APPENDIX D

GEOTECHNICAL ENGINEERING REPORT

Preliminary Geotechnical Study

Oak Creek Sanitary Trunk Sewer

Lincoln Wastewater System

Lincoln, Nebraska

PREPARED FOR

HDR Engineering, Inc.

301 South 13th Street – Suite 701

Lincoln, NE 68508

September 27, 2005

PREPARED BY

HWS

Solutions Through Service

HWS
Solutions Through Service

HWS Consulting Group
825 J Street, Box 80358
Lincoln, NE 68501-0358
402.479.2200 • Fax: 402.479.2276
hws.com

September 27, 2005

Mr. Kent Prior
HDR Engineering, Inc.
301 South 13th Street
Cornhusker Plaza – Suite 701
Lincoln, NE 68508

REFERENCE: Preliminary Geotechnical Study
Oak Creek Sanitary Trunk Sewer
Lincoln Wastewater System
Lincoln, Nebraska

Dear Mr. Prior:

The proposed preliminary alignment will start at Manhole No. 68 of the existing Oak Creek Trunk Sewer located on the west side of the main runway at the Lincoln Municipal Airport in Lincoln, Nebraska. From this location (Station 100+00), the alignment will run west along the north side of Oak Creek to the intersection of West Craw and NW 41st Street. The sewer alignment splits in two with the secondary alignment (Stations 300+00 to 379+00) crossing Oak Creek to the west and then heading north along NW 42nd Street, ending just north of West Cuming Street. The east alignment heads north along NW 41st Street to Air Park Road, then east along Air Park Road to NW 38th Street, then north along NW 38th Street, ending at Highway 34 (Station 287+57).

As requested, HWS Consulting Group Inc. (HWS) has performed a subsurface exploration and a preliminary geotechnical study of the subsurface soils at the referenced site. The purpose of these services was to address geotechnical issues for the preliminary design of the proposed sanitary sewer. This report summarizes the findings of the subsurface exploration and the preliminary geotechnical study.

SUBSURFACE EXPLORATION

A program of Dutch friction-cone soundings, test borings, and soil sampling was performed at the project site on July 11 and 12, 2005. Four (4) Dutch friction-cone soundings and four (4) exploratory borings were taken to depths of between 17 and 32 feet below the existing grade to establish the general subsurface conditions of the area under consideration. The borings were made immediately beside the four soundings.

The Dutch friction-cone soundings were performed with a mechanical penetrometer in accordance with ASTM D 3441-98, Standard Method for Deep, Quasi-Static, Cone, and Friction Cone Penetration Tests of Soil. The mechanical penetrometer operates incrementally, using a set of inner rods to operate a telescoping penetrometer tip and to transmit the

components of penetration resistance (cone bearing and friction sleeve resistance) to the surface for measurement. The plot of the test data identifies the relative positions and thicknesses of hard and soft layers.

The borings were made in accordance with ASTM D 1452-80 (Reapproved 2000), Standard Practice for Soil Investigation and Sampling by Auger Borings. A machine-driven, continuous-flight auger having a diameter of 6 inches was used to advance borings for sampling. All bore holes were stable and casing was not required. Water level readings were made in the auger borings at times and under conditions stated on the boring logs.

Penetration tests were performed with a CME Automatic Free-Fall SPT Hammer in accordance with ASTM D 1586-99, Standard Method for Penetration Test and Split-Barrel Sampling of Soils. Representative samples of soil were obtained for identification purposes. The resistance of the soil to penetration of the sampler, measured in blows per foot (N), is an indication of the relative density of cohesionless soil and of the consistency of cohesive soil.

The piezometer, installed on the northwest corner of NW 42 and West Mathis Streets, consists of a 2-inch-diameter schedule 40 PVC pipe and 10-foot-long well screen. The bottom of the piezometer and well screen was placed 27 feet below grade. 10-20 silica sand was backfilled around the well screen up to 2 feet above the top of the screen. From the top of the sand pack (15 feet below grade) to the surface, bentonite grout was placed between the piezometer casing and outside edge of hole to seal the well screen and sand pack from infiltration of surface water.

Eight (8) relatively undisturbed soil samples were recovered for visual observation and laboratory testing. This sampling was performed in accordance with ASTM D 1587-00, Standard Method for Thin-Walled Tube Sampling of Soil, utilizing an open-tube sampler having an outside diameter of 3.0 inches.

The vicinity map and the boring location plan are presented in Appendix A. The penetration diagrams (see Appendix B) present the results of the Dutch friction-cone soundings. The boring logs (refer to Appendix C) 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 D, groundwater data, the penetration resistance recorded in blows per 0.5-ft increments of depth, and the locations of undisturbed samples of soil.

The locations of the soundings and borings were determined by HDR. Elevations (approximate) at the sounding and boring locations were determined by reference to design files provided by HDR. Elevations are referenced to the NAVD 88 Datum. Water level readings were made in the auger borings at times and under conditions stated on the boring logs.

LABORATORY ANALYSES

The split-barrel and undisturbed soil samples obtained during the subsurface exploration were examined in the laboratory by a member of HWS' professional engineering staff to supplement the field identification. Standard tests were performed on selected samples to determine the engineering properties of the foundation materials.

The moisture contents and dry unit weights of selected undisturbed soil samples were determined in the laboratory. These test results are presented in the boring logs opposite the

respective sample locations. The moisture contents were determined in accordance with either ASTM D 4643-00, Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method, or ASTM D 2216-98, Standard Test Method for Determination of Water (Moisture) Content of Soil and Rock by Mass. The dry unit weights were determined in accordance with the Displacement Method of the Corps of Engineers, EM1110-2-1906, Appendix II, Unit Weights, Void Ratio, Porosity, and Degree of Saturation. These data correlate with the strength and compressibility of the soil. High moisture content and low density usually indicate low strength and high compressibility.

The unconfined compressive strengths of several undisturbed samples were estimated in the laboratory with a calibrated hand penetrometer. These strengths are presented on the boring logs and are estimates only. Actual values are generally lower than the estimated values indicated on the boring logs.

The unconfined compressive strengths of three (3) undisturbed samples of subsurface soils were determined in accordance with ASTM D 2166-00, Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. These data are summarized in Table 1, and the complete test reports are presented in Appendix E.

TABLE 1
Unconfined Compression Test Data

Boring No.	Depth ft	Moisture %	Dry Density lbf/ft^3	Unconfined Compressive Strength, $tons/ft^2$
B-1	6.3 – 6.9	23.1	97.0	1.5
B-2	7.4 – 8.1	20.7	102.0	2.0
B-2	17.4 – 18.0	27.6	95.0	0.6

Consolidated, undrained triaxial compression tests were performed on three specimens of a sample of the subsurface soils to provide data on the shearing strength of this material. The triaxial compression tests were performed in accordance with ASTM D 4767-95, Standard Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils. Specimens were backpressure saturated prior to shearing. Pore pressure measurements were taken during shearing, thus permitting both total stress and effective stress strength parameters to be determined. A summary of the test data is shown in Table 2, and the complete test reports are presented in Appendix F.

TABLE 2
Triaxial Compression Test Data

Boring No.	Depth ft.	Phi(ø) degrees	Cohesion (c) lbf/ft^2
B-2	17.4 – 18.0	11.0[a] 32.0[b]	400[a] 0[b]

[a]Total stress value.
[b]Effective stress value based on maximum principal effective stress ratio.

The plasticity characteristics of two (2) air-dried soils were determined in accordance with ASTM Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (D 4318-00). These limits of consistency (Atterberg limits) are used in the Unified Soil

Classification System as a basis for laboratory differentiation between materials of appreciable plasticity (clays) and slightly plastic or nonplastic materials (silts). The test results are presented in Table 3.

TABLE 3
Atterberg Limits

Boring No.	Depth ft	Liquid Limit, %	Plastic Limit, %	Plasticity Index	Group Symbol
B-1	6.3 – 6.9	46	20	26	CL
B-3	16.7 – 17.3	33	22	11	CL

Washed sieve analyses were performed on two (2) samples of the subsurface materials. The results of these tests, performed in accordance with ASTM C 136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregates, are presented in Table 4.

TABLE 4
Particle Size Distribution of Mineral Aggregates

Boring No.	Depth ft.	Total Percentage Finer by Weight										
		1"	3/4"	½"	3/8"	#4	#8	#16	#30	#50	#100	#200
B-2	25.5 – 27.0	100	100	98	96	88	79	68	52	19	4	3
B-2	30.5 – 32.0	100	100	99	97	89	78	60	36	15	7	4

Falling head permeability tests were performed on two (2) relatively undisturbed specimens of alluvial clays in accordance with Corp of Engineers, EM1110-2-1906, Appendix VII, Permeability Test procedures, and the test results are shown in Table 5. These specimens were selected to represent the soil samples that would have some of the lowest coefficients of permeability. The coefficients of permeability listed in Table 5 probably do not represent a macro coefficient of permeability for the alluvial clay formation because of interbedded seams of sands and silts that are typically present in the clay alluvium. In addition, vertical joints are often present in these soils due to desiccation during and after deposition of the soils, which can result in higher coefficients of permeability.

TABLE 5
Falling Head Permeability Test Data

Boring No.	Depth ft	Dry Density lbf/ft^3	Moisture Content, %	Coefficient of Permeability cm/sec
B-1	13.0 – 13.5	101.7	23.9	2.4E-08
B-3	17.3 – 17.8	95.3	27.1	3.8E-07

A series of chemical tests were performed on two (2) representative samples of the subsurface soils. These tests were used to evaluate the soils for specific chemical factors that could be aggressive to concrete and steel. These factors are pH, sulfates, oxidation-reduction potential, and chlorides. The results of these tests are presented in Table 6, and the complete test results are provided in Appendix G.

TABLE 6
Chemical Tests on Soil Samples

Boring No.	Depth ft.	pH	Sulfates mg/kg	Oxidation-Redox. Potential (mV)	Chlorides mg/kg
B-1	5.0 – 5.6	6.7	12	184	21
B-3	7.0 – 7.5	6.6	24	225	13

Eight (8) crumb tests and one (1) pinhole dispersion test were performed on subsurface materials. The pinhole test was conducted in accordance with ASTM D 4647-93 (Reapproved 1998), Method C, Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test. The crumb tests were performed in accordance with ASTM D 6572-00, Standard Test Methods for Determining Dispersive Characteristics of Clayey Soils by the Crumb Test. The crumb test is an indicator test used in the identification of dispersive soils, and the pinhole test is a definitive test of dispersiveness. A summary of the test results is presented in Table 7.

TABLE 7
Dispersion Test Data

Boring No.	Depth ft	Crumb-Test Grade[a]		Pinhole Test Results[b]
		10 min.	1 hr.	
B-1	6.3 – 6.9	2	2	
B-1	13.0 – 13.5	1	1	
B-2	7.4 – 8.1	2	2	
B-2	17.4 – 18.0	2	4	
B-3	8.4 – 9.0	1	1	
B-3	17.3 – 17.8	3	4	ND-1
B-4	5.0 – 6.5	1	1	
B-4	16.1 – 16.6	1	3	

[a]Crumb-Test Grades:
1 - Nondispersive; 2 - Intermediate; 3 - Dispersive; 4 – Highly Dispersive

[b]Pinhole-Test Classification:

D1 D2	ND4 ND3	ND2 ND1
Dispersive	Intermediate	Nondispersive

D1, D2 - Dispersive clay that fails rapidly under a 2-in. head.
ND4, ND3 - Dispersive clay that erodes slowly under a 2-in., 7-in., or 15-in. head.
ND2, ND1 - Nondispersive clay with very slight to no colloidal erosion under 15-in. head.

GEOLOGY AND SITE CONDITIONS

The city of Lincoln lies in the Dissected Till Plains section of Nebraska, a part of the Central Lowland province of the Interior Plains physiographic division[1]. The project site is located in the northwestern portion of Lincoln and is situated in alluvial bottomlands adjacent to Oak Creek. Oak Creek has been straightened and deepened and the original channel and its meanders are not evident by examining surface features.

The subsurface materials encountered at the boring locations are briefly described below in descending order of occurrence. Detailed descriptions are provided in the boring logs, which are presented in Appendix C.

Soil Zone	Description
Fill	Lean clay with sand; medium plasticity; moist; hard; encountered to 1.0 feet at boring B-3.
Alluvium	Fat clay, lean clay, lean clay with sand, silty clay, poorly graded sand; low to high plasticity, nonplastic; moist to saturated; very soft to hard, medium dense to dense; encountered to the depth of all borings.

Groundwater was encountered at elevations of 1144.0 and 1149.2 feet (18.0 and 20.8 feet below existing grade) at boring B-2 and piezometer P-1, respectively. Groundwater was not encountered to the depths of borings B-1, B-3, and B-4. The water table could be expected to fluctuate several feet depending on surface drainage, rainfall, vegetation, temperature, and other factors.

DISCUSSION

1. **General Soil Conditions.** The soils encountered at borings B-1, B-3, and B-4 generally consisted of clay soils that ranged from very soft to hard. At boring B-2, sands were encountered at 24.5 feet below existing grade. Open cut trenching, when allowed, is expected to be a suitable construction method.

2. **Groundwater.** As previously discussed, groundwater was encountered at boring B-2 and piezometer P-1 at elevations of approximately 1144.0 and 1149.2 feet (18.0 and 20.8 feet below existing grade), respectively. Boring B-2 is in the vicinity of the proposed siphon across Oak Creek. The siphon flow line (elevation 1137.8 feet) will be approximately 6 feet below the water table and situated near the top of the clean sands encountered in boring B-2.

3. **Trenchless Construction.** Trenchless installation methods (for example, utility tunneling, pipe jacking, or microtunneling) might be used at the proposed siphon location (Stations 300+62 to 302+50). A brief summary of the soil and groundwater conditions at the siphon location is presented in Table 8.

---

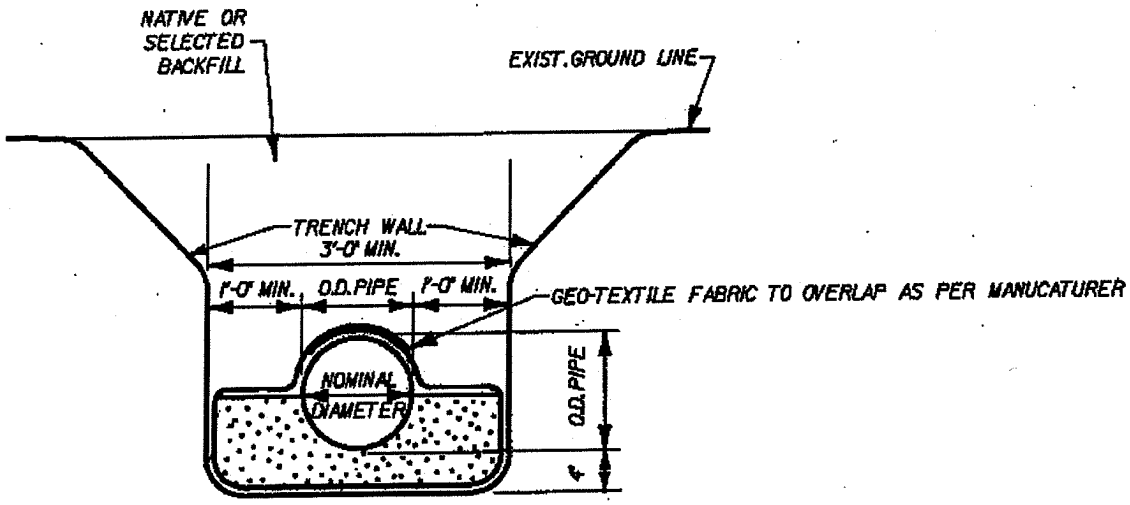
[1] Physiographic Provinces of North America, Map by A. K. Lobeck, 1948; The Geographical Press; Columbia University, New York

TABLE 8
Brief Description of Soil and Groundwater Conditions At Siphon Location

Location	Boring No.	Groundwater*	General Soil Conditions
Siphon	B-2	6.2' above	Medium stiff to stiff lean clays. Clean sands might be encountered within a foot of flowline elevation.

*Approximate distance that the water table is above or below the proposed flow line of the sewer.

4. **Dispersive Soils.** The laboratory crumb tests indicate that some of the tested soils may be dispersive. Therefore, HWS suggests that a nonwoven geotextile (such as Contech C-60NW or equal) completely encapsulate all bedding and foundation materials placed on the project. The geotextile should be overlapped as shown in the following figure. A geotextile need **not** be placed between the foundation and bedding materials.



5. **Applicability of Recommendations.** The recommendations presented in this report are based in part upon HWS' analyses of the data from the Dutch friction-cone soundings and soil borings. The penetration diagrams, boring logs, and related information depict subsurface conditions only at the specific sounding and boring locations and at the time of the subsurface exploration. Soil conditions may differ between the soundings and exploratory borings and might change with the passage of time. The nature and extent of any variations between the sounding and boring locations or of any changes in soil conditions (e.g., drying of soil) might not become evident until excavation and construction of the trunk sewer project have begun.

HWS should be contacted if any questions arise concerning this report or if changes in the preliminary nature, design, or location of the sewer line are planned. This report shall not be reproduced, except in full, without the written approval of HWS Consulting Group Inc.

Submitted By

HWS CONSULTING GROUP INC.

Prepared by:

Jason E. Herr, E.I.

Reviewed by:

Doyle B. Petersen, P.E. 9-27-05

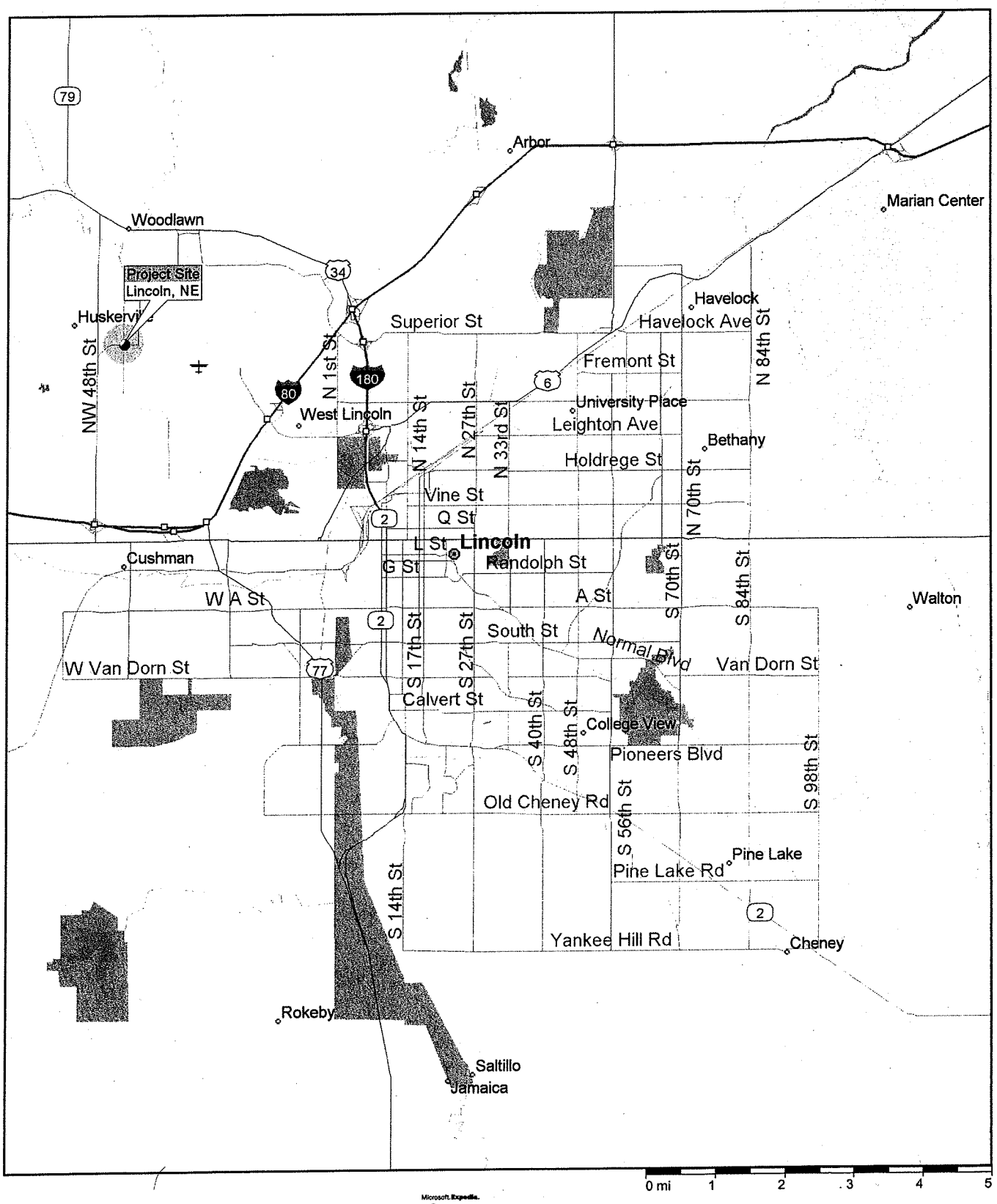
REGISTERED PROFESSIONAL ENGINEER
DOYLE B. PETERSEN
E-5528
STATE OF NEBRASKA

JEH/jeh
Enclosures
52-85-3167
octs_pre_report.doc
Orig. & 2 pc.: HDR Engineering, Inc.

APPENDIX A.

VICINITY MAP AND BORING LOCATION PLAN

Vicinity Map
Oak Creek Trunk Sewer



Microsoft Expedia
Streets98

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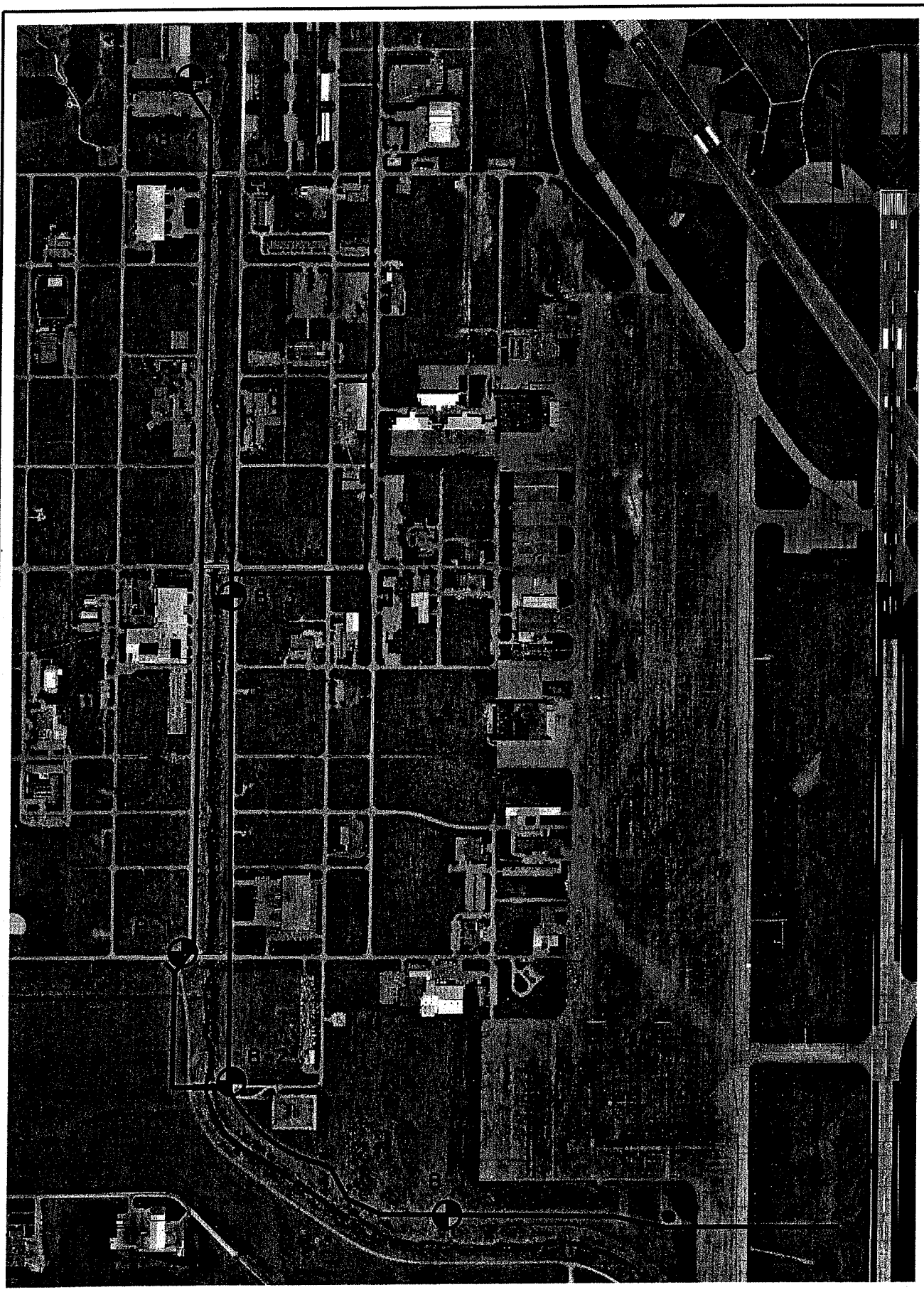

SCALE: 1" = 1000'

OAK CREEK TRUNK SEWER
LINCOLN, NEBRASKA

BORING LOCATION PLAN

A1

APPENDIX B.

DUTCH FRICTION-CONE PENETRATION DIAGRAMS

HWS Consulting Group Inc.
LINCOLN OFFICE
825 J Street, Box 80358
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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-1**
LOCATION: **B-1**
SURFACE ELEVATION: **1161.2 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

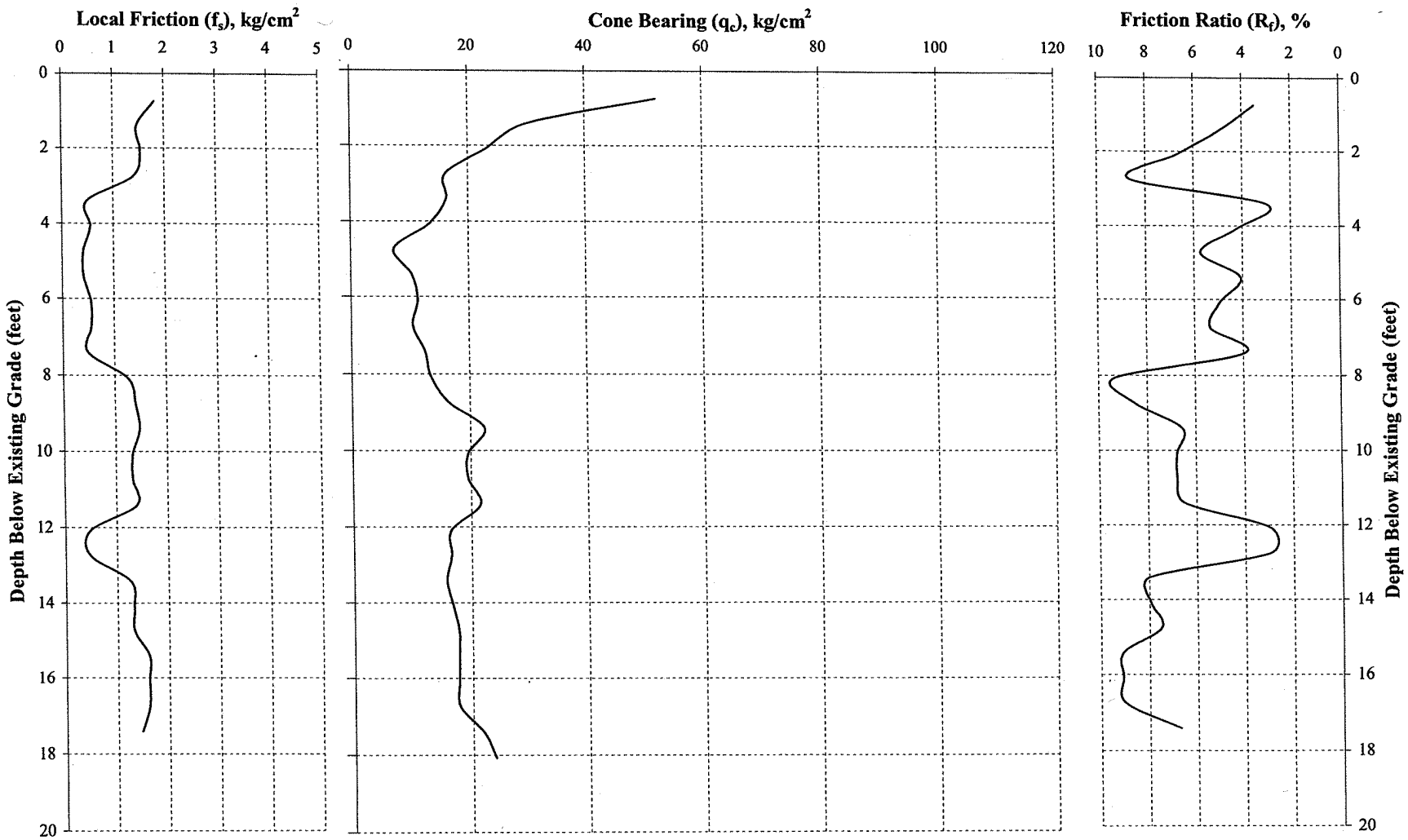

Figure B-1a

HWS Consulting Group Inc.
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Lincoln, NE 68501-0358
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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-2**
LOCATION: **B-2**
SURFACE ELEVATION: **1162.0 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

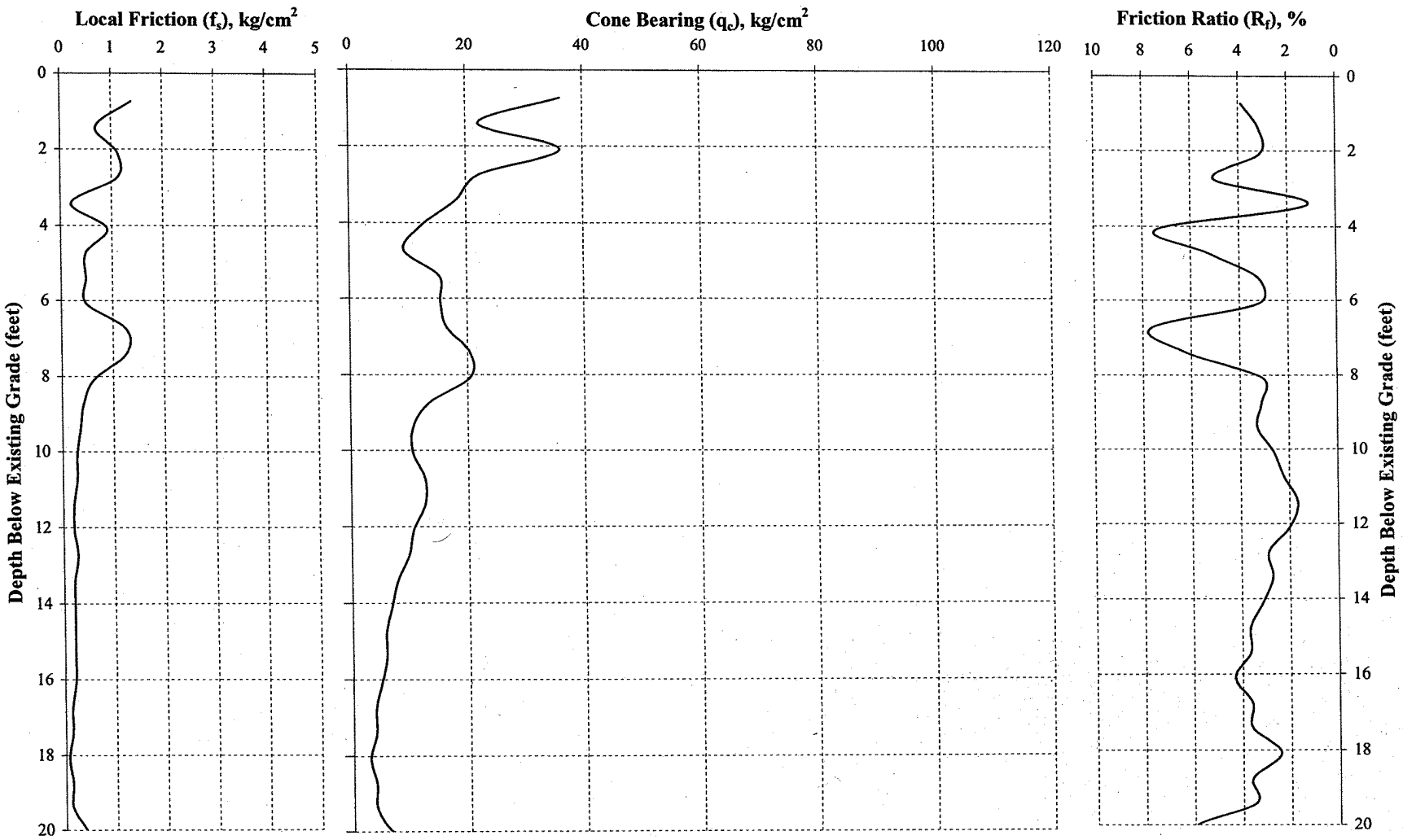

Figure B-2a

HWS Consulting Group Inc.
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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-2**
LOCATION: **B-2**
SURFACE ELEVATION: **1162.0 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

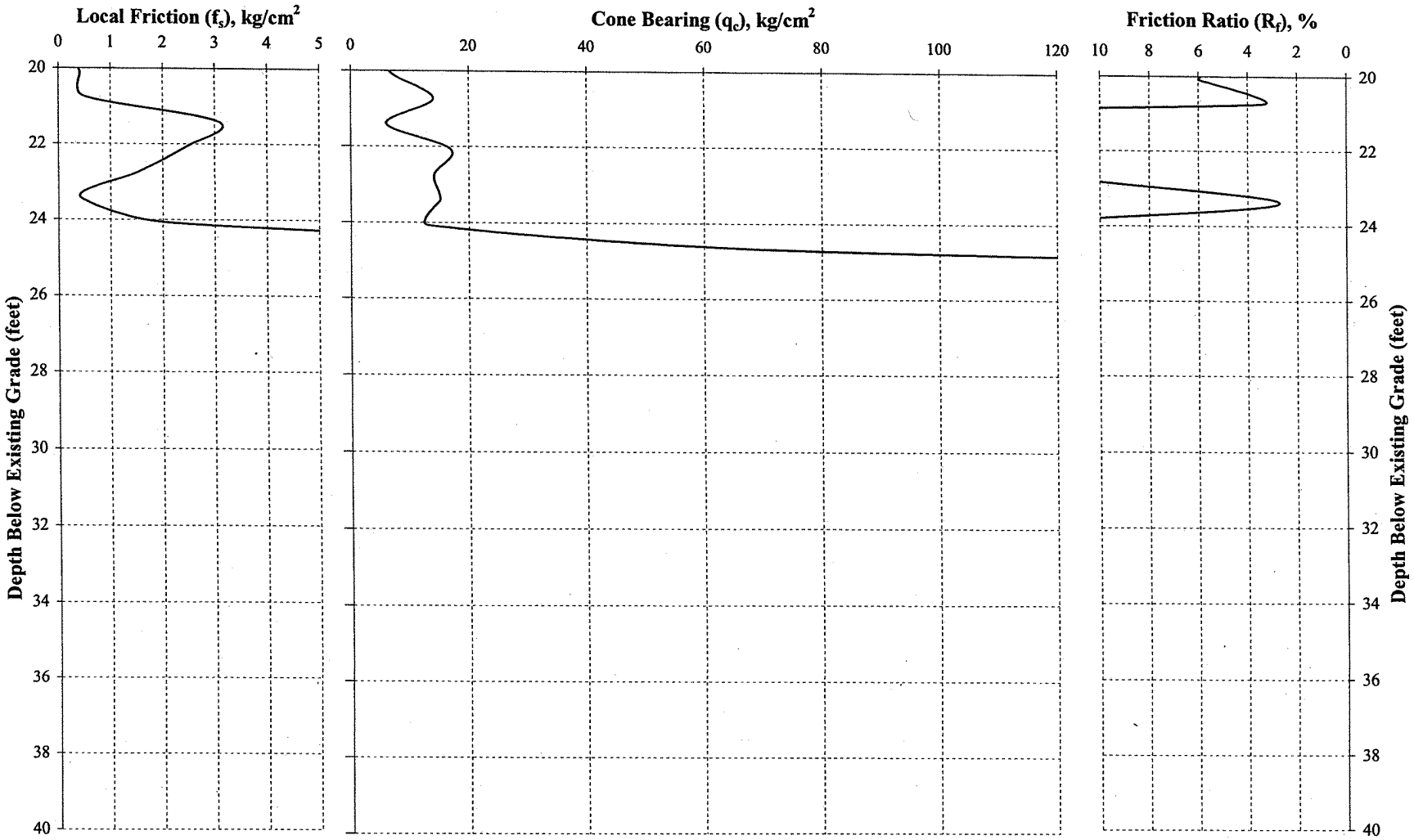

Figure B-2b

HWS Consulting Group Inc.
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Lincoln, NE 68501-0358
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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-3**
LOCATION: **B-3**
SURFACE ELEVATION: **1167.3 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

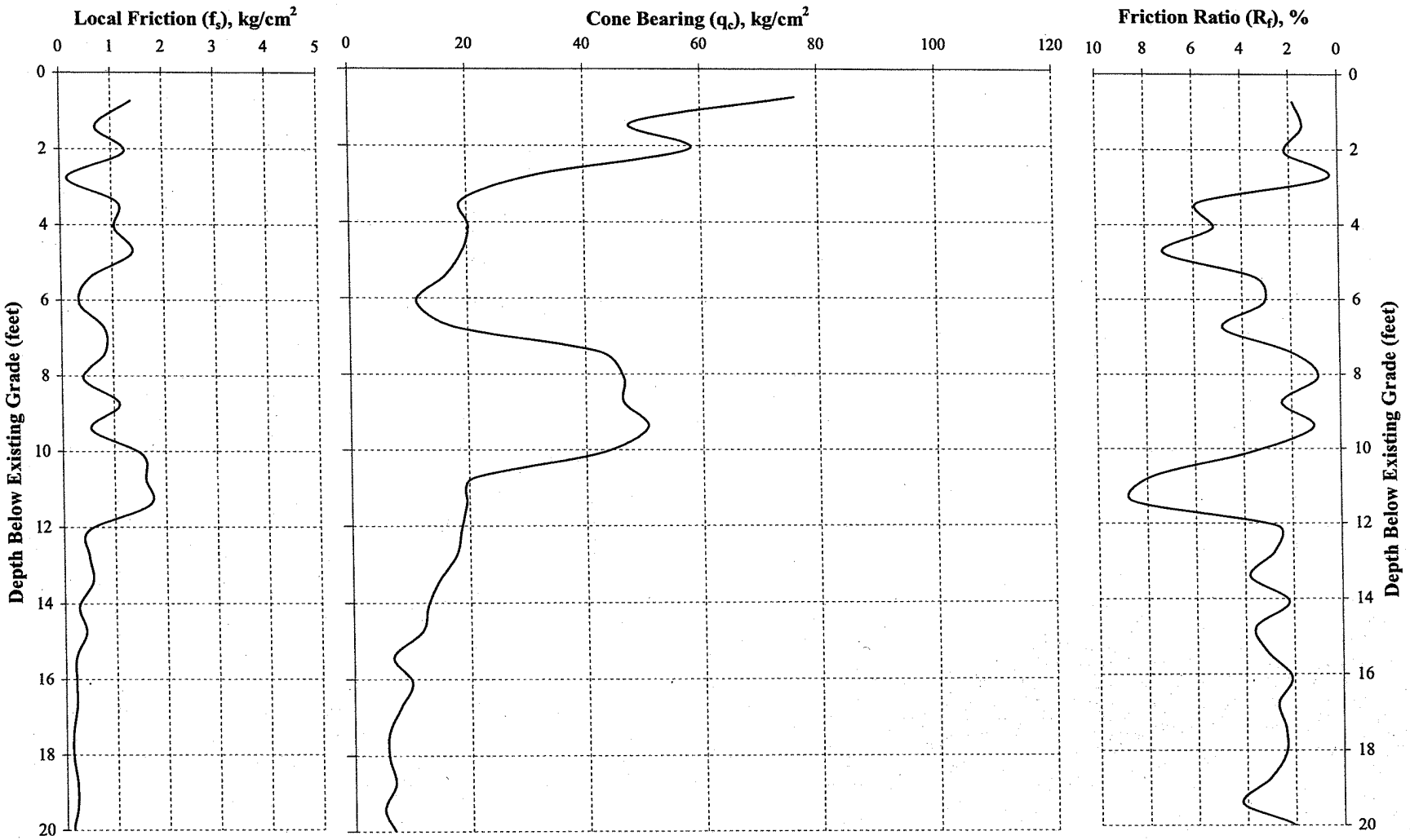

Figure B-3a

HWS Consulting Group Inc.
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Lincoln, NE 68501-0358
(402) 479-2200

PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-3**
LOCATION: **B-3**
SURFACE ELEVATION: **1167.3 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

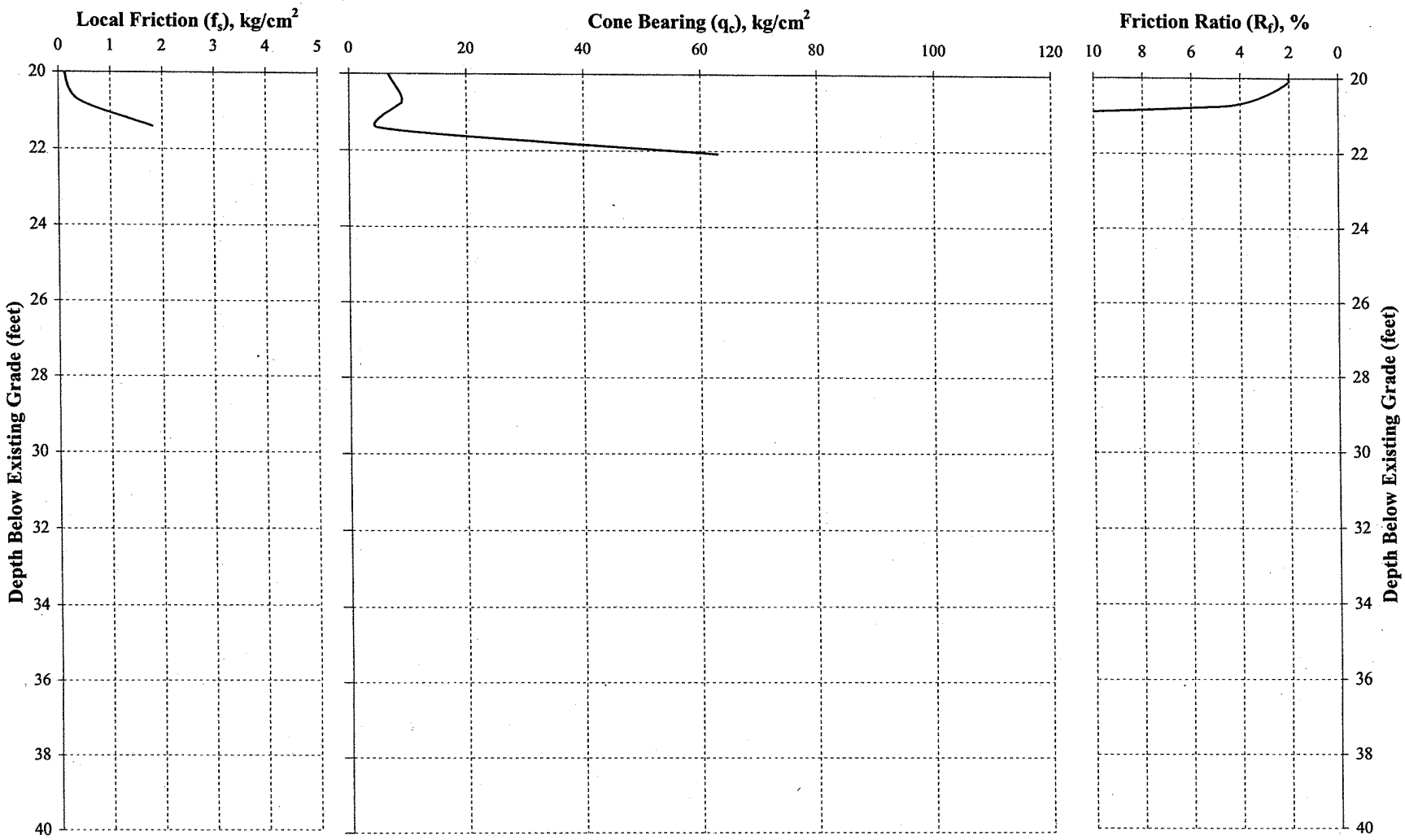

Figure B-3b

HWS Consulting Group Inc.
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(402) 479-2200

PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Oak Creek Trunk Sewer**
Lincoln, Nebraska

SOUNDING NO.: **S-4**
LOCATION: **B-4**
SURFACE ELEVATION: **1170.0 feet**

DATE: **July 11, 2005**
TESTED BY: **MS**
RECORDED BY: **PN**

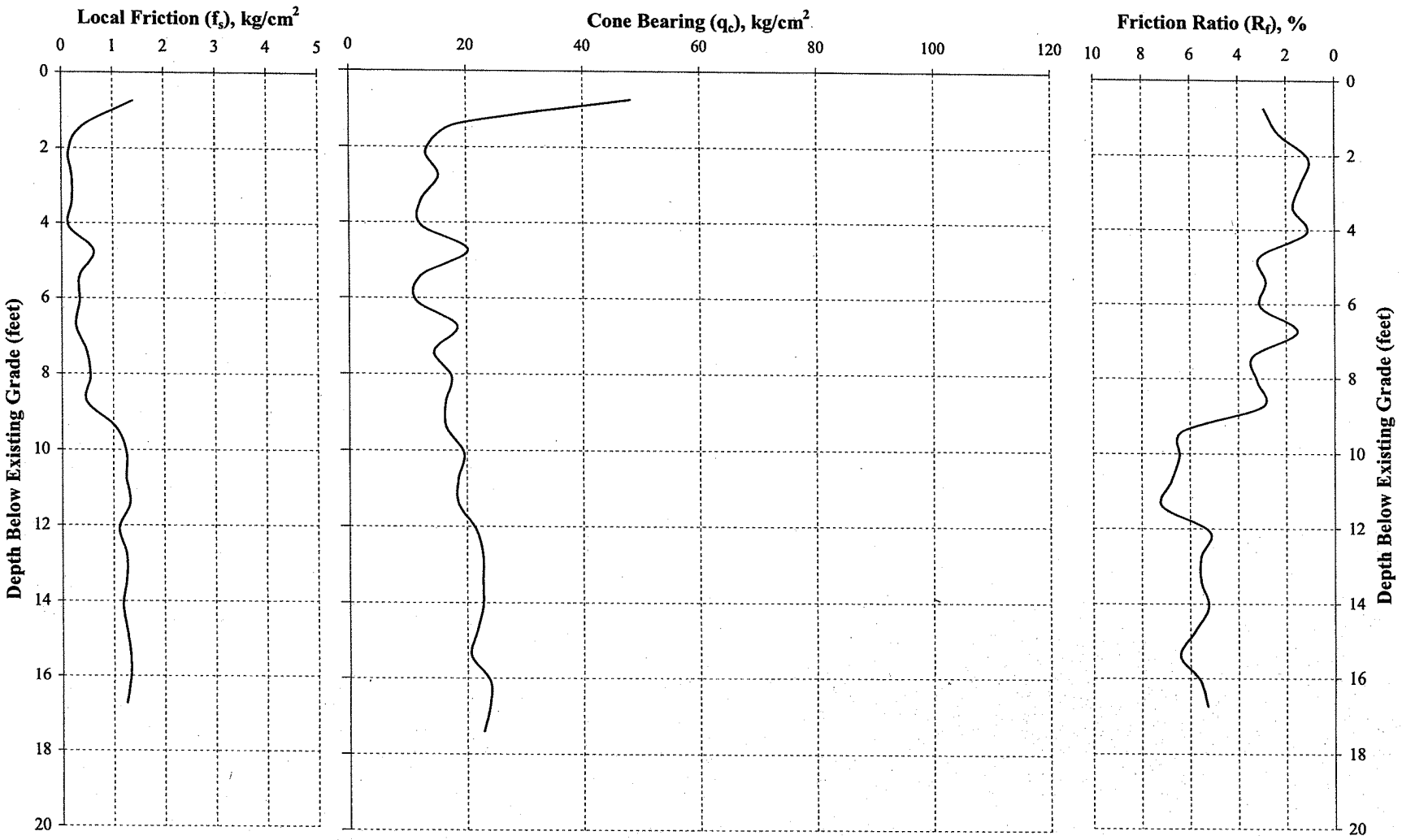


Figure B-4a

APPENDIX C.

BORING LOGS

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 128+50, CENTERLINE
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: B-1
SHEET 1 of 1
DATE: 7-12-2005

WATER LEVELS ▽ Groundwater was not encountered.

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	qu (tsf)	DRY DENSITY (pcf)	MOISTURE (%)	DEPTH (feet)
1161.2	0.0		CL/ML - SILTY CLAY; low to medium plasticity; olive brown; moist; very stiff. (Alluvium)					0.0
1159.2	2.0		CL/ML - SILTY CLAY; low to medium plasticity; dark olive brown; wet; stiff. (Alluvium)					2.5
1157.2	4.0		CL - LEAN CLAY; medium plasticity; dark brown; wet; very stiff. (Alluvium)					5.0
				1	2.4*	87.7	24.4	
1155.2	6.0		CL - LEAN CLAY; high plasticity; dark brown heavily mottled with olive brown; wet; very stiff. (Alluvium)		2.6*	93.6	23.5	
					3.5*			7.5
								10.0
1149.2	12.0		CL - LEAN CLAY; 5-15% fine sand; medium plasticity; olive brown slightly mottled with dark brown and yellowish red; wet; very stiff. (Alluvium)					12.5
				2	2.4*			
1147.9	13.3		CH - FAT CLAY; 5-15% fine sand; high plasticity; dark gray heavily mottled with olive brown; wet; very stiff. (Alluvium)		2.9*			
								15.0
								17.5
1143.2	18.0		Boring Terminated at: 18.0ft					20.0

* Unconfined compressive strength was estimated using a calibrated hand penetrometer.

Figure C - 1

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 149+00, CENTERLINE
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: B-2
SHEET 1 of 2
DATE: 7-12-2005

WATER LEVELS ▼ 18.0 on 7-13-2005

ELEV (NAVD88)	DEPTH (feet)	LITHOLOGY DESCRIPTION	SAMPLE	SPT	qu (tsf)	DRY DENSITY (pcf)	MOISTURE (%)	DEPTH (feet)
1162.0	0.0	CL/ML - SILTY CLAY; low to medium plasticity; brown; moist; stiff. (Alluvium)						0.0
								2.5
1158.5	3.5	CL - LEAN CLAY; medium plasticity; very dark brown; wet; medium stiff. (Alluvium)						
								5.0
1156.5	5.5	CH - FAT CLAY; high plasticity; dark grayish brown; wet; very stiff. (Alluvium)			3.8*	95.4	24	
			3		3.7*			
1154.5	7.5	CL - LEAN CLAY; medium plasticity; dark olive brown slightly mottled with yellowish red and dark gray; wet; very stiff. (Alluvium)			3.9*	101.4	20.9	7.5
					3.75*			
								10.0
1150.0	12.0	CL - LEAN CLAY; Same as above except stiff. (Alluvium)						
								12.5
1148.0	14.0	CL - LEAN CLAY; 5-15% fine sand; medium plasticity; dark grayish brown; wet; medium stiff. (Alluvium)						
								15.0
1146.0	16.0	CL - LEAN CLAY with Sand; 15-25% fine sand; medium plasticity; dark grayish brown; wet to saturated; very soft to soft. (Alluvium)			0.75*			
			4		0.4*			
					0.4*	93.0	30.1	17.5
					0.2*			
1142.0	20.0							20.0

* Unconfined compressive strength was estimated using a calibrated hand penetrometer.

Figure C - 2a

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 149+00, CENTERLINE
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: B-2
SHEET 2 of 2
DATE: 7-12-2005

WATER LEVELS ▼ 18.0 on 7-13-2005

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	SPT	qu (tsf)	DRY DENSITY (pcf)	MOISTURE (%)	DEPTH (feet)
			CL - LEAN CLAY; Same as above except medium stiff. (Alluvium)						20.0
1140.0	22.0		CL - LEAN CLAY; medium plasticity; dark greenish gray; saturated; stiff. (Alluvium)						22.5
1137.5	24.5		SP - POORLY GRADED SAND; fine to coarse sand; yellowish brown; saturated; medium dense to dense. (Alluvium)						25.0
					1 4 9 (13)				27.5
									30.0
					9 16 18 (34)				
1130.0	32.0		Boring Terminated at: 32.0ft						32.5
									35.0
									37.5
									40.0

* Unconfined compressive strength was estimated using a calibrated hand penetrometer.

Figure C - 2b

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 185+00, CENTERLINE
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: B-3
SHEET 1 of 1
DATE: 7-12-2005

WATER LEVELS ▽ Groundwater was not encountered.

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	qu (tsf)	DRY DENSITY (pcf)	MOISTURE (%)	DEPTH (feet)
1167.3	0.0		CL - LEAN CLAY with Sand; 15-25% fine sand; medium plasticity; yellowish brown heavily mottled with dark brown; moist; hard. (Fill)					0.0
1166.3	1.0		CL - LEAN CLAY; medium plasticity; dark olive brown; moist; very stiff. (Alluvium)					2.5
								5.0
1161.8	5.5		CL - LEAN CLAY; medium plasticity; dark grayish brown; wet; stiff. (Alluvium)					
1160.8	6.5		CH - FAT CLAY; high plasticity; grayish brown; wet; very stiff. (Alluvium)			86.9	18.4	
1159.8	7.5		CH - FAT CLAY; Same as above except hard. (Alluvium)	5	4.1*			7.5
								10.0
1156.8	10.5		CH - FAT CLAY; Same as above except very stiff. (Alluvium)					
1155.3	12.0		CL - LEAN CLAY; medium plasticity; olive brown; wet; very stiff. (Alluvium)					12.5
1153.3	14.0		CL - LEAN CLAY; Same as above except stiff. (Alluvium)					15.0
1150.8	16.5		CL - LEAN CLAY; Same as above except medium stiff. (Alluvium)	6	1.1* 1.0* 0.4*	92.9	28	17.5
1149.3	18.0		Boring Terminated at: 18.0ft					20.0

* Unconfined compressive strength was estimated using a calibrated hand penetrometer.

Figure C - 3

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 379+00, CENTERLINE
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: B-4
SHEET 1 of 1
DATE: 7-12-2005

WATER LEVELS ▽ Groundwater was not encountered.

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	qu (tsf)	DRY DENSITY (pcf)	MOISTURE (%)	DEPTH (feet)
1164.2	0.0		CL - LEAN CLAY; medium plasticity; dark brown; moist; hard. (Alluvium)					0.0
1162.7	1.5		CL - LEAN CLAY; medium plasticity; dark brown heavily mottled with dark grayish brown; moist to wet; very stiff. (Alluvium)					2.5
1159.7	4.5		CH - FAT CLAY; high plasticity; dark grayish brown; wet; hard. (Alluvium)	7	+4.5*	97.2	23.8	5.0
								7.5
1154.7	9.5		CH - FAT CLAY; high plasticity; olive brown slightly mottled with yellowish red; wet; very stiff. (Alluvium)					10.0
1152.2	12.0		CH - FAT CLAY; high plasticity; dark grayish brown; wet; very stiff. (Alluvium)					12.5
				8	2.7* 3.4*			15.0
					2.0*	100.6	21.9	
1147.2	17.0		Boring Terminated at: 17.0ft					17.5
								20.0

* Unconfined compressive strength was estimated using a calibrated hand penetrometer.

Figure C - 4

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 341+00, 30' LT.
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: P-1
SHEET 1 of 2
DATE: 7-12-2005

WATER LEVELS ▼ 20.8 on 9-13-2005

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	DEPTH (feet)
1170.0	0.0		CL - LEAN CLAY; medium plasticity; very dark brown; wet; stiff. (Topsoil)		0.0
1169.5	0.5		CL/ML - SILTY CLAY; low to medium plasticity; dark brown; moist; stiff. (Alluvium)		2.5
					5.0
1164.0	6.0		CL - LEAN CLAY; medium plasticity; black; wet; stiff. (Alluvium)		7.5
1162.0	8.0		CL - LEAN CLAY; medium plasticity; dark brown heavily mottled with dark grayish brown; wet; stiff. (Alluvium)		
1160.0	10.0		CH - FAT CLAY; high plasticity; dark grayish brown; wet; hard. (Alluvium)		10.0
1159.0	11.0		CL - LEAN CLAY; medium plasticity; dark grayish brown; wet; stiff. (Alluvium)		12.5
1156.0	14.0		CL - LEAN CLAY; medium plasticity; grayish brown; wet; medium stiff. (Alluvium)		15.0
					17.5
1152.0	18.0		CL - LEAN CLAY with Sand; 20-30% fine sand; medium plasticity; grayish brown; saturated; medium stiff. (Alluvium)		
1150.0	20.0				20.0

Figure C - 5a

HWS
Solutions Through Service

825 J Street
Lincoln, NE 68508
402-479-2200 * Fax: 402-479-2276

PROJECT: Oak Creek Trunk Sewer

LOCATION: STA. 341+00, 30' LT.
Lincoln, Nebraska

JOB NO.: 52-85-3167
RIG / METHOD: CME 75HT / Straight Auger
CREW: MS & PN

BORING LOG

BORING No.: P-1
SHEET 2 of 2
DATE: 7-12-2005

WATER LEVELS ▼ 20.8 on 9-13-2005

ELEV (NAVD88)	DEPTH (feet)	LOG	LITHOLOGY DESCRIPTION	SAMPLE	DEPTH (feet)
			CL - LEAN CLAY with Sand; Same as above. (Alluvium)		20.0
					22.5
1147.0	23.0		SC - CLAYEY SAND; 60-70% fine sand; 30-40% fines, medium plasticity; dark grayish brown; saturated; medium dense. (Alluvium)		
					25.0
1144.0	26.0		CH - FAT CLAY; high plasticity; dark grayish brown; saturated; medium stiff. (Alluvium)		
1143.0	27.0		Boring Terminated at: 27.0ft		27.5
					30.0
					32.5
					35.0
					37.5
					40.0

BORING LOG OCTS LOGS.GPJ HWS.GDT 09/13/05

Figure C - 5b

APPENDIX D.

CRITERIA USED FOR VISUAL SOIL CLASSIFICATION

TABLE D-1

Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]			Group	Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[1]
			$Cu < 6$ and/or $1 \geq Cc \geq 3$[E]	SP	Poorly graded sand[1]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OL	Organic clay[K,L,M] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor		PT	Peat	

[A] Based on the material passing the 3-in. (77-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded with silt
GP-GC poorly graded gravel with clay
[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
[H] If fines are organic, add "with organic fines' to group name.
[I] If soil contains $\geq$ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains $\geq$30% plus No. 200, predominantly sand, add "sandy" to group name.
[M] If soil contains $\geq$30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI $\geq$4 and plots on or above "A" line.
[O] PI <4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

TABLE D-2

CRITERIA FOR DESCRIBING MOISTURE CONDITION OF CLAY SOIL	
Description	**Criteria**
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp, slightly wet, moisture content below plastic limit.
Wet	Moisture content above the plastic limit.
Saturated	Very wet. Usually soil is below water table.

TABLE D-3

CRITERIA FOR DESCRIBING MOISTURE CONDITION OF GRANULAR SOIL	
Description	**Criteria**
Dry	Absence of moisture, dry to the touch.
Moist	Damp but no visible free water.
Wet	Visible free water.
Saturated	Usually soil is below water table.

TABLE D-4

CRITERIA FOR DESCRIBING CONSISTENCY OF CLAY SOIL	
Density	**Penetration Resistance, N Blows per 12 in.**
Very Soft	Less Than 2
Soft	2-4
Medium	4-8
Stiff	8-15
Very Stiff	15-30
Hard	Greater Than 30

TABLE D-5

CRITERIA FOR DESCRIBING DENSITY OF COARSE-GRAINED SOIL	
Density	**Penetration Resistance, N Blows per 12 in.**
Loose	Less Than 10
Medium	10-30
Dense	30-50
Very Dense	Greater Than 50

TABLE D-6

CRITERIA FOR DESCRIBING STRENGTH OF ROCK	
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.

APPENDIX E.

UNCONFINED COMPRESSION TEST REPORTS

HWS
Solutions Through Service

LINCOLN OFFICE
825 "J" Street
P.O. Box 80358
Lincoln, Nebraska
(402) 479-2200

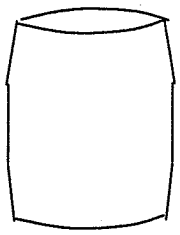
UNCONFINED - COMPRESSION TEST

ASTM Designation: D 2166-98a

Project	Oak Creek Trunk Sewer				
Job No.	52-85-3167.0114	Boring No.	B-1	Depth	6.3'-6.9'
Sample No.	T-1-1	Lab No.	17918	Classification	
Type of Specimen	3" Tube			Humidity During Trimming	71%
Remarks					

MOISTURE	
Container Number	977
Total Wet Wt. (g)	120.4
Total Dry Wt. (g)	106.2
Container Wt. (g)	44.9
Water Content (%)	23.1
Saturation (%)	85.6

SKETCH



Specimen Diameter (in)	2.814
Initial Length (in)	5.244
Wet Wt. of Specimen (g)	1022.5
End Area (in^2)	6.22
Volume (in^3)	32.61
Wet Unit Wt. (lbs/ft^3)	119.4
Dry Unit Wt. (lbs/ft^3)	97.0
Length/Diameter	1.9

	(lbs/in^2)	($tons/ft^2$)
Uncon. Compressive Strength =	**20.8**	**1.5**
Shear Strength =	**10.4**	**0.7**

Strain at failure = 2.7%
Avg. Strain Rate (%/min) = 1.0%

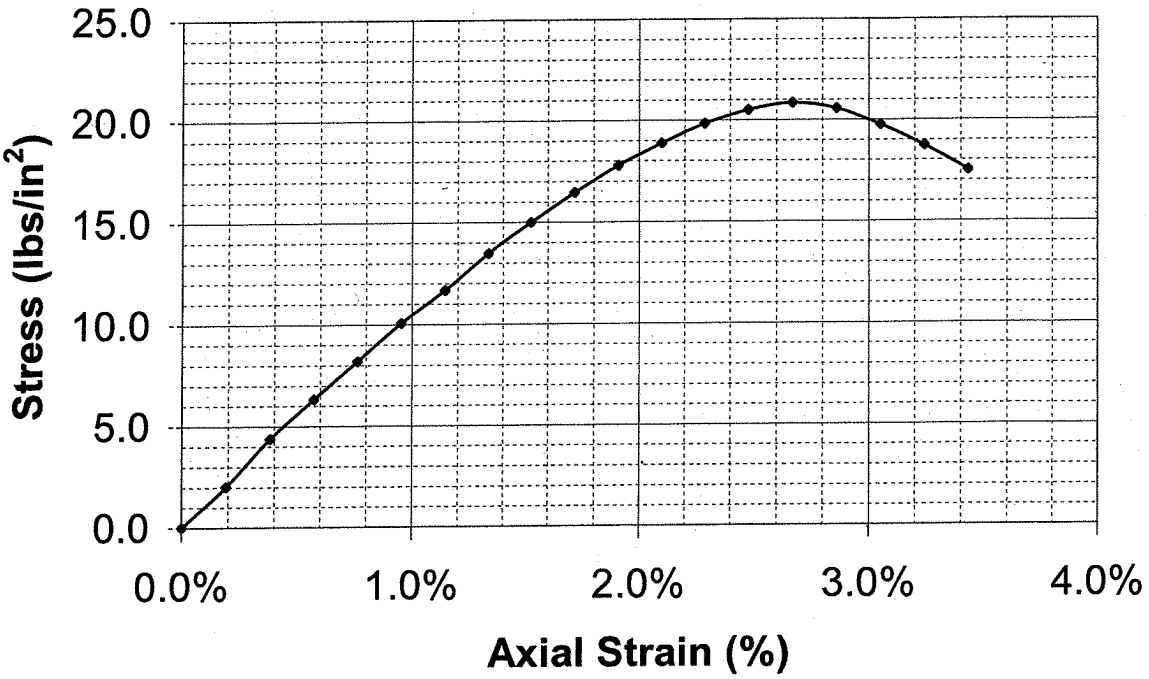


Figure E-1

HWS
Solutions Through Service

LINCOLN OFFICE
825 "J" Street
P.O. Box 80358
Lincoln, Nebraska
(402) 479-2200

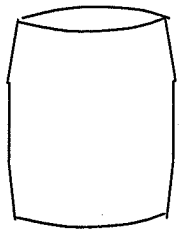
UNCONFINED - COMPRESSION TEST

ASTM Designation: D 2166-98a

Project	Oak Creek Trunk Sewer				
Job No.	52-85-3167.0114	Boring No.	B-2	Depth	7.4'-8.1'
Sample No.	T-2-1	Lab No.	17920	Classification	
Type of Specimen	3" Tube			Humidity During Trimming	70%
Remarks					

MOISTURE	
Container Number	956
Total Wet Wt. (g)	146.5
Total Dry Wt. (g)	129.0
Container Wt. (g)	44.5
Water Content (%)	20.7
Saturation (%)	86.9

SKETCH



Specimen Diameter (in)	2.856
Initial Length (in)	5.636
Wet Wt. of Specimen (g)	1167.0
End Area (in^2)	6.41
Volume (in^3)	36.11
Wet Unit Wt. (lbs/ft^3)	123.1
Dry Unit Wt. (lbs/ft^3)	102.0
Length/Diameter	2.0

	(lbs/in^2)	($tons/ft^2$)
Uncon. Compressive Strength =	**28.2**	**2.0**
Shear Strength =	**14.1**	**1.0**

Strain at failure = 3.0%
Avg. Strain Rate (%/min) = 0.9%

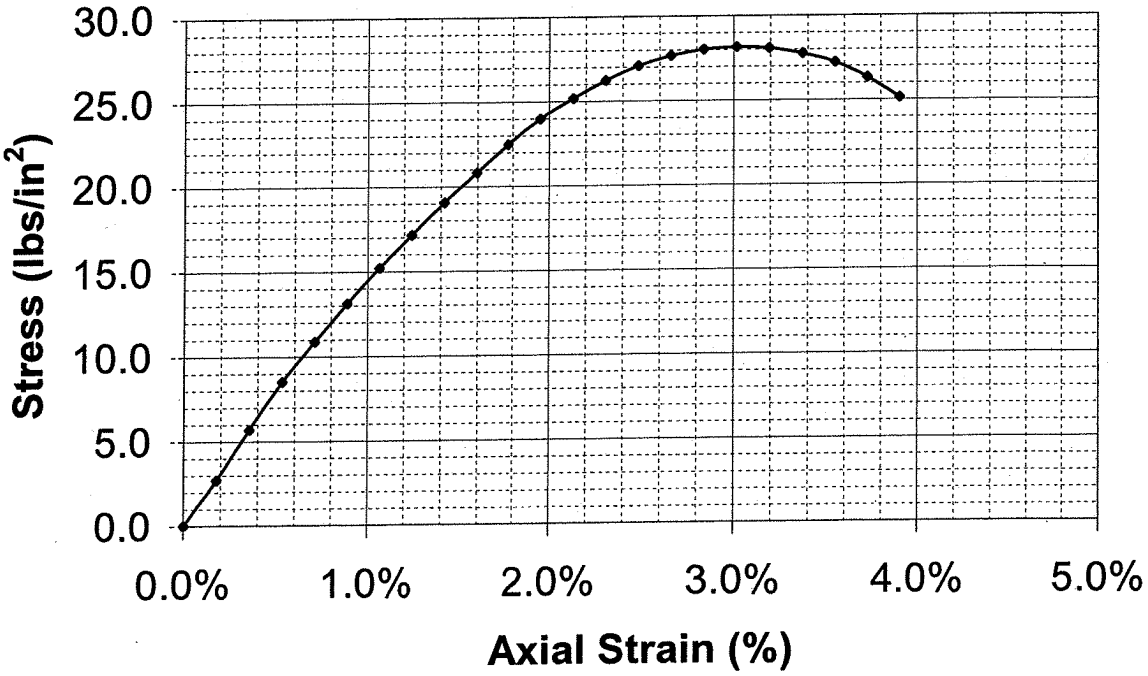


Figure E-2

HWS
Solutions Through Service

LINCOLN OFFICE
825 "J" Street
P.O. Box 80358
Lincoln, Nebraska
(402) 479-2200

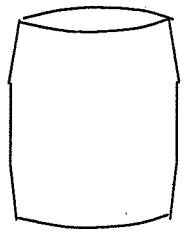
UNCONFINED - COMPRESSION TEST

ASTM Designation: D 2166-98a

Project	Oak Creek Trunk Sewer				
Job No.	52-85-3167.0114	Boring No.	B-2	Depth	17.4'-18.0'
Sample No.	T-2-2	Lab No.	17921	Classification	
Type of Specimen	Trimmed			Humidity During Trimming	75%
Remarks					

MOISTURE	
Container Number	1073
Total Wet Wt. (g)	249.7
Total Dry Wt. (g)	204.2
Container Wt. (g)	38.9
Water Content (%)	27.6
Saturation (%)	97.3

SKETCH



Specimen Diameter (in)	1.402
Initial Length (in)	2.931
Wet Wt. of Specimen (g)	144.0
End Area (in^2)	1.54
Volume (in^3)	4.52
Wet Unit Wt. (lbs/ft^3)	121.2
Dry Unit Wt. (lbs/ft^3)	95.0
Length/Diameter	2.1

	(lbs/in^2)	($tons/ft^2$)		
Uncon. Compressive Strength =	**8.4**	**0.6**	**Strain at failure =**	**8.9%**
Shear Strength =	**4.2**	**0.3**	**Avg. Strain Rate (%/min) =**	**1.0%**

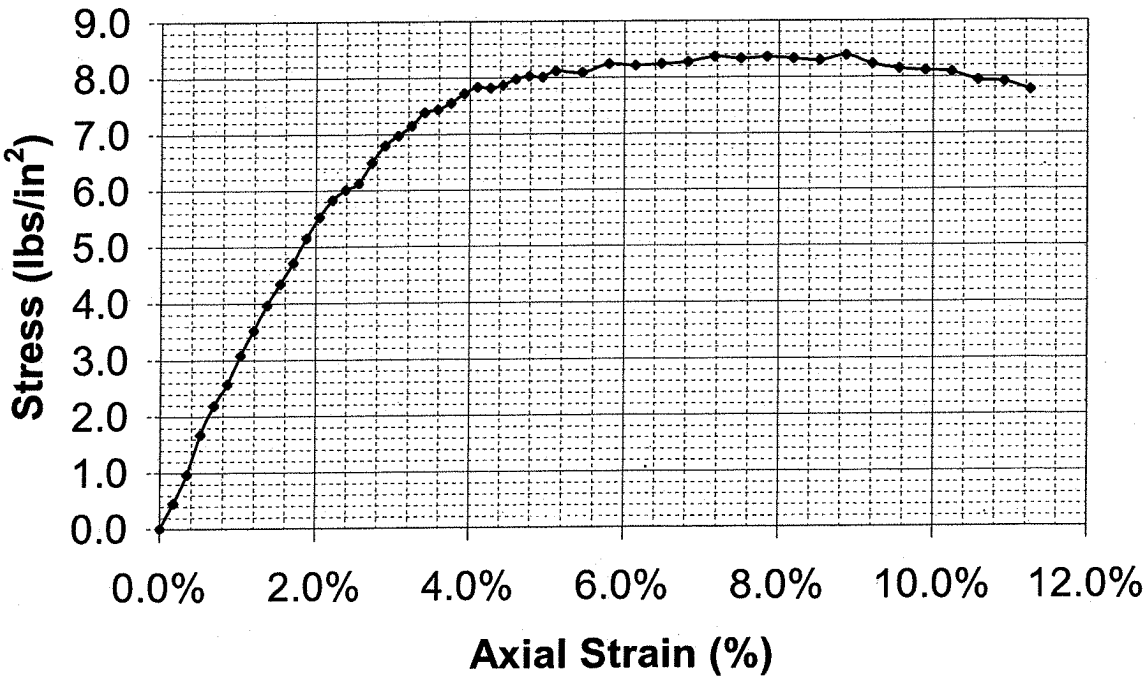


Figure E-3

APPENDIX F.

TRIAXIAL COMPRESSION TEST REPORTS

HWS

LINCOLN OFFICE
825 J St., Box 80358
Lincoln, NE 68501

PROJECT and STATE			SAMPLE LOCATION
OAK CREEK TRUNK SEWER			B–2
FIELD SAMPLE NO. T–2–2	DEPTH 17.4'–18.0'	GEOLOGIC ORIGIN	
TYPE OF SAMPLE 3" TUBE	TESTED AT HWS, Lincoln, NE	APPROVED BY	DATE 8–4–2005

INDEX TEST DATA

USCS _____; LL _____; PI _____

%FINER(mm): 0.002 _____; 0.005 _____;

0.074(#200) _____

G_S (–#4) _____; G_S (+#4) _____

STANDARD: γ_d MAX. _____ pcf; W_0 _____ %

MODIFIED: γ_d MAX. _____ pcf; W_0 _____ %

SPECIMEN DATA

HEIGHT 2.94 "; DIAMETER 1.40 "

MATERIALS TESTED PASSED _____ SIEVE

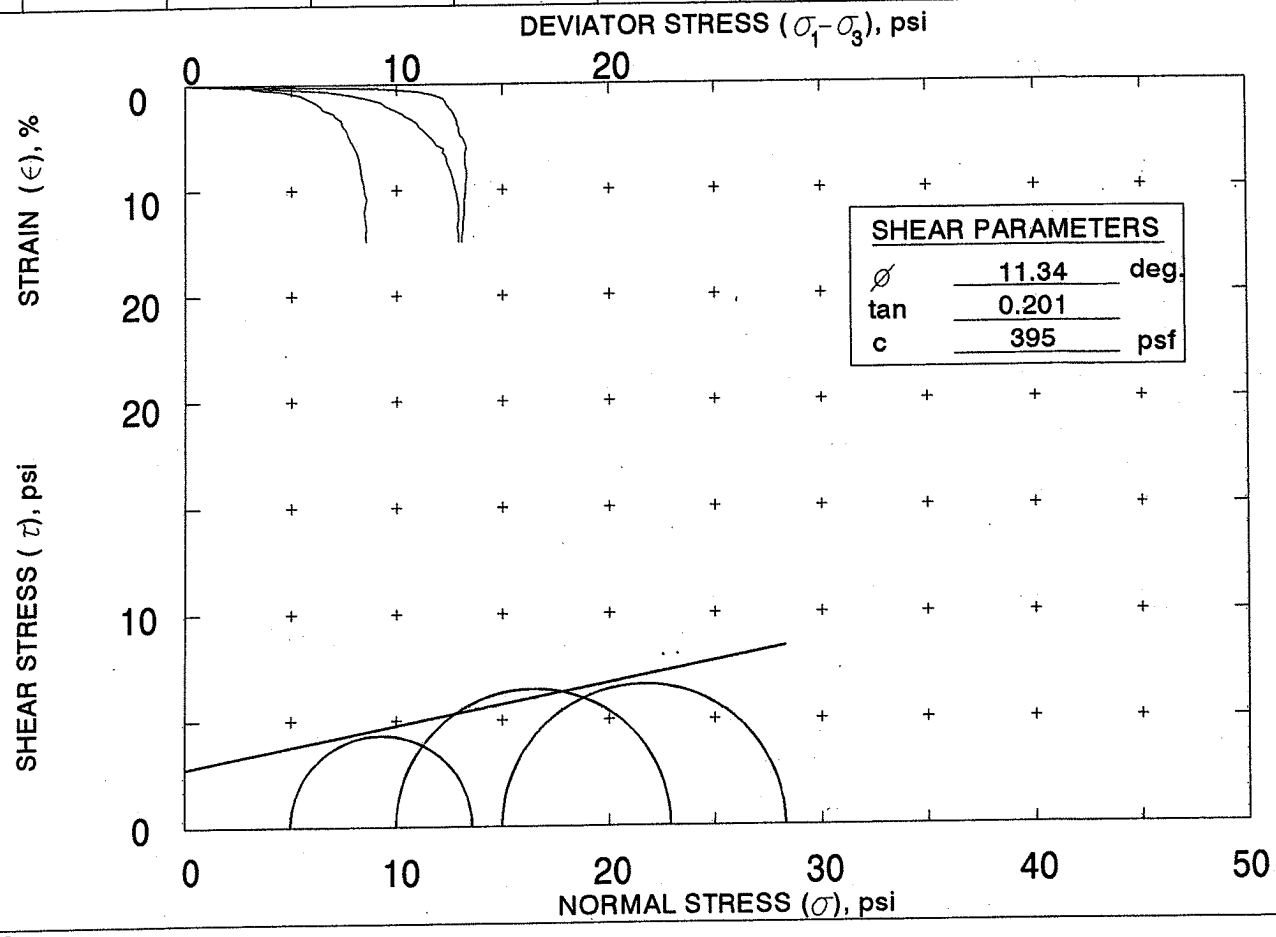
METHOD OF PREPARATION TRIMMED FROM 3" TUBE SAMPLE

MOLDING MOISTURE _____ %

MOLDED AT _____ % OF γ_d MAXIMUM

TYPE OF TEST	
UU	☐
CU	☐
$\overline{CU}$	☒
CD	☐

DRY DENSITY INITIAL (pcf ☒ / g/cc ☐)	DRY DENSITY CONSOLIDATED (pcf ☒ / g/cc ☐)	B PARAMETER	MOISTURE CONTENT, % START OF TEST	MOISTURE CONTENT, % DEG. OF SAT. AT START OF TEST	MOISTURE CONTENT, % END OF TEST	TIME OF CONSOLIDATION (hrs.)	MINOR PRINCIPAL STRESS σ_3 (psi.)	DEVIATOR STRESS $\sigma_1 - \sigma_3$ (psi.)	AXIAL STRAIN AT FAILURE, ϵ (%)
92.9	94.3	99	29.9	99.9	28.6	15.5	5.0	8.6	10.92
95.6	97.8	98	27.9	99.8	26.2	15.5	10.0	12.9	12.27
97.1	98.9	97	26.3	97.4	25.0	15.5	15.0	13.3	8.96



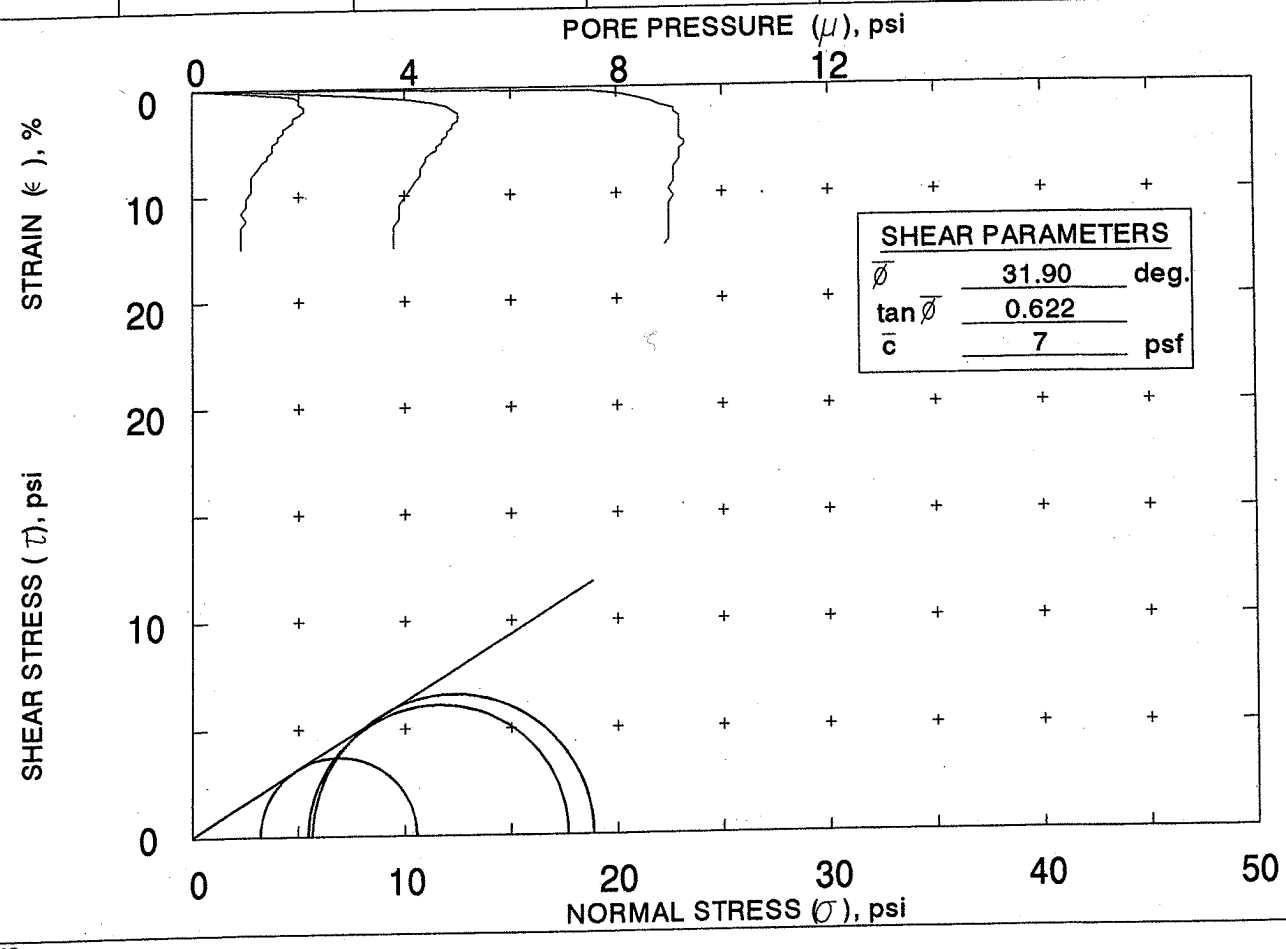
REMARKS

LINCOLN OFFICE
825 J St., Box 80358
Lincoln, NE 68501

TRIAXIAL SHEAR TEST

PROJECT and STATE: OAK CREEK TRUNK SEWER			SAMPLE LOCATION: B–2
FIELD SAMPLE NO.: T–2–2	DEPTH: 17.4'–18.0'	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: 3" TUBE	TESTED AT: HWS, Lincoln, NE	APPROVED BY:	DATE: 8–4–2005

MINOR PRINCIPAL STRESS σ_3 (psi)	PORE PRESSURE, μ (psi)	EFFECTIVE MINOR PRINCIPAL STRESS $\bar{\sigma}_3$ (psi)	DEVIATOR STRESS, $\sigma_1 - \sigma_3$ (psi)	FAILURE CRITERIA MAXIMUM PRINCIPAL EFFECTIVE STRESS RATIO	AXIAL STRAIN AT FAILURE, ϵ (%)
5.0	1.8	3.2	7.4	$\left(\frac{\bar{\sigma}_1}{\bar{\sigma}_3}\right)_{MAX.}$	3.41
10.0	4.5	5.5	12.2		6.13
15.0	9.3	5.7	13.2		5.51



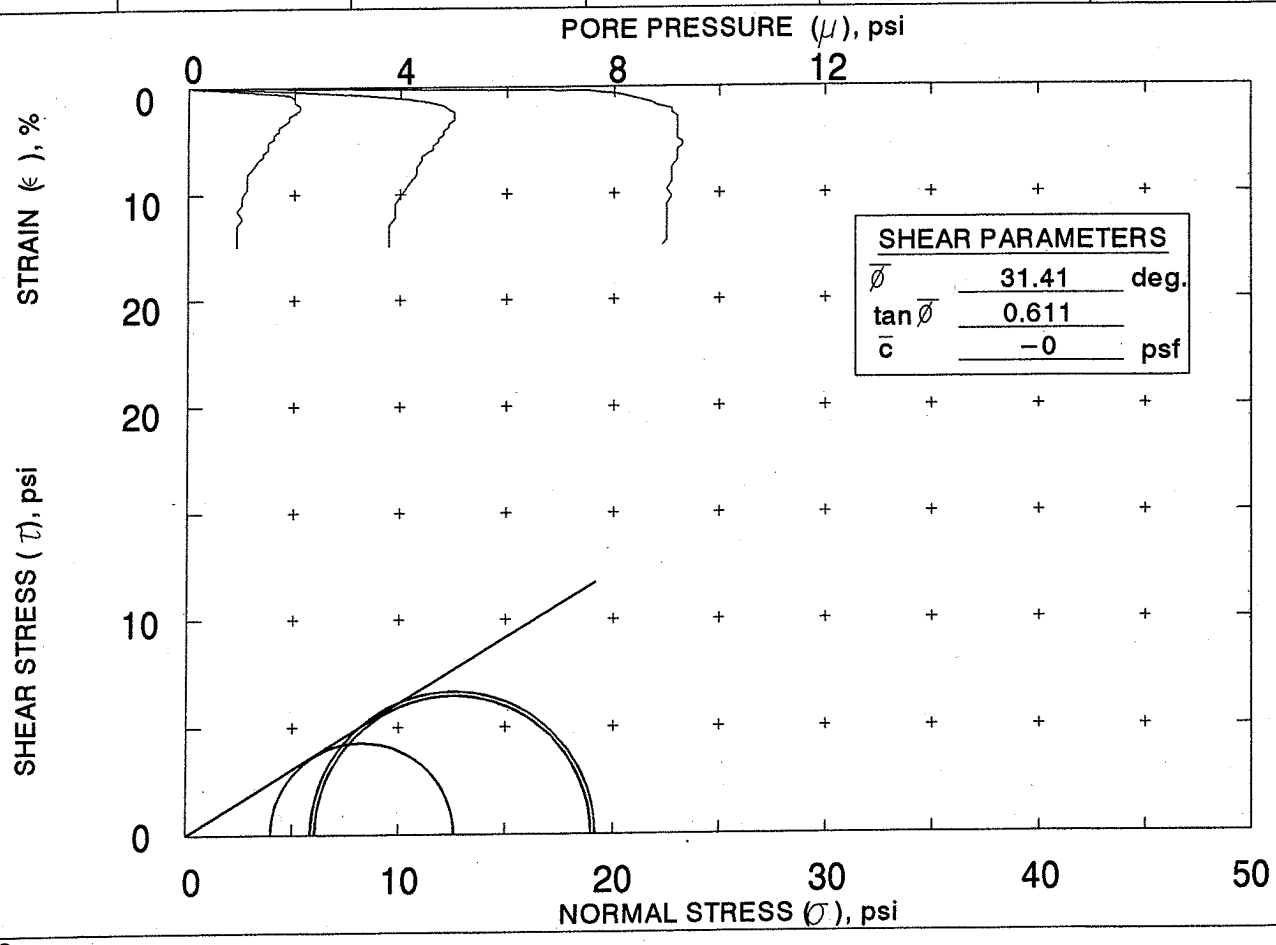
REMARKS

LINCOLN OFFICE
825 J St., Box 80358
Lincoln, NE 68501

TRIAXIAL SHEAR TEST

PROJECT and STATE			SAMPLE LOCATION
OAK CREEK TRUNK SEWER			B–2
FIELD SAMPLE NO.	DEPTH	GEOLOGIC ORIGIN	
T–2–2	17.4'–18.0'		
TYPE OF SAMPLE	TESTED AT	APPROVED BY	DATE
3" TUBE	HWS, Lincoln, NE		8–4–2005

MINOR PRINCIPAL STRESS σ_3 (psi)	PORE PRESSURE, μ (psi)	EFFECTIVE MINOR PRINCIPAL STRESS $\bar{\sigma}_3$ (psi)	DEVIATOR STRESS, $\sigma_1 - \sigma_3$ (psi)	FAILURE CRITERIA MAXIMUM DEVIATOR STRESS	AXIAL STRAIN AT FAILURE, ϵ (%)
5.0	1.0	4.0	8.6	$(\sigma_1 - \sigma_3)_{MAX.}$	10.92
10.0	3.9	6.1	12.9		12.27
15.0	9.1	5.9	13.3		8.96



REMARKS

PROJECT Oak Creek Trunk Sewer
LAB NO. 17921
CELL NO. 1

SAMPLE IDB-2; T-2-2; 17.4'-18.0'
JOB NO. 52-85-3167.0114

CELL PRESSURE	65.0
BACK PRESSURE	60.0
CONSOLIDATION PRESS.	5.0

SP. GR. 2.68

SPECIMEN DATA	INITIAL	FINAL
DIAMETER		
TOP, in.	1.396	HERE
MIDDLE, in.	1.396	HERE
BOTTOM, in.	1.396	HERE
AVERAGE DIA.,in.	1.396	0.000
HEIGHT, in.	2.945	HERE
MOIST WT., gm	142.76	HERE
END AREA,sq.in.	1.531	
VOLUME, cu. in.	4.51	
UNIT WT., gm/cc	1.932	
WET UNIT WT,pcf	120.64	

MOISTURE DATA	INITIAL	FINAL
CAN NUMBER	978	2131
TOTAL WET WT.,gm	281.87	184.40
TOTAL DRY WT.,gm	227.32	153.12
WT. OF WATER, gm	54.55	31.28
CAN WEIGHT, gm	44.81	43.61
DRY WT. SOIL, gm	182.51	109.51
PERCENT MOISTURE	29.89	28.56
DRY UNIT WT.,pcf	92.88	94.30
THEO. SAT.,%	99.94	XXXXXXXXX

HEIGHT CHANGE,in. 0.014

AXIAL DIAL in.	AXIAL LOAD lbs.	PORE PRESS u	STRAIN %
0.000	13.0	60.0	0.00
0.010	18.3	61.0	0.34
0.020	21.1	61.9	0.68
0.030	22.9	62.0	1.02
0.040	24.0	62.0	1.36
0.050	25.1	62.1	1.71
0.060	25.9	62.1	2.05
0.070	26.2	62.0	2.39
0.080	27.0	61.9	2.73
0.090	27.2	61.9	3.07
0.100	27.7	61.8	3.41
0.110	27.8	61.7	3.75
0.120	28.0	61.7	4.09
0.130	28.3	61.6	4.44
0.140	28.4	61.6	4.78
0.150	28.6	61.5	5.12
0.160	28.8	61.5	5.46
0.170	29.0	61.5	5.80
0.180	29.2	61.4	6.14
0.190	29.4	61.4	6.48
0.200	29.6	61.3	6.82
0.220	29.8	61.2	7.51
0.240	30.0	61.1	8.19
0.260	30.2	61.1	8.87
0.280	30.5	61.1	9.55
0.300	30.7	61.0	10.24
0.320	31.0	61.0	10.92
0.340	31.0	60.9	11.60
0.360	31.1	61.0	12.28
0.380	31.3	60.9	12.96
0.400	31.5	60.9	13.65
0.420	31.6	60.9	14.33
0.440	31.8	60.9	15.00
0.460			15.69
0.480			16.38
0.500			17.06
0.520			17.74
0.540			18.42
0.560			19.11
0.580			19.79
0.600			20.47
0.620			21.15
0.640			21.84
0.660			22.52
0.680			23.20

DEVIATOR STRESS	GEN PORE PRESS	SIGMA THREE (BAR)	SIGMA ONE (BAR)	PRIN. STRESS RATIO	SIGMA SUB ALPHA	TAU SUB ALPHA
0.00	0.00	5.00	5.00	1.00	5.00	0.00
3.14	1.00	4.00	7.14	1.79	4.79	1.36
4.62	1.90	3.10	7.72	2.49	4.26	2.00
5.44	2.00	3.00	8.44	2.81	4.36	2.36
5.79	2.00	3.00	8.79	2.93	4.45	2.51
6.14	2.10	2.90	9.04	3.12	4.43	2.66
6.33	2.10	2.90	9.23	3.18	4.48	2.74
6.50	2.00	3.00	9.50	3.17	4.62	2.81
6.98	1.90	3.10	10.08	3.25	4.85	3.02
7.08	1.90	3.10	10.18	3.28	4.87	3.07
7.37	1.80	3.20	10.57	3.30	5.04	3.19
7.40	1.70	3.30	10.70	3.24	5.15	3.20
7.49	1.70	3.30	10.79	3.27	5.17	3.24
7.64	1.60	3.40	11.04	3.25	5.31	3.31
7.67	1.60	3.40	11.07	3.26	5.32	3.32
7.76	1.50	3.50	11.26	3.22	5.44	3.36
7.85	1.50	3.50	11.35	3.24	5.46	3.40
7.94	1.50	3.50	11.44	3.27	5.49	3.44
8.03	1.40	3.60	11.63	3.23	5.61	3.48
8.12	1.40	3.60	11.72	3.25	5.63	3.51
8.20	1.30	3.70	11.90	3.22	5.75	3.55
8.25	1.20	3.80	12.05	3.17	5.86	3.57
8.30	1.10	3.90	12.20	3.13	5.97	3.59
8.34	1.10	3.90	12.24	3.14	5.98	3.61
8.44	1.10	3.90	12.34	3.16	6.01	3.65
8.48	1.00	4.00	12.48	3.12	6.12	3.67
8.58	1.00	4.00	12.58	3.14	6.14	3.71
8.50	0.90	4.10	12.60	3.07	6.22	3.68
8.47	1.00	4.00	12.47	3.12	6.12	3.67
8.51	0.90	4.10	12.61	3.07	6.23	3.68
8.54	0.90	4.10	12.64	3.08	6.23	3.70
8.51	0.90	4.10	12.61	3.08	6.23	3.69
8.54	0.90	4.10	12.64	3.08	6.24	3.70
-9.23	-60.00	65.00	55.77	0.86	62.69	-4.00
-9.17	-60.00	65.00	55.83	0.86	62.71	-3.97
-9.11	-60.00	65.00	55.89	0.86	62.72	-3.95
-9.05	-60.00	65.00	55.95	0.86	62.74	-3.92
-9.00	-60.00	65.00	56.00	0.86	62.75	-3.89
-8.94	-60.00	65.00	56.06	0.86	62.77	-3.87
-8.88	-60.00	65.00	56.12	0.86	62.78	-3.84
-8.82	-60.00	65.00	56.18	0.86	62.80	-3.82
-8.76	-60.00	65.00	56.24	0.87	62.81	-3.79
-8.70	-60.00	65.00	56.30	0.87	62.82	-3.77
-8.64	-60.00	65.00	56.36	0.87	62.84	-3.74
-8.59	-60.00	65.00	56.41	0.87	62.85	-3.72

VOLUME CC	73.88	STRAIN	
MOISTURE	29.89	10.92	
DRY DENSITY	92.88		
SATURATION	99.94		
CONSOL HT	2.931		
CON END AREA	1.516	STRAIN	
FINAL DRY DEN	94.30	3.41	
FINAL MOIST	28.56		

TOTAL STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER
8.58	1.00	5.00	13.58	9.29

EFFECTIVE STRESS: MAX DEV STRESS CRITERION
4.00

EFFECTIVE STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER		
7.37	1.80	3.20	10.57	6.88	5.041367	3.189248
					6.144184	3.713727

PROJECT Oak Creek Trunk Sewer
LAB NO. 17921
CELL NO. 2

SAMPLE IDB-2; T-2-2; 17.4'-18.0'
JOB NO. 52-85-3167.0114

SP. GR. 2.68

CELL PRESSURE	60.0
BACK PRESSURE	50.0
CONSOLIDATION PRESS.	10.0

SPECIMEN DATA	INITIAL	FINAL
DIAMETER		
TOP, in.	1.394	HERE
MIDDLE, in.	1.394	HERE
BOTTOM, in.	1.394	HERE
AVERAGE DIA.,in.	1.394	0.000
HEIGHT, in.	2.948	HERE
MOIST WT., gm	144.49	HERE
END AREA,sq.in.	1.526	
VOLUME, cu. in.	4.499	
UNIT WT., gm/cc	1.959	
WET UNIT WT,pcf	122.32	

MOISTURE DATA		FINAL
CAN NUMBER	1073	2188
TOTAL WET WT.,gm	266.85	179.02
TOTAL DRY WT.,gm	217.08	149.54
WT. OF WATER, gm	49.77	29.48
CAN WEIGHT, gm	38.86	37.07
DRY WT. SOIL, gm	178.22	112.47
PERCENT MOISTURE	27.93	26.21
DRY UNIT WT.,pcf	95.62	97.83
THEO. SAT.,%	99.82	XXXXXXXXX

HEIGHT CHANGE,in. 0.013

AXIAL DIAL in.	AXIAL LOAD lbs.	PORE PRESS u	STRAIN %
0.000	11.9	50.0	0.00
0.010	18.9	51.9	0.34
0.020	23.1	53.2	0.68
0.030	25.5	54.1	1.02
0.040	27.2	54.5	1.36
0.050	28.8	54.8	1.70
0.060	29.6	54.9	2.04
0.070	30.2	55.0	2.39
0.080	30.9	55.0	2.73
0.090	31.3	55.0	3.07
0.100	31.9	54.9	3.41
0.110	32.3	54.9	3.75
0.120	32.5	54.8	4.09
0.130	32.9	54.8	4.43
0.140	33.3	54.7	4.77
0.150	33.6	54.7	5.11
0.160	33.9	54.6	5.45
0.170	34.2	54.6	5.79
0.180	34.8	54.5	6.13
0.190	34.8	54.4	6.47
0.200	35.1	54.4	6.81
0.220	35.4	54.3	7.50
0.240	35.8	54.3	8.18
0.260	36.2	54.2	8.86
0.280	36.5	54.1	9.54
0.300	36.8	54.0	10.22
0.320	37.1	53.9	10.90
0.340	37.4	53.9	11.58
0.360	37.6	53.9	12.27
0.380	37.8	53.8	12.95
0.400	37.9	53.8	13.63
0.420	38.2	53.8	14.31
0.440	38.4	53.8	14.99
0.440	38.4	53.8	15.00
0.480			16.35
0.500			17.04
0.520			17.72
0.540			18.40
0.560			19.08
0.580			19.76
0.600			20.44
0.620			21.12
0.640			21.81
0.660			22.49
0.680			23.17

DEVIATOR STRESS	GEN PORE PRESS	SIGMA THREE (BAR)	SIGMA ONE (BAR)	PRIN. STRESS RATIO	SIGMA SUB ALPHA	TAU SUB ALPHA
0.00	0.00	10.00	10.00	1.00	10.00	0.00
4.27	1.90	8.10	12.37	1.53	9.17	1.85
6.67	3.20	6.80	13.47	1.98	8.47	2.89
7.88	4.10	5.90	13.78	2.33	7.87	3.41
8.61	4.50	5.50	14.11	2.57	7.65	3.73
9.28	4.80	5.20	14.48	2.78	7.52	4.02
9.46	4.90	5.10	14.56	2.86	7.47	4.10
9.81	5.00	5.00	14.81	2.96	7.45	4.25
10.22	5.00	5.00	15.22	3.04	7.55	4.42
10.43	5.00	5.00	15.43	3.09	7.61	4.52
10.77	4.90	5.10	15.87	3.11	7.79	4.66
10.98	4.90	5.10	16.08	3.15	7.84	4.75
11.06	4.80	5.20	16.26	3.13	7.97	4.79
11.27	4.80	5.20	16.47	3.17	8.02	4.88
11.47	4.70	5.30	16.77	3.16	8.17	4.97
11.61	4.70	5.30	16.91	3.19	8.20	5.03
11.75	4.60	5.40	17.15	3.18	8.34	5.09
11.89	4.60	5.40	17.29	3.20	8.37	5.15
12.21	4.50	5.50	17.71	3.22	8.55	5.29
12.16	4.40	5.60	17.76	3.17	8.64	5.26
12.29	4.40	5.60	17.89	3.19	8.67	5.32
12.37	4.30	5.70	18.07	3.17	8.79	5.36
12.51	4.30	5.70	18.21	3.19	8.83	5.42
12.64	4.20	5.80	18.44	3.18	8.96	5.47
12.71	4.10	5.90	18.61	3.15	9.08	5.50
12.78	4.00	6.00	18.78	3.13	9.19	5.53
12.84	3.90	6.10	18.94	3.11	9.31	5.56
12.90	3.90	6.10	19.00	3.12	9.33	5.59
12.91	3.90	6.10	19.01	3.12	9.33	5.59
12.90	3.80	6.20	19.10	3.08	9.43	5.59
12.84	3.80	6.20	19.04	3.07	9.41	5.56
12.90	3.80	6.20	19.10	3.08	9.42	5.58
12.89	3.80	6.20	19.09	3.08	9.42	5.58
12.89	3.80	6.20	19.09	3.08	9.42	5.58
-8.58	-50.00	60.00	51.42	0.86	57.86	-3.72
-8.53	-50.00	60.00	51.47	0.86	57.87	-3.69
-8.47	-50.00	60.00	51.53	0.86	57.88	-3.67
-8.42	-50.00	60.00	51.58	0.86	57.90	-3.65
-8.37	-50.00	60.00	51.63	0.86	57.91	-3.62
-8.31	-50.00	60.00	51.69	0.86	57.92	-3.60
-8.26	-50.00	60.00	51.74	0.86	57.94	-3.58
-8.20	-50.00	60.00	51.80	0.86	57.95	-3.55
-8.15	-50.00	60.00	51.85	0.86	57.96	-3.53
-8.10	-50.00	60.00	51.90	0.87	57.98	-3.51
-8.04	-50.00	60.00	51.96	0.87	57.99	-3.48

TOTAL STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER
12.91	3.90	10.00	22.91	16.45

EFFECTIVE STRESS: MAX DEV STRESS CRITERION
6.10

EFFECTIVE STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER		
12.21	4.50	5.50	17.71	11.60	8.552392	5.286742
					9.326268	5.587896

VOLUME CC	73.74	STRAIN
MOISTURE	27.93	12.27
DRY DENSITY	95.62	
SATURATION	99.82	
CONSOL HT	2.935	
CON END AREA	1.513	STRAIN
FINAL DRY DEN	97.83	6.13
FINAL MOIST	26.21	

PROJECT Oak Creek Trunk Sewer
LAB NO. 17921
CELL NO. 3

SAMPLE IDB-2; T-2-2; 17.4'-18.0'
JOB NO. 52-85-3167.0114

SP. GR. 2.68

CELL PRESSURE	75.0
BACK PRESSURE	60.0
CONSOLIDATION PRESS.	15.0

SPECIMEN DATA	INITIAL	FINAL
DIAMETER		
TOP, in.	1.399	HERE
MIDDLE, in.	1.400	HERE
BOTTOM, in.	1.401	HERE
AVERAGE DIA.,in.	1.400	0.000
HEIGHT, in.	2.941	HERE
MOIST WT., gm	145.77	HERE
END AREA,sq.in.	1.539	
VOLUME, cu. in.	4.527	
UNIT WT., gm/cc	1.964	
WET UNIT WT,pcf	122.64	

MOISTURE DATA	INITIAL	FINAL
CAN NUMBER	936	2240
TOTAL WET WT.,gm	281.12	181.54
TOTAL DRY WT.,gm	231.92	152.96
WT. OF WATER, gm	49.20	28.58
CAN WEIGHT, gm	44.67	38.50
DRY WT. SOIL, gm	187.25	114.46
PERCENT MOISTURE	26.28	24.97
DRY UNIT WT.,pcf	97.12	98.91
THEO. SAT.,%	97.44	XXXXXXXXX

HEIGHT CHANGE,in. 0.038

AXIAL DIAL in.	AXIAL LOAD lbs.	PORE PRESS u	STRAIN %
0.000	14.4	60.0	0.00
0.010	28.4	67.5	0.34
0.020	31.9	68.1	0.69
0.030	33.8	68.4	1.03
0.040	35.0	68.7	1.38
0.050	35.8	68.8	1.72
0.060	36.4	69.1	2.07
0.070	36.7	69.1	2.41
0.080	37.0	69.2	2.76
0.090	37.2	69.2	3.10
0.100	37.4	69.2	3.44
0.110	37.5	69.2	3.79
0.120	37.7	69.2	4.13
0.130	37.8	69.2	4.48
0.140	38.0	69.2	4.82
0.150	38.3	69.3	5.17
0.160	38.5	69.3	5.51
0.170	38.7	69.2	5.86
0.180	38.8	69.2	6.20
0.190	38.8	69.2	6.54
0.200	38.9	69.2	6.89
0.220	39.1	69.1	7.58
0.240	39.4	69.1	8.27
0.260	39.6	69.1	8.96
0.280	39.7	69.0	9.65
0.300	39.9	69.1	10.33
0.320	40.0	69.0	11.02
0.340	40.2	69.0	11.71
0.360	40.4	69.0	12.40
0.380	40.5	69.0	13.09
0.400	40.7	69.0	13.78
0.420	40.8	69.0	14.47
0.435	41.0	68.9	15.00
0.452			15.57
0.480			16.53
0.500			17.22
0.520			17.91
0.540			18.60
0.560			19.29
0.580			19.98
0.600			20.67
0.620			21.36
0.640			22.05
0.660			22.74
0.680			23.42

DEVIATOR STRESS	GEN PORE PRESS	SIGMA THREE (BAR)	SIGMA ONE (BAR)	PRIN. STRESS RATIO	SIGMA SUB ALPHA	TAU SUB ALPHA
0.00	0.00	15.00	15.00	1.00	15.00	0.00
8.96	7.50	7.50	16.46	2.19	9.74	3.88
10.90	8.10	6.90	17.80	2.58	9.63	4.72
11.77	8.40	6.60	18.37	2.78	9.54	5.10
12.17	8.70	6.30	18.47	2.93	9.34	5.27
12.30	8.80	6.20	18.50	2.98	9.28	5.33
12.37	9.10	5.90	18.27	3.10	8.99	5.36
12.51	9.10	5.90	18.41	3.12	9.03	5.42
12.66	9.20	5.80	18.46	3.18	8.96	5.48
12.73	9.20	5.80	18.53	3.20	8.98	5.51
12.81	9.20	5.80	18.61	3.21	9.00	5.55
12.82	9.20	5.80	18.62	3.21	9.01	5.55
12.90	9.20	5.80	18.70	3.22	9.02	5.58
12.91	9.20	5.80	18.71	3.23	9.03	5.59
12.98	9.20	5.80	18.78	3.24	9.04	5.62
13.11	9.30	5.70	18.81	3.30	8.98	5.68
13.19	9.30	5.70	18.89	3.31	9.00	5.71
13.26	9.20	5.80	19.06	3.29	9.11	5.74
13.26	9.20	5.80	19.06	3.29	9.12	5.74
13.21	9.20	5.80	19.01	3.28	9.10	5.72
13.21	9.20	5.80	19.01	3.28	9.10	5.72
13.22	9.10	5.90	19.12	3.24	9.21	5.73
13.29	9.10	5.90	19.19	3.25	9.22	5.76
13.30	9.10	5.90	19.20	3.25	9.22	5.76
13.24	9.00	6.00	19.24	3.21	9.31	5.73
13.25	9.10	5.90	19.15	3.25	9.21	5.74
13.19	9.00	6.00	19.19	3.20	9.30	5.71
13.19	9.00	6.00	19.19	3.20	9.30	5.71
13.19	9.00	6.00	19.19	3.20	9.30	5.71
13.13	9.00	6.00	19.13	3.19	9.28	5.68
13.12	9.00	6.00	19.12	3.19	9.28	5.68
13.06	9.00	6.00	19.06	3.18	9.26	5.65
13.08	8.90	6.10	19.18	3.14	9.37	5.66
-10.11	-60.00	75.00	64.89	0.87	72.47	-4.38
-10.01	-60.00	75.00	64.99	0.87	72.50	-4.34
-9.95	-60.00	75.00	65.05	0.87	72.51	-4.31
-9.88	-60.00	75.00	65.12	0.87	72.53	-4.28
-9.82	-60.00	75.00	65.18	0.87	72.55	-4.25
-9.75	-60.00	75.00	65.25	0.87	72.56	-4.22
-9.68	-60.00	75.00	65.32	0.87	72.58	-4.19
-9.62	-60.00	75.00	65.38	0.87	72.60	-4.16
-9.55	-60.00	75.00	65.45	0.87	72.61	-4.14
-9.49	-60.00	75.00	65.51	0.87	72.63	-4.11
-9.42	-60.00	75.00	65.58	0.87	72.65	-4.08
-9.35	-60.00	75.00	65.65	0.88	72.66	-4.05

VOLUME CC	74.20	STRAIN
MOISTURE	26.28	8.96
DRY DENSITY	97.12	
SATURATION	97.44	
CONSOL HT	2.903	
CON END AREA	1.500	STRAIN
FINAL DRY DEN	98.91	5.51
FINAL MOIST	24.97	

TOTAL STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER
13.30	9.10	15.00	28.30	21.64971

EFFECTIVE STRESS: MAX DEV STRESS CRITERION
5.90

EFFECTIVE STRESS VALUES

DSTRESS	GENPORPR	SIG3	SIG1	CENTER		
13.19	9.30	5.70	18.89	12.2926	8.996298	5.709188
					9.224856	5.758651

APPENDIX G.

SOIL CORROSIVITY DATA

Report Number
05-206-2053

Midwest Laboratories, Inc.®

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www.midwestlabs.com

REPORT OF ANALYSIS

Mail to:

HWS CONSULTING GROUP
825 J ST PO BOX 80358
LINCOLN NE 68508-2958

For: (1170) HWS CONSULTING GROUP
(402)479-2200

Date Reported: 07/25/05
Date Received: 07/18/05

OAK CREEK TRUNK SEWER

RECEIVED
JUL 26 2005
HWS

Lab number: 1093422

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Sample ID: SAMPLE 1 B-1 5.0-5.6						
Chloride	21	mg/kg	1	EPA 9056	dmg-07/21	jjd-07/25
Oxidation reduction potential	184	mV	25	SM 2580B	dmg-07/20	jpt-07/22
Sulfate	12	mg/kg	1	EPA 9056	dmg-07/21	jjd-07/25
pH	6.7	S.U.		EPA 9045	jpt-07/20	jpt-07/22
Sample ID: SAMPLE 2 B-3 7.0-7.5						
Chloride	13	mg/kg	1	EPA 9056	dmg-07/21	jjd-07/25
Oxidation reduction potential	225	mV	25	SM 2580B	dmg-07/20	jpt-07/22
Sulfate	24	mg/kg	1	EPA 9056	dmg-07/21	jjd-07/25
pH	6.6	S.U.		EPA 9045	jpt-07/20	jpt-07/22

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
Client Services

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