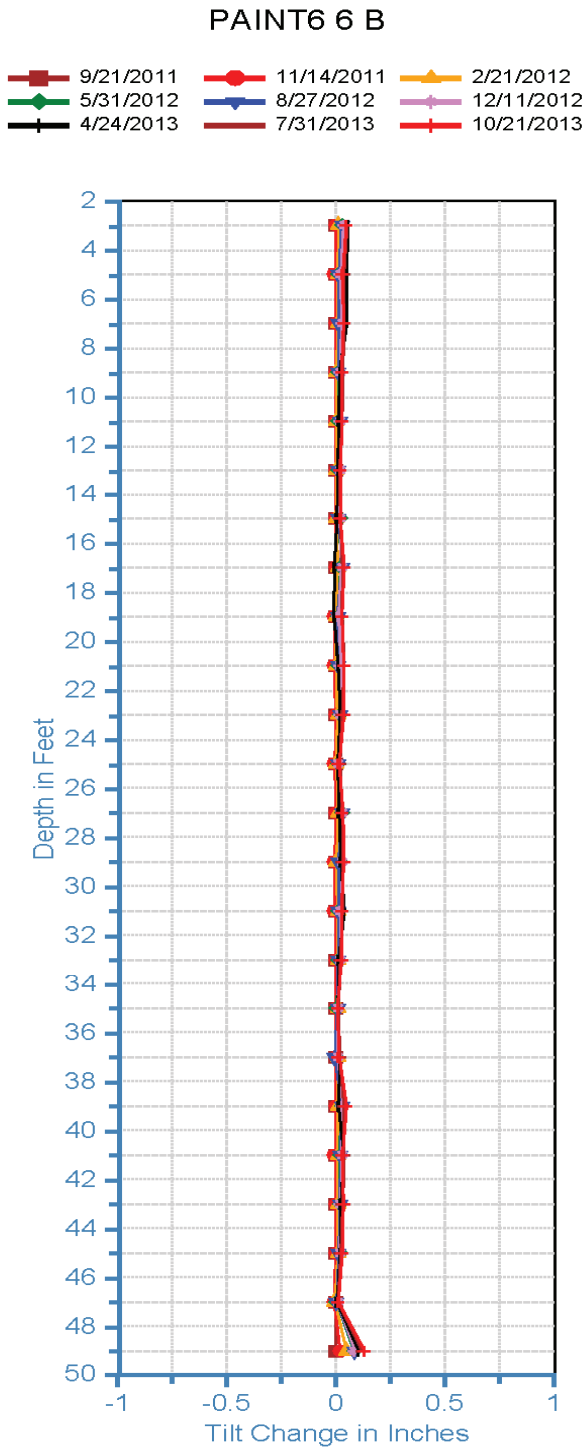
FIG. 9c





This plot presents change in tilt at each measurement depth along length of casing (incremental), to isolate zones of movement.

I-94 Painted Canyon Landslide
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CASING 6 INCLINOMETER INCREMENTAL DISPLACEMENT

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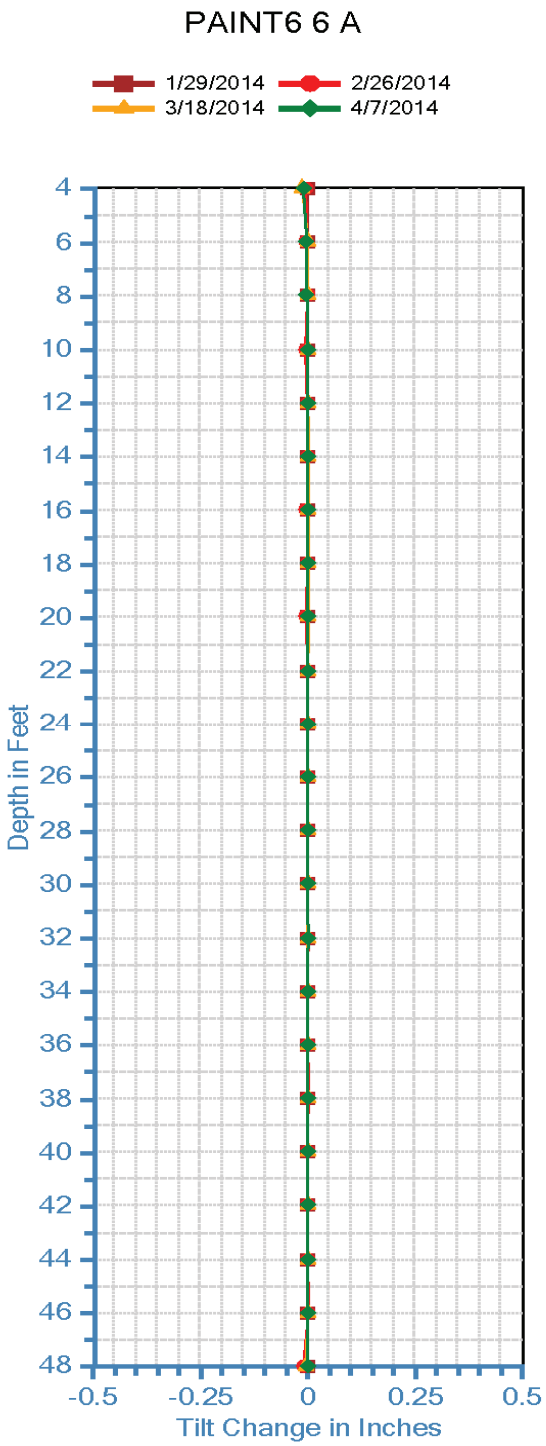
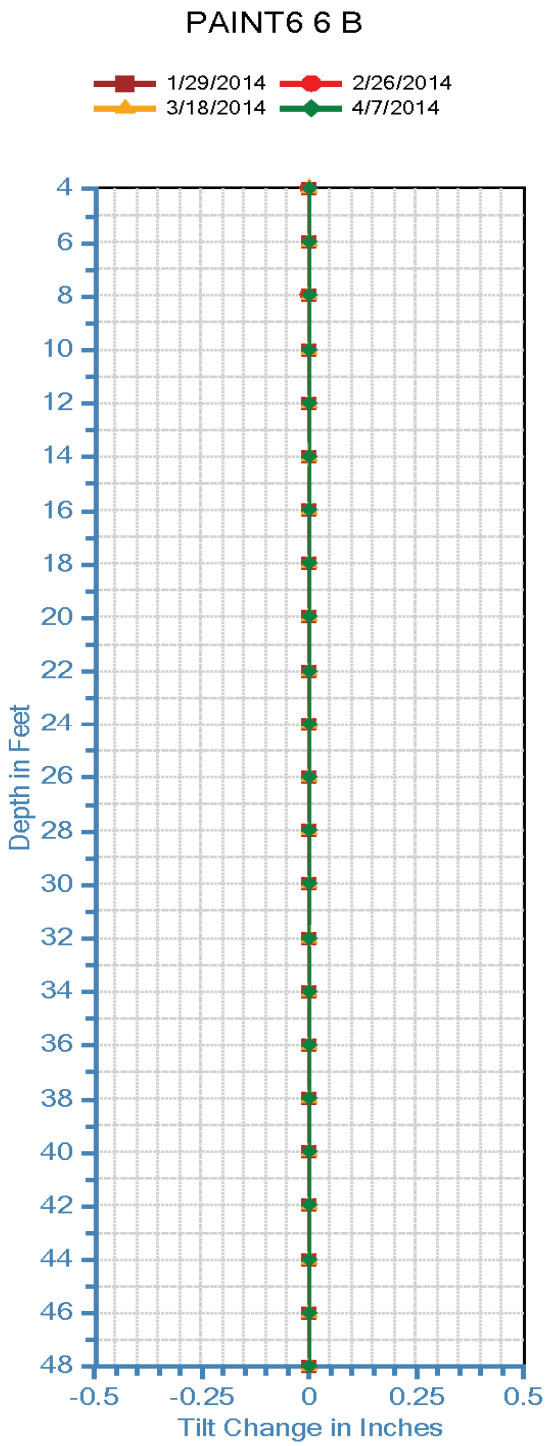
FIG. 10a





This plot presents change in tilt at each measurement depth along length of casing (incremental), to isolate zones of movement.

I-94 Painted Canyon Landslide
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CASING 6 INCLINOMETER INCREMENTAL DISPLACEMENT NEW PROBE ONLY

April 2014 21-1-01400-001

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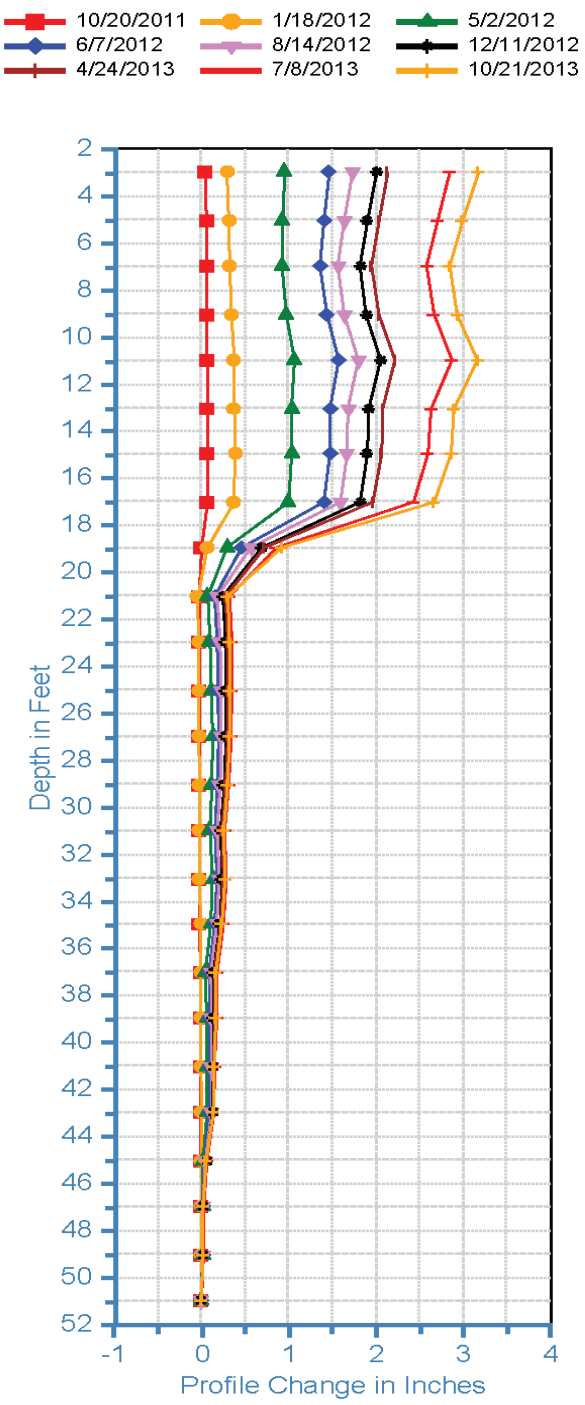
FIG. 10b

PAINT7 7 A
Initial: 9/21/2011



PAINT7 7 B
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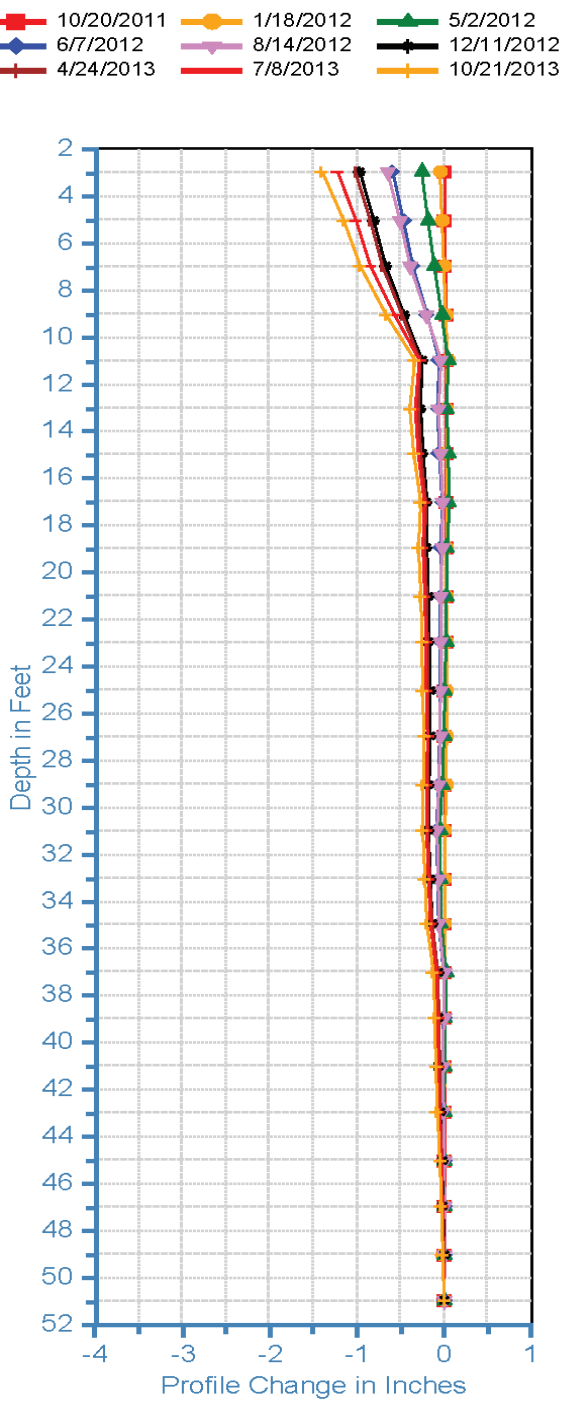

I-94 Painted Canyon Landslide
Project No. SER-5-094(107)030, PCN 20549
Billings County, North Dakota

CASING 7 INCLINOMETER
CUMULATIVE DISPLACEMENT

April 2014 21-1-01400-001

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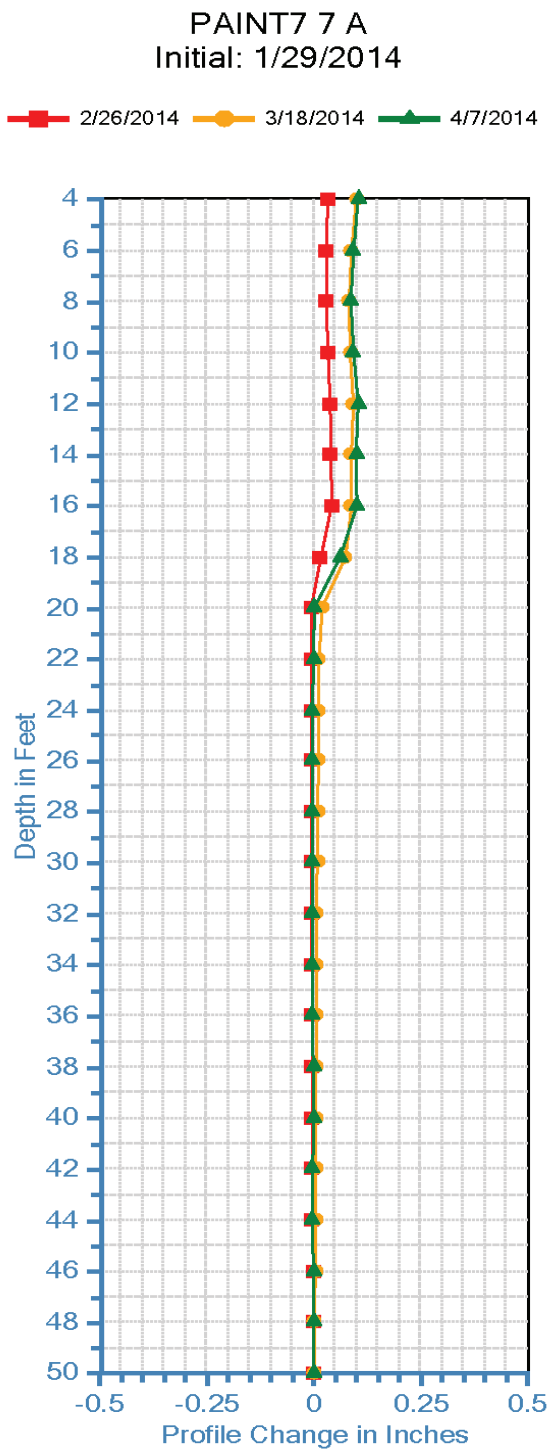
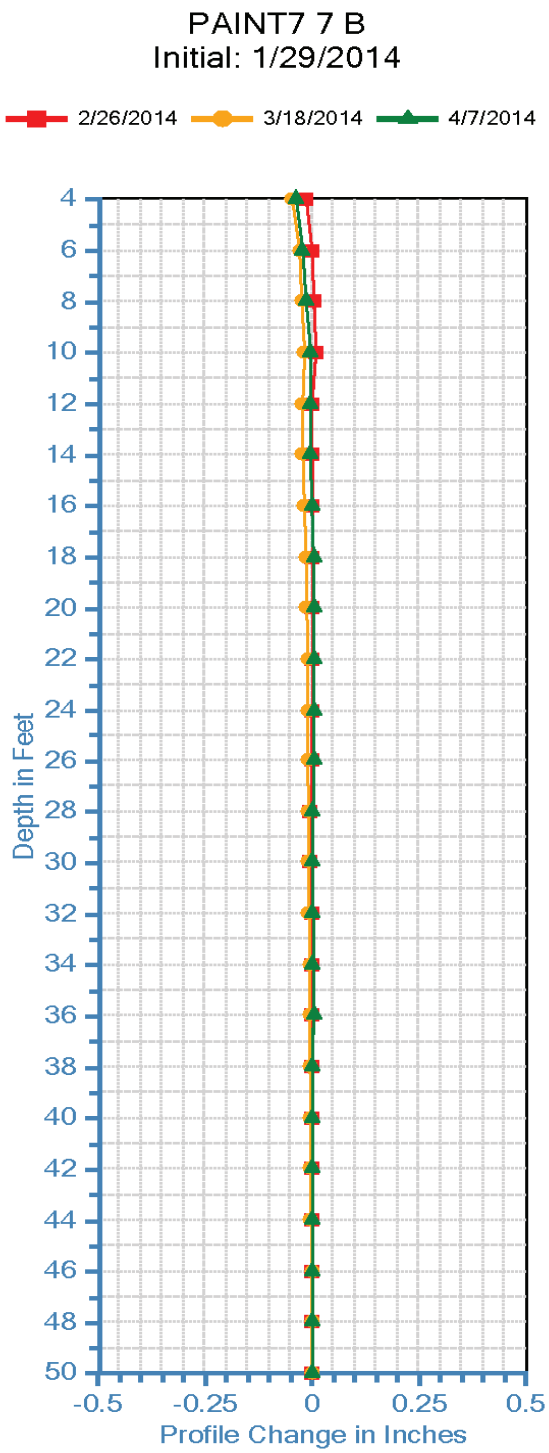
FIG. 11a





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CASING 7 INCLINOMETER
CUMULATIVE DISPLACEMENT
NEW PROBE ONLY

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SHANNON & WILSON, INC.
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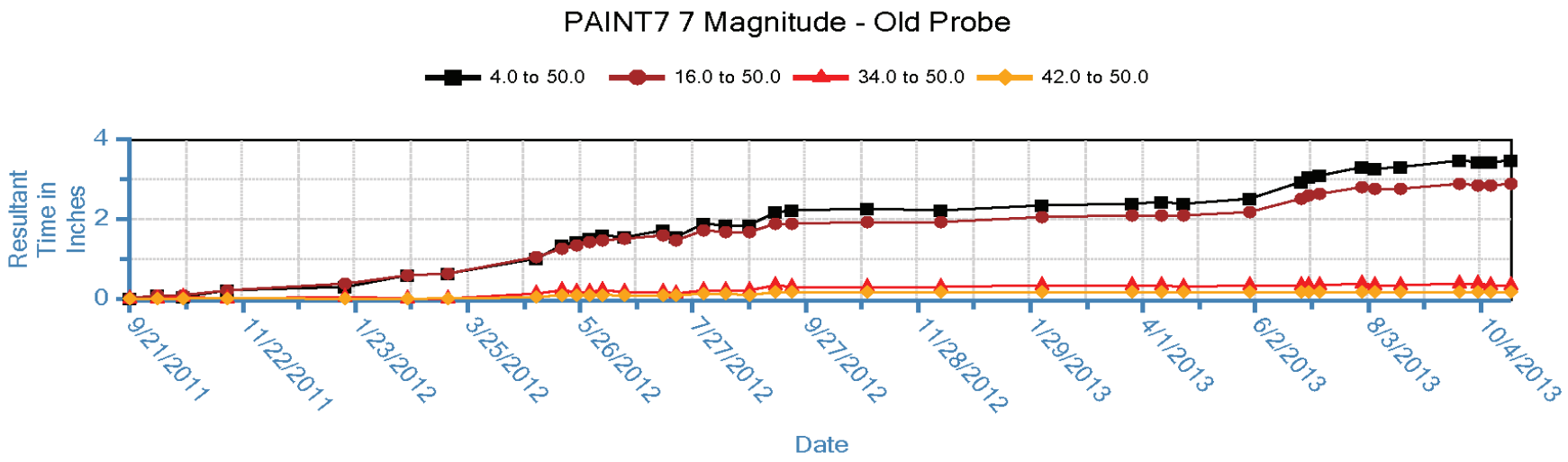
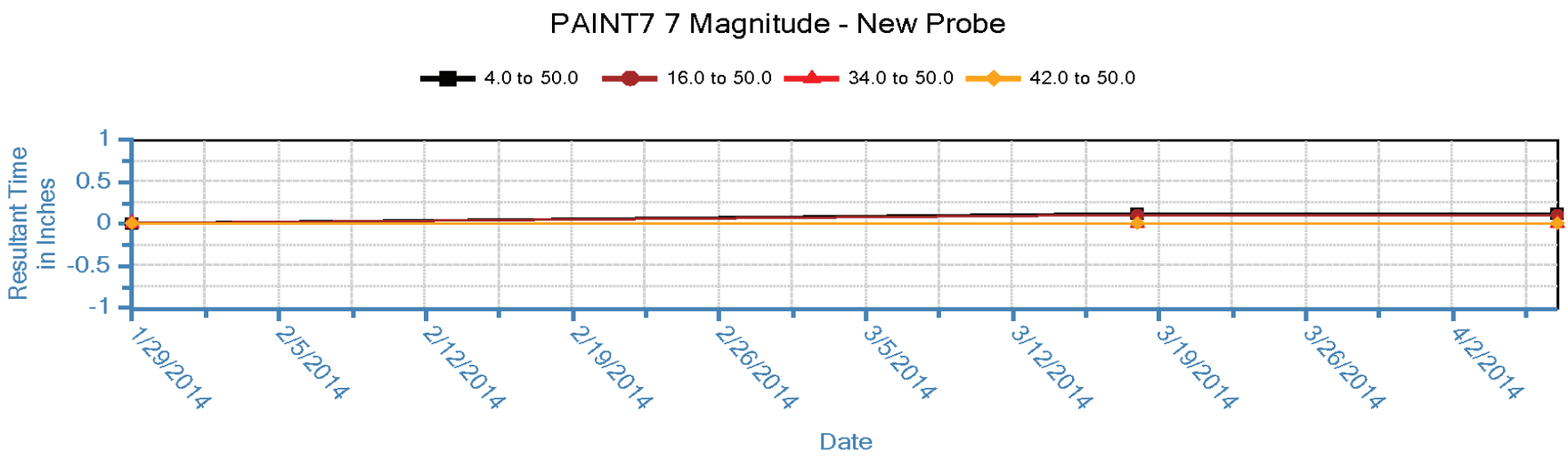
FIG. 11b





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CASING 7 INCLINOMETER
RESULTANT TIME DISPLACEMENT

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SHANNON & WILSON, INC.
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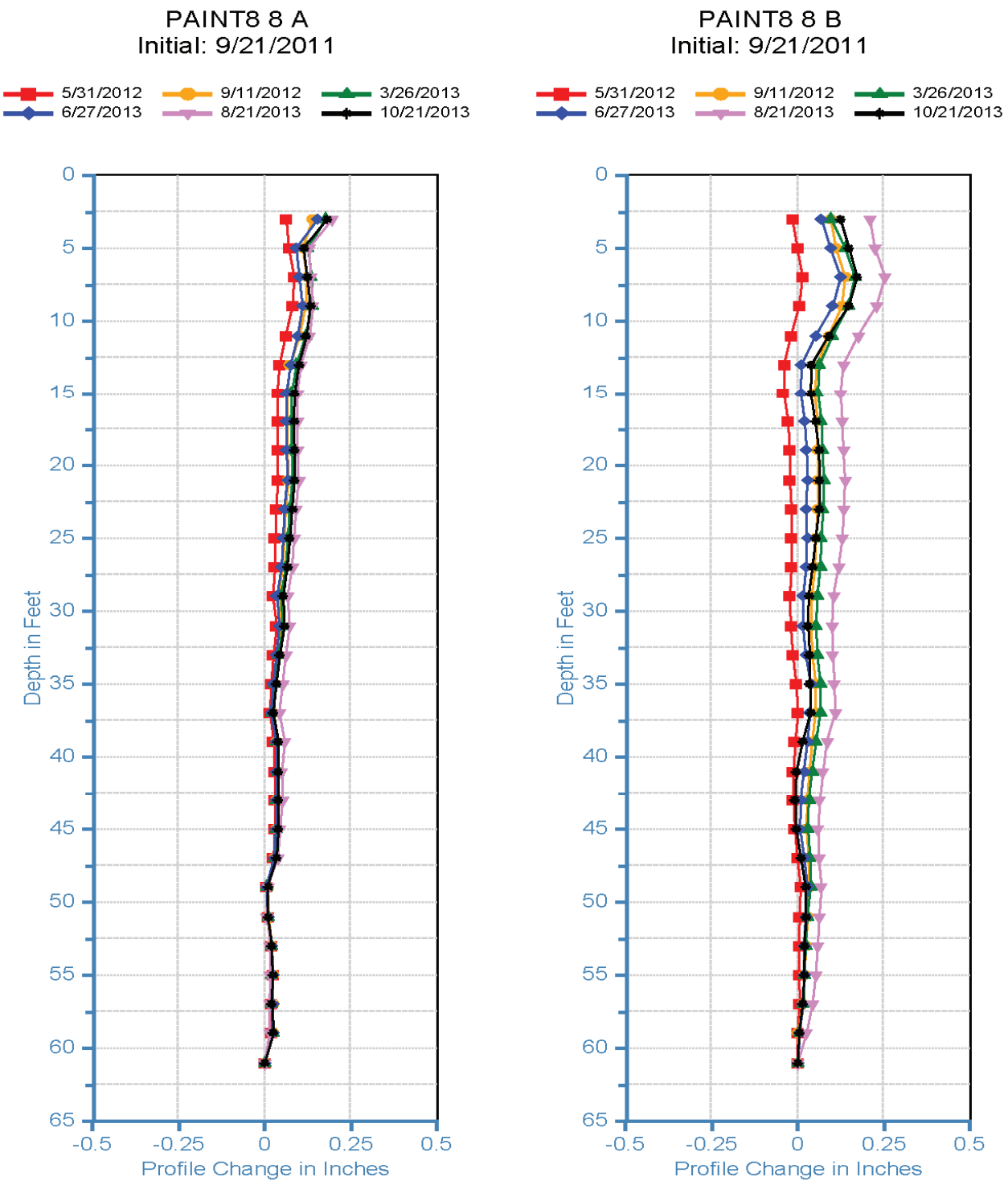
FIG. 11c

FIG. 11c



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CUMULATIVE DISPLACEMENT
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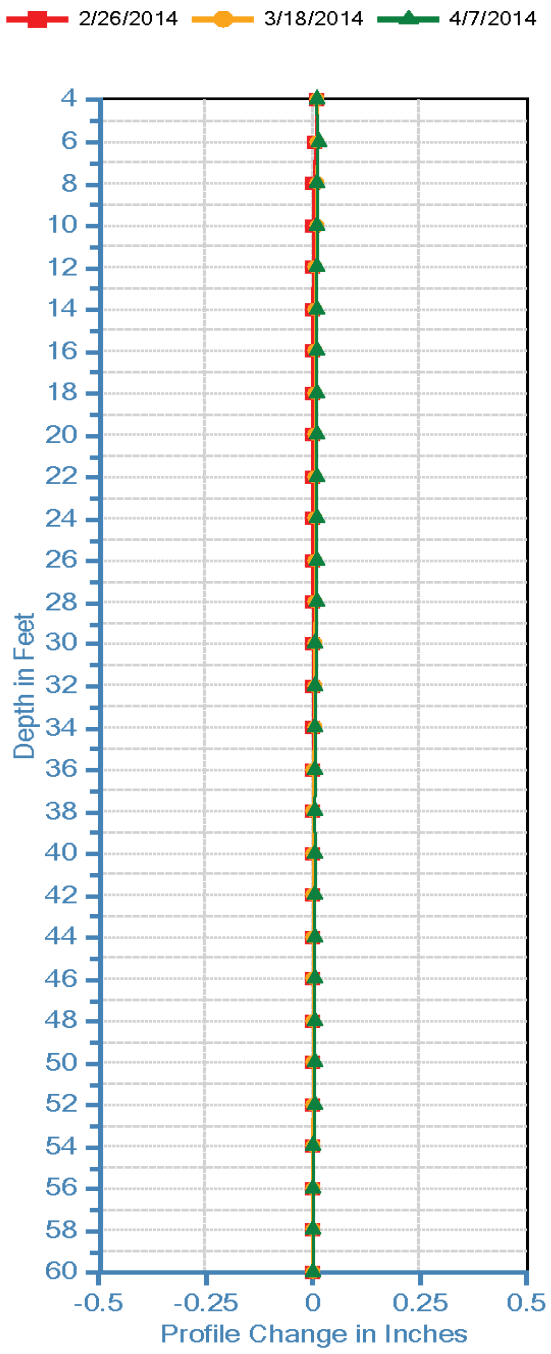
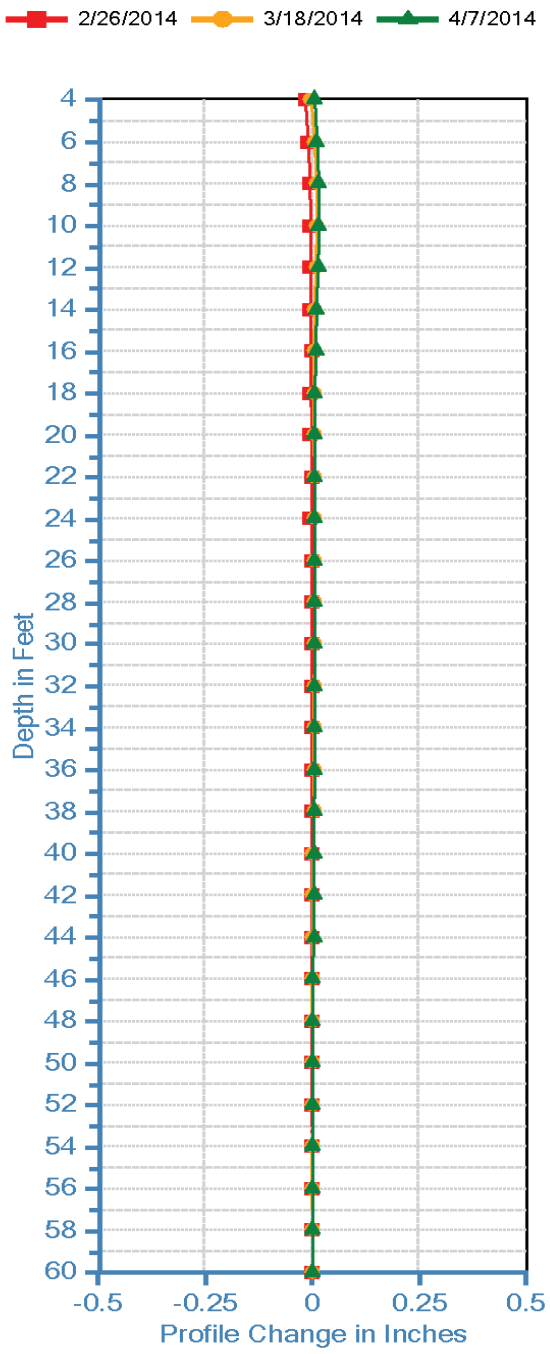
FIG. 12a

PAINT8 8 A
Initial: 1/29/2014



PAINT8 8 B
Initial: 1/29/2014



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CUMULATIVE DISPLACEMENT
NEW PROBE ONLY

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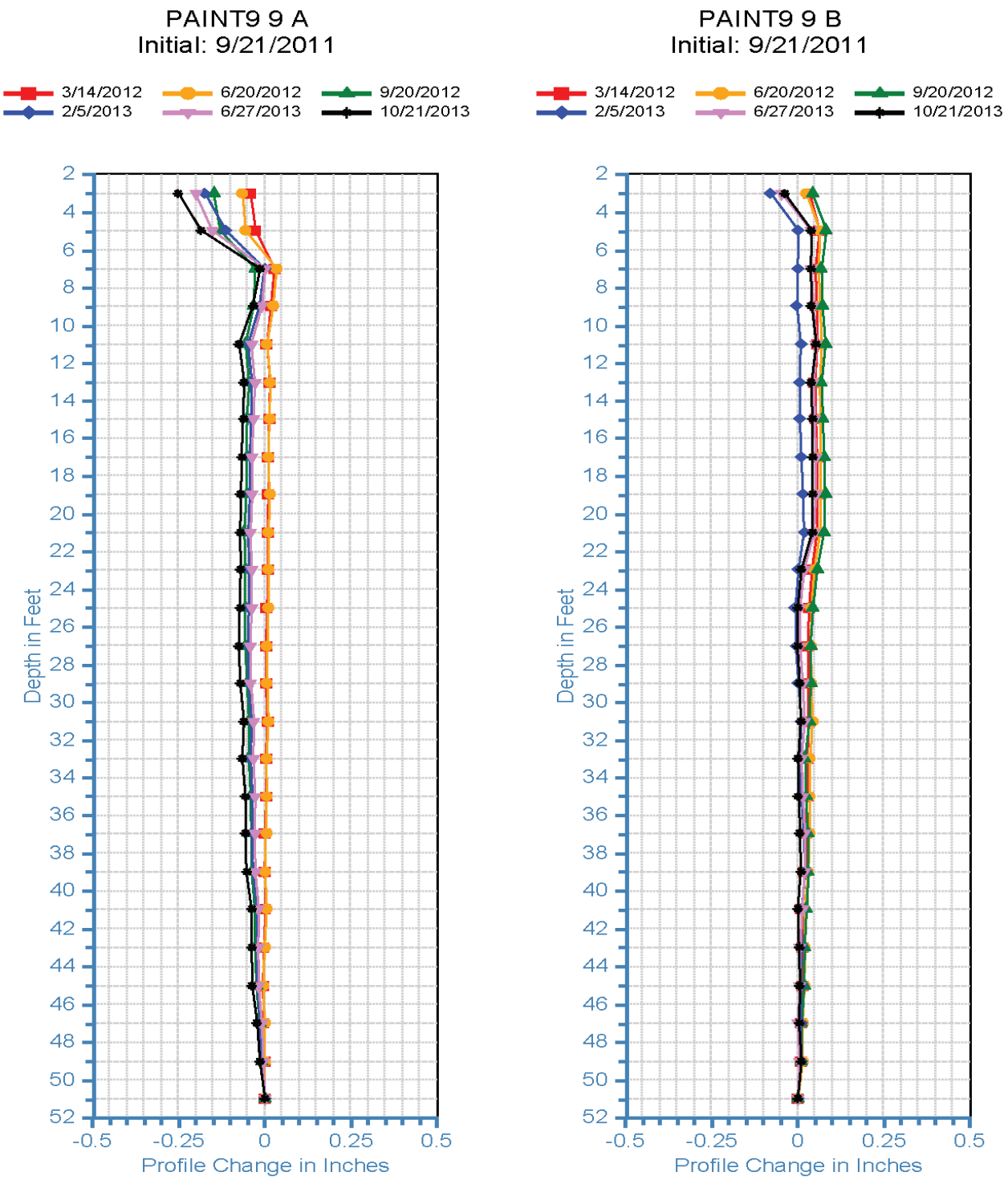
FIG. 12b



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CUMULATIVE DISPLACEMENT
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SHANNON & WILSON, INC.
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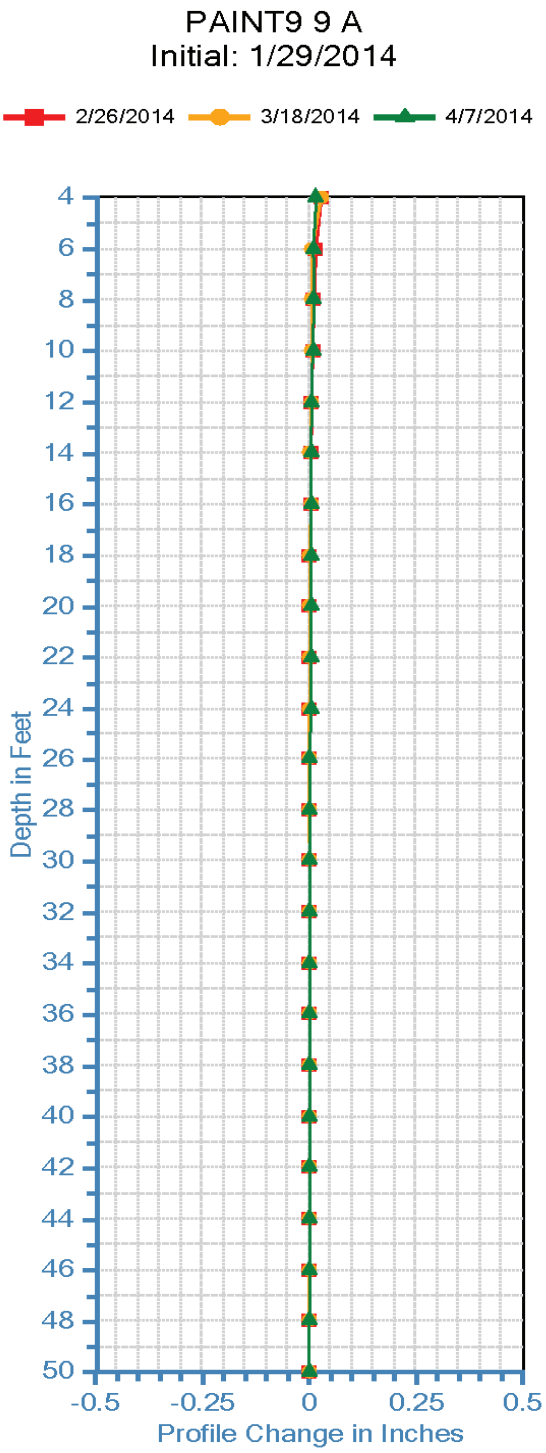
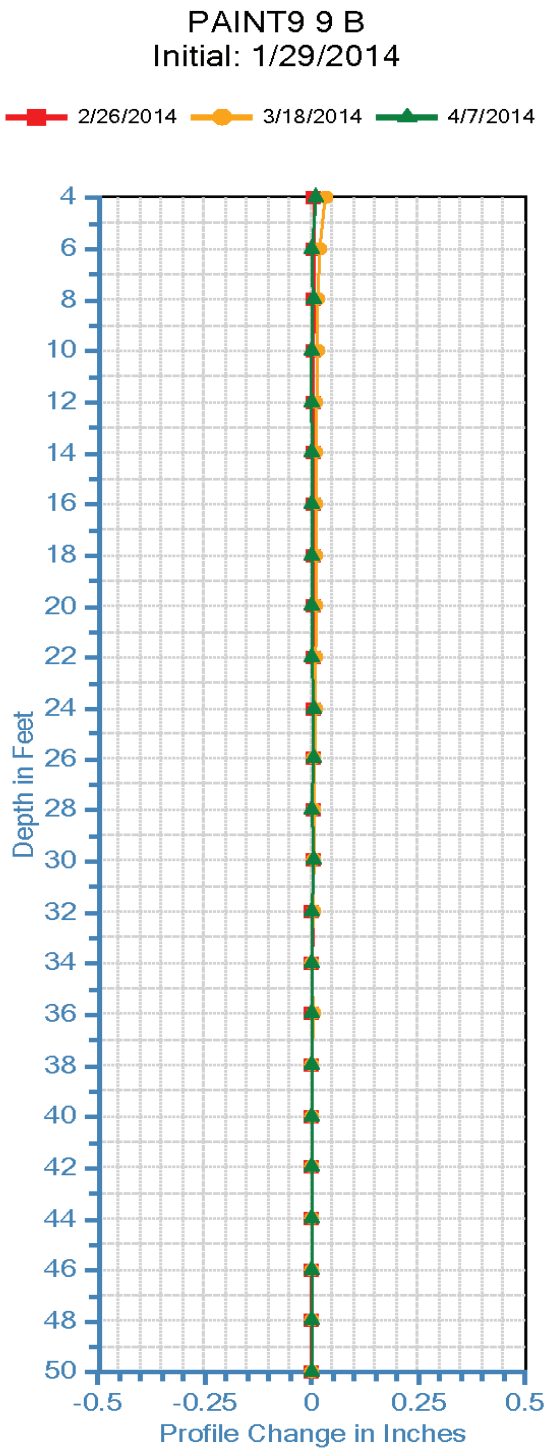
FIG. 13a





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CASING 9 INCLINOMETER
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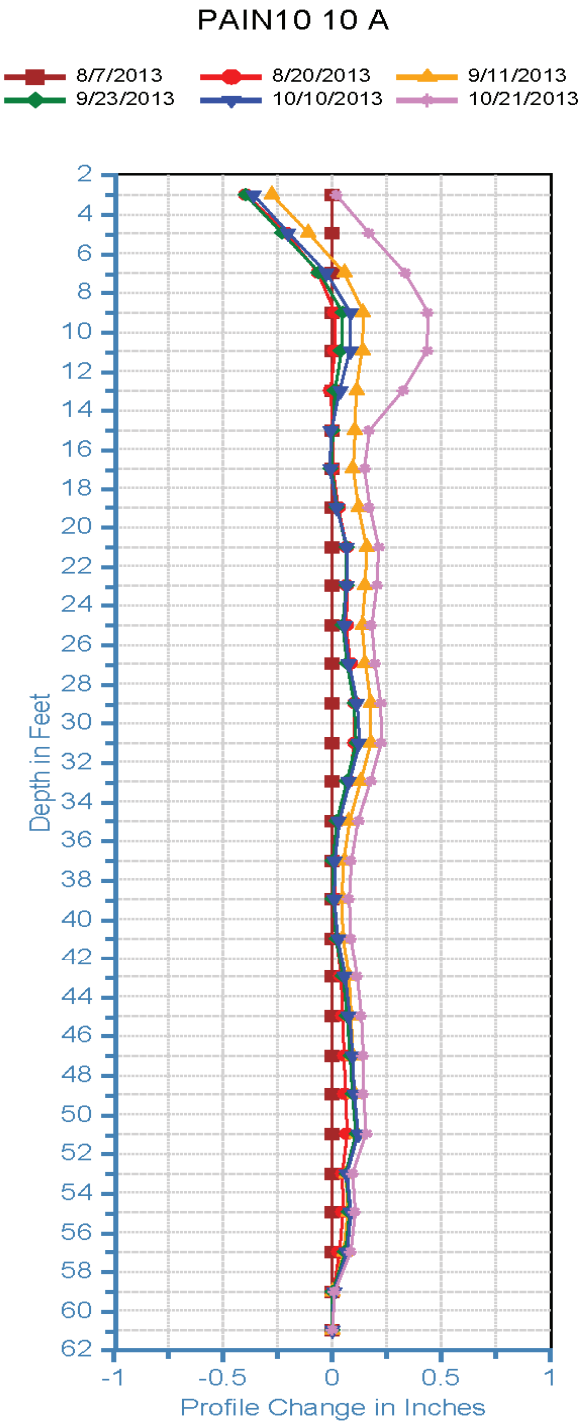
FIG. 13b



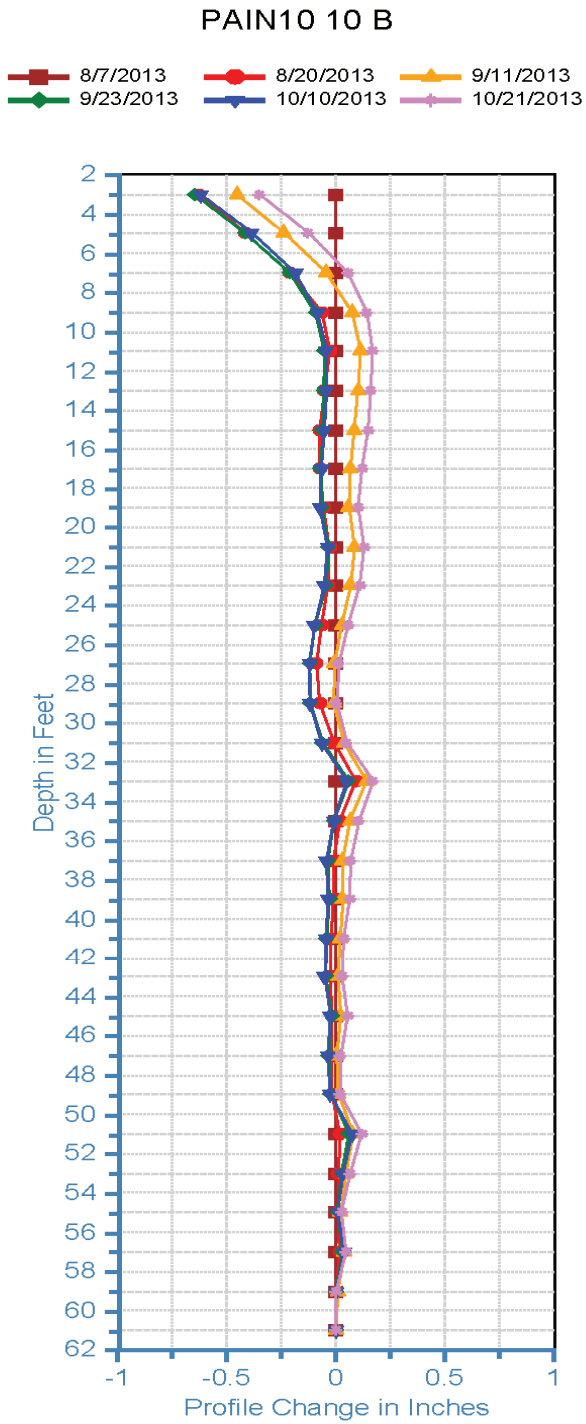


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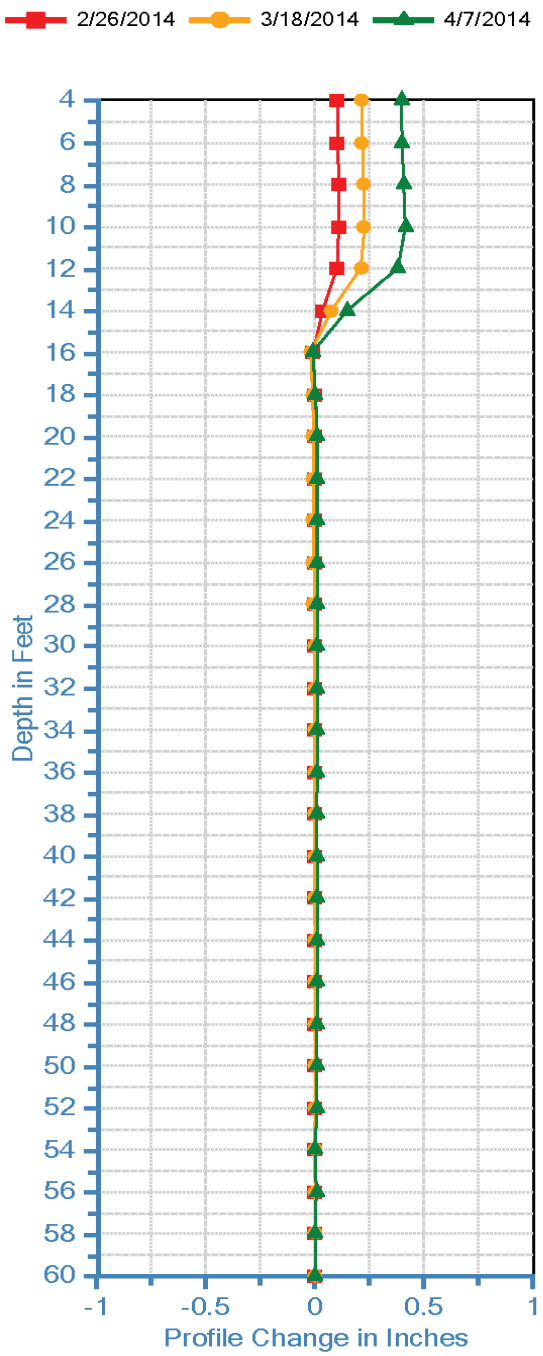
FIG. 14a

PAIN10 10 A
Initial: 1/29/2014



PAIN10 10 B
Initial: 1/29/2014

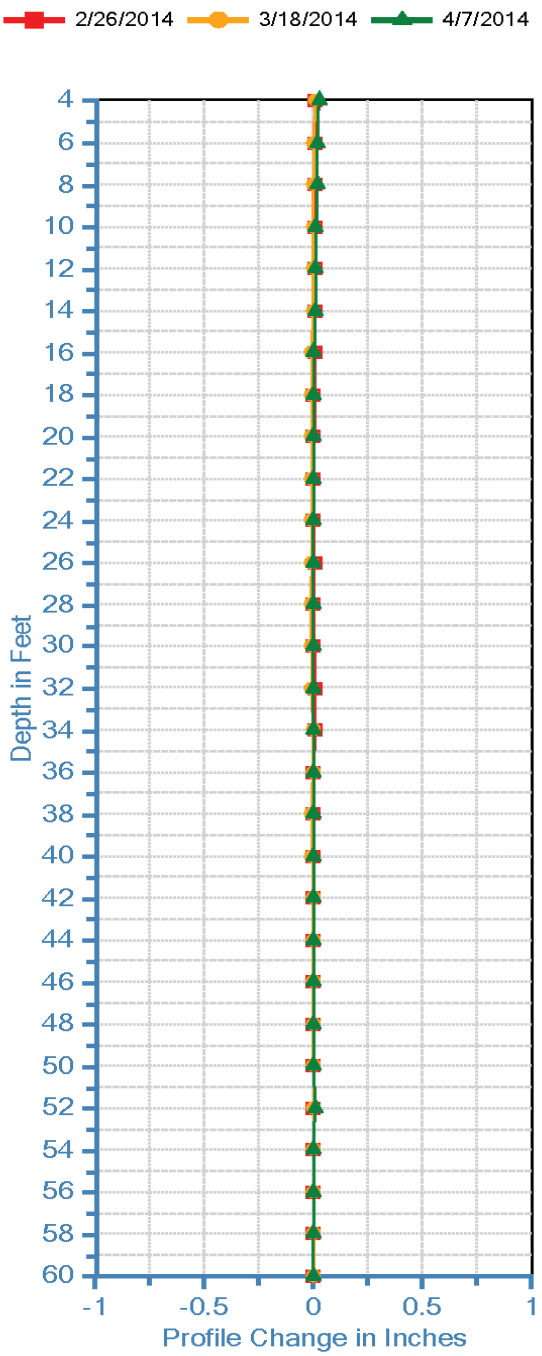


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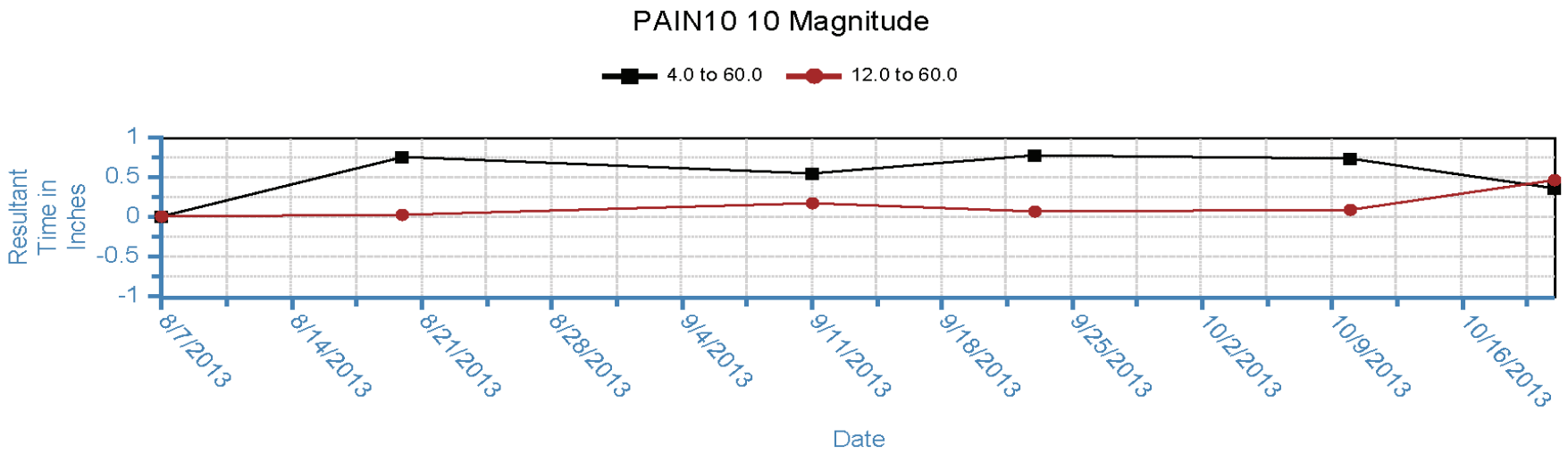
FIG. 14b



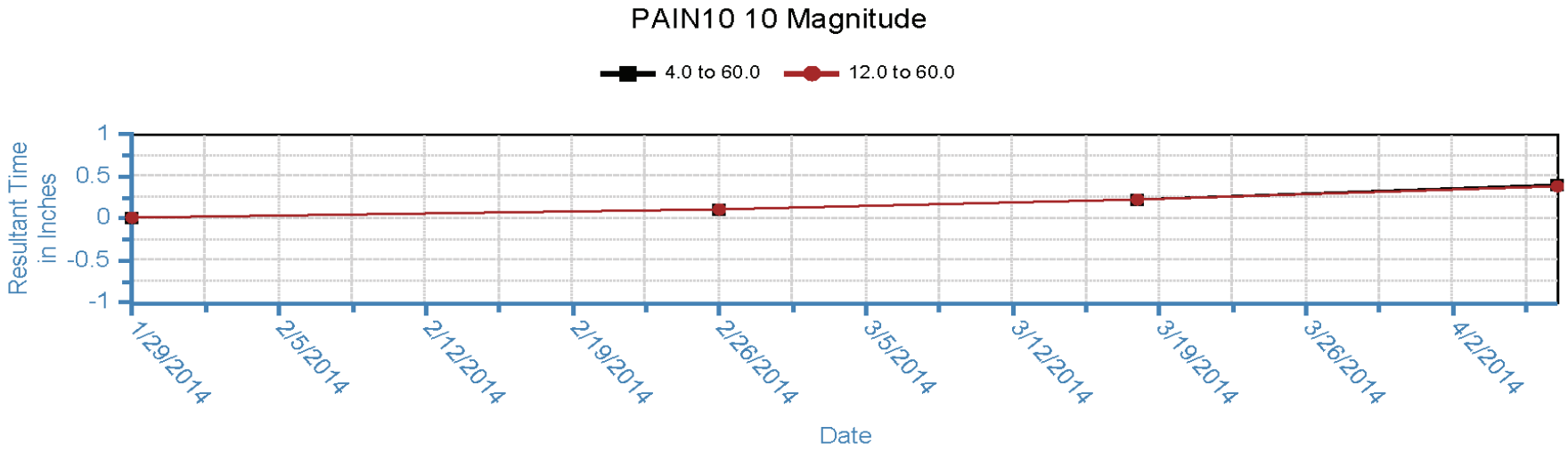


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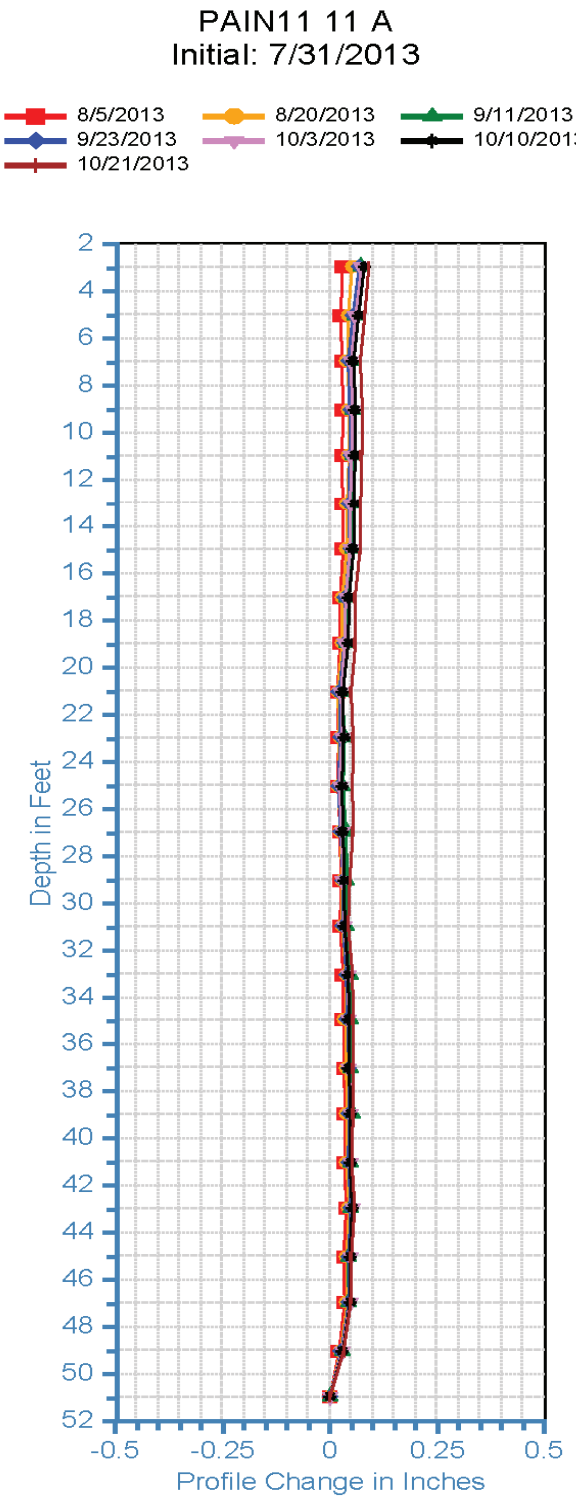
FIG. 14c

FIG. 14c



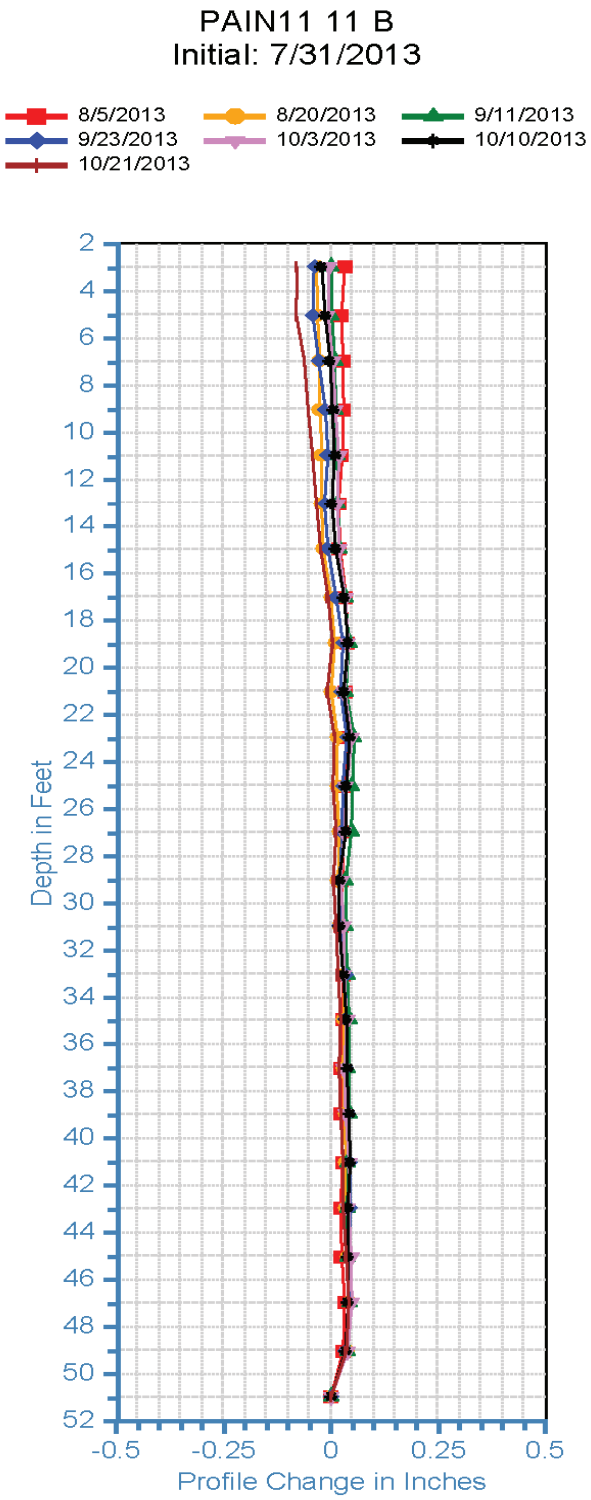


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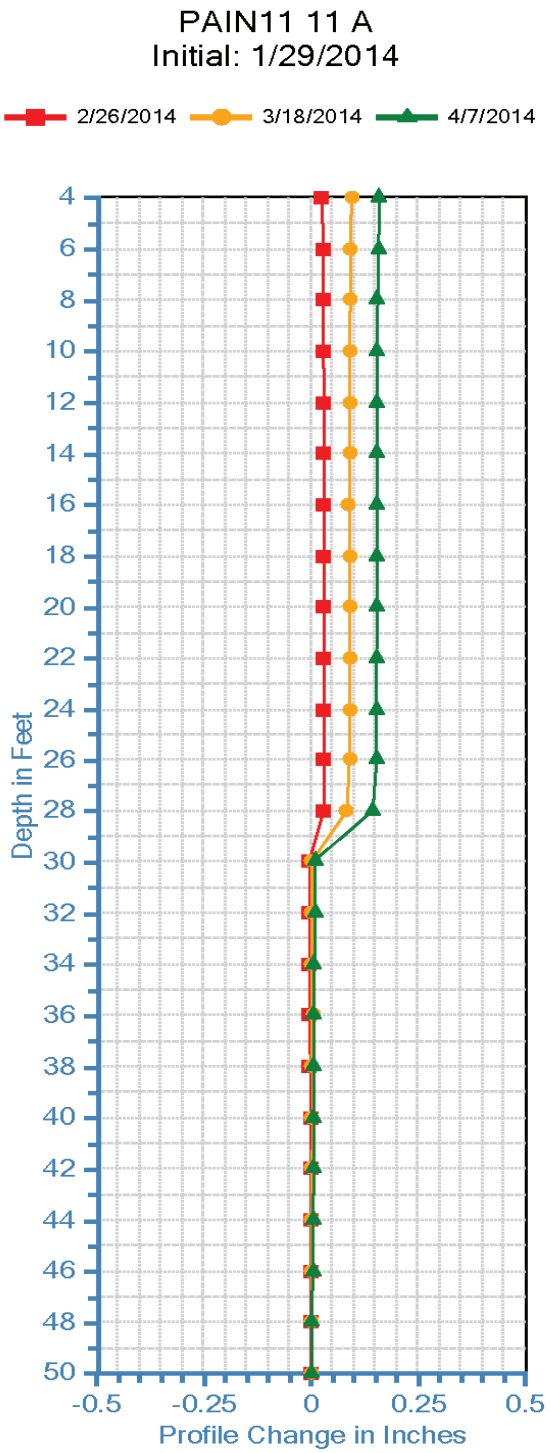
FIG. 15a



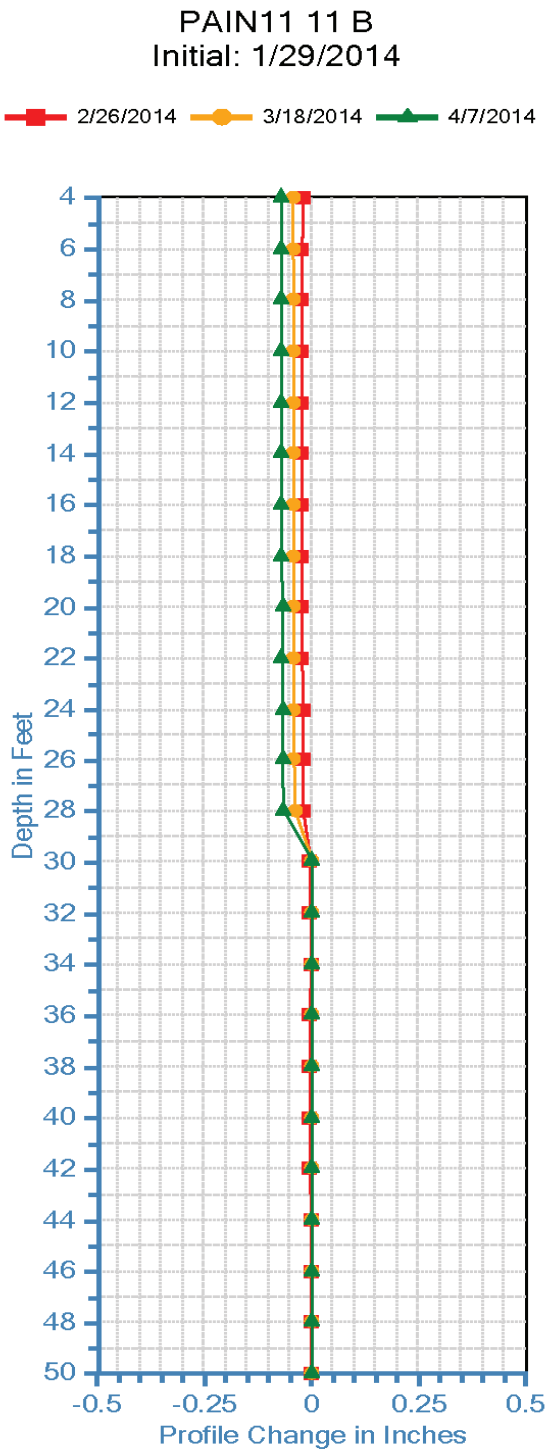


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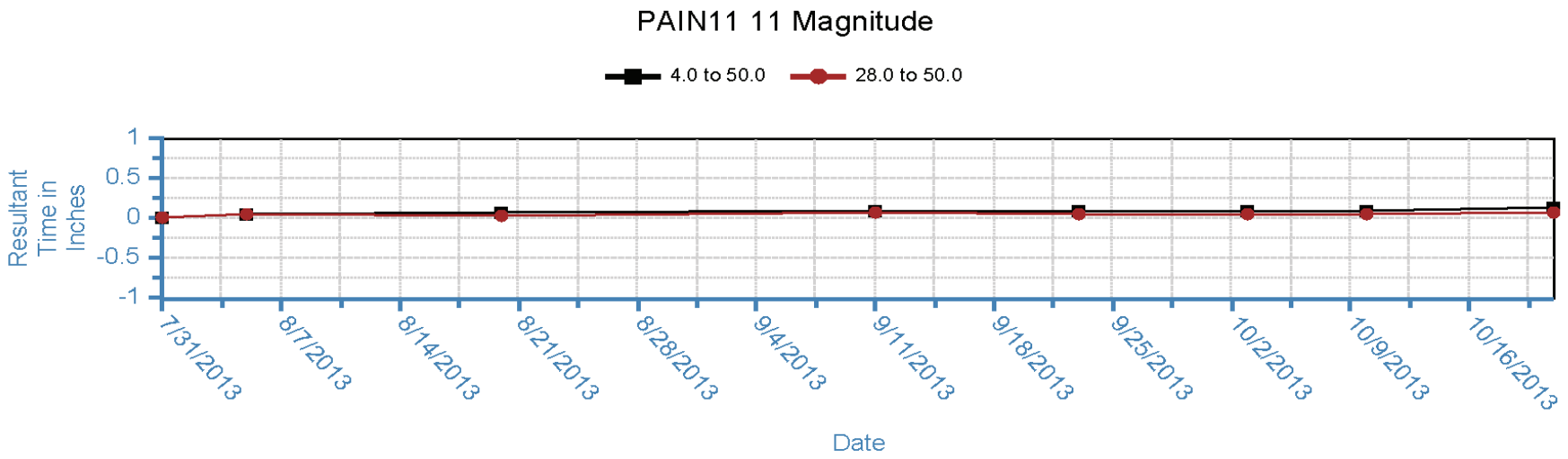
FIG. 15b



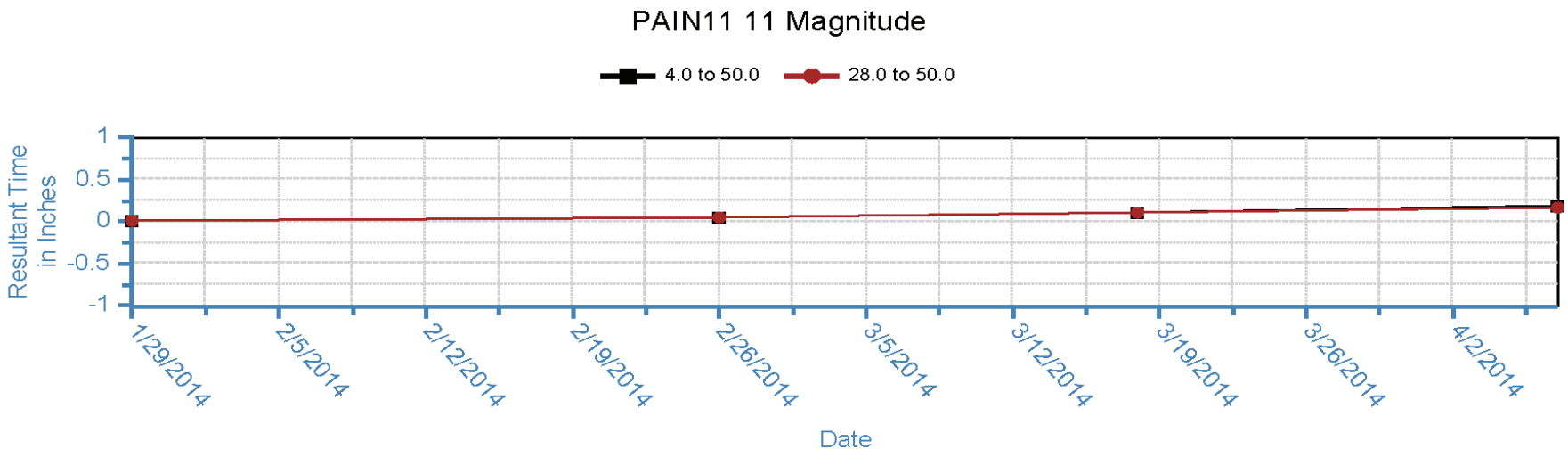


FIG. 15c

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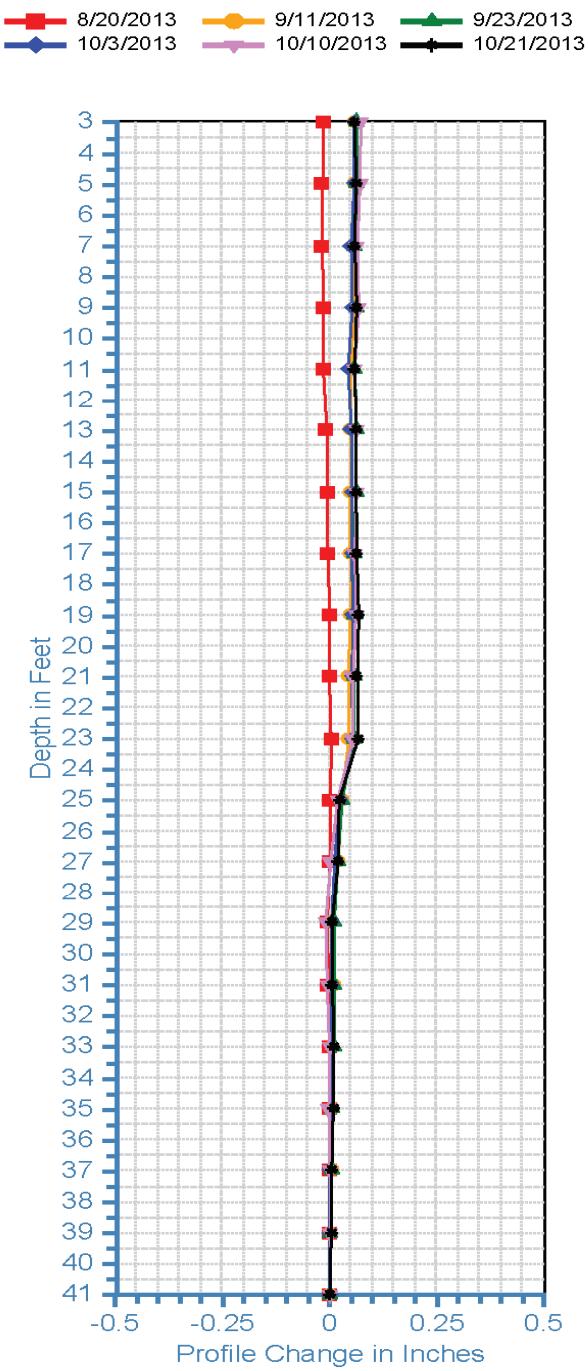
FIG. 15c

PAIN12 12 A
Initial: 8/5/2013



PAIN12 12 B
Initial: 8/5/2013

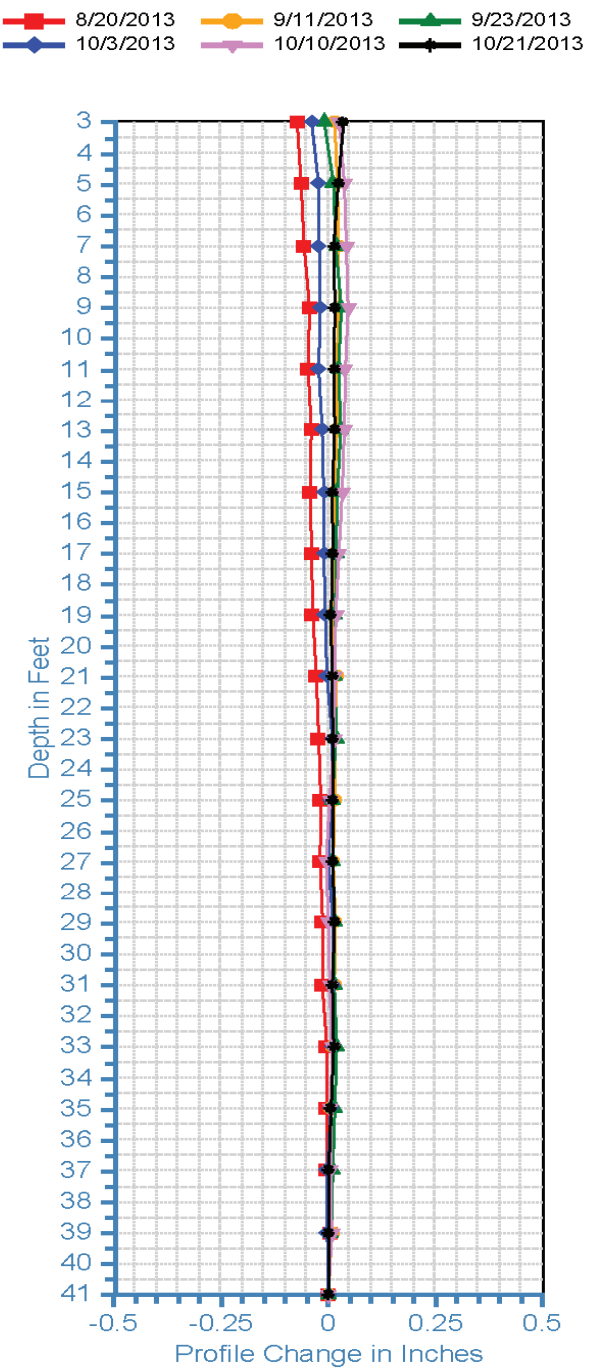


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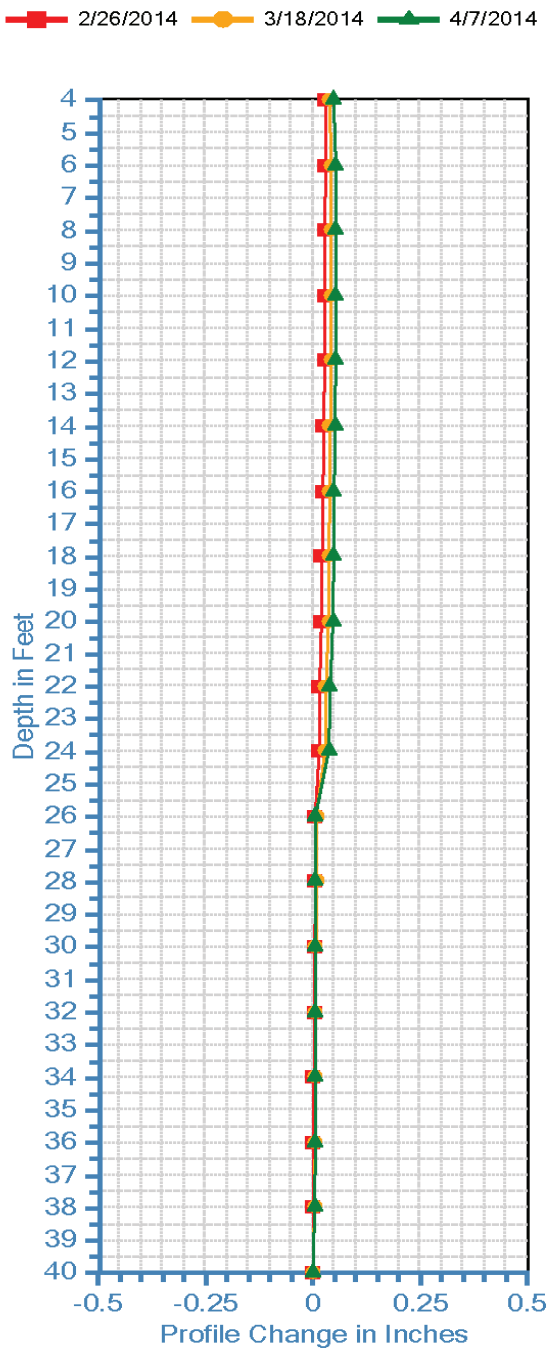
FIG. 16a

PAIN12 12 A
Initial: 1/29/2014



PAIN12 12 B
Initial: 1/29/2014

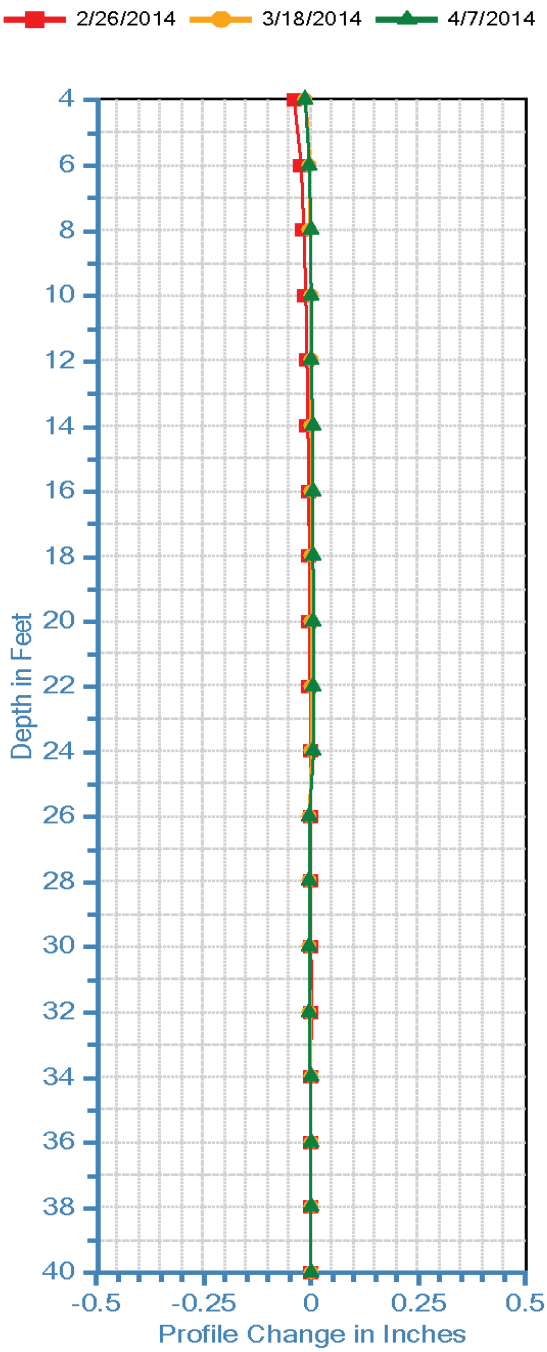


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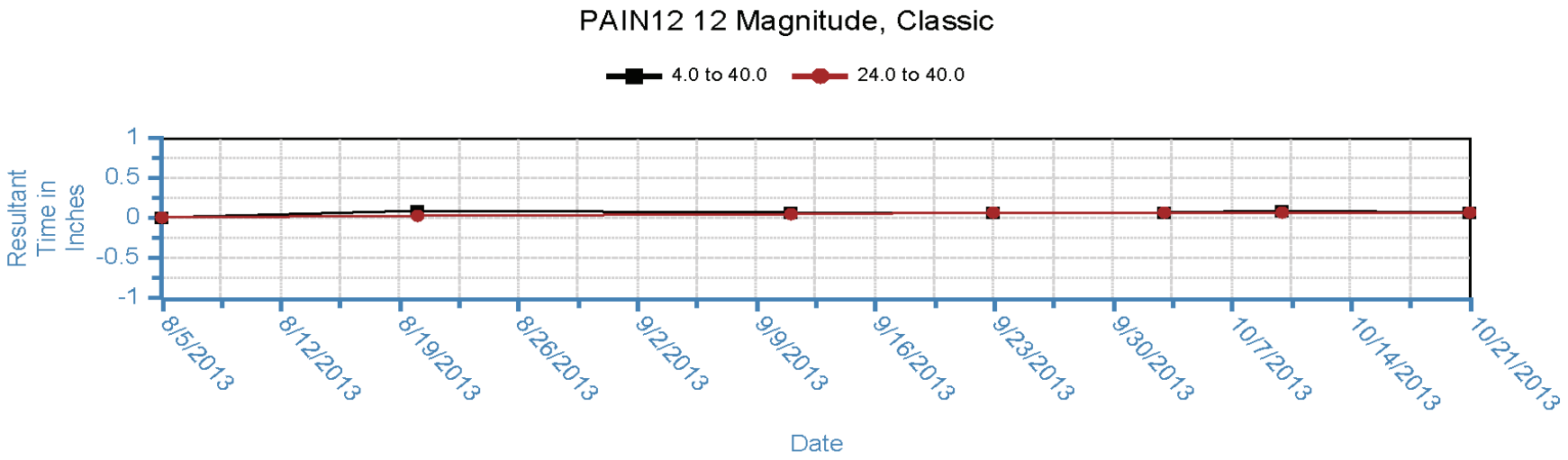
FIG. 16b



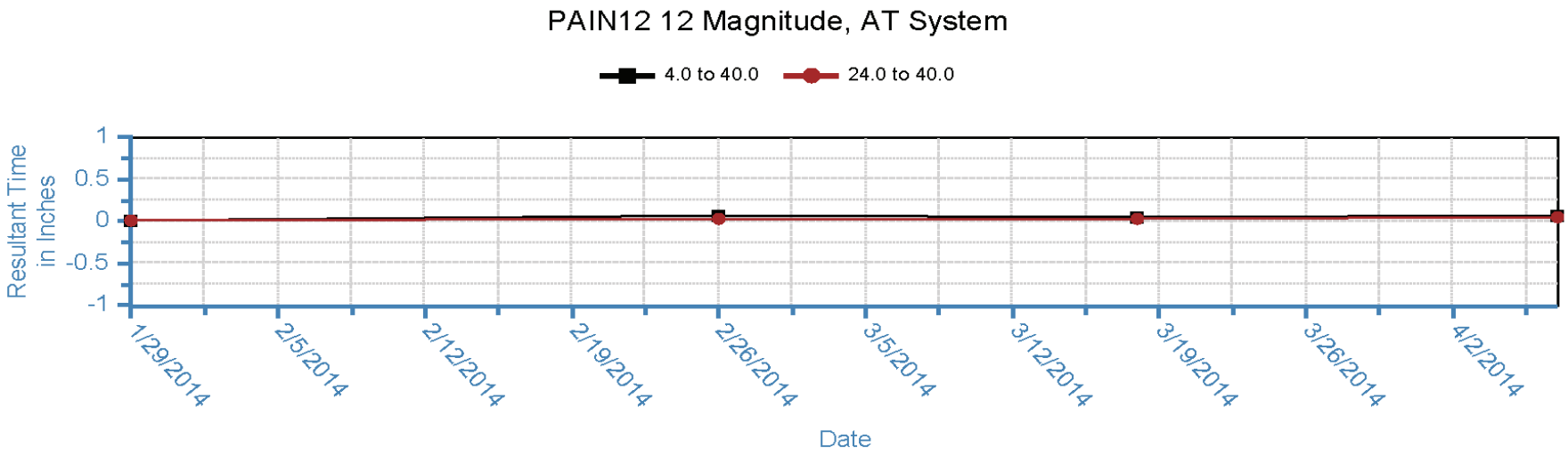


FIG. 16c

I-94 Painted Canyon Landslide
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CASING 12 INCLINOMETER RESULTANT TIME DISPLACEMENT

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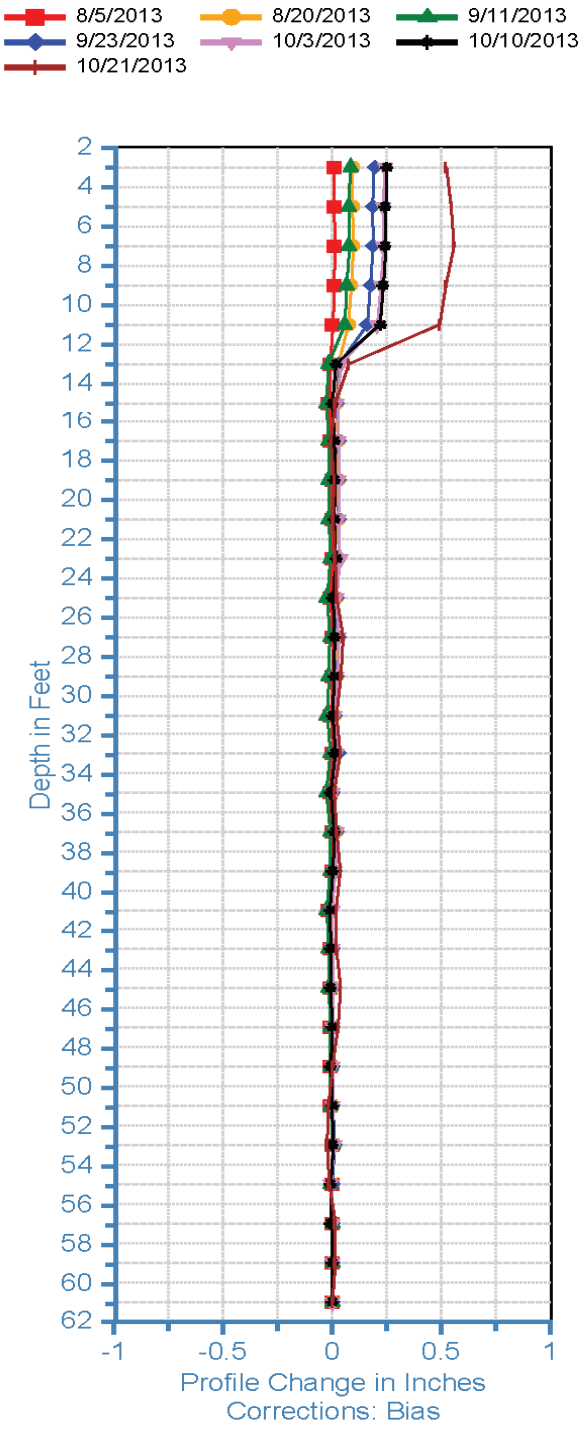
FIG. 16c

PAIN13 13 A
Initial: 7/31/2013



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Initial: 7/31/2013

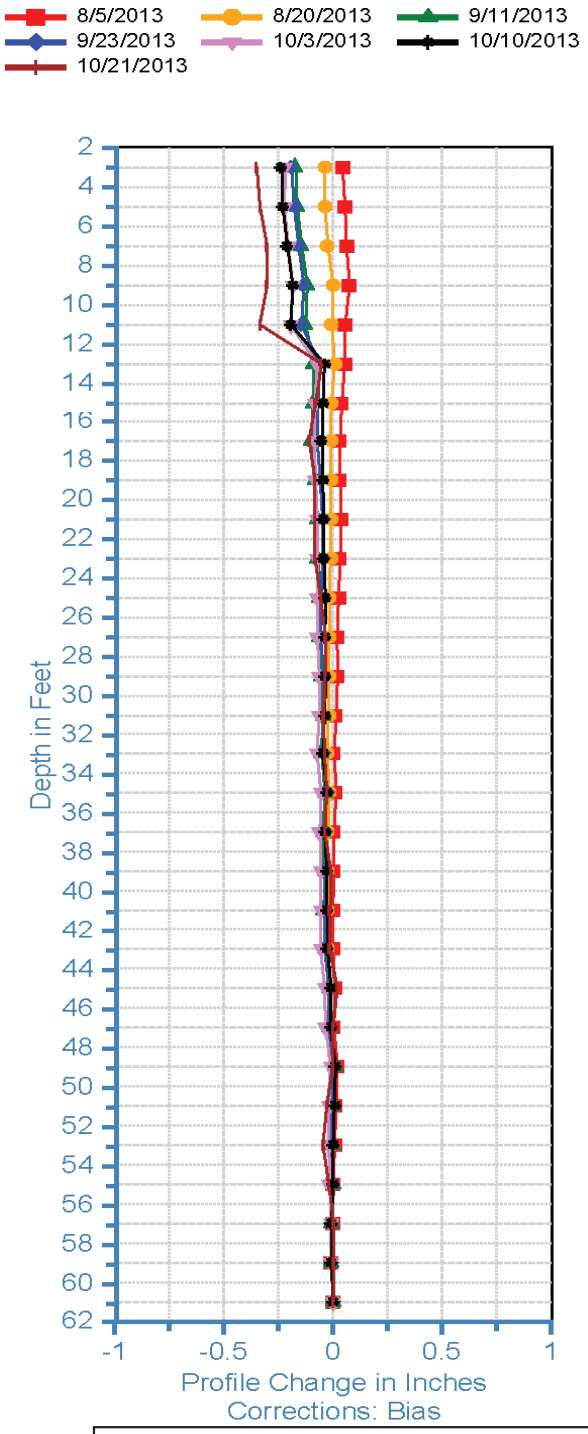

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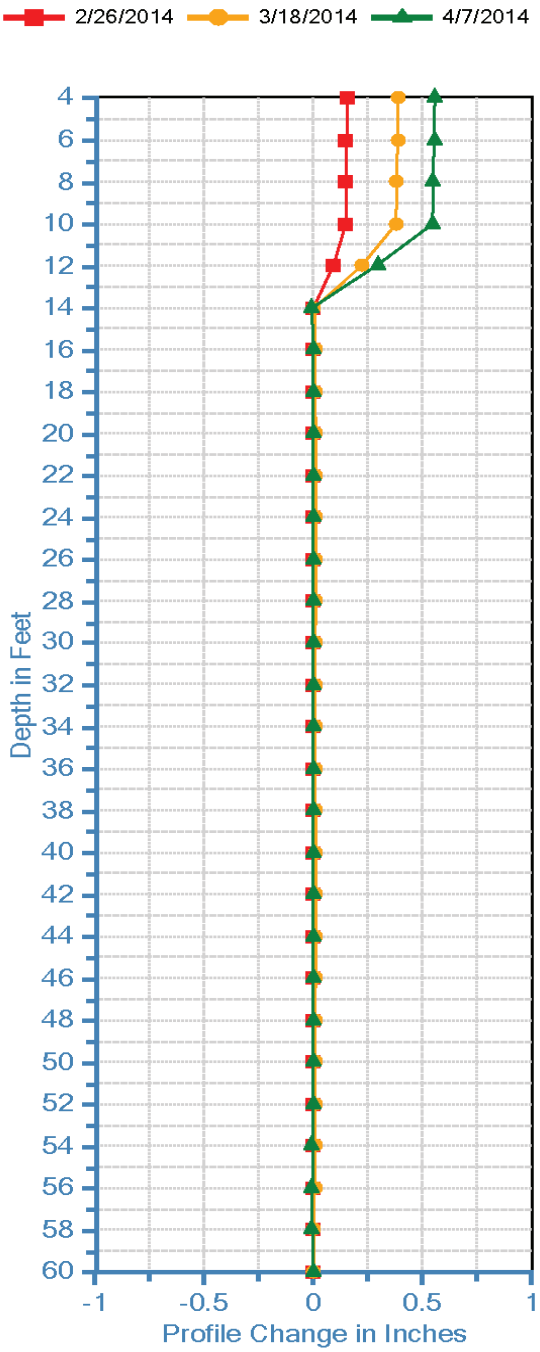
FIG. 17a

PAIN13 13 A
Initial: 1/29/2014



PAIN13 13 B
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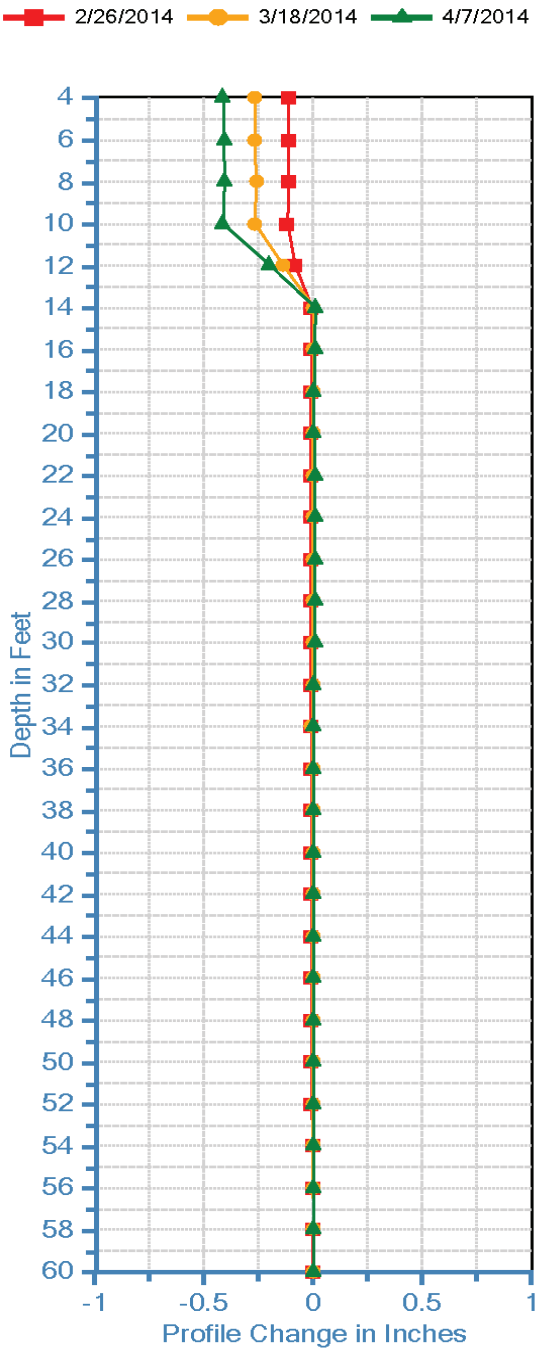

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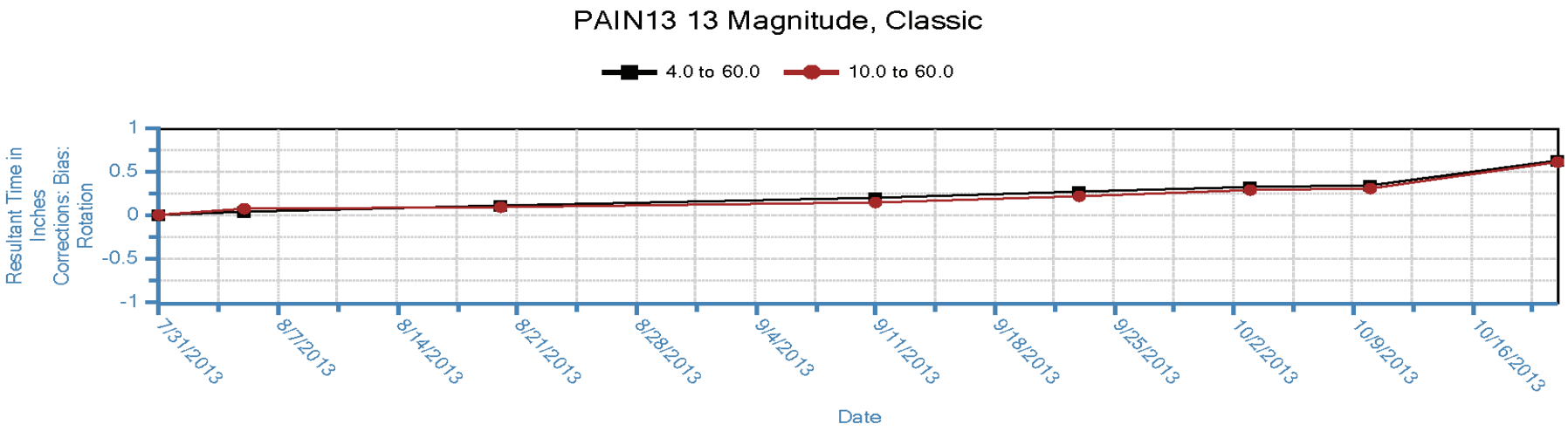
FIG. 17b



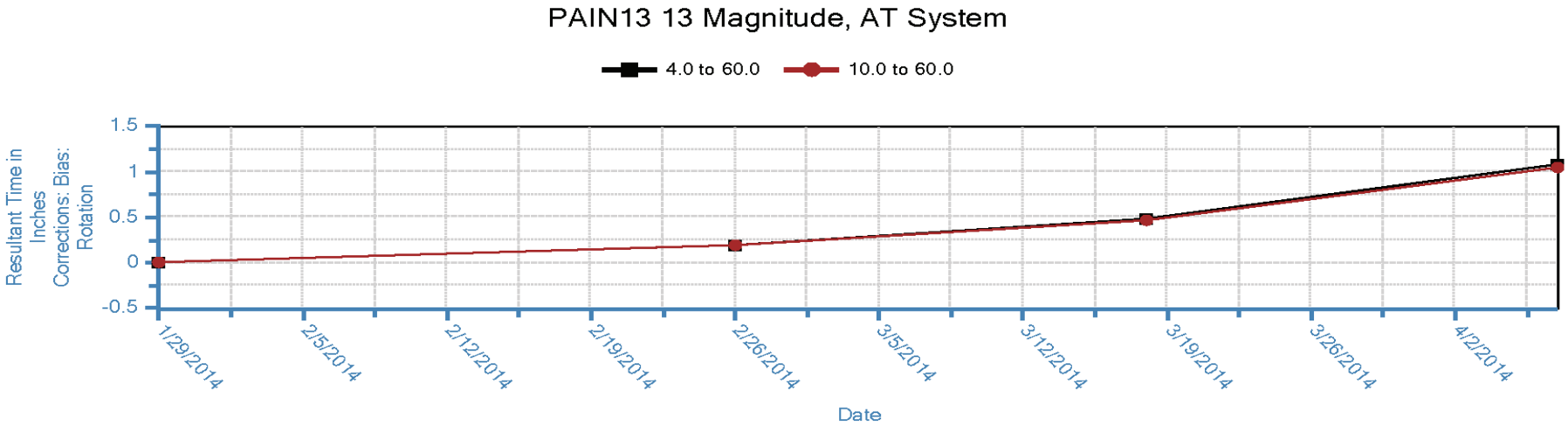


FIG. 17c

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FIG. 17c