Appendix K

Geotechnical Considerations

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Geotechnical Considerations Appendix K

1. Purpose

This appendix presents specific geotechnical study relevant to the project and future anticipated geotechnical analysis/design. Geotechnical data was secured from various sources related to the project site location in general and previous site related projects. SCI Engineering, INC. obtained soil borings, with laboratory analysis and interpretation.

2. Project Features

Key features of the project include design and construction of new water control structures and a new pump station, construction of setback with exterior berm degrade, restore historic meanders, and reforestation. These features are designed to protect and/or enhance wetland and floodplain habitat.

3. Location

The project features are located in Pool 25 of the Mississippi River along the right descending bank between river miles (RM) 261.1 and 263.8, adjacent to the town of Annada in Pike County, Missouri. The description of the potential feasible project features are described in Section 3.2 and the location are depicted in Figure 6 of the main report.

4. Physiography

The project area is located entirely in bottomland composed of alluvium. The soils on the project area are found on 0-2% slope and are occasionally to frequently flooded. Soils at Clarence Cannon National Wildlife Refuge (CCNWR) are Holocene alluvial deposits predominantly of the Chequest-Dockery-Carlow association (Figure 15 of main report). Blackoar and Dockery silt loams, Chequest silty clay loams, and Carlow silty clays compose most soils on CCNWR and their distribution reflects slight differences in elevation and distance from the Mississippi (Love 1997). These silt and clay deposits range in thickness from 20-30 feet above older sand and gravel deposits deposited during glacial outwash periods. Some small sand inclusions occur within the silt and clay deposits; these are usually less than 10 feet deep. The bedrock beneath CCNWR consists of shale and limestone of the Maquoketa Shale deposited in the Ordovician period (Willman and Frye 1970, Willman et al. 1975). Approximately 100-120 feet of Quaternary sediments overlie this bedrock (Piskin and Bergstrom 1975, MDC 1973).

5. Subsurface Exploration

A geotechnical study site investigation was performed on June 30, 2009 by SCI Engineering, INC. The geotechnical report site investigation is attached at the end of this appendix, and indicated that the borrow areas consist of high plastic clays classified CH. These soils are suitable for use as embankment fill. Five hand-augured (HA) borings designated HA-13 through 17 and one conventional boring, designated B-2 were augured or drilled within the vicinity of proposed site improvements. HA 13 and 15 and boring B-2 were drilled within the North unit area, HA 14 and 17 in the South unit area and HA 16 in the River unit area.

The HA's and boring B-2 were advanced to a depth of 6.0' and 17.0', respectively and samples were obtained at 1.0' (HA) and 2.5' – 5.0' (B-2) intervals in the fine-grained blanket. Split-spoon samples were recovered using a 2" outside-diameter, split-barrel sampler, driven by an automatic hammer. No Shelby tube samples were recovered, however, hand penetrometer test were performed value varies from 4 to

6 KSF within the first 12.0' and 1.0 KSF at 14.0'. The boring locations and boring logs are shown as attachments within this appendix.

In conjunction with the geotechnical study site investigation performed by SCI Engineering, INC the Clarence Cannon National Wildlife Refuge office secured what it seems to be part of an exploration subsurface program done by GEI Consultant INC. The subsurface program data received from the Clarence Cannon National Wildlife Refuge office are not complete. The borings location with the exception of boring B-113, geotech report and some boring logs were not provided, however, the exploration was drilled within the Clarence Cannon National Wildlife Refuge area, and were consistent with the information collected by SCI Engineering, INC. The subsurface exploration, which includes boring logs, is bound within this appendix section.

6. Laboratory Testing

In order to determine selected engineering properties, the following laboratory tests were performed on selected samples recovered from the borings:

- Visual descriptions by color and texture of each sample
- Natural moisture content of each cohesive sample
- Hand penetrometer determinations of the approximate compressive strength of cohesive samples
- Atterberg Limits test on all cohesive samples
- Grain size analyses of all coarse grained samples

Laboratory testing results are indicated on the boring profiles within the appendix.

7. Stratigraphy

The subsurface profile of the project area consists of medium stiff high plastic clay with trace organics. Medium stiff to stiff high plastic clay with varying amounts of sand was encountered below depth of 17 feet, where medium dense sand (SP) was encountered to the depths of boring termination, at 20 feet. The soils are typically brown and grey, medium to fine sands below brown and grey fat and lean clays and silts, with occasional interbedded silt and sand lenses within the fine-grained blanket soils. Fat clays were generally found between approximate elevations 443' and 426' NGVD. Auger refusal was not obtained, however, borings drilled in the Ted Shanks Conservation Area, which is located on similar soils upstream in Pool 24, refusal was observed at a depth of 92.5 feet below grade (assumed on intact bedrock), at elevation 361.3' NGVD.

8. Hydrologic Soil Group

Using Natural Resource Conservation Service data, the soils within the Clarence Cannon National Wildlife Refuge area was broken down into either Hydrologic Soil Group C or D. The definitions of these groups are listed below.

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table,

soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

CH classified material is considered to be impervious and are typically found in very poorly drained areas which are occasionally flooded.

9. Anticipated Future Geotechnical/Construction Considerations

In order to complete the geotechnical analyses/design of the project features/structures, it is necessary to assign geotechnical design parameters to the foundation and embankment materials. The design parameters include soil shear strength parameters, unit weights and compressibility. The development of the geotechnical design parameters is based upon soil descriptions, standard penetration (N) values, sieve analyses, unit weight, moisture content, and pocket penetrometer and unconfined compressive strength testing. Additional geotechnical exploration and testing will be warranted at structural locations to provide information for the final design of critical structures/features.

Although the boring and HA information indicates that the dewatering effort should not be significant for the relatively shallow excavations and structures, in the event dewatering is required, dewatering methods will need to be investigated for applicability to the project.

Design allowable bearing capacity for the new pump station structure. These types of structure are usually founded on driven piles to support the structural load and to increase the bearing capacity.

Additional geotechnical exploration and testing will be required along the proposed setback alignment to support completion of an underseepage analyses along this embankment. This analysis should ensure that the project can function with the design water levels and differential heads in place without creating excess vertical gradients through the surficial fine-grained blanket**.**

Approval for the borrow area designations by the Geotechnical engineer. Borrow areas must be monitored during construction to ensure that all borrowed soil is suitable for berm and setback construction and are in compliance with the general restrictions stipulated by the Geotechnical engineer.

Prior to placement of any grade-raise fill, all vegetation should be stripped from the surface of the proposed embankment alignments to a minimum depth of 6 inches, and should be either disposed of off-site or stockpiled for reuse as turfing material following grading activities. Prior to fill placement for new embankment construction, the newly stripped foundation soils should be verified to be stable under the applied loads of construction traffic. Any areas that exhibit excessive rutting or pumping should be over excavated of soft or disturbed materials, and the spoils should be moisture conditioned and recompacted to at least 90% of the material's standard Proctor density (ASTM D698) within the range of optimum moisture -2% to +4%.

Fill soils should be placed in maximum 8 inch loose lifts and compacted by not less than four complete coverages of a tamper-type roller or crawler-type tractor, or by not less than two complete coverages of a rubber-tired roller. The sheep feet shall be 7 to 9 inches in clear projection from the cylindrical surface of the roller and shall have a face area of not less than 5 nor more than 10 square inches. The weight of the roller when fully loaded shall not be less than 4,000 pounds per linear foot of drum length and when empty shall not be more than 2,500 pounds per foot of drum length.

After embankments have been constructed to finished grades, the slopes and crowns should be seeded and turfed. If the spoils from stripping surface vegetation are stockpiled, they may be incorporated into the upper 6 inches of embankment fill to aid in returfing. It is permissible for the spoils to be tracked for compaction by an acceptable crawler-type tractor, with no compaction requirement for the upper 6 inches of turfing fill. Turfing is the only vegetation permitted on the embankments (as an erosion control measure

References

Love, C.L. 1997. *Soil Surveys of Pike County, Missouri.* United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Missouri Agricultural Experiment Stations.

Piskin, K. and R.E. Bergstrom. 1975. *Glacial Drift in Illinois: Thickness and Character.* Illinois State Geologic Survey. Urbana, Illinois. 35p.

Willman, H.B., E. Atherton, T.C. Buschback, C. Collinson, J.C. Frye, M.E. Hopkins, J.A. Lineback, and J.A. Simon. 1975. *Handbook of Illinois Stratigraphy*. Illinois State Geological Survey Bulletin 95: 1-261.

Willman, H.B., and J.C. Frye. 1970. *Pleistocene Stratigraphy of Illinois.* Illinois State Geological Survey Bulletin 94: 1-204.

SCI ENGINEERING, INC.
CONSULTANTS IN DEVELOPMENT, DESIGN AND CONSTRUCTION
GEOTECHNICAL
ENVIRONMENTAL
NATURAL RESOURCES
CULTURAL RESOURCES
CONSTRUCTION SERVICES

June 30, 2009

Mr. Eric Held
Ducks Unlimited
201 North Belle, Room 109
Shawnee, Oklahoma 74801

RE: Geotechnical Report
Ducks Unlimited – B.K. Leach and Clarence Cannon Borrow Areas
Lincoln and Pike Counties, Missouri
SCI No. 2009-0198.10

Dear Mr. Held:

At your request, SCI Engineering, Inc. (SCI) performed a geotechnical study at the referenced sites. The purpose of our geotechnical services was to explore the subsurface conditions and develop design and construction recommendations for the earth-related phases of the project. Our services were provided in general accordance with our proposals dated March 30, and June 9, 2009.

SITE AND PROJECT DESCRIPTION

Borrow areas are planned for sites located within the B.K. Leach Conservation Area in Lincoln County, Missouri and the Clarence Cannon National Wildlife Refuge in Pike County, Missouri. Both sites are located within the Mississippi River floodplain. The location of the sites is shown on USGS Topographic Maps enclosed as Figures 1 and 2, *Vicinity and Topographic Map*. We understand that approximately 1½ feet of material will be removed from the sites to create a wetland. The sites are comprised of relatively level farm fields. A pump station is planned along the riverside toe of the levee at the B.K Leach location. Additionally, a Blue Handle Structure, consisting of a 60-inch reinforced concrete pipe (RCP), gate and headwall, is planned for the Clarence Cannon location. The areas of the proposed construction are shown on the *Site Plans*, Figures 3 and 4.

We have not reviewed, nor are we aware of, any previous studies on this specific site, by SCI or others, that would affect the preparation of this report.

SUBSURFACE EXPLORATION

Seventeen hand-augered borings, designated HA-1 through HA-17, and two conventional borings, designated B-1 and B-2 were augered or drilled at the approximate locations shown on the *Site Plans*. These locations were selected and surveyed by Ducks Unlimited. Approximate ground surface elevations at the borings are interpolated from the most recent USGS map, dated 1993. Detailed information regarding the nature and thickness of the soils encountered, and the results of the field sampling and laboratory testing are shown on the enclosed Hand Auger and Boring Logs. A Hand Auger and Boring Log Legend and Nomenclature Sheet, to aid with interpretation of the logs, is also enclosed. Drilling was delayed due to high river levels and flooding of the fields.

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B.K. Leach Conservation Area

This site is divided into two portions which are the Sherman Tract in the west and the Old Area in the east. Nine hand-augered borings, HA-1 through HA-9, as well as B-1 were drilled within the Old Area. Alternating layers of high plastic clay (CH in accordance with the Unified Soil Classification System and ASTM D 2487), low plastic silty clay (CL), silt (ML), and sand (SC, SM) were encountered. In B-4, B-5, B-7, and B-8 high plastic clay was present to a depth of 3 feet below the proposed borrow area grade.

The pump station boring, B-1, encountered existing fill material consisting of soft low plastic silty clay to a depth of 3 feet. Soft to medium stiff high plastic clay was encountered below the fill to a depth of 8 feet, where very loose to loose sand was encountered to the depth of boring termination, at 15 feet. Borings HA-10 through HA-12 were drilled within the Sherman Tract and encountered high plastic clay from the ground surface to the terminating depths of the hand augers, at 6 feet. As an exception, sand (SP) was encountered at a depth of 4½ feet in HA-10.

Based on the Soil Survey of Lincoln County, Missouri, issued in March 1990, the site soils consist of the Portage clay, Carlow silty clay loam, and the Kampville silt loam. The soils are typically dark gray to brown mottled clay and silt or silty clay loam. These soils are typically found in very poorly drained to somewhat poorly drained areas which are occasionally flooded. In general, the soils encountered in our borings and the information known about the site were consistent with the soil survey information.

Groundwater was observed at depths of 2 to 3½ feet during the exploration within the Old Area, with the exception of HA-6, where groundwater was not observed and B-1, where groundwater was observed at a depth of 8 feet. Groundwater was observed in the Sherman Tract at depths of 5 feet in HA-10 and 5½ feet in HA-12. Groundwater will likely be encountered during excavation. It should be noted that the groundwater level is subject to seasonal and climatic variations, and other factors; and may be present at different locations and depths in the future. Groundwater will likely correlate to the levels within the Mississippi River

Clarence Cannon National Wildlife Refuge

Borings HA-13 through HA-17, as well as B-2 were drilled at this site. The hand augers encountered high plastic clay (CH) from the ground surface to their terminating depth at 6 feet. The Blue Handle Structure boring, B-2, encountered 3 feet of existing fill that was associated with the roadway and berm. The fill material consisted of medium stiff high plastic clay with trace organics. Medium stiff to stiff high plastic clay with varying amounts of sand was encountered below the fill to a depth of 17 feet, where medium dense sand (SP) was encountered to the depths of boring termination, at 20 feet.

Based on the Soil Survey of Pike County, Missouri, issued in July 1997, the site soils consist of the Chequest silty clay loam and Carlow silty clay. The soils are typically dark gray to brownish gray mottled firm clay to friable silty clay loam. These soils are typically found in very poorly drained areas which are occasionally flooded. In general, the soils encountered and the information known about the site were consistent with the soil survey information.

Groundwater was not observed in the shallow hand-augered borings; however, it was observed at a depth of 14 feet in B-2. We do not anticipate that groundwater will be encountered during excavation for the borrow areas; however, it may be encountered during the excavation for the Blue Handle Structure, depending on its depth.

DISCUSSION AND RECOMMENDATIONS

Borrow Excavation

Based on the results of our exploration, it appears that the high plastic materials that comprise the existing floodplain within the B.K. Leach – Sherman Tract and the Clarence Cannon site are appropriate for containment of the water when the area is flooded. However, pervious soils were encountered near the proposed borrow area grade in the B.K. Leach – Old Area. In this area, it may be necessary to excavate and replace the pervious soils with high plastic clay, possibly from the Sherman Tract, to a depth of 3 feet below the proposed borrow area grade. We typically recommend at least 3 feet of high plastic clay for undisturbed clay liners where water bodies are created. A liner of this thickness reduces the possibility that animals, such as muskrats and crawdads, burrow through the liner and create internal drainage issues. Secondly, the potential for inclusion of sandy layers from the inherent variation of flood plain deposits is less likely. As an alternative, and if the risk is acceptable to the owner, a lesser amount of high plastic clay, not less than 18 inches, could be acceptable, understanding that there is a possibility of drainage from the burrowing animals. It should be noted, however, the overexcavation may not be feasible unless performed during a drier time of the year due to the shallow depth of groundwater.

Within questionable areas, such as the Old Area, SCI should be retained to probe the soils, after cutting, to observe the depth of high plastic clay; these holes should be backfilled with bentonite slurry to ensure the retention of water after the area is flooded. Where the clay thickness is less than the design value, the pervious soils should be undercut and replaced with high plastic clay from the cut areas. The replacement clay should be compacted in accordance with our recommendations below.

Site Development

Replacement fill for the borrow areas, should be placed in maximum 8-inch-thick loose lifts and mechanically compacted to at least 90 percent of its modified Proctor maximum dry density (ASTM D 1557). We recommend that any fill placed have a liquid limit greater than 50 and a plasticity index greater than 20 in order to hold water when the area is flooded.

Soft soils will be encountered for this site. It is likely that soft materials extend to a depth of several feet beneath the bottom of the proposed excavation. Based on our experience, clay soils can be excavated with conventional scrapers down to about 4 feet above the groundwater table. Challengers, or low pressure ground equipment can typically excavate within about 2 feet of the water table. At this point, a trackhoe, working from a bench at an elevation a few feet above the groundwater level, can start at one end of the proposed flooded area and excavate down to the planned bed, digging progressively from one end to the other. Based on our knowledge of the site, it appears that a trackhoe working from a bench will be required within the B.K. Leach - Old Area, while scrapers may be feasible for the other sites.

Pump Station and Blue Handle Structure

Excavation below the water table is likely for both the pump station and the Blue Handle structure, depending on their depths; therefore, we anticipate that soft soils will be encountered and that pumping of groundwater or dewatering will be required. Additionally, these conditions could lead to instability of the excavations. Temporary shoring may be needed to maintain a stable excavation.

Excavation Bracing Requirements

In the *Federal Register*, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P." This document was issued to provide for the safety of workers entering excavations, including utility trenches, basements, footings, and others. All operations should be performed under the supervision of qualified site personnel in accordance with OSHA regulations.

LIMITATIONS

The recommendations provided herein are for the exclusive use of our client. It is imperative that SCI be contacted by any third-party interests to evaluate the applicability of this report relative to use by anyone other than our client. Our recommendations are specific only to the project described, and are not meant to supercede more stringent requirements of local ordinances. They are based on subsurface information obtained at seventeen specific widely-spaced, hand-augered boring locations and two conventional borings within the project area; our understanding of the project; and geotechnical engineering practice consistent with the standard of care. No other warranty is expressed or implied. SCI should be contacted if conditions encountered are not consistent with those described.

We appreciate the opportunity to have worked with you on this project. If you have any questions or if we can be of further assistance, please call.

Respectfully,

SCI ENGINEERING, INC.

STATE OF MISSOURI
MARK A. HARMS
NUMBER
E-23568
REGISTERED PROFESSIONAL ENGINEER

Timothy J. Barrett, E.I.
Staff Engineer

Mark A. Harms, P.E.
President

TJB/MAH/rah

Enclosures
- Figures 1 and 2 - Vicinity and Topographic Maps
- Figures 3 and 4 - Site Plans
- Boring Log Legend and Nomenclature
- Boring Logs
- Hand Auger Log Legend and Nomenclature
- Hand Auger Logs

Two additional copies submitted.

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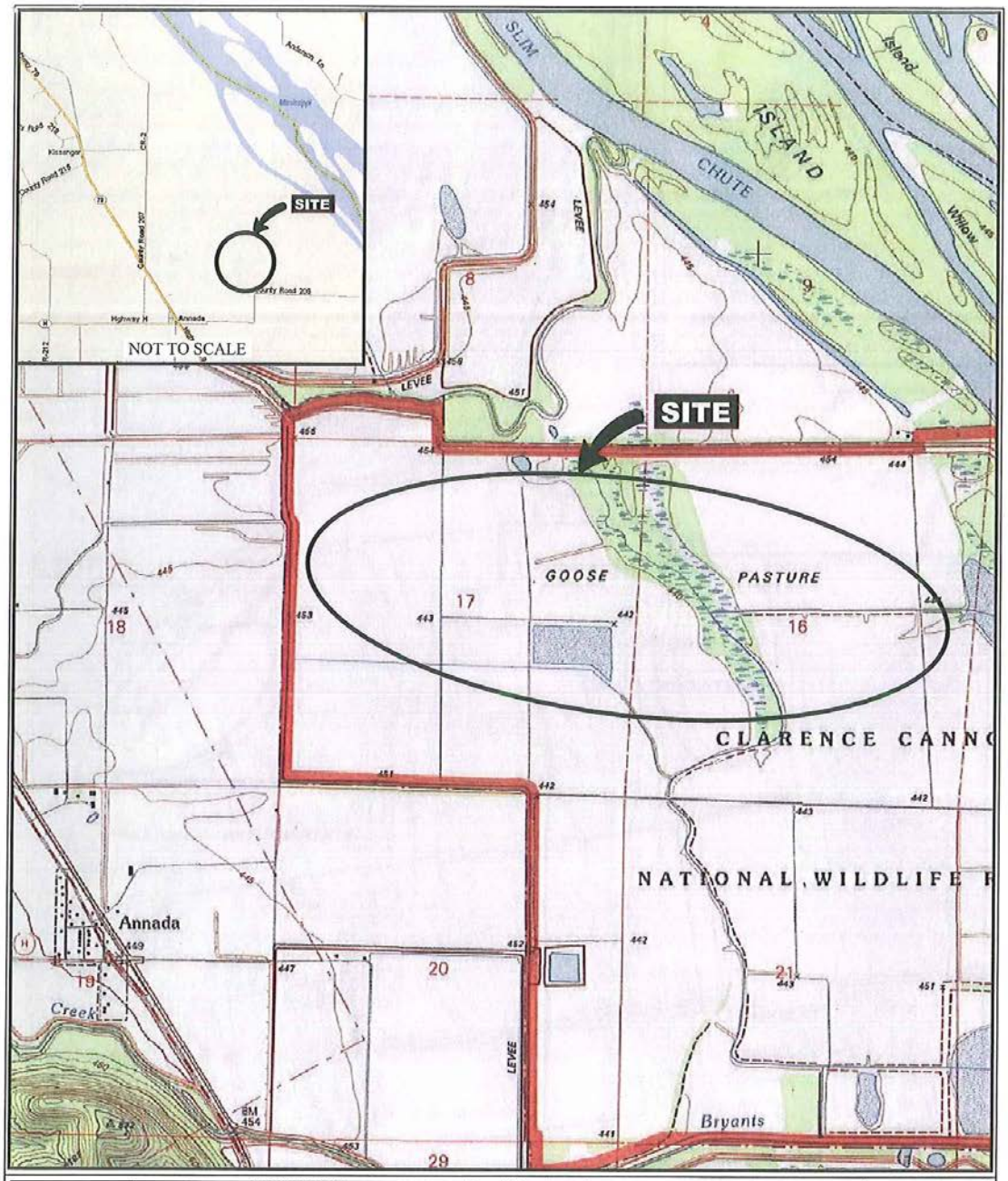
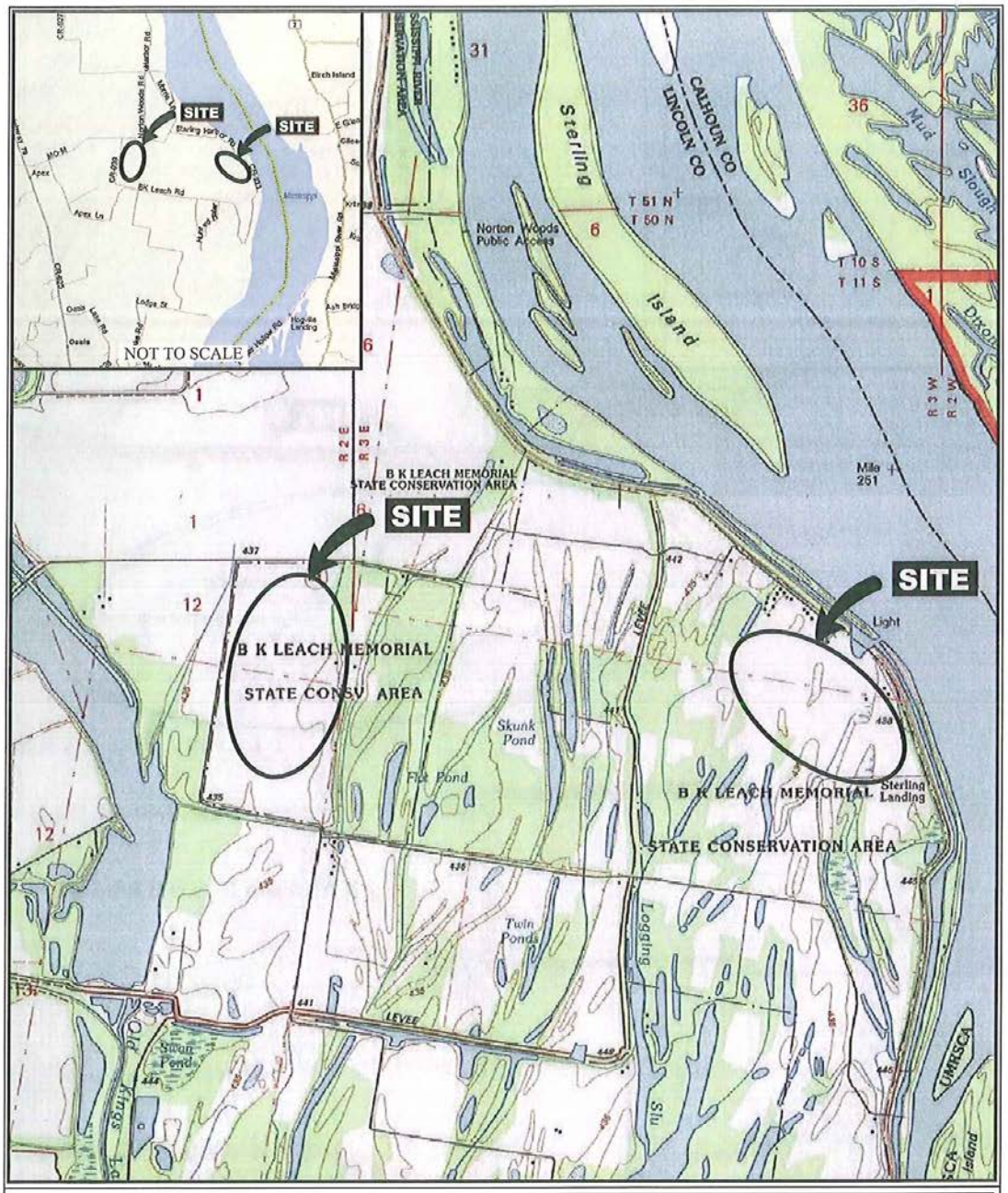


PROJECT NAME DUCK UNLIMITED - B.K. LEACH BORROW AREAS PIKE COUNTY, MISSOURI				General Notes/Legend USGS TOPOGRAPHIC MAP ANNADA, MISSOURI-ILLINOIS QUADRANGLE DATED 1993 5' CONTOURS
VICINITY AND TOPOGRAPHIC MAP				
DRAWN BY	DKM	DATE	JOB NUMBER	
CHECKED BY	TJB	07/2009	2009-0198.10	MICROSOFT STREETS AND TRIPS 2007

N W E S

SCALE 1" = 2000'

FIGURE 1



SCI	PROJECT NAME DUCK UNLIMITED - CLARENCE CANNON BORROW AREAS LINCOLN COUNTY, MISSOURI		General Notes/Legend USGS TOPOGRAPHIC MAP FOLEY, MISSOURI-ILLINOIS QUADRANGLE HAMBURG, MISSOURI-ILLINOIS QUADRANGLE DATED 1993 5' CONTOURS	N W E S
	VICINITY AND TOPOGRAPHIC MAP			SCALE 1" = 2000'
	DRAWN BY DKM CHECKED BY TJB	DATE 07/2009	JOB NUMBER 2009-0198.10	MICROSOFT STREETS AND TRIPS 2007	FIGURE 1

SCALE 1" = 800'	**PROJECT NAME** DUCK UNLIMITED - B.K. LEACH BORROW AREAS PIKE COUNTY, MISSOURI	**General Notes/Legend** INDICATES APPROXIMATE SOIL BORING LOCATION INDICATES APPROXIMATE HAND AUGER LOCATIONS AERIAL PHOTOGRAPH OBTAINED FROM http://earth.google.com/ DIMENSIONS AND LOCATIONS ARE APPROXIMATE; ACTUAL MAY VARY. DRAWING SHALL NOT BE USED OUTSIDE THE CONTEXT OF THE REPORT FOR WHICH IT WAS GENERATED.
JOB NUMBER 2009-0198.10	SITE PLAN	
DATE 07/2009		
DRAWN BY DKM		
CHECKED BY TJB		
FIGURE 3		

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BORING LOG LEGEND AND NOMENCLATURE

Depth is in feet below ground surface. **Elevation** is in feet mean sea level, site datum, or as otherwise noted.

Sample Type

- **SS** Split-spoon sample, disturbed, obtained by driving a 2-inch-O.D. split-spoon sampler (ASTM D 1586).
- **NX** Diamond core bit, nominal 2-inch-diameter rock sample (ASTM D 2113).
- **ST** Thin-walled (Shelby) tube sample, relatively undisturbed, obtained by pushing a 3-inch-diameter, tube (ASTM D 1587).
- **CS** Continuous sample tube system, relatively undisturbed, obtained by split-barrel sampler in conjunction with auger advancement.
- **SV** Shear vane, field test to determine strength of cohesive soil by pushing or driving a 2-inch-diameter vane, and then shearing by torquing soil in existing and remolded states (ASTM D 2573).
- **BS** Bag sample, disturbed, obtained from cuttings.

Recovery is expressed as a ratio of the length recovered to the total length pushed, driven, cored.

Blows Numbers indicate blows per 6 inches of split-spoon sampler penetration when driven with a 140-pound hammer falling freely 30 inches. The number of total blows obtained for the second and third 6-inch increments is the N value (Standard Penetration Test or SPT) in blows per foot (ASTM D 1586). Practical refusal is considered to be 50 or more blows without achieving 6 inches of penetration, and is expressed as a ratio of 50 to actual penetration, e.g., 50/2 (50 blows for 2 inches).

For analysis, the N value is used when obtained by a cathead and rope system. When obtained by an automatic hammer, the N value may be increased by a factor of 1.3.

Vane Shear Strength is expressed as the peak strength (existing state) / the residual strength (remolded state).

Description indicates soil constituents and other classification characteristics (ASTM D 2488) and the Unified Soil Classification (ASTM D 2487). Secondary soil constituents (expressed as a percentage) are described as follows:

Trace	0 to 10
Some	10 to 35
By Modifier	35 to 50

Stratigraphic Breaks may be observed or interpreted, and are indicated by a dashed line. Transition between described materials may be gradual.

Laboratory Test Results

- Natural moisture content (ASTM D 2216) in percent.
- Dry density in pounds per cubic foot (pcf).
- Hand penetrometer value of apparently intact cohesive sample in kips per square foot (ksf).
- Unconfined compressive strength (ASTM D 2166) in kips per square foot (ksf).
- Liquid and Plastic Limits (ASTM D 4318) in percent.

RQD (Rock Quality Designation) is the ratio between the total length of core segments 4 inches or more in length and the total length of core drilled. RQD (expressed as a percentage) indicates insitu rock quality as follows:

Excellent	90 to 100
Good	75 to 90
Fair	50 to 75
Poor	25 to 50
Very Poor	0 to 25

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** B-1
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER Midwest Drilling, Inc. **HAMMER** Automatic **PROJECT NO.** 2009-0198.10
EQUIPMENT CME-750 w/CFA **ELEVATION** 435± **DATE DRILLED** 06/07/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
					FILL: Gray and brown, low plastic, clay, trace fine sand									
	1	SS		1 2 3				23		1.5				
3					CLAY (CH): Brownish gray, high plastic, clay									432
	2	SS		2 2 3				40		1.5				
6														429
	3	SS		2 3 3				34		3.0				
					SAND (SP): Brown and gray, fine sand									
9	4	SS		1 1 2				26						426
12														423
	5	SS		3 4 6				25						
15					Boring terminated at 15 feet.									420
18														417

WATER LEVEL:
- ____ NONE OBSERVED WHILE DRILLING
- 8.0 ft WHILE DRILLING
- ____ ft ____ HRS AFTER DRILLING
- ____ ft ____ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** B-2
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER Midwest Drilling, Inc. **HAMMER** Automatic **PROJECT NO.** 2009-0198.10
EQUIPMENT CME-750 w/CFA **ELEVATION** 443± **DATE DRILLED** 06/20/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
					FILL: Brown, high plastic clay, trace organics									
	1	SS		3 4 5				25		5.0				441
3					CLAY (CH): Brownish gray, high plastic									
	2	SS		3 3 5				30		4.0				438
6					Becomes brown and gray									
	3	SS		3 5 5				26		5.0				435
9	4	SS		3 4 5	Some fine sand			23		6.0				432
12					SANDY CLAY (CH): Brown and gray, high plastic, sand is fine									
	5	SS		3 5 6				23		1.0				429
15														
					SAND (SP): Brown and gray, fine									426
18														
	6	SS		3 5 7										

Boring terminated at 20 feet.

WATER LEVEL:

		NONE OBSERVED WHILE DRILLING
14.0	ft	WHILE DRILLING
	ft	HRS AFTER DRILLING
	ft	DAYS AFTER DRILLING

REMARKS:

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HAND AUGER LOG

LEGEND AND NOMENCLATURE

Items shown in Hand Auger Logs refer to the following:
(Where shown in parenthesis, sampling and testing were performed in general accordance with applicable ASTM standard methods or practices.)

1. **Depth** - Depth below ground surface (feet).

2. **Field Sample/Test** - Types designated by letters.

   DT - Drive tube sample, relatively undisturbed, obtained by driving 2-inch diameter, thin-walled tube (ASTM D 2937).

   BS - Bag sample, disturbed.

   JS - Jar sample, disturbed.

   PP - Pocket penetrometer: approximation of shear strength of unconfirmed compression test (ksf – kips per square foot).

   SV - Shear vane field test to measure strength of cohesive soil by pushing or driving a 19 or 33 mm diameter vane, and then shearing by torquing soil in existing and remolded states (ASTM D 4648).

   Vane Shear Strength - Shear strength of soil expressed as the peak strength (existing state/residential strength (remolded state)

3. **Description** - Description according to the Unified Soil Classification: Description indicates soil constituents and other classification characteristics (ASTM D 2488). A line indicates approximate location of stratigraphic change between soil types and the transition may be gradual.

4. **Laboratory Test Results**

   - Natural moisture content (ASTM D 2216).
   - Dry density in pounds per cubic foot (pcf).
   - Unconfined compressive strength (ASTM D 2166) in kips per square foot (ksf).
   - Liquid limit (ASTM D 4318) in percent.
   - Plastic limit (ASTM D 4318) in percent.

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
LOCATION Lincoln and Pike Counties, Missouri
DRILLER SCI Engineering Inc. HAMMER n/a
EQUIPMENT Hand Auger ELEVATION 435±

BORING NUMBER HA-1
SHEET 1 of 1
PROJECT NO. 2009-0198.10
DATE DRILLED 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	RECOVERY (in/in)	BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			SILTY CLAY (CL): Brownish gray, low plastic			21						
	2	HA			CLAY (CH): Gray, high plastic			30						
	3	HA						33						
3	4	HA			SILT (ML): Gray, low plastic			32						432
	5	HA			SILTY CLAY (CL): Gray, low plastic, trace sand			33						
	6	HA						31						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:
_____ NONE OBSERVED WHILE DRILLING
2.0 ft WHILE DRILLING
_____ ft ___ HRS AFTER DRILLING
_____ ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
LOCATION Lincoln and Pike Counties, Missouri
DRILLER SCI Engineering Inc. HAMMER n/a
EQUIPMENT Hand Auger ELEVATION 435±
BORING NUMBER HA-2
SHEET 1 of 1
PROJECT NO. 2009-0198.10
DATE DRILLED 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			27						
	2	HA			SILTY CLAY (CL): Gray, low plastic			38						
	3	HA			SILT (ML): gray, low plastic			33						
3	4	HA			SILTY CLAY (CL): Brownish gray, low plastic			36						432
	5	HA						36						
	6	HA						35				37	14	
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

	NONE OBSERVED WHILE DRILLING
2.0	ft WHILE DRILLING
	ft ___ HRS AFTER DRILLING
	ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
LOCATION Lincoln and Pike Counties, Missouri
DRILLER SCI Engineering Inc. HAMMER n/a
EQUIPMENT Hand Auger ELEVATION 435±

BORING NUMBER HA-3
SHEET 1 of 1
PROJECT NO. 2009-0198.10
DATE DRILLED 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	RECOVERY (in/in)	BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH) Brown and gray, high plastic			22						
	2	HA						31						
	3	HA			CLAYEY SAND (SC): Brown and gray, fine. Low plastic, clay			23						
3	4	HA			SILTY CLAY (CL): Brownish gray, low plastic, trace fine sand			34						432
	5	HA			SILT (ML): Brown and Gray, trace fine sand			33						
	6	HA						33						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

	NONE OBSERVED WHILE DRILLING
3.0	ft WHILE DRILLING
	ft ___ HRS AFTER DRILLING
	ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-4
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			26						
	2	HA			Becomes brownish gray			29						
	3	HA						29						
3	4	HA						29						432
	5	HA			SILTY CLAY (CL/CH): Brownish gray, medium plastic Trace fine sand			33				45	22	
	6	HA			SILT (ML): Brown			34						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:
NONE OBSERVED WHILE DRILLING
2.0 ft WHILE DRILLING
ft ___ HRS AFTER DRILLING
ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-5
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			SAND (SP): Brown and gray			3						
	2	HA			CLAY (CH): Grayish brown, high plastic			30						
	3	HA						30						
3	4	HA						29						432
	5	HA			Trace fine sand			28						
	6	HA			SILTY CLAY (CL): Grayish brown, low plastic			31						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

		NONE OBSERVED WHILE DRILLING
3.5	ft	WHILE DRILLING
	ft	HRS AFTER DRILLING
	ft	DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-6
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
					4" Topsoil									
	1	HA			CLAY (CH): Brown, high plastic			28						
	2	HA						26						
					SILTY CLAY (CL): Brown, low plastic									
	3	HA						27						
3					SILTY CLAY (CL-ML) Grayish Brown, low plastic, trace sand, high plastic seam									432
	4	HA						28						
	5	HA						29				27	7	
					SILTY SAND (SM): Brown, fine. Low plastic, clay									
	6	HA						30						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
LOCATION Lincoln and Pike Counties, Missouri
DRILLER SCI Engineering Inc. HAMMER n/a
EQUIPMENT Hand Auger ELEVATION 435±

BORING NUMBER HA-7
SHEET 1 of 1
PROJECT NO. 2009-0198.10
DATE DRILLED 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
					2" Topsoil									
	1	HA			CLAY (CH): Brown, high plastic, trace roots			30						
	2	HA			No roots			29						
	3	HA						20						
3	4	HA			SANDY CLAY (CH): Brown and gray, high plastic. Fine sand			27						432
	5	HA						32						
	6	HA						33						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
BORING NUMBER HA-8
LOCATION Lincoln and Pike Counties, Missouri
SHEET 1 of 1
DRILLER SCI Engineering Inc.
HAMMER n/a
PROJECT NO. 2009-0198.10
EQUIPMENT Hand Auger
ELEVATION 435±
DATE DRILLED 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
					1" Topsoil									
	1	HA			CLAY (CH): Gray, high plastic			24						
	2	HA						37						
	3	HA			Becomes grayish brown			33						
3	4	HA						33						432
	5	HA			SANDY SILT (ML): Brown and gray, low plastic. Fine sand			27						
	6	HA						28						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

	NONE OBSERVED WHILE DRILLING
2.0	ft WHILE DRILLING
	ft ___ HRS AFTER DRILLING
	ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-9
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Brown, high plastic			23						
	2	HA						30						
	3	HA						29						
3	4	HA			SANDY CLAY (CL): Grayish brown, low plastic. Fine sand			26						432
	5	HA						29						
	6	HA			SILT (ML): Brown and gray, low plastic, some fine sand			30						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

	NONE OBSERVED WHILE DRILLING
3.0	ft WHILE DRILLING
	ft ___ HRS AFTER DRILLING
	ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-10
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Brownish gray, high plastic, trace roots			36						
	2	HA			No roots			31						
	3	HA						24						
3	4	HA			SANDY CLAY (CH): Brown and gray, high plastic. Fine sand			18						432
	5	HA			SAND (SP): Brown, fine			17						
	6	HA						25						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:
NONE OBSERVED WHILE DRILLING
5.0 ft WHILE DRILLING
ft ___ HRS AFTER DRILLING
ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-11
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/04/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Brown and gray, high plastic			31						
	2	HA						32						
	3	HA			Becomes gray			31						
3	4	HA			Becomes brownish gray			27				90	55	432
	5	HA						28						
	6	HA						28						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
___ ft WHILE DRILLING
___ ft ___ HRS AFTER DRILLING
___ ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-12
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 435± **DATE DRILLED** 06/08/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Brown and gray, high plastic			32						
	2	HA						30						
					Trace sand									
	3	HA						25						
3														432
	4	HA						24						
	5	HA						26						
	6	HA						27						
6					Boring terminated at 6 feet.									429
9														426
12														423
15														420
18														417

WATER LEVEL:

	NONE OBSERVED WHILE DRILLING
5.5	ft WHILE DRILLING
	ft ___ HRS AFTER DRILLING
	ft ___ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-13
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 440± **DATE DRILLED** 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			38						
	2	HA						39						438
3	3	HA						37						
	4	HA						38						
	5	HA			Becomes brownish gray			36						435
6	6	HA						31						
					Boring terminated at 6 feet.									
														432
9														
														429
12														
														426
15														
														423
18														

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
BORING NUMBER HA-14
LOCATION Lincoln and Pike Counties, Missouri
SHEET 1 of 1
DRILLER SCI Engineering Inc.
HAMMER n/a
PROJECT NO. 2009-0198.10
EQUIPMENT Hand Auger
ELEVATION 440±
DATE DRILLED 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Brown, high plastic			43						
	2	HA			Becomes gray			42						438
3	3	HA						44						
	4	HA			Becomes brownish gray			42						
	5	HA						40						435
6	6	HA						39						
					Boring terminated at 6 feet.									432
9														429
12														426
15														423
18														

WATER LEVEL:

X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-15
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 440± **DATE DRILLED** 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			39						
	2	HA						40						438
3	3	HA						40						
	4	HA						39						
	5	HA						39						435
6	6	HA						40				85	53	
					Boring terminated at 6 feet.									
														432
9														
														429
12														
														426
15														
														423
18														

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
____ ft WHILE DRILLING
____ ft ____ HRS AFTER DRILLING
____ ft ____ DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas **BORING NUMBER** HA-16
LOCATION Lincoln and Pike Counties, Missouri **SHEET** 1 **of** 1
DRILLER SCI Engineering Inc. **HAMMER** n/a **PROJECT NO.** 2009-0198.10
EQUIPMENT Hand Auger **ELEVATION** 440 **DATE DRILLED** 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			43						
	2	HA						45						438
3	3	HA						47				71	43	
	4	HA						47						
	5	HA						40						435
6	6	HA						36						
					Boring terminated at 6 feet.									
														432
9														
														429
12														
														426
15														
														423
18														

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

BORING LOG

PROJECT Ducks Unlimited - B.K. Leach/Clarence Cannon Borrow Areas
LOCATION Lincoln and Pike Counties, Missouri
DRILLER SCI Engineering Inc. HAMMER n/a
EQUIPMENT Hand Auger ELEVATION 440±

BORING NUMBER HA-17
SHEET 1 of 1
PROJECT NO. 2009-0198.10
DATE DRILLED 06/05/09

DEPTH (ft)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE RECOVERY (in/in)	SAMPLE BLOWS (per 6 in)	DESCRIPTION (UNIFIED SOIL CLASSIFICATION)	GRAPHIC	SEE REMARK NO.	LABORATORY TEST RESULTS: MOISTURE CONTENT (%)	DRY DENSITY (pcf)	HAND PENETROMETER (ksf)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	LIQUID LIMIT	PLASTICITY INDEX	ELEVATION (ft)
	1	HA			CLAY (CH): Gray, high plastic			41						
	2	HA						39						438
3	3	HA						39						
	4	HA						39						
	5	HA						36						435
6	6	HA						33						
					Boring terminated at 6 feet.									
														432
9														
														429
12														
														426
15														
														423
18														

WATER LEVEL:
X NONE OBSERVED WHILE DRILLING
ft WHILE DRILLING
ft HRS AFTER DRILLING
ft DAYS AFTER DRILLING

REMARKS:

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following suggestions and observations are offered to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical study is unique, each geotechnical report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical report without first conferring with the geotechnical engineer who prepared it. *And no one—not even you*—should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Report Is Based on a Unique Set of Project-specific Factors

Geotechnical engineers consider a number of unique project-specific factors when establishing the scope of a study. Typical factors include the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and its configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical report include those that affect the:

- function and character of the proposed structure,
- elevation, configuration, location, orientation, or loading of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical report whose adequacy may have been affected by the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions *only* at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective way of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Report is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

The preceding paragraphs are based on information provided by ASFE.

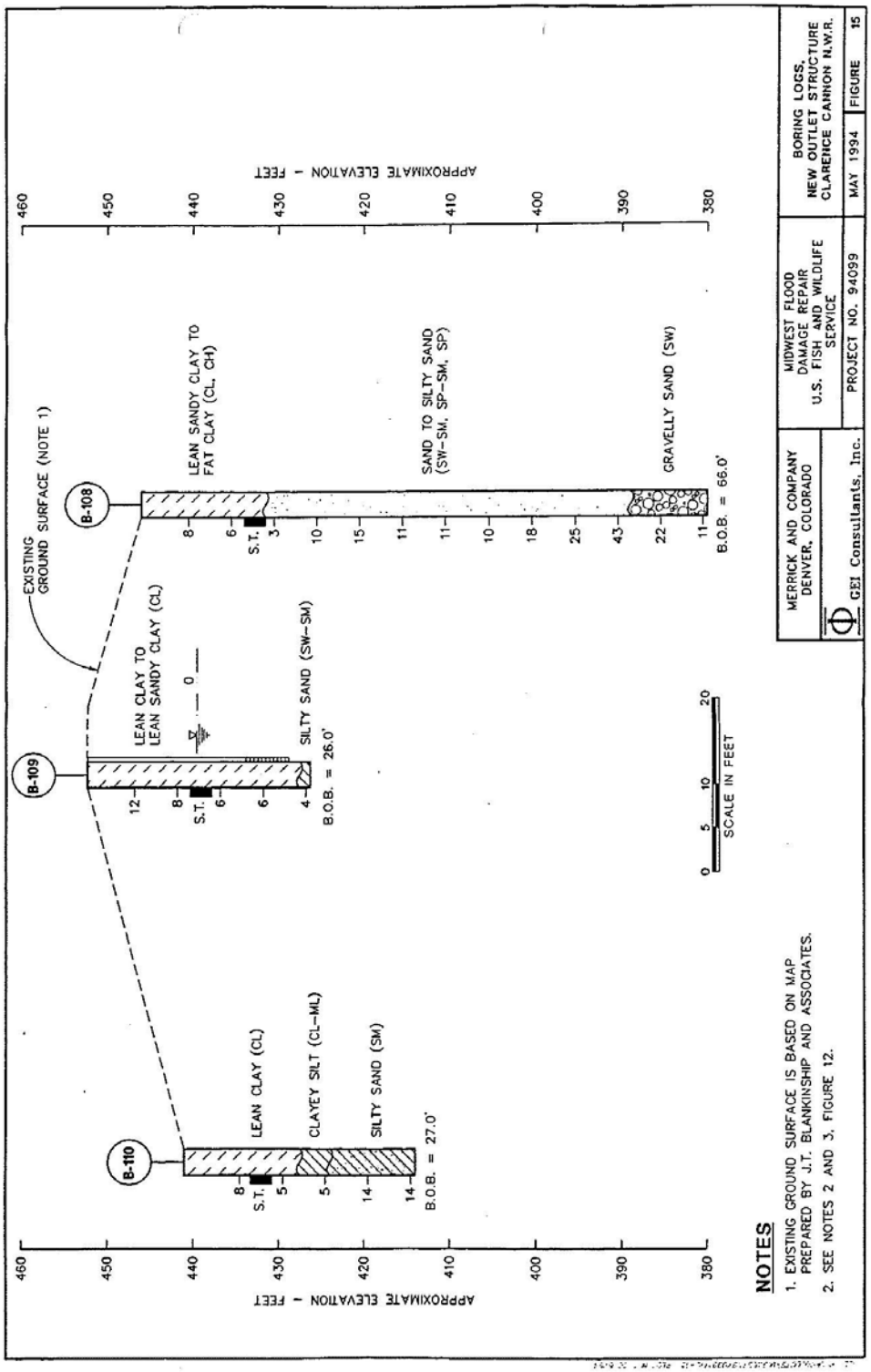
ASFE

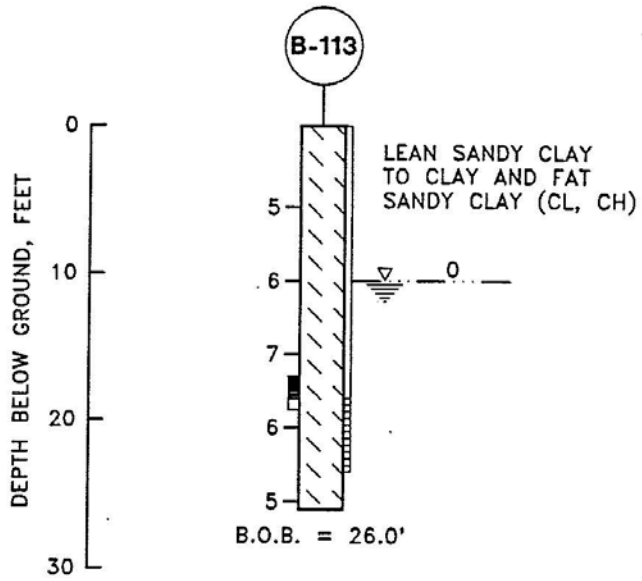
8811 Colesville Road, Suite G106
Silver Spring, Maryland 20910
Telephone 301-565-2733 Facsimile 301-589-2017
Email info@asfe.org www.asfe.org

LAT:39°16'49"
LON:-90°48'54"
LAT:39°16'33"
LON:-90°48'47"
LAT:39°16'45"
LON:-90°48'17"
LAT:39°16'22"
LON:-90°48'15"
LAT:39°16'33"
LON:-90°47'58"
CLARENCE CANON NWR
MO-51-1

APPENDIX

DETAILED SOILS BORING LOGS
AND
LABORATORY TEST DATA


APPROXIMATE ELEVATION - FEET
460
450
440
430
420
410
400
390
380
EXISTING GROUND SURFACE (NOTE 1)
B-108
LEAN SANDY CLAY TO FAT CLAY (CL, CH)
SAND TO SILTY SAND (SW-SM, SP-SM, SP)
GRAVELLY SAND (SW)
8
6
3
10
15
11
11
10
18
25
43
22
11
S.T.
B.O.B. = 66.0'
B-109
LEAN CLAY TO LEAN SANDY CLAY (CL)
SILTY SAND (SW-SM)
12
8
6
6
4
S.T.
B.O.B. = 26.0'
B-110
LEAN CLAY (CL)
CLAYEY SILT (CL-ML)
SILTY SAND (SM)
8
5
5
14
14
S.T.
B.O.B. = 27.0'
0
5
10
20
SCALE IN FEET
NOTES
1. EXISTING GROUND SURFACE IS BASED ON MAP PREPARED BY J.T. BLANKINSHIP AND ASSOCIATES.
2. SEE NOTES 2 AND 3, FIGURE 12.
MERRICK AND COMPANY
DENVER, COLORADO
GEI Consultants, Inc.
MIDWEST FLOOD DAMAGE REPAIR
U.S. FISH AND WILDLIFE SERVICE
PROJECT NO. 94099
BORING LOGS,
NEW OUTLET STRUCTURE
CLARENCE CANNON N.W.R.
MAY 1994
FIGURE 15

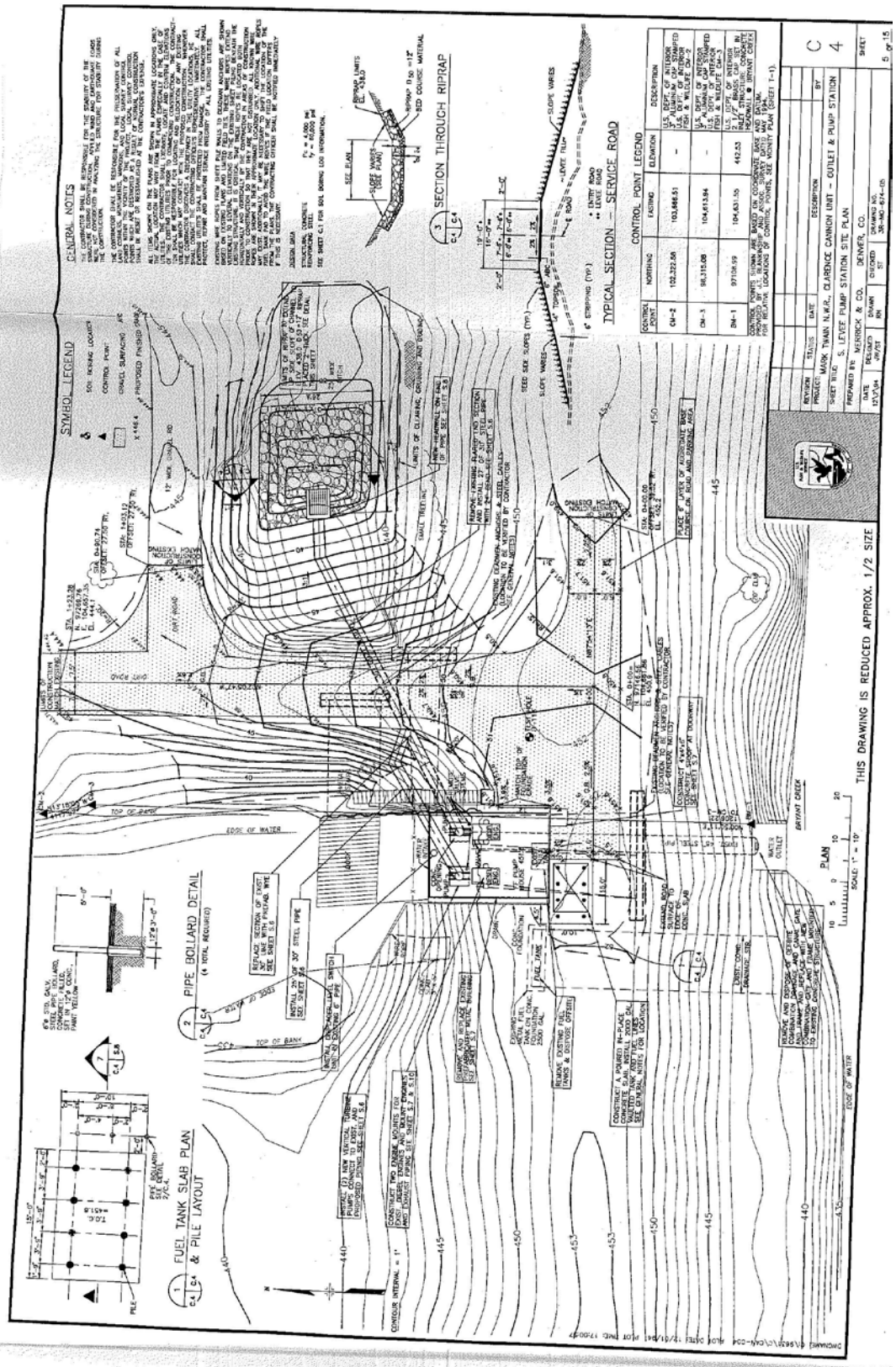


NOTES

1. SEE NOTES 1 AND 2, FIGURE 15.

MERRICK AND COMPANY DENVER, COLORADO	MIDWEST FLOOD DAMAGE REPAIR U.S. FISH AND WILDLIFE SERVICE	BORING LOG EXISTING PUMP HOUSE CLARENCE CANNON N.W.R.	
GEI Consultants, Inc.	PROJECT NO. 94099	MAY 1994	FIGURE 17

FILE: P:\PROJECTS\MIDWEST\94099\FIG-17 PRPLOT @ 1=1 5/94


GENERAL NOTES
SYMBOL LEGEND
CONTROL POINT
GRAVEL SURFACING
PROPOSED FINISHED GRADE
PIPE BOLLARD DETAIL
(4 TOTAL REQUIRED)
FUEL TANK SLAB PLAN
& PILE LAYOUT
SECTION THROUGH RIPRAP
TYPICAL SECTION — SERVICE ROAD
CONTROL POINT LEGEND
CONTROL POINT
NORTHING
EASTING
ELEVATION
DESCRIPTION
CN-2
102,222.58
103,886.51
U.S. DEPT. OF INTERIOR 3" ALUMINUM CAP STAMPED FISH & WILDLIFE CN-2
CN-3
98,315.08
104,613.94
U.S. DEPT. OF INTERIOR 3" ALUMINUM CAP STAMPED FISH & WILDLIFE CN-3
DN-1
97106.59
104,633.50
442.53
U.S. DEPT. OF INTERIOR 2 1/2" BRASS CAP SET IN HEXAGONAL CONCRETE MONUMENT CN-1
CONTROL POINTS SHOWN ARE BASED ON COORDINATE GRID AND DATUM, PROVIDED BY U.S. BLANKENSHIP, SEE SHEET C-1 FOR DETAILS FOR RELATIVE LOCATIONS OF CONTROL POINTS, SEE VICINITY PLAN (SHEET 1-1).
REVISION
STATUS
DATE
DESCRIPTION
BY
PROJECT MARK TWAIN N.W.R., CLARENCE CANNON UNIT – OUTLET & PUMP STATION
SHEET TITLE S. LEVEE PUMP STATION SITE PLAN
PREPARED BY: MERRICK & CO. DENVER, CO.
DATE 12/17/04
DESIGNED JR/SS
DRAWN BR
CHECKED JT
DRAWING NO. 38-MO-014-05
C 4
SHEET 5 of 15
THIS DRAWING IS REDUCED APPROX. 1/2 SIZE
PLAN
SCALE: 1" = 10'
EDGE OF WATER
TOP OF BANK
BRYANT CREEK
FUEL TANK
WATER OUTLET
CONTOUR INTERVAL = 1'

BORING LOCATION CLA. CANNON N.W.R. DATE START / FINISH 5/4/94 , 5/4/94 | G108

GROUND ELEVATION (NGVD) _____ DRILLED BY CIDCO

GROUNDWATER EL. 3.3' DATE 5/4/94 LOGGED BY KJS TOTAL DEPTH (FT) 66.0 | PG. 3 OF 3

EL. FT.	DEPTH FT.	SAMPLE TYPE and NO.	BLOWS PER 6 IN.	PEN IN.	REC IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS
	60	S-12	11 10 12	18	18	61.0		S-12: WIDELY GRADED SAND W/ GRAVEL: MEDIUM TO COARSE SAND, ROUNDED, 20-30% MEDIUM GRAVEL, ONE PIECE 1-INCH SIZE, ROUNDED, ~5% NON PLASTIC FINES, MEDIUM DENSE, BROWN, WET. (SW)
	65	S-13	7 5 6	18	9	64.5 66.0 B.O.B.		S-13: WIDELY GRADED SAND WITH GRAVEL: MOSTLY COARSE SAND, ROUNDED, 40-45% MEDIUM TO COARSE GRAVEL, MAX SIZE 1-INCH, ROUNDED TO SUB ANGULAR, <5% NON PLASTIC FINES, MEDIUM DENSE, BROWN, WET. (SW)
	70							
	75							
	80							
	85							
	90							

BLOWS PER 6" - 140 LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN OD SPLIT SPOON SAMPLER
PEN - PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC - RECOVERY LENGTH OF SAMPLE
RQD - LENGTH OF SOUND CORES >4IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES UP - FIXED PISTON
UO - OSTERBERG
GROUNDWATER

NOTES:
SEE PAGE 1 OF 3

5/4/94 DATE
94099 PROJECT
GEI Consultants, Inc.

BORING LOCATION CLA. CANNON N.W.R. DATE START / FINISH 5/4/94 , 5/4/94

GROUND ELEVATION (NGVD) _____ DRILLED BY CIDCO

GROUNDWATER EL. 12.8' DATE 5/4/94 LOGGED BY KJS TOTAL DEPTH (FT) 26.0

B109

PG. 1 OF 1

EL. FT.	DEPTH FT.	SAMPLE TYPE and NO.	BLOWS PER 6 IN.	PEN IN.	REC IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS
	0							S-1: LEAN CLAY: HOMOGENEOUS, MEDIUM TO LOW PLASTICITY, ~10% FINE SAND, STIFF, ROOTS, WOOD PIECES IN TOP PART OF SAMPLE, BROWN/GRAY, SLI. MOIST. (CL) Q_p = 2.75 tsf
	5	S-1	4 6 6	18	18	4.5 / 6.0		
								S-2: LEAN SANDY CLAY: HOMOGENEOUS, MED. TO LOW PLASTICITY, ~10% FINE SAND, MEDIUM STIFF TO STIFF, BROWN/GRAY, SLI. MOIST. (CL) Q_p = 1.5 tsf
	10	S-2	3 4 4	18	18	9.5 / 11.0		
		U-1	PUSH	27	27	12.0 / ▽ 12.8' / 14.25 / 14.5		U-1: LEAN CLAY: SIMILAR TO S-2 (CL)
	15	S-3	2 3 3	18	18	16.0		S-3: LEAN CLAY: SIMILAR TO S-2, MEDIUM STIFF. (CL) Q_p = 1.0 tsf
								S-4: LEAN SANDY CLAY SIMILAR TO S-2, MEDIUM STIFF. (CL) Q_p = 1.0 tsf
	20	S-4	2 3 3	18	18	19.5 / 21.0		
								S-5: SILTY SAND: FINE TO MEDIUM SAND, ROUNDED, ~12% NON PLASTIC FINES, <5% FINE GRAVEL, V. LOOSE TO LOOSE, BROWN, WET. (SW-SM)
	25	S-5	1 2 2	18	18	24.5 / 26.0 SAMPLER ROD SINKS UNDER W.O.H.		
	B.O.B.							
	30							

BLOWS PER 6" - 140 LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN OD SPLIT SPOON SAMPLER
PEN - PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC - RECOVERY LENGTH OF SAMPLE
RQD - LENGTH OF SOUND CORES >4IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES UF - FIXED PISTON
UO - OSTERBERG
▽ GROUNDWATER

NOTES:
1. CME 850 TRACK RIG
2. OBSERVATION WELL INSTALLED

5/4/94 DATE
94099 PROJECT

GEI Consultants, Inc.

BORING LOCATION CL. CANNON N.W.R. DATE START / FINISH 5/3/94 , 5/3/94 | B110

GROUND ELEVATION (NGVD) _____ DRILLED BY CIDCO

GROUNDWATER EL. 4.8 DATE 5/3/94 LOGGED BY KJS TOTAL DEPTH (FT) 27.0 | PG. 1 OF 1

EL. FT.	DEPTH FT.	SAMPLE TYPE and NO.	BLOWS PER 6 IN.	PEN IN.	REC IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS
	0							S-1: LEAN CLAY: HOMOGENEOUS, MEDIUM PLASTICITY, < 5% FINE SAND, MED. STIFF TO STIFF, GRAY, SLI. MOIST. (CL) Qp = 1.5 tsf
						▽ 4.8'		
	5	S-1	3 4 4	18	18	5.5		U-1: LEAN CLAY: SIMILAR TO S-1. (CL)
						7.0		
		U-1	PUSH	27	27	8.0		S-2: LEAN CLAY: HOMOGENEOUS, MED. TO LOW PLASTICITY, ~10% FINE SAND, MEDIUM STIFF, GRAY, SLI. MOIST. (CL) Qp = 1.5 tsf
	10					10.25		
		S-2	2 2 3	18	18	10.5 12.0		
								S-3: CLAYEY SILT: HOMOGENEOUS. LOW PLASTICITY, 25% FINE TO MEDIUM SAND, ROUNDED, COARSING WITH DEPTH, MED. STIFF, GRAY, WET. (CL-ML)
	15					15.5		
		S-3	1 1 4	18	18	17.0		S-4: SILTY SAND: MOSTLY MEDIUM SAND, ROUNDED, 20-30% LOW PLASTICITY FINES, ~10% FINE GRAVEL, ROUNDED, MAX 1/4 INCH, MEDIUM DENSE, GRAY TO BROWN, WET. (SM)
	20					20.5		
		S-4	5 6 8	18	18	22.0		S-5: SILTY SAND: SIMILAR TO S-4. (SM)
	25					25.5		
		S-5	4 6 8	18	12	27.0 B.O.B.		
	30							

BLOWS PER 6" - 140 LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN OD SPLIT SPOON SAMPLER
PEN - PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC - RECOVERY LENGTH OF SAMPLE
RQD - LENGTH OF SOUND CORES > 4IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES
UF - FIXED PISTON
UO - OSTERBERG
▽ GROUNDWATER

NOTES:
1. CME 850 TRACK RIG.
2. BORING BACKFILLED WITH SAND.

5/3/94 DATE | 94099 PROJECT

GEI Consultants, Inc.

BORING LOCATION CLARENCE CANNON NWR DATE START / FINISH 5/02/94, 5/02/94 | B 113

GROUND ELEVATION (NGVD) _____ DRILLED BY CENTRAL ILLINOIS DRILLING

GROUNDWATER EL. 10.9 DATE 5/4/94 LOGGED BY KJS TOTAL DEPTH (FT) 26.0 | PG. 1 OF 1

EL. FT.	DEPTH FT.	SAMPLE TYPE and NO.	BLOWS PER 6 IN.	PEN IN.	REC IN.	REMARKS	GRAPHIC LOG	SOIL AND ROCK DESCRIPTIONS
	0							S-1: FAT SANDY CLAY: HOMOGENEOUS, MEDIUM TO HIGH PLASTICITY, 10-15% FINE SAND, MEDIUM STIFF, GRAY, SLIGHTLY MOIST. (CH) Qp = 1.0 tsf
	5	S-1	3 3 2	18	16	4.5 / 6.0		
								S-2: FAT SANDY CLAY: HOMOGENEOUS, MEDIUM TO HIGH PLASTICITY, 10-20% FINE SAND, MEDIUM STIFF, GRAY, SLIGHTLY MOIST. (CH) Qp = 0.75 tsf
	10	S-2	2 3 3	18	18	9.5 / 11.0		
						▽ 13.7'		S-3: FAT SANDY CLAY: SIMILAR TO S-2. (CH) Qp = 0.5 tsf
	15	S-3	2 3 4	18	15	14.5 / 16.0		U-1: FAT SANDY CLAY: SIMILAR TO S-2 (CH) Qp = 1.25 tsf
		U-1	PUSH	27	18	17.0 / 19.25 / 19.50		S-4: LEAN CLAY: HOMOGENEOUS LOW TO MEDIUM PLASTICITY, <15% FINE SAND, MED. STIFF, GRAY, SLI. MOIST. (CL) Qp = 1.25 tsf
	20	S-4	2 3 3	18	16	21.0		
	25	S-5	2 2 3	18	18	24.5 / 26.0 B.O.B.		S-5: LEAN SANDY CLAY: HOMOGENEOUS, LOW TO MED. PLASTICITY, ~40% FINE SAND, MED STIFF, GRAY, MOIST. (CL) Qp = 0.75 tsf
	30							

BLOWS PER 6" - 140 LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN OD SPLIT SPOON SAMPLER
PEN - PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC - RECOVERY LENGTH OF SAMPLE
RQD - LENGTH OF SOUND CORES >4 IN./LENGTH CORED, %
S - SPLIT SPOON SAMPLE
U - UNDISTURBED SAMPLES UF - FIXED PISTON
UO - OSTERBERG
▽ GROUNDWATER

NOTES:
1. CME 850 TRACK RIG.
2. WATER AT 13.7'.
3. OBSERVATION WELL INSTALLED.

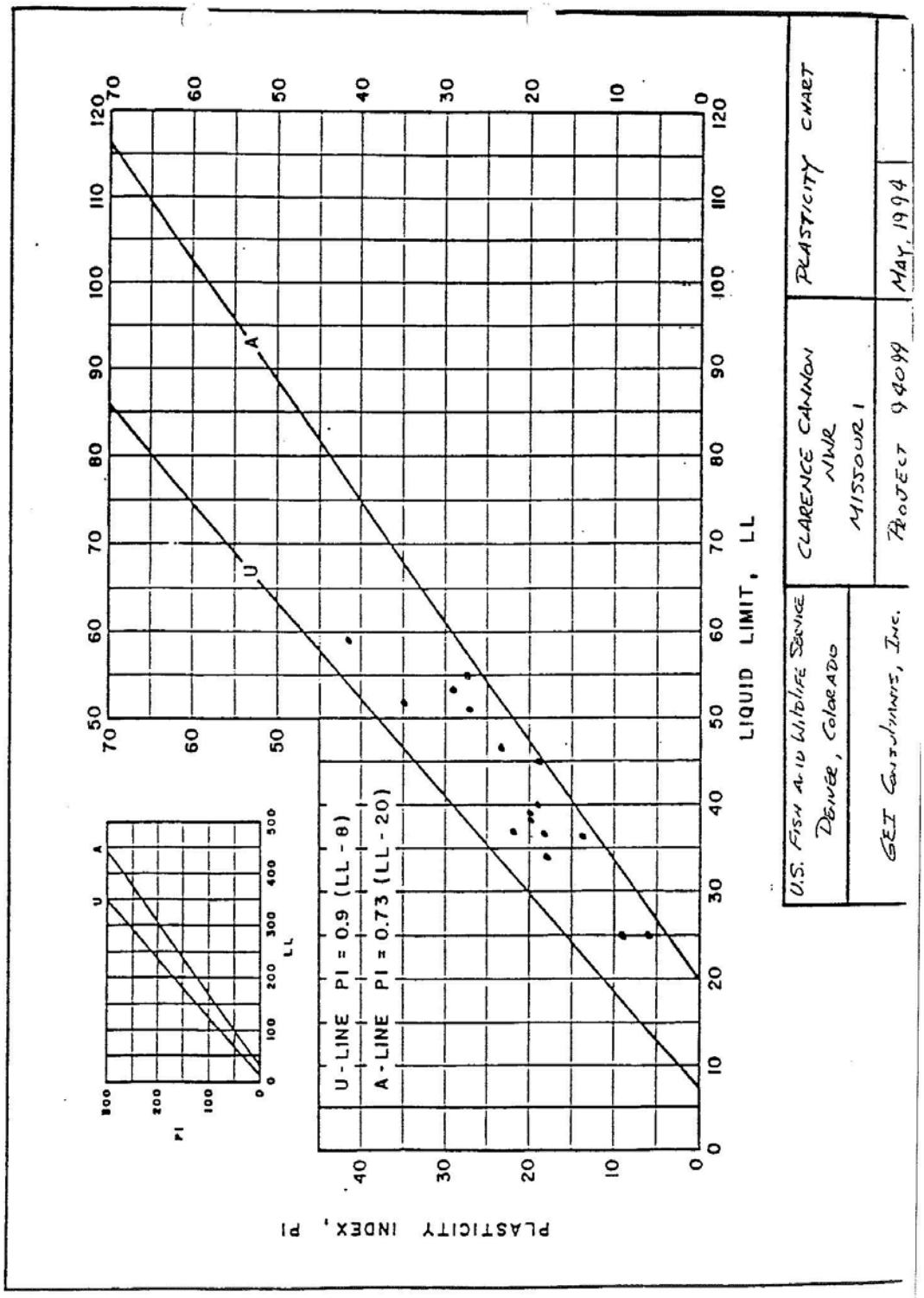
5/2/94 DATE | 94099 PROJECT

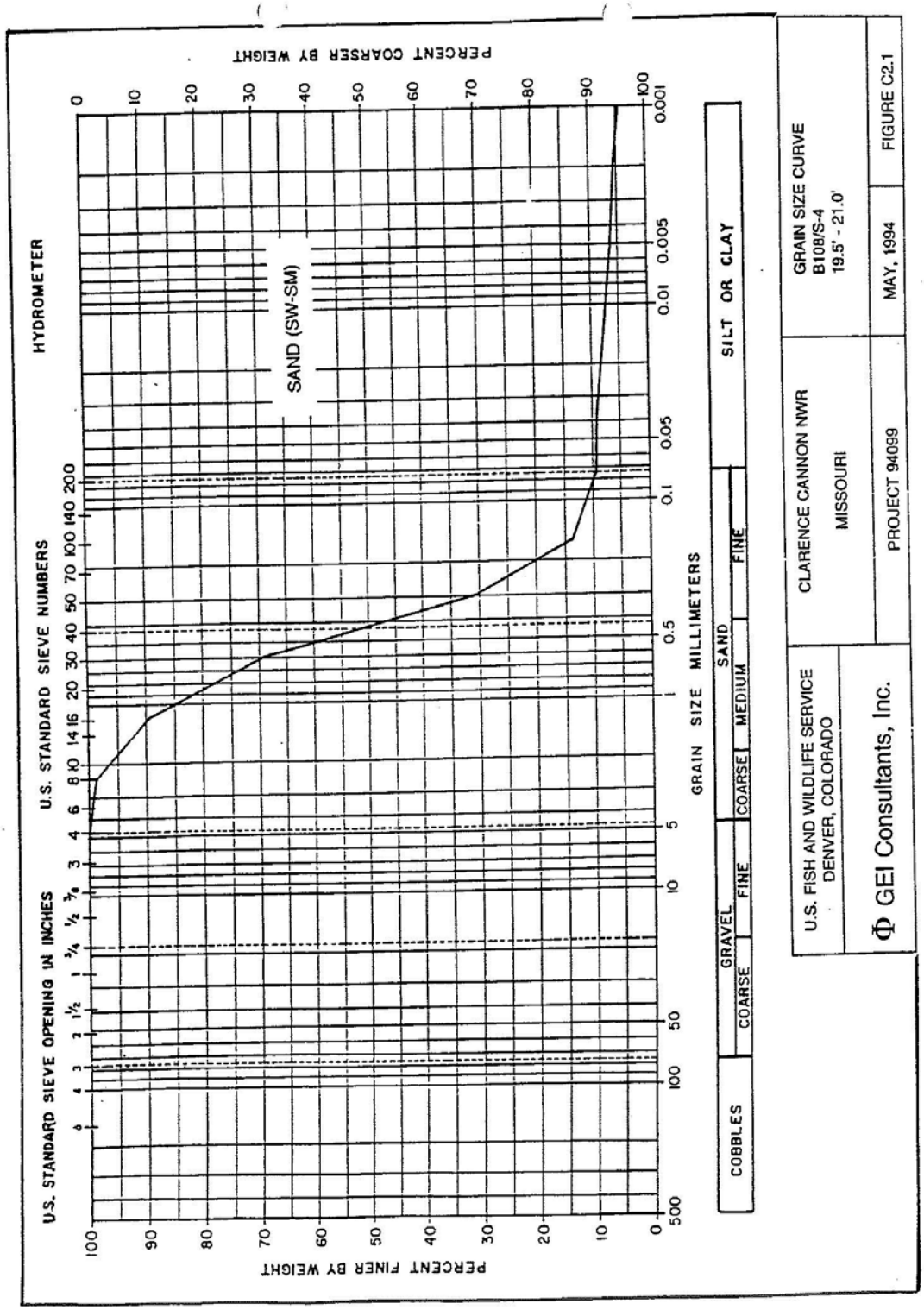
GEI Consultants, Inc.

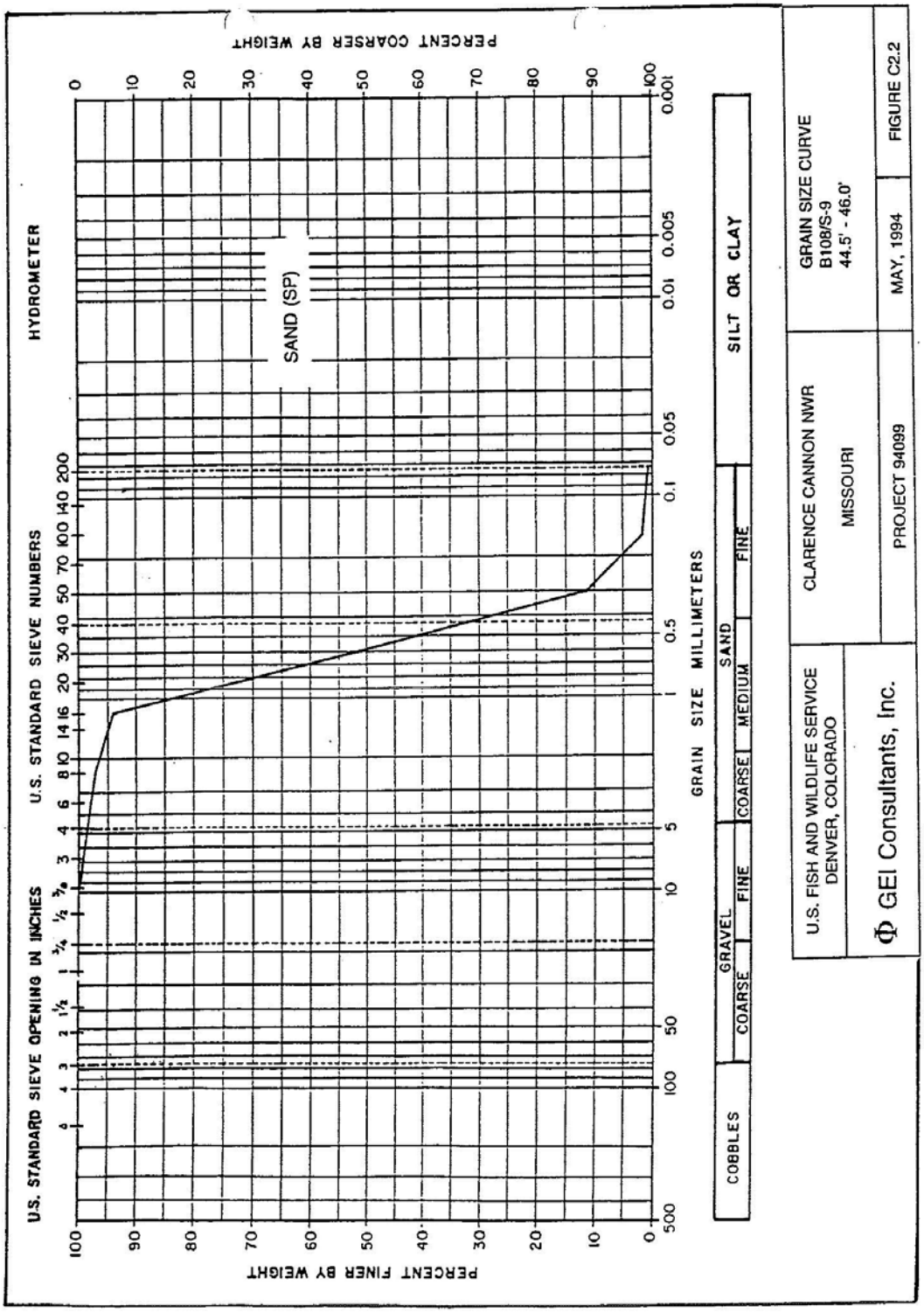
TABLE C.3 - ATTERBERG LIMITS AND NATURAL WATER CONTENTS
SOIL SAMPLES
USFWS MIDWEST FACILITIES PROJECT
CLARENCE CANNON NATIONAL WILDLIFE REFUGE

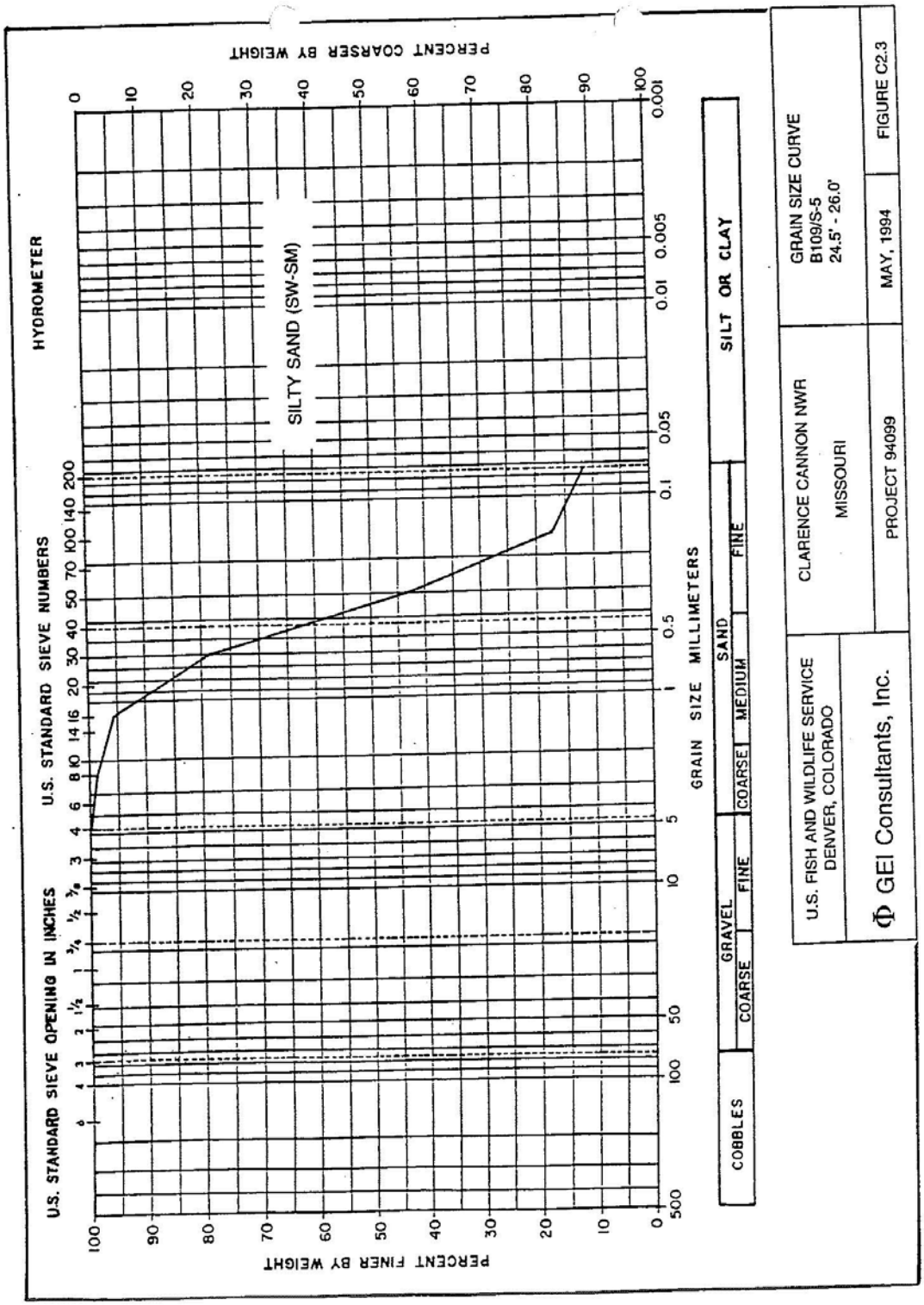
Borehole No.	Sample No.	Sample Description	Depth (feet)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
B108	S-1	Lean Sandy Clay (CL)	4.5-6.0	20.1	34	16	18
B108	U-1	Fat Clay (CH)	12.0-14.25	33.6	53	24	29
B108	S-4	Sand (SW-SM)	19.5-21.0	-	-	-	NP
B109	S-2	Lean Sandy Clay (CL)	9.5-11.0	21.0	37	15	22
B109	U-1	Lean Clay (CL)	12.0-14.25	22.7	36	23	13
B109	S-4	Lean Sandy Clay (CL)	19.5-21.0	39.0	46	23	23
B109	S-5	Silty Sand (SW-SM)	24.5-26.0	-	-	-	NP
B110	S-1	Lean Clay (CL)	5.5-7.0	24.7	38	18	20
B110	U-1	Lean Clay (CL)	8.0-10.25	30.6	45	27	18
B110	S-2	Lean Clay (CL)	10.5-12.0	37.5	40	21	19
B110	S-3	Clayey Silt (CL-ML)	15.5-17.0	-	25	19	6
B111	S-2	Lean Sandy Clay (CL)	9.0-10.5	25.6	37	19	18
B111	U-1	Fat Sandy Clay (CH)	11.5-13.75	24.2	55	28	27
B112	S-1	Lean Clay (CL)	4.5-6.0	27.6	39	19	20
B113	S-1	Fat Sandy Clay (CH)	4.5-6.0	32.6	59	17	42
B113	S-3	Fat Sandy Clay (CH)	14.5-16.0	31.2	52	17	35
B113	U-1	Fat Sandy Clay (CH)	17.0-19.25	29.8	51	24	27
B113	S-5	Lean Sandy Clay (CL)	24.5-26.0	24.5	25	16	9

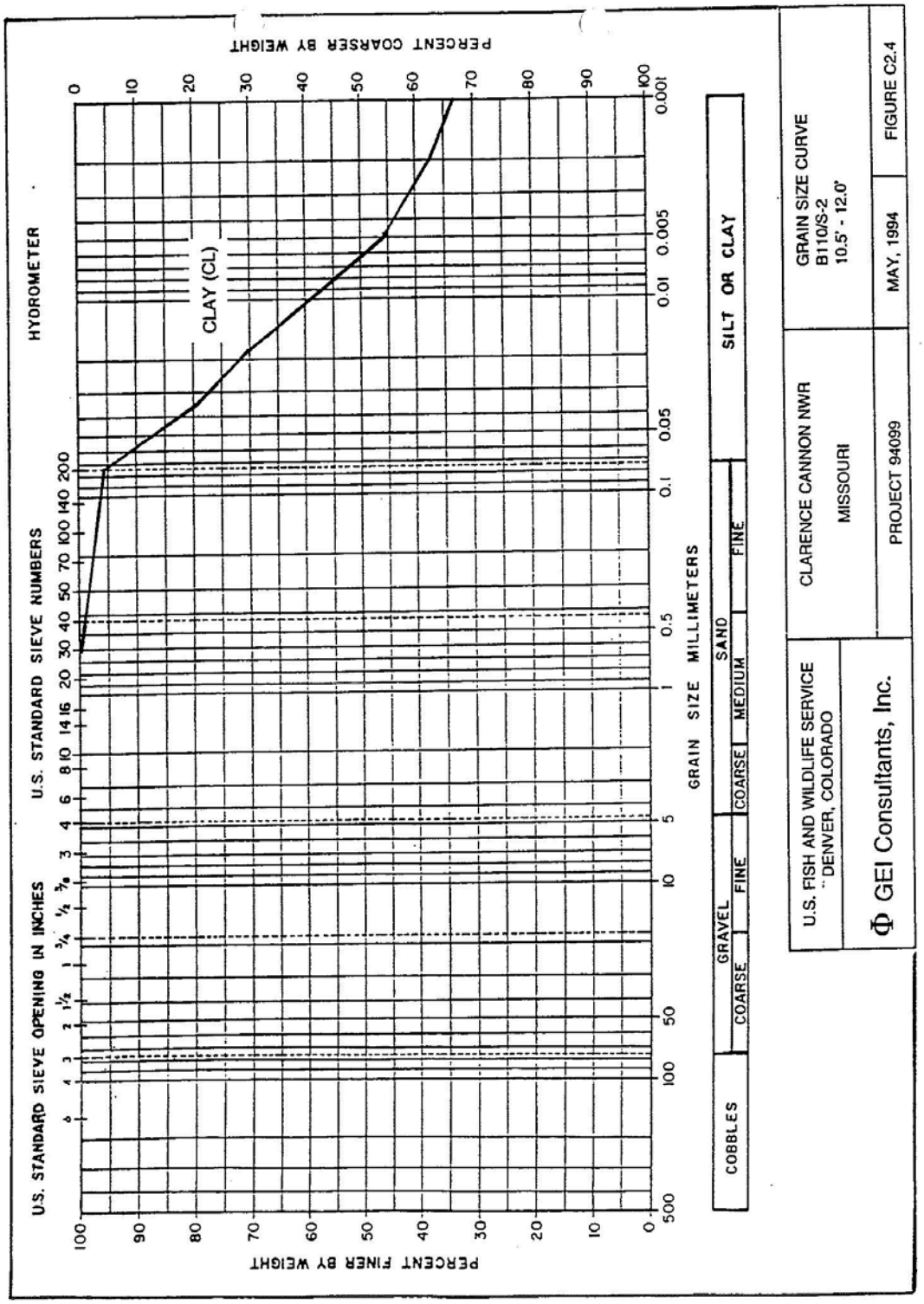
9409\REPORT\TABLE.C3

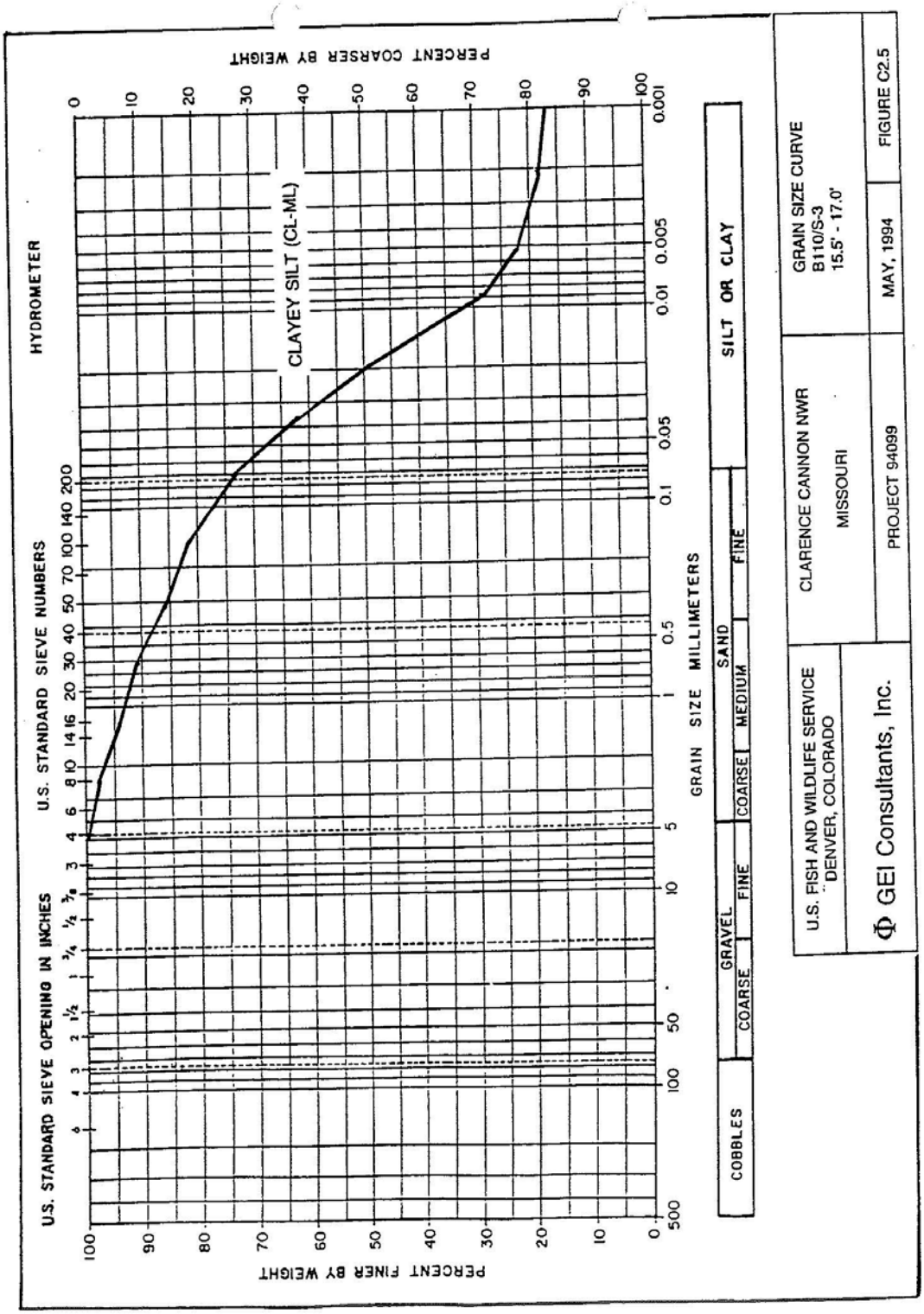

U-LINE PI = 0.9 (LL - 8)
A-LINE PI = 0.73 (LL - 20)
LIQUID LIMIT, LL
PLASTICITY INDEX, PI
U
A
LL
PI
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI CONSULTANTS, INC.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
PLASTICITY CHART
MAY, 1994

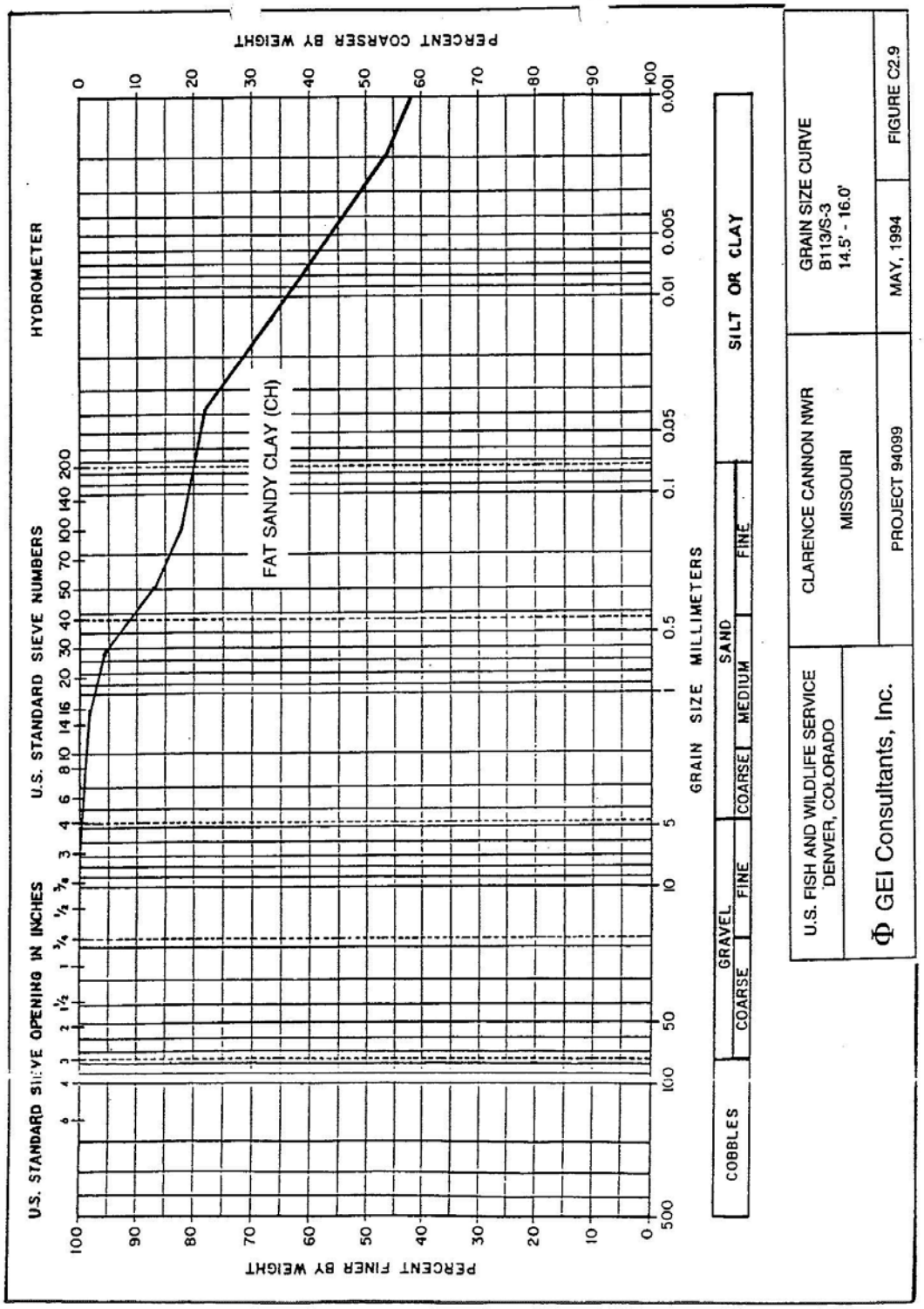

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
SAND (SW-SM)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B108/S-4
19.5' - 21.0'
MAY, 1994
FIGURE C2.1

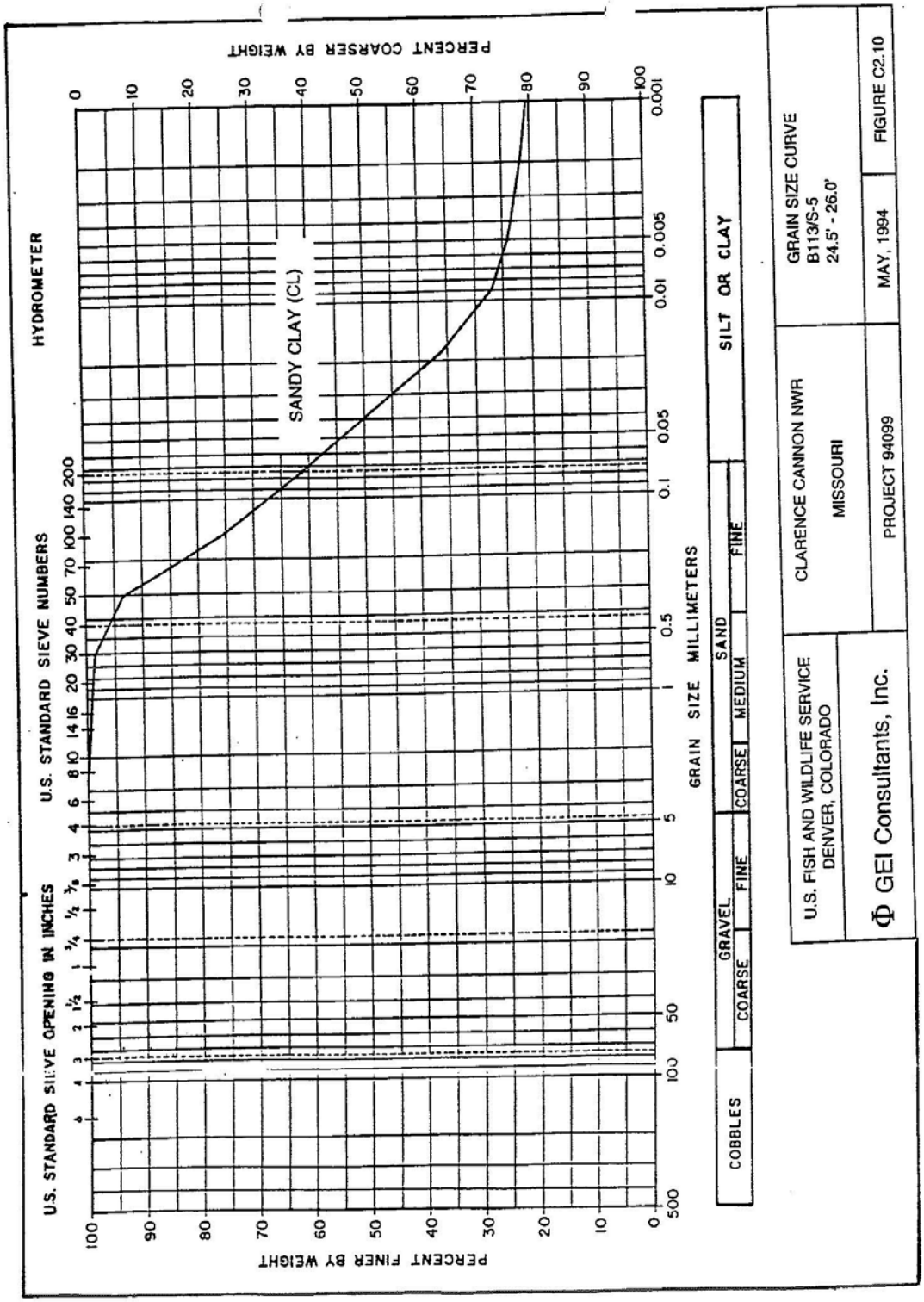

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
SAND (SP)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B108/S-9
44.5' - 46.0'
MAY, 1994
FIGURE C2.2

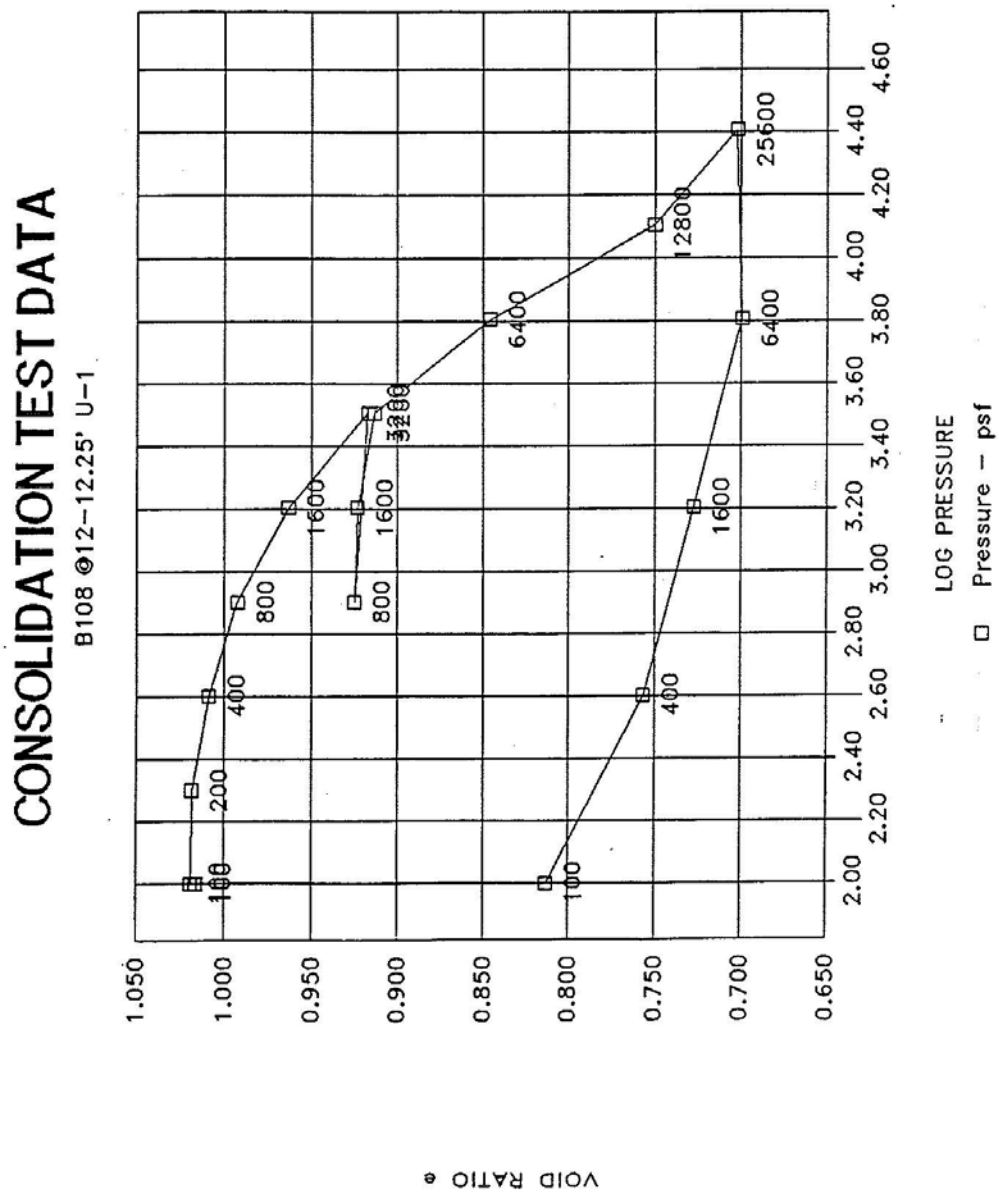

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
SILTY SAND (SW-SM)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B109/S-5
24.5' - 26.0'
MAY, 1994
FIGURE C2.3

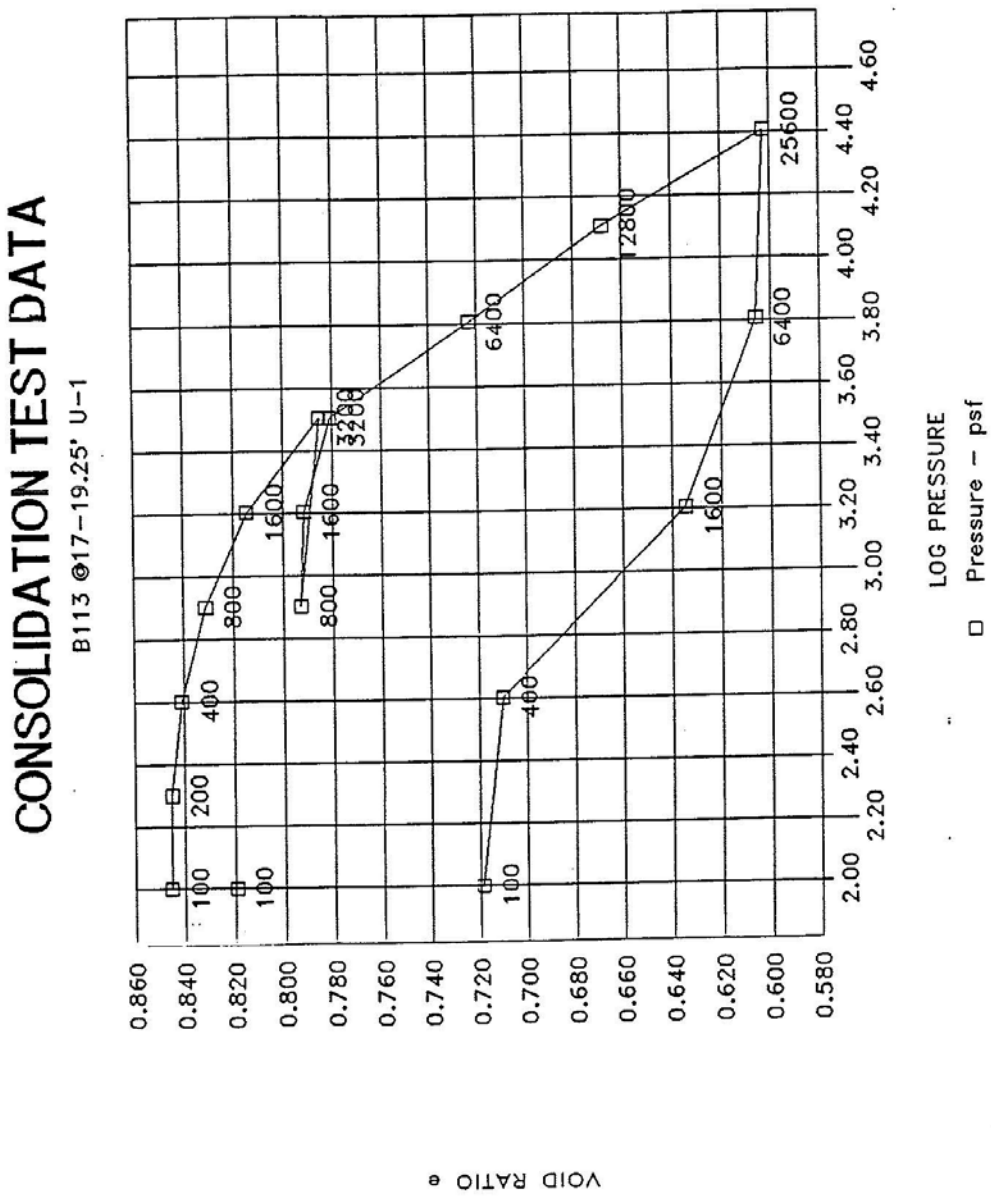

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
CLAY (CL)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B110/S-2
10.5' - 12.0'
MAY, 1994
FIGURE C2.4


HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. STANDARD SIEVE OPENING IN INCHES
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
CLAYEY SILT (CL-ML)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B110/S-3
15.5' - 17.0'
MAY, 1994
FIGURE C2.5


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
FAT SANDY CLAY (CH)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
GRAIN SIZE CURVE
B113/S-3
14.5' - 16.0'
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
MAY, 1994
FIGURE C2.9
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
SANDY CLAY (CL)
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
U.S. FISH AND WILDLIFE SERVICE
DENVER, COLORADO
GEI Consultants, Inc.
CLARENCE CANNON NWR
MISSOURI
PROJECT 94099
GRAIN SIZE CURVE
B113/S-5
24.5' - 26.0'
MAY, 1994
FIGURE C2.10


CONSOLIDATION TEST DATA
B108 @12-12.25' U-1
VOID RATIO e
1.050
1.000
0.950
0.900
0.850
0.800
0.750
0.700
0.650
2.00
2.20
2.40
2.60
2.80
3.00
3.20
3.40
3.60
3.80
4.00
4.20
4.40
4.60
LOG PRESSURE
Pressure - psf
100
200
400
800
1600
3200
6400
12800
25600


CONSOLIDATION TEST DATA
B113 @17-19.25' U-1
VOID RATIO e
0.860
0.840
0.820
0.800
0.780
0.760
0.740
0.720
0.700
0.680
0.660
0.640
0.620
0.600
0.580
2.00
2.20
2.40
2.60
2.80
3.00
3.20
3.40
3.60
3.80
4.00
4.20
4.40
4.60
LOG PRESSURE
Pressure - psf
100
200
400
800
1600
3200
6400
12800
25600