

National Park Service Investigator Annual Report - 2017

**Nebraska Department of Transportation
Niobrara N-12 Maintenance
Bow Creek Wetland Mitigation Site
NDOT Project No. Misc-12-5(1016)
NDOT Control No. 32093
T.32N, R. 2E, S. 01
Cedar County, NE**

PREPARED FOR

**Missouri National Recreational River
National Park Service
508 East 2nd Street
Yankton, South Dakota 57078**

February 2018



Alfred Benesch & Company
14748 W. Center Road, Suite 200
Omaha, NE 68144-2029
www.benesch.com
P 402-333-5792
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February 15, 2018

Lisa Yager
Missouri National Recreational River
National Park Service
508 East 2nd Street
Yankton, SD 57078

Subject: National Park Service Investigator Annual Report – 2017

Dear Ms. Yager,

The Nebraska Department of Transportation (NDOT) received a National Park Service (NPS) research permit (Permit# MNRR-2017-SCI-0007) on October 18, 2017 for soil borings and the installation of piezometers to determine soils and groundwater levels at a potential wetland mitigation site (Bow Creek Mitigation Site) located within the NPS's Missouri National Recreational River.

NDOT contracted Alfred Benesch & Company (Benesch) to perform borings. Benesch staff visited the site on December 20, 2017 to conduct the field work. Soil cores were collected from each of the five boring sites to determine soil types. Two piezometers were installed to monitor groundwater levels at site. Water levels are planned to be collected every month to every three months by hand or with an automatic water level logger.

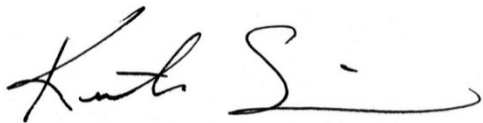
Attached you will find the Geo-technical Report showing the locations and results of the soil borings that were performed on December 20, 2017. Data collection for this project is ongoing.

The five soils borings were dug to a depth of five feet. The borings show that the site consists of alluvial sand (poorly graded sand and poorly graded sand with silt), sandy loam (silty sand), and loam (sandy silt). The alluvial sands are not considered suitable for use in the proposed construction of the sandbar, but are for the proposed bench on each side of the chute. For a detailed description of the borings see Appendix C of the attached Geotechnical Data Report.

Groundwater varied between 2.0 feet below existing grade to 4.9 feet below existing grade. Piezometers were installed at two of the boring locations (PZ-1 and PZ-2, shown on Figure 2 of the attached Geotechnical Data Report) at a depth of 4 to 7 feet below existing grade.

If you have any questions please contact me at 402-333-5792.

Sincerely,

A handwritten signature in black ink, appearing to read "Keith Simmons". The signature is fluid and cursive, with the first name "Keith" and the last name "Simmons" written in a single continuous stroke.

Keith Simmons
Project Scientist II

Attachments: Geotechnical Data Report

Attachments

Geotechnical Data Report

GEOTECHNICAL DATA REPORT

**Nebraska Department of Transportation
Niobrara N-12 Maintenance
Bow Creek Wetland Mitigation Site
NDOT Project No. Misc-12-5(1016)
NDOT Control No. 32093
T.32N, R. 2E, S. 01
Cedar County, NE**

PREPARED FOR

Nebraska Department of Transportation
1500 State Highway 2
Lincoln, Nebraska 68508

January 30, 2018



Alfred Benesch & Company
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January 30, 2018

Nebraska Department of Transportation
c/o Mr. Andy Miller
14748 West Center Road, Suite 200
Omaha, NE 68144

REFERENCE: Geotechnical Data Report
Niobrara N-12 Maintenance - Bow Creek Wetland Mitigation Site
NDOT Project No. Misc-12-5(1016)
NDOT Control No. 32093
T. 32N, R. 2E, S. 01
Cedar County, NE

Dear Andy:

Alfred Benesch & Company (Benesch) is pleased to submit the enclosed report that summarizes the findings of a geotechnical engineering study and provides recommendations related to the wetland mitigation for the referenced project.

If any questions arise concerning this report or if additional information is needed about soil conditions at this site, please contact Benesch for assistance.

Respectfully yours,

A handwritten signature in blue ink that reads "Brant Wells".

Brant Wells
Field/Lab Operations Manager

Enclosures

Electronic Copy: NDOT, c/o Andy Miller, Benesch

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1.0 INTRODUCTION

Alfred Benesch & Company (Benesch) has been requested by Nebraska Department of Transportation (NDOT) to perform soil characterization and install piezometers for groundwater monitoring for Niobrara N-12 Maintenance Project wetland mitigation site located 2 miles northeast of Wynot, Cedar County Nebraska (T. 32N, R. 2E, S.01). The proposed wetland mitigation includes restoring wetlands and sandbar construction.

Benesch performed the following services: (a) auger borings, soil sampling, and installation of piezometers to determine the groundwater levels and depth, (b) characterization of soils for texture, sand content, color, density, moisture content and (c) performing laboratory hydrometer tests on samples collected from the proposed site.

2.0 SUBSURFACE EXPLORATION

A program of borings and soil sampling was performed at the project site on December 20, 2017. Five (5) exploratory borings were advanced to a depth of 5 feet below the existing grade to establish the characterization of soils for texture, color, density, moisture content and soil permeability in the area under consideration.

The borings were made in accordance with ASTM D 1452, Standard Practice for Soil Investigation and Sampling by Auger Borings. The machine-driven borings used a continuous-flight auger having a diameter of 6 inches. The bore holes were stable and casing was not required. A piezometer was installed at two (2) locations (PZ-1, PZ-2) to a depth of approximately 4 to 7 feet below existing grade to allow for monitoring of the groundwater at the site.

The vicinity map and the boring location plan are presented in Appendix A. The boring logs (see Appendix B) present the data obtained in the subsurface exploration. The logs include the surface elevations, the approximate depths and elevations of major changes in the character of the subsurface materials, visual descriptions of the materials in accordance with the criteria presented in Appendix C, groundwater data, and the locations of undisturbed samples of soil.

The locations of the borings and piezometers were located in the field using a hand-held GPS unit are scheduled to be surveyed by a Benesch survey crew in the near future. Water level readings were made in the auger borings at times and under conditions stated on the boring logs.

3.0 LABORATORY ANALYSES

The bulk soil/sand samples obtained during the subsurface exploration were examined in the laboratory by a member of Benesch's professional engineering staff to supplement the field identification. Standard tests were performed on selected samples to determine the engineering properties of the foundation materials.

Determinations of the distribution of particle sizes in samples of onsite alluvial materials were made in accordance with AASHTO Designation T 88, Standard Method of Particle Size Analysis of Soils. The composition of each of these samples is presented in Table 1.

TABLE 1
PARTICLE-SIZE DATA

Boring No.	Depth, ft.	Percent Gravel (Greater than 4.76 mm)	Percent Sand (0.074-4.76 mm)	Percent Silt (0.002-0.074 mm)	Percent Clay (Less than 0.002 mm)
B-1	3.0-5.0	0.8	94.3	2.5	2.4
B-2	0.0-2.0	0.0	46.5	42.6	10.9
B-3	2.0-5.0	0.0	94.2	3.9	1.9
B-4	0.0-4.0	0.0	82.8	13.7	3.5
B-5	1.0-4.0	0.0	97.0	1.5	1.5

4.0 GEOLOGY AND SITE CONDITIONS

The project site is located in Cedar County on alluvial bottomlands of the Missouri River Floodplain. The bottomlands are a flood plain setting consisting of relatively deep deposits of alluvium.

Soils generally consist of alluvial sand (poorly graded sand and poorly graded sand with silt), sandy loam (silty sand), and loam (sandy silt) per the tertiary system with the USCS classification shown in parenthesis. Detailed descriptions are provided in the boring logs, which are presented in Appendix C.

The alluvial sand is considered suitable for use in proposed sandbar construction. The remaining sandy loam and loam materials are not considered suitable for proposed sandbar construction but are suitable for use in construction of bench on each side the proposed chute.

Groundwater was encountered at elevations ranging from 2.0 to 4.9 feet below existing grade. The water table could be expected to fluctuate several feet depending on surface drainage, rainfall, irrigation, vegetation, temperature, and other factors.

5.0 APPLICABILITY OF RESULTS

The boring logs and related information depict subsurface conditions only at the specific boring locations and at the time of the subsurface exploration. Soil conditions might differ between the exploratory borings and might change with the passage of time. The nature and extent of any variations between the boring locations or of any changes in soil conditions might not become evident until grading operations for the referenced project have begun.

Benesch should be contacted if any questions arise concerning this report. This report shall not be reproduced, except in full, without the written approval of Alfred Benesch & Company.

Prepared By:

Reviewed By:

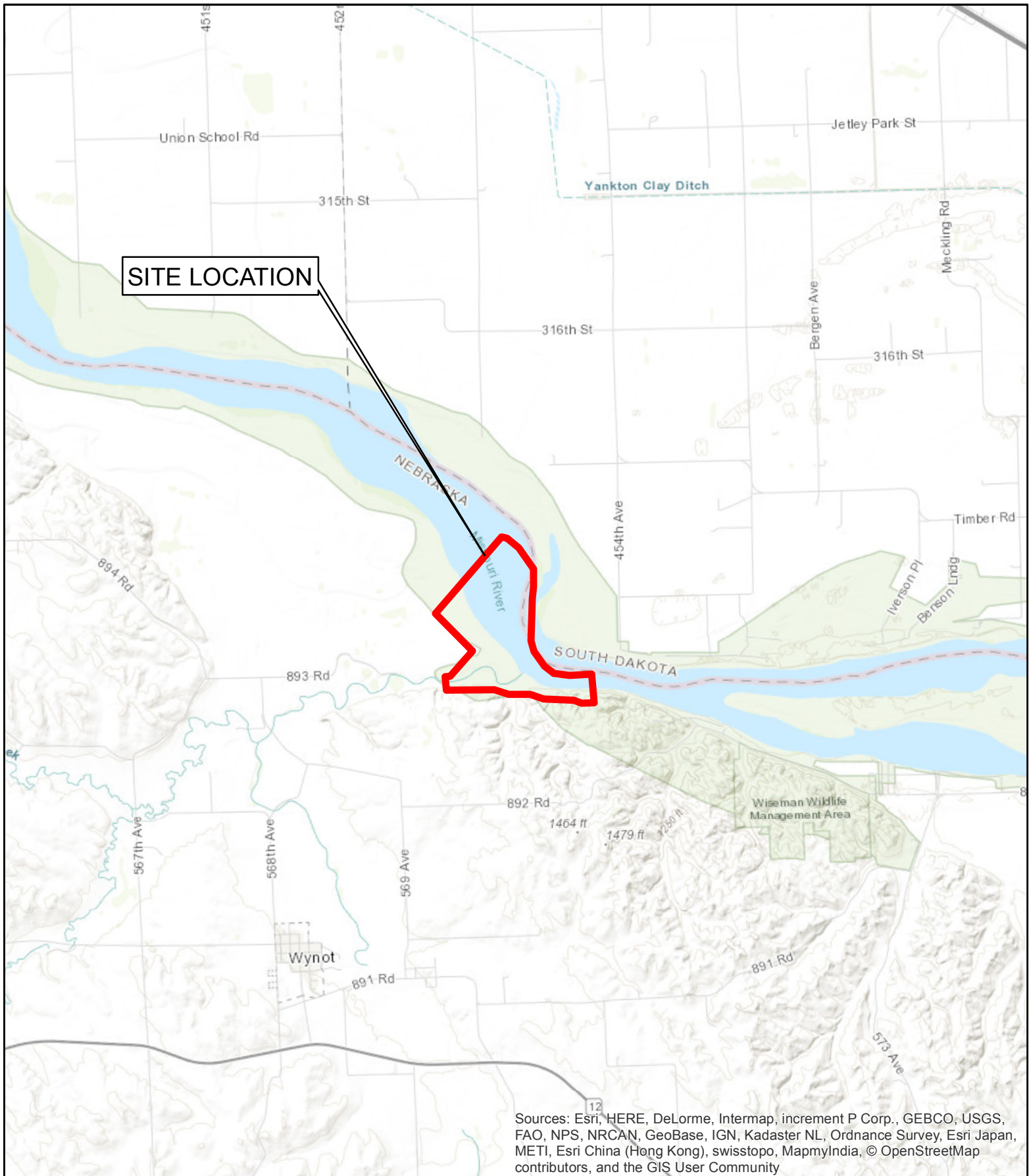


Brant Wells
Field/Lab Operations Manager



Brandon Desh, P.E.
Geotechnical Engineer

APPENDIX A. VICINITY MAP AND BORING LOCATION PLAN



USGS Topographic Imagery



0 2,500 5,000 10,000
Feet



Y:\Omaha\120100S\00120163.00\GIS\BORING MAPS\FIG - 1 - LocationMap.mxd

LOCATION MAP - FIGURE - 1

NDOR
Niobrara N-12 Maintenance
Cedar County, NE
T. 32N, R. 2E, S. 01, 02
T. 32N, R. 3E, S. 06, 07



NAIP 2014 Cedar County Aerial Imagery

BORING LOCATION MAP - FIGURE - 2

NDOR

Niobrara N-12 Maintenance
Cedar County, NE

T. 32N, R. 2E, S. 01, 02
T. 32N, R. 3E, S. 06, 07



0 150 300 600
Feet



APPENDIX B. BORING LOGS



825 M Street, Suite 100
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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation

LOCATION: W -97.14193 N 42.77597

JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: B-1

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ Cave in @ 2.1 3.0 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	MOISTURE (%)	SAND CONTENT (%)	DEPTH (feet)
	0.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; brown (10YR 4/3); wet; loose. (Alluvium)		19.9	93	0.0
	1.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; brown (10YR 3/4); wet; loose. (Alluvium)		17.2	97	
	2.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine to medium sand; 0-5% nonplastic fines; dark grayish brown (10YR 4/2); wet; loose. (Alluvium)		20.7	99	2.5
	3.0		SAND; (SP) Poorly-Graded Sand; trace of fine gravel; 95-100% fine to coarse sand; 0-5% nonplastic fines; very dark grayish brown (10YR 3/2); saturated; loose. (Alluvium)		19.2	96	
	4.0		SAND; (SP) Poorly-Graded Sand; trace of fine gravel; 95-100% fine to coarse sand; 0-5% nonplastic fines; very dark grayish brown (10YR 3/2); saturated; loose. (Alluvium)		20.9	95	
	5.0		Boring Terminated at: 5.0ft				5.0
							7.5
							10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 1



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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation

LOCATION: W -97.14000 N 42.77425

JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: B-3

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ Cave in @ 4.0' 4.9 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	MOISTURE (%)	SAND CONTENT (%)	DEPTH (feet)
	0.0		SANDY LOAM; (SM) Silty Sand; 75-85% fine sand; 15-25% nonplastic fines; brown (10YR 4/3); moist; loose. (Alluvium)				0.0
	1.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; brown (10YR 5/3); moist; loose. (Alluvium)		7.9	89	
	2.5						2.5
	3.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; brown (10YR 5/3); moist; loose. (Alluvium)		10.8	97	
	4.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; dark brown (10YR 3/3); wet to saturated; loose. (Alluvium)				
	5.0		Boring Terminated at: 5.0ft				5.0
	7.5						7.5
	10.0						10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 3



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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation

LOCATION: W -97.14163 N 42.77482

JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: B-2

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ Cave in @ 4.7'

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	MOISTURE (%)	SAND CONTENT (%)	DEPTH (feet)
	0.0		LOAM; (ML) Sandy Silt; 40-50% fine sand; low plasticity; dark brown (10YR 3/3); wet; loose. (Alluvium)		18.6	46	0.0
	2.0		SANDY LOAM; (SM) Silty Sand; 75-85% fine sand; 15-25% nonplastic fines; dark yellowish brown (10YR 4/4); moist to wet; loose. (Alluvium)				2.5
	3.0		Same as above except with very dark gray (2.5Y 3/1) silty clay seams. (Alluvium)		10.6	80	
	4.0		SANDY LOAM; (SM) Silty Sand; 50-60% fine sand; 40-50% nonplastic low plastic fines; dark grayish brown (2.5Y 4/2) mottled with reddish brown (5YR 4/3); wet; loose. (Alluvium)		25.4	55	
	5.0		Boring Terminated at: 5.0ft				5.0
							7.5
							10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 2



825 M Street, Suite 100
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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation
LOCATION: W -97.13900 N 42.77314
JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: B-4

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ 2.3 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	MOISTURE (%)	SAND CONTENT (%)	DEPTH (feet)
	0.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; dark brown (10YR 3/3); saturated; very loose. (Alluvium)		28.2	91	0.0
	2.0		SANDY LOAM; (SM) Silty Sand; 75-85% fine sand; 15-25% nonplastic fines; dark brown (10YR 3/3); saturated; very loose; with few 1/2"-thick organic silt seams. (Alluvium)				2.5
	3.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; black (2.5Y 2.5/1); saturated; very loose. (Alluvium)		26.9	89	
	4.0		Same as above except with sandy silt seams. (Alluvium)				
	5.0		Boring Terminated at: 5.0ft				5.0
							7.5
							10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 4



825 M Street, Suite 100
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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation

LOCATION: W -97.13743 N 42.77285

JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: B-5

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ Cave in @ 4.5 4.7 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	MOISTURE (%)	SAND CONTENT (%)	DEPTH (feet)
	0.0		SANDY LOAM; (SM) Silty Sand; 70-80% fine sand; 20-30% nonplastic fines; dark brown (10YR 3/3); moist to wet; very loose. (Alluvium)		21.4	73	0.0
	1.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; dark yellowish brown (10YR 3/4); moist to wet; loose. (Alluvium)		12	99	
	2.5				16.4	98	2.5
	3.0		Same as above except brown (10YR 4/3); wet to saturated. (Alluvium)				
	4.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; very dark gray (2.5Y 3/1); saturated; loose; with very dark gray silt seams. (Alluvium)		27.9	94	
	5.0		Boring Terminated at: 5.0ft				5.0
							7.5
							10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 5



825 M Street, Suite 100
Lincoln, NE 68508
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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation

LOCATION: W -97.14301 N 42.77609

JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: PZ-1

SHEET 1 of 1

DATE: 12-20-0201

WATER LEVELS ∇ 7.0 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	DEPTH (feet)
	0.0		SAND; (SP-SM) Poorly-Graded Sand with Silt; 85-95% fine sand; 5-15% nonplastic fines; brown (10YR 4/3); wet; loose. (Alluvium)		0.0
	1.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; brown (10YR 3/4); wet; loose. (Alluvium)		
	2.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; brown (10YR 3/4); wet; loose. (Alluvium)		2.5
	3.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine to medium sand; 0-5% nonplastic fines; dark grayish brown (10YR 4/2); wet; loose. (Alluvium)		
	4.0				5.0
					7.5
					10.0
			Boring Terminated at: 10.0ft		

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 6



825 M Street, Suite 100
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276
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PROJECT: Santee Spur & Monowi to Vedral Wetland
Nebraska Department of Transportation
LOCATION: W -97.13823 N 42.77296
JOB NO.: 00120163.00
RIG / METHOD: Bobcat / Straight Auger
CREW: O'Malley & BW

BORING LOG

BORING No.: PZ-2

SHEET 1 of 1

DATE: 12-20-2017

WATER LEVELS ∇ 4.0 IAD

ELEV	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	DEPTH (feet)
	0.0		SANDY LOAM; (SM) Silty Sand; 70-80% fine sand; 20-30% nonplastic fines; dark brown (10YR 3/3); moist to wet; very loose. (Alluvium)		0.0
	1.0		SAND; (SP) Poorly-Graded Sand; 95-100% fine sand; 0-5% nonplastic fines; dark yellowish brown (10YR 3/4); moist to wet; loose. (Alluvium)		
	4.0		Same as above except brown (10YR 4/3); wet to saturated. (Alluvium)		
	7.0		Same as above except saturated (Alluvium)		
	10.0		Boring Terminated at: 10.0ft		10.0

BORING LOG SANTEE SPUR LOGS.GPJ HWS.GDT 1/30/18

Figure B - 7

APPENDIX C. CRITERIA USED FOR SOIL CLASSIFICATION

USCS SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LESS THAN 5% FINES)		GW	WELL-GRADED GRAVEL
				GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES (MORE THAN 12% FINES)		GM	SILTY GRAVEL (LOW PLASTIC FINES)
				GC	CLAYEY GRAVEL (MEDIUM TO HIGH PLASTIC FINES)
MORE THAN 50% OF MATERIALS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS (LESS THAN 5% FINES)		SW	WELL-GRADED SAND
				SP	POORLY-GRADED SAND
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (MORE THAN 12% FINES)		SM	SILTY SAND (LOW PLASTIC FINES)
				SC	CLAYEY SAND (MEDIUM TO HIGH PLASTIC FINES)
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	SILT (0-15% SAND) SILT WITH SAND (15-30% SAND) SANDY SILT (30-50% SAND)
				CL	LEAN CLAY (0-15% SAND) LEAN CLAY WITH SAND (15-30% SAND) SANDY LEAN CLAY (30-50% SAND)
				OL	ORGANIC SILTS AND LEAN CLAYS
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	ELASTIC SILT (0-15% SAND) ELASTIC SILT WITH SAND (15-30% SAND) SANDY ELASTIC SILT (30-50% SAND)
				CH	FAT CLAY (0-15% SAND) FAT CLAY WITH SAND (15-30% SAND) SANDY FAT CLAY (30-50% SAND)
				OH	ORGANIC ELASTIC SILTS AND FAT CLAYS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

GENERAL NOTES

CRITERIA FOR DESCRIBING CLAY SOILS

MOISTURE CONDITION		CONSISTENCY	
Description	Criteria	Description	Penetration Resistance, N_{60} (blows/ft) ¹
Dry	Absence of moisture, dusty, dry to touch.	Very Soft	Less than 3
Moist	Damp, slightly wet, moisture content below plastic limit.	Soft	3 to 4
Wet	Moisture content above the plastic limit.	Medium Stiff	5 to 8
Saturated	Very wet. Usually soil is below the water table.	Stiff	9 to 16
		Very Stiff	16 to 32
		Hard	Greater than 32

CRITERIA FOR DESCRIBING GRANULAR SOILS

MOISTURE CONDITION		DENSITY	
Description	Criteria	Description	Penetration Resistance, N_{60} (blows/ft) ¹
Dry	Absence of moisture, dry to the touch.	Very Loose	Less than 5
Moist	Damp but no visible free water.	Loose	5 to 10
Wet	Visible free water.	Medium Dense	11 to 30
Saturated	Usually soil is below water table.	Dense	31 to 50
		Very Dense	Greater than 50

CRITERIA FOR DESCRIBING ROCK

STRENGTH/HARDNESS

Description	Criteria
Very Soft	Permits denting by moderate pressure of the fingers.
Soft	Resists denting by the fingers, but can be abraded and pierced to a shallow depth by a pencil point.
Moderately Soft	Resists a pencil point, but can be scratched and cut with a knife blade.
Moderately Hard	Resistant to abrasion or cutting by a knife blade, but can be easily dented or broken by light blows of a hammer.
Hard	Can be deformed or broken by repeated moderate hammer blows.
Very Hard	Can be broken only by heavy, and in some rocks, repeated hammer blows.

¹Blow counts shown on the boring logs are those recorded directly in the field and have not been corrected for hammer efficiency. The boring log blow counts must be corrected to an equivalent hammer efficiency of 60% in order to use the criteria in this table.