8642

TECHNICAL JUSTIFICATION OF EQUIVALENCY FOR SURFACE IMPOUNDMENT REQUIREMENTS FOR THE TEMPORARY STORAGE AREA BASIN AND SITE WATER TREATMENT PLANT EQUALIZATION BASIN

MAY, 1991

Technical Justification of Equivalency for Surface Impoundment Requirements

As a part of the overall cleanup of the Weldon Spring quarry and Weldon Spring chemical plant, the DOE is planning to construct a lined basin for storage of leachate and runoff water at the Temporary Storage Area (TSA), and also a lined equalization basin for the site water treatment plant (SWTP).

The current design of these facilities includes from top to bottom, a 60 mil HDPE synthetic liner, a leachate collection system, a secondary 60 mil HDPE synthetic membrane, and a 1/4-inch bentonite liner composite underlain by 6 inches of compacted subgrade. A conceptual diagram of this configuration is shown in Figure 1.

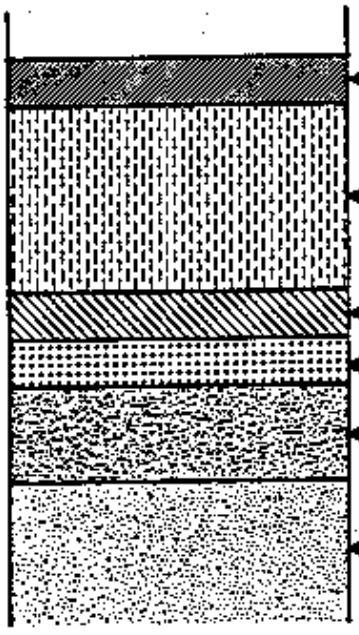
The state of Missouri RCRA requirements (Ref. 5), include a synthetic liner and a leachate collection system underlain by 3 feet of 1×10^{-8} cm/sec clay layer. The 3 feet of 1×10^{-8} cm/sec clay can not be met with the existing soils at the TSA or the SWTP, but the proposed system exceeds the state requirements due to the extremely low permeability of the added premanufactured composite liner.

The operational life of these facilities is expected to be 10 years. Synthetic composite liners are a preferable low permeability barrier to clay for short term durations (i.e. less than 30 years). The following reasons are in support of the current design for the two impoundments.

1. Clay materials resulting from planned excavations within TSA and site water treatment plant areas cannot achieve low enough permeabilities (i.e. 1×10^{-8} cm/sec), even with extensive compaction (Appendixes A and C). The average hydraulic conductivity deducted from laboratory tests performed on four remolded samples obtained from the TSA area was only 1.33×10^{-7} cm/sec, compared with an average of less than 3×10^{-9} cm/sec resulting from samples obtained from the same soil unit in the northwest portion of the site (Appendixes A and B).

2. Since the performance period of the proposed units is low, the thickness of the low permeability soil liner is not as important as the overall low permeability of the system used in the current design. Assuming the primary synthetic liner and the leachate collection system fail, then the state

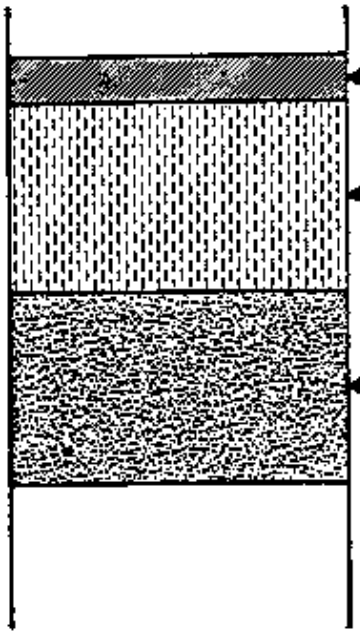
1. CURRENT DESIGN



BREAKTHROUGH TIME = 143 YEARS

PERMITTIVITY = $6.6 \times 10^{-12} SEC^{-1}$

2. STATE REQUIREMENT



BREAKTHROUGH TIME = 8.7 YEARS

PERMITTIVITY = $1.09 \times 10^{-10} SEC^{-1}$

NOT TO SCALE

CONCEPTUAL DIAGRAM

FIGURE 1

REPORT NO.:		EXHIBIT NO.:	A/PI/086/0591
ORIGINATOR: SDG	DRAWN BY: GLN	DATE:	5/91

requirement is intended to provide long term protection with 3 ft of low permeability clay. The current design is intended to provide a second line of defense against any leakage from the basins with the secondary composite liner, and mid-long term protection provided by the bentonite composite, the 6 inches of compacted subgrade and the more than 20 ft of in situ soil material.

3. An added practical benefit of the current design is the close contact between the lower synthetic liner and the bentonite layer. The bentonite layer adheres to the synthetic liner, so that any compromise in the synthetic liner will be sealed with the bentonite material.

In order to compare the current design with the state requirements, calculations were performed to compare the permittivities of the two systems. The permittivity is defined as the ratio between the hydraulic conductivity and thickness, and is measured in $Sec.^{-1}$. (Ref. 4) This parameter defines the capability of a system to reduce <u>and</u> retard infiltration.

Using this parameter and the effective porosity of a layer, the breakthrough time can be roughly estimated. The calculated effective porosity for a low permeability clay liner is 0.07 to 0.08 (Appendix A). For conservative purposes, a value of 0.03 for the effective porosity was selected for both systems. The average hydraulic conductivity for each system is calculated using the following relation, according to Todd (Ref. 2).

$$K_{AV} = \frac{Z_1 + Z_2 + \ldots + Z_n}{\frac{Z_1}{K_1} + \frac{Z_2}{K_2} + \ldots + \frac{Z_n}{K_n}}$$

where K_i and Z_i are permeabilities and thicknesses for each layer.

The permittivity is

$$T = \frac{K_{AV}}{Z_1 + Z_2 + \ldots + Z_n}$$

and the breakthrough time is

$$t = \frac{e}{T} = \frac{(Z_1 + Z_2 + \ldots + Z_n)\, e}{K_{AV}}$$

where e is the effective porosity.

<u>Option 1. (Current Design)</u>
Synthetic Liner
Leachate Collection
Synthetic Liner - 60 mil (0.15 cm), $K_1 = 1 \times 10^{-12}$cm/sec (Ref. 3)
Bentonite Composite - 1/4" (0.63 cm), $K_2 = 1 \times 10^{-9}$cm/sec (Ref. 3)
Compacted Subgrade - 6"
Natural Soil - 20'

Note: The upper HDPE synthetic liner is not considered in calculations.

The average permeability is:

$$K_{AV} = \frac{0.15 + 0.63}{\dfrac{0.15}{1 \times 10^{-12}} + \dfrac{0.63}{1 \times 10^{-9}}} = 5.17 \times 10^{-12}\ cm/sec.$$

Permittivity

$$T = \frac{5.17 \times 10^{-12}}{(0.15 + 0.63)} = 6.6 \times 10^{-12}\ \text{sec}^{-1}$$

Breakthrough time to compacted subgrade:

$$t = \frac{0.03}{6.6 \times 10^{-12}} = 4.52 \times 10^{9}\,\text{sec} = 143\,\textit{years.}$$

Option 2 (State Requirements)

Synthetic liner
Leachate collection
Compacted clay - 3' (91.5 cm) with K= 1×10^{-8} cm/sec

Note: The upper HDPE synthetic liner is not included in calculations.

Permittivity:

$$T = \frac{1 \times 10^{-8}}{91.5} = 1.09 \times 10^{-10}\,\text{sec}^{-1}$$

Breakthrough time through the compacted clay liner:

$$t = \frac{0.03}{1.09 \times 10^{-10}} = 2.74 \times 10^{8}\,\text{sec} = 8.7\,\textit{years}$$

In conclusion, the permittivity of the current design is two orders of magnitude lower than that calculated considering state requirements. Also, the estimated breakthrough time is increased from approximately nine years to more than one hundred years.

APPENDIX A

OPERATION

COMPANY

FORM ENG 8-A/74

ITEM NO. Appendix A. SHEET 1 OF ___ PAGE ___

JOB

EST. BY S. G. DATE 04/24/91

SUMMARY OF CALCULATION RESULTS

Seven boreholes, GTS1 through GTS-7 were drilled in May-June 1989 in the Temporary Storage Area. Locations of these boreholes are shown on figure 2-1. Borehole logs are presented in Appendix B. In addition, two boreholes GT-73 and GT-74 were drilled in April 1991 within the Site Water Treatment plant area. Field logs of these boreholes are also attached in Appendix B.

Laboratory test results on samples taken from borings GTS-1 through GTS-7 are shown in Appendix A. A summary of these results is presented in table 2-1. Although laboratory tests results on samples from GT-73 and GT-74 are not yet available, the lithologic logs of these boreholes show materials very similar to those identified in GTS-1 through GTS-7.

Average values of geotechnical parameters for representative samples from GTS1 through GTS-7 are shown in table 2-2. A logarithmic mean was used to obtain the average permeability for these samples.

Performing the same calculations for a soil compacted at +4% wet of optimum moisture levels to:

$$\gamma_d = 95\% \times 103.9 = 98.7 \text{ pcf}$$

$$e' = \frac{2.71 \times 62.4}{98.7} = 0.713$$

$$S = \frac{21.95 \times 2.71 \times 98.7}{2.71 \times 62.4 - 98.7} = 83.4\%$$

$$n = \frac{0.713}{1.713} = 0.416$$

$$n' = 0.416 \times (1 - 0.834) = 0.069$$

Selecting a value of 0.03 for the effective porosity, the results are on the conservative side.

Also, for conservative reasons, the same value of 0.0 was used for the bentonite layer.

Hydraulic conductivities for the HDPE and bentonite layer were selected on the conservative side. For the HDPE a value of 1×10^{-12} cm/sec was used in calculations. For the bentonite layer, the hydraulic conductivity was selected 1×10^{-9} cm/sec (Ref 4, 5).

TABLE 2-1.

112996

SUMMARY OF SOIL TEST RESULTS

(sheet 6 of 10)

112996
3*BM-310.768

Hole or Trench Number	Sample Number	Depth (ft) From	Depth (ft) To	Laboratory Classification UNCS	Mechanical Analysis (%) Gravel	Mechanical Analysis (%) Sand	Mechanical Analysis (%) Fines	Atterberg Limits (%) LL	Atterberg Limits (%) PI	Shrinkage Limit (%)	Specific Gravity G	Natural W (%)	Natural γ_d (PCF)	Std. Proctor Compaction (ASTM D698) Optimum W (%)	Std. Proctor Compaction (ASTM D698) Optimum γ_d (PCF)	Triaxial Permeability γ_d (PCF)	Triaxial Permeability (conf. pressure) (KSF)	Triaxial Permeability γ (cm/sec)	Consolidation C_c	Consolidation C_r	Consolidation P_c' (KSF)	Soil Unit
GIS-1	SI-01	5.0	7.5	CL	0	3	97	40	20			I 26.7 M 23.3 B 22.0	87.5	17.5 (comp. GIS-3,	102.6 with SI-02)		(1) 2 x 10^{-7} (composite with GIS-3, SI-03)					F
GIS-2	SI-02	2.5	5.0									I 28.2 M 21.5 B 24.6	95.0	18.5 (comp. GIS-4,	103.0 with SI-04)		(1) 6 x 10^{-8} (composite with GIS-4, SI-04)					F
	SI-04	7.5	10.0									I 20.5 M 20.7	103.0 102.1									F
	comp.	2.5	10.0	CL	0	3	97	44	24													
GIS-3	SI-02	5.0	7.5	CH	1	3	96	53	34			I 28.0 M 29.8 B 37.6	89.9	(composite as GIS-1, SI-03)			(composite see GIS-1, SI-03)					F
GIS-4	SI-02	2.5	5.0	CH	0	4	88	50	20			I 28.2 M 28.4 B 28.9	92.5	17.7 (comp.)	101.5		(1) 2 x 10^{-7} (composite)					F
	SI-04	7.5	10.0	CL	0	6	94	41	21			I 26.7 M 21.5 B 21.5	102.9									F
GIS-5	BULK	0.0	5.0	CH	1	7	92	51	35			31.7		17.5	100.4		(1) 2 x 10^{-8}					DF
GIS-6	BULK	0.0	5.0	CL	0	1	99	43	21			19.7		18.1	104.6		(1) 1 x 10^{-7}					F
GIS-7	BULK	0.0	5.0	CH	0	3	95	59	35			21.8		19.2	102.7		(1) 3 x 10^{-8}					DF

sheet 4

OPERATION

COMPANY

FORM ENG 8-A/74

ITEM NO. Appendix A. SHEET 5 OF ___ PAGE ___

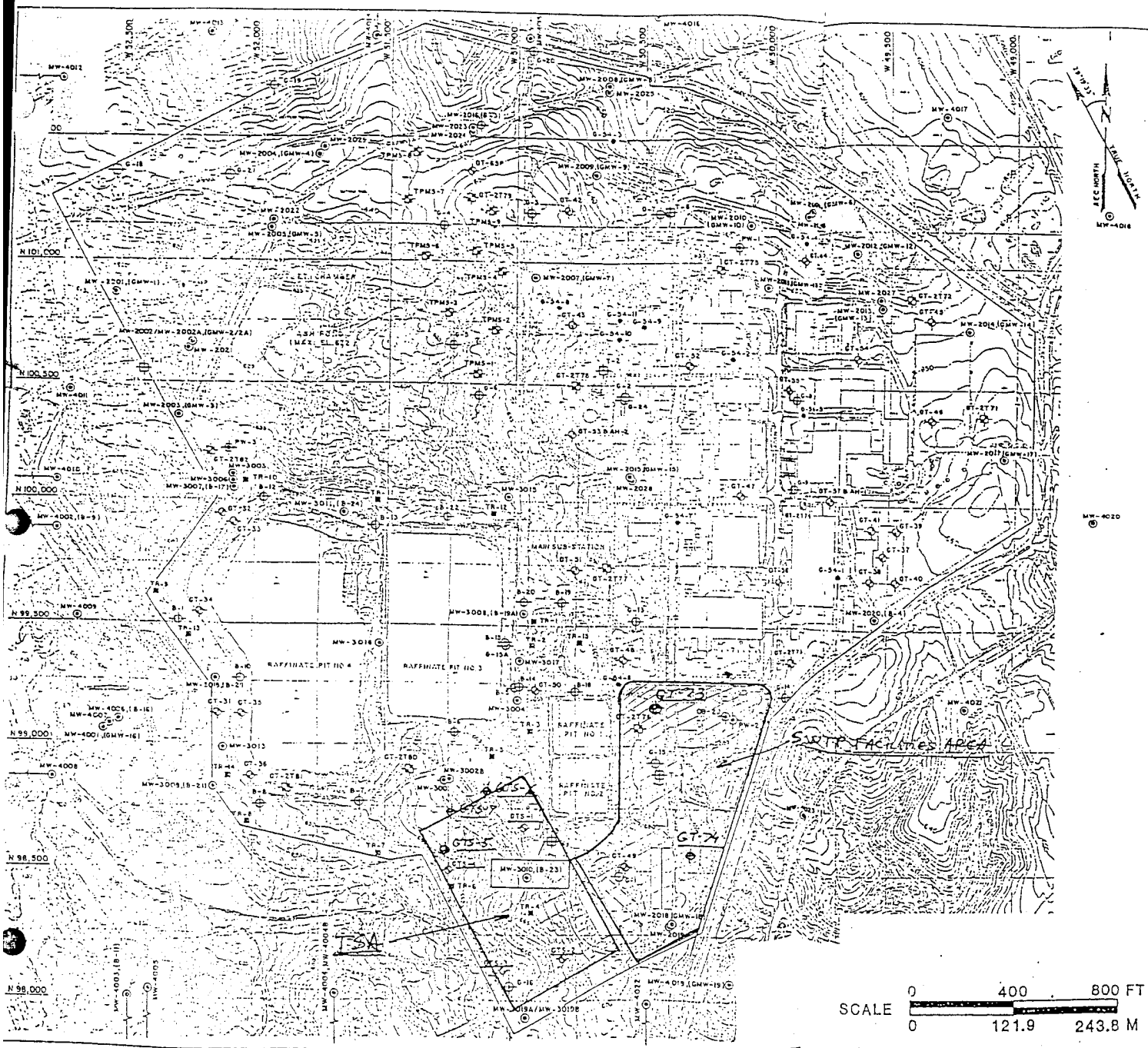
JOB

EST. BY S G DATE 07/24/81

TABLE 2-2

Average values of geotechnical parameters for TSA area

PARAMETER	MEAN VALUE	ST. DEVIATION	No. of SAMPLES CONSIDERED
Liquid limit	45.3	5.4	6
Plasticity index	24.6	5.4	6
Moisture content %	25.8	4.4	18
Dry density (pcf)	97.5	5.3	7
Optimum moisture	17.95	0.4	4
Max. dry density (pcf)	103.9	1.2	4
Hydraulic conductivity (cm/sec)	1.33×10^{-7}		4
Unit	Ferrelview		
Classification	CL - CH		
Depth	approx 2' to 10'		



LEGEND:

- B-22 — BNI MONITOR WELL (1983), OLD I.D. IN PARENTHESIS
- G-24 — BNI BOREHOLE (1983)
- (GMW-11) — BNI MONITORING WELL (1986), OLD I.D. IN PARENTHESIS
- GT-57 — MKE PHASE I BOREHOLE (1988)
- MW-4023 — MKF AND JEG MONITORING WELL (1988), INCLUDING INCORPORATED BNI WELLS (B AND GMW SERIES)
- PW-3 OR OB-2J — MKE PUMPING WELL (1986)
- GT-2782 — MKE PHASE I TEST PIT (1988)
- AH-2 GT-67P OR GTS-7 — MKE PHASE II BOREHOLE (1989)
- TPMS-9 — MKF TEST PIT (1990)

SCALE 0 400 800 FT
0 121.9 243.8 M

TEST PITS, MONITOR WELLS AND BOREHOLES LOCATION MAP

FIGURE 2-1

REPORT NO.: WP-238		DRAWING NO.: B/CP/126/1290	
DESIGNATOR: SDG	DRAWN BY: GLN	DATE: 12/90	

APPENDIX B

GEOTECHNICAL BORING LOG LEGEND

SYMBOLIC LOG

	CLAY		GRAVELLY CLAY
	SILT		CLAYEY GRAVEL
	SAND		SANDY CLAY
	GRAVEL		TOPSOIL
	SILTY CLAY		SHALE
	CLAYEY SILT		CHERTY LIMESTONE

SAMPLER DESIGNATIONS

SS = STANDARD PENETRATION SAMPLER (2.0" SPLIT SPOON)

SB = CALIFORNIA SAMPLER (3.0" SPLIT BARREL)
X = LINERS COLLECTED

ST = 3.0" SHELBY TUBE
P.P. = POCKET PENETROMETER, UNCONFINED COMPRESSIVE STRENGTH (Tons/Sq.Ft.)

GROUNDWATER MEASUREMENTS

6.5'; 6/9 ▽ = DEPTH & DATE OF INITIAL WATER LEVEL MEASUREMENT

2.9'; 6/16 ▼ = DEPTH & DATE OF STABILIZED WATER LEVEL MEASUREMENT

COLORS

SOIL & ROCK COLORS FROM MUNSELL SOIL AND GSA ROCK COLOR CHARTS

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Hole Number: GTS-1

Project: Geotechnical Investigation - Phase II	Location: Temporary Storage Area
Coordinates: (AEC) N. 98657.1 W. 50964.4	Drilling Contractor: Hannibal Testing Labs.
Drill Make and Model: CME 55: 6 7/8" Hollow Stem Auger, 3½", I.D.	Depth Top of Rock: 39.8'
Depth Casing & Size: none	Hole Size: 6 7/8"
Elevation: 665.35 ft. G.S.	Angle from Vert. and Bearing: Vertical
Depth Bottom of Hole: 39.8'	
Water Level: none	Fluid & Additives: none
Date Start: 5/11/89	Date Finish: 5/12/89
Logger: P. Patchin	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0						CLAYEY SILT, nonplastic, brown (10YR 4/3) w/roots, organics, FeOx nodules, v. stiff (2.75) last 1" 1.8
		1.0 2.5	SS 01	7"	2-3-4 7		mottled lt. yellowish brown (2.5Y 6/4) and yellowish brown (10Y 5/8), damp to dry. ML.
		2.5 4.0	SS 02	11"	2-4-5 9		CLAYEY SILT (40% clay) slightly plastic, mottled lt. brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/8) FeOx) damp to dry, MnOx blebs, FeOx stain, ML-CL
	5	5.0 7.5	ST 03	12"			as above, damp, pp=2.5, non-plastic, ML FERRELVIEW 7.8
		7.5 9.0	SS 04	18"	2-3-5 8		SILTY CLAY, mottled as above, damp FeOx nodules (20% silt), slight to mod. plasticity. V. stiff 2.25 CL
	10	10.0 12.5	ST 05	20"			CLAY med. to high plasticity, mottled lt. yellowish brown (2.5Y 6/4) and yellowish brown (10Y 5/8), damp, v. little silt, FeOx nodules, no MnOx, v. stiff (2.5) CL-CH.
		12.5 14.0	SS 06	18"	2-3-4 7		CLAY as above, with white non-calcareous soft inclusions, pp=3.0 CH FERRELVIEW
	15	15.0 17.5	ST 07	28"			CLAY, gravelly (10%) mod. plasticity, mottled as above, slightly damp, abundant MnOx streaks, 16.3
		17.5 19.0	SS 08	17"	2-8-9 17		FeOx nodules. Gravel is subrounded igneous and metamorphics, very stiff (3.25) CL-CH CLAY TILL Clay gravelly as above, increased MnOx stringers and FeOx blebs to 7mm, igneous gravel to 2cm (15%) damp to dry. Sandy (5%) coarse, very stiff (3.75) CL
	20	20.0 21.5	ST 09	29"			CLAY as above, sandy, predominantly yellowish brown (10YR 5/8) moist, pp=2.75 CL CLAY TILL
		22.5 24.0	SS 10	18"	3-9-10 19		CLAY as above, no mottling; with hard L.S. gravel, vert. fractures w/MnOx, pp=3.75, sandy, dry to damp, CL
	25						See next page for sample ST11

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121

Hole Number: GTS-1

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0	ST 11	16"			Sampler drove rock & caved last 8" of Shelby tube. Cut offtube 8" from bottom. Rock was calcareous. Gravelly CLAY as above, dry pp=3.5 CL
		27.2					Sampler refusal
		27.5 29.0	SS 12	18"	4-10-11 21		CLAY as above, abundant MnOx & fractures with leaching pp=4.5 dry CLAY TILL
	30	30.0 31.5	SB 13	5"	8-19-20 39		Pushed a large (7cm) rock at end of sampler. CLAY as above, damp pp=3. 31.8
		32.5 34.0	SS 14	17"	6-14-17 31		CLAYEY SAND to SILT (v. fine)(20% clay)lt.gray (10YR 7/2) nonplastic, dry to damp, abundant FeOx nodules to 3mm. Hard (> 4.0) no gravel mottled with lt.yellowish brn. (10YR 6/4) SC-ML BASAL TILL? 34.9
	35	35.0 36.5	SB 15	12"	6-12-13 25		GRAVELLY CLAY, slight plasticity, yellowish red, no silt (5YR 5/6) mottled with pinkish gray (5YR 6/2) 5% chert gravel to 12mm, minor finely xln L.S. (dark); damp, blocky, w/minor MnOx; FeOx blebs, hard (4.5) CL Residuum
		37.5 39.0	SS 16	3"	7-11-20 31		Pushed rock, (lithographic limestone, gray 10YR 6/1) GRAVELLY CLAY, as above, pp=4.5, dry 39.8
	40						Auger refusal @39.8' @8:40a.m. 5/12/89

Note: In end of clean-out tube before grouting was large chert gravel (7cm) with weathering rinds and pyrite (fresh) inclusions. Also more leached looking clay.

Collected bulk sample from 0-5.0' from auger cuttings.

Grouted hole to surface with Volclay grout.

Performed a constant head test at 36.5'. No take.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Hole Number: GTS-2

Project: Geotechnical Investigation - Phase II	Location: Temporary Storage Area
Coordinates: N.98100.4 W.50751.9 (AEC)	Drilling Contractor: Hannibal Testing Labs

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME-55, 6 7/8" Hollow Stem Auger; 3½" I.D.	37.3'	none	6 7/8"

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
668.17 ft. G.S.	Vertical	37.3'

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
None	None	5/9/89	5/10/89	P. Patchin

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0	0 1.5	SS 01	12"	2-6-7 13		SILTY CLAY, mod. plasticity, mottled light gray (10YR 7/1) and yellow (10YR 7/6), moist, roots, organics. CL. Bottom 6" is clayey silt, dk grayish brown (10YR 4/2) non-plastic, v. stiff (2.25) ML
		2.5 5.0	ST 02	18"			SILTY CLAY, low plasticity, mottled light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6) very stiff (2.25) damp, CL. FeOx blebs, MnOx stringers. Silt ~30-40%.
	5	5.0 6.5	SS 03	18"	3-5-8 13		As above pp=2.0 CL FERRELVIEW
		7.5 10.0	ST 04	28"			As above, pp=2.25 minor fine gravel, CL
	10	10.0 11.5	SS 05	18"	7-9-10 19		As above, pp=2.0 2" soft saturated zone at 10.8', overall moist CL.
		12.5 15.0	ST 06				CLAY, as above, less silty (10%) high plasticity, moist, CH pp=2.5
	15	15.0 16.5	SS 07	18"	2-5-10 15		CLAY as above, pp=2.75, high plasticity, damp, with slickensides, CL-CH FERRELVIEW
		17.5 20.0	ST 08	0"	Sample fell out no recovery		Shelby tube sampler empty. Drove split barrel sampler to pick up sample. At end of split barrel was SILTY CLAY as above, dry, increase MnOx streaks, minor fine gravel, CL
	20	20.0 21.5	SS 09	18"	2-4-6 10		CLAY, as above, dry, pp=3.25, minor gravel, CL-CH 22.0
		22.5 25.0	ST 10	26"			CLAY, as above but with increased (10%) fine gravel/coarse sand, dry, low plasticity, hard (3.75) CL CLAY TILL
	25						

See next page for SS11 sample description

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121

Hole Number: GTS-2

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0 26.5	SS 11	18"	3-7-8 15		SILTY CLAY, gravelly (15%) low plasticity, dry, hard (4.25), gravel fraction subround igneous, mafic, possible metamorphic rock, sandy (10%), predominantly yellowish brown (10YR 5/8) CL
		27.5 29.0	SB 12	12"	4-7-14 21		as above pp=4.5 dry
							CLAY TILL
	30	30.0 31.5	SS 13	18"	5-7-12		as above, less sand and silt, more plastic pp=4.0 gravel up to 3cm (chert).
		32.5 34.0	SB 14	0"	4-11-12		No sample, pushed rock. At end of split barrel is white (5Y 8/1) clay with decomposed L.S. CL 34.2
							RESIDUUM?
	35	35.0 36.5	SB 15	12"	13-39-30 >50		CLAYEY GRAVEL, nonplastic, dry, gravel up to 5cm, white (5Y 8/1), weathered limestone and chert (90%) minor clay, white (5Y 8/2) and MnOx and FeOx staining; last
					37.3'		4" is light gray (5Y 7/2) clay, "soapy", dry.
							Auger Refusal at 37.3' at 3:40pm 5/9/89
	40						

Note: Constant head tests at 10.0' and 25.0'. No take on both. Attempted test at 36.5' but could not seat NW drill rod due to rock.

Took bulk sample from 0-5' from auger cuttings.

Grouted hole to surface with Volclay grout.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Hole Number: GTS-3

Project: Geotechnical Investigation - Phase II	Location: Temporary Storage Area
Coordinates: N.93118.6- W.51076.9 (AEC)	Drilling Contractor: Hannibal Testing Labs

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME-55, 6 7/8" Hollow Stem Auger with 3¼" I.D.	31.5'	none	6 7/8"

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
654.97 ft. G.S.	Vertical	31.5'

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
None	None	5/5/89	5/8/89	P. Patchin

Elevation	Depth Below Surface	Sample Interval	Sample Type & Number	Recovery	Standard Penetration Test Results 6"-6"-6" (N)	Symbolic Log	Soil Description (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0						Augered to 2.5'
							FERRELVIEW
		2.5 4.0	SS 01	5"	2-1-1 2		SILTY CLAY, low plasticity, dark yllwsh brn(10YR 3/4) mottled with yellowish red (10YR 4/6), moist, soft (.75) CL
	5	5.0 7.5	ST 02	17"			CLAY, high plasticity, mottled red (2.5YR 4/8) and brn (10YR 5/3), minor black (MnOx) streaks, moist, med. stiff (1.0) CH
		8.0 9.5	SS 03	11"	2-7-8 15		CLAY, as above, light gray (10YR 7/1), slightly silty, no mottling, moist, stiff (1.5), CH
	10	10.0 12.5	ST 04	28"			SILTY CLAY, 15% silt, low to med plasticity, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1) with abundant FeOx nodules and MnOx streaks, damp, very stiff (4.0), CL
							FERRELVIEW
		12.5 14.0	SS 05	18"	1-8-9 17		As above, grading to siltier (~30%) minor fine sand and gravel at bottom, v. stiff (3.0) CL 13.5
							CLAY TILL
	15	15.0 17.5	ST 06	29"			SILTY CLAY, low plasticity, yellowish brown (10YR 5/6) mottled with light gray (5Y 7/2), damp very stiff (4.0) approx. 15% fine gravel (igneous & metamorphic)subrnd abundant FeOx blebs & MnOx stringers. CH
		17.5 19.0	SS 07	10"	3-12-18 30		SANDY GRAVEL, nonplastic, white (10YR 8/1) 60% large angular chert gravel, (gray 10YR 6/1) up to 2cm, minor clay (5%), minor FeOx stain; dry. GM 18.5
							BASAL TILL
	20	20.0 22.5	ST 08	16"			CLAY, low to med plasticity, white, (5Y 8/1), damp, blocky, stiff, (2.0) with FeOx and MnOx stringers, "soapy", with approx. 25% decomposed limestone? (high reaction to HCL) CL. 21.3
		22.5 24.0	SS 09	12"	9-10-15 25		As above, increase in FeOx stain, with very angular pale blue chert, pp=2.0
	25						RESIDUUM?

See next page for SB11 Sample description.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121

Hole Number: GTS-3

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0	SB		13-14-15		CLAY, gravelly, light brownish gray (2.5Y 6/2), mod.
		26.5	10	6"	29		to high plasticity, with FeOx staining (10YR 6/6) & MnOx stringers; stiff (1.23) 25% subangular chert gravel to 4cm, no limestone, CL RESIDUUM?
		27.5	SS		10-22-23		GRAVEL, with minor clay, nonplastic, dry 10% clay,
		29.0	11	10"	45		gravel is cherty limestone to 3cm, also sand size decomposed rock, all stained with FeOx, GC.
		30.0					As above w/50% clay to 30.2', gravel (cont'd below)
	30		SB12	6"	50 - > 50		
		30.5			refusal		AUGER REFUSAL RESIDUUM? 31.5

@8:50 am 5/8/89

is predominantly chert gravel. At 30.2 is weathered bedrock with mainly chert and clay (brownish yellow 10YR 5/6), chert pieces to 4cm. Also white clay (5Y 8/1) with MnOx stringers. FeOx stain throughout with minor weathered limestone and limey clay.

Grouted hole to surface with Volclay grout.

Note: Performed constant head test at 7.5', 17.5', and 22.5'. No take on all tests.

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121

Hole Number: GTS-4

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

Coordinates: N.98448.6 W.51237.2 (AEC)

Drilling Contractor: Hannibal Testing Labs

Drill Make and Model: CME 55, 6 7/8" Hollow Stem Auger: 3½" I.D.

Depth Top of Rock: 27.3

Depth Casing & Size: none

Hole Size: 6 7/8"

Elevation: 652.20 ft. G.S.

Angle from Vert. and Bearing: Vertical

Depth Bottom of Hole: 27.5

Water Level: None

Fluid & Additives: None

Date Start: 5/10/89

Date Finish: 5/11/89

Logger: P. Patchin

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	0	00 1.5	SS 01	9"	3-7-6 13		CLAYEY SILT, non-plastic, dark brn (10YR 3/3) abund. roots & organics, moist. Last 3" brn (10Y 5/3) w/med. gravel & dry ML. TOPSOIL/FILL 2.0
		2.5 5.0	ST 02	27"			SILTY CLAY, slight plasticity, mottled brn (10YR 5/3) & strong brn (7.5YR 5/6), dry to damp, abund. FeOx stn, 25% silt, occasional blkorganic? blebs, v. stiff (2.25) CL
	5	5.0 6.5	SS 03	16"	2-3-6 9		CLAYEY SILT (~30% clay) non-plastic, mottled lt. grnsh gray (10YR 6/2) & brnsh yellow (10YR 6/8), dry to damp, w/bl organic? blebs (prob. FeOx), v. stiff (2.25) ML FERRELVIEW
		7.5 10.0	ST 04	30"			As above, increased SILT (80-90%) w/FeOx blebs, more lt. brnsh gray (10YR 6/2), damp, stiff (1.75) ML 10.3
	10	10.0 11.5	SS 05	18"	2-5-7 12		CLAY, gravelly, mod. plasticity, mottled yellowish brn (10YR 6/8) and lt. gray (minor) (10YR 7/1), chert gravel (subrnd) fine to 1cm (10%) minor sand, abund FeOx nods & MnOx stringers, v/stiff (2.25). CL-CH
		12.5 15.0	ST 06	30"			As above, sandier, less mottling, pp=3.25, w/vert & horiz. fractures w/MnOx staining and leaching, dry-damp CL.
	15	15.0 16.5	SS 07	16"			As above, pp=3.5, no mottling; slight to mod. plasticity. CL-CH CLAY TILL
avel	6"						
		17.5 20.0	ST 08	26"			CLAY, mod. plasticity, lt. yellowish brn (10YR 6/4), hard (4.25) abund FeOx blebs 5% rounded gravel, v. little sand, dry to damp, no fractures, CL-CH
	20	20.0 21.5	SS 09	15"	4-8-7 15		As above, pp=3.75, abund angular chert gravel @20.5 for 4" yellowish brown (10YR 5/7) abund. MnOx streaks; damp, no L.S. CL-CH 22.8
		22.5 24.0	SB 10	6"	8-15-5 20		CLAYEY GRAVEL, w/angular chert gravel up to 6cm in diam. (possible silicified L.S.) BASAL TILL? 23.7
	25						GRAVELLY CLAY, slt. plasticity, wh. (5Y 8/2) mottled w/brnsh ylw (10YR 6/8) mottling, 20% chert (ang) gravel (pieces) up to 5cm long, vuggy w/wthring rinds, clay is moist and talc-like, no L.S., CL-CH RESIDUUM

See next page for sample SB11

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121

Hole Number: GTS-4

Project: Geotechnical Investigation - Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0 26.5	SB 11	6"	17-19-12		CLAYEY GRAVEL, nonplastic 20% clay is "talc like", lt olive yellow (10YR 6/6), damp, w/ abund. FeOx, also decomposed L.S (HCL reaction), angular chert gravel 27.5
							loose silty matrix, GC RESIDUUM?
							Auger refusal @ 27.5'
							@ 3:50pm 5/10/89
	30						
							Note: GTS-4 Bulk Sample taken from 0-5.0' from auger cuttings.
							Grouted hole to surface with Volclay grout.
							Constant head test at 5.0' and 24.0'. No take on both.

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2
Project Number: 5121
Contract WP117
Hole Number: GTS-5

Project: Geotechnical Investigation Phase II	Location: Temporary Storage Area
Coordinates: N.98607.7 W.51245.8 (AEC)	Drilling Contractor: Hannibal Testing Laboratories

Drill Make and Model:	Depth Top of Rock:	Depth Casing & Size:	Hole Size:
CME-55 H.S. Augers 6-7/8", 3 1/4"	37.0	None	6-7/8"

Elevation:	Angle from Vert. and Bearing:	Depth Bottom of Hole:
G.S. 662.64 ft.	Vertical	37.0

Water Level:	Fluid & Additives:	Date Start:	Date Finish:	Logger:
Dry	None	12:50 6/5/89	11:10 6/6/89	A. Benfer

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	GTS-5 Bulk	2.5					(Bulk sample of cuttings, GTS-5, collected from 0 to 5.0 feet).
	5	5.0	ST 01	29"			CLAY, highly plastic, mottled brownish yellow (10YR 6/6) and dark gray (10YR 4/1), moist, minor black, stiff to very stiff (2.0), CH, contains minor rounded limestone gravel (¼"), possible fill.
		6.5	SS 02	13"	2.2.2 4		As above, bottom 2" mottled blue and olive gray (5Y 5/2) with decomposed grass.
							FILL 7.5
		7.5	ST 03				SILTY CLAY, low plasticity, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1), moist very stiff (2.25), CL, minor FeOx.
	10	10.0		19"			
		10.0 11.5	SS 04	17"	2.4.4 8		As above, mostly light yellowish brown (10YR 6/4), with ~20% black FeOx, pp=2.2
							FERRELVIEW 12.5
		12.5	ST 05				CLAY, highly plastic, mottled yellowish brown (10YR 5/6) and gray (10YR 6/1), moist, stiff (1.5), CH. Contains ~10% FeOx and <5% spherical nodules (1/8"), trace limestone sand.
	15	15.0		20"			
		15.0 16.5	SS 06	18"	2.1.3 4		As above, pp=2.2, 16.0-16.5, 5% sand.
		17.5	ST 07				Disturbed
	20	20.0		23"			
							FERRELVIEW 20.5
		20.0 21.5	SS 08	18"	2.2.5 7		SILTY CLAY, medium plasticity, 10% sand, 10% fine subrounded gravel, brownish yellow (10YR 6/6) with black MnOx stringers, moist, very stiff (3.0), CH.
		22.5 24.5	ST 09	32"	Pushed 24"		As above, mottled with light gray (10YR 7/1), less sand and gravel, pp=3.0.
	25						CLAY TILL

5/89
29

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121
Contract WP117

Hole Number
GTS-5

Project: Geotechnical Investigation Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25						
5/5/89 5/6/89		25.0 26.5	SS 10	18"	2.6.3 19		26.0-28.0 as above, increase in gravel >50%, predominantly chert, up to 2", subrounded, pp(clay)=3.5.
		27.5 29.0	SB 11	12"	7.12.16 28		As above, pp=4.5+, hard, 15% fine to coarse sand, trace gravel (1/4"), MnOx stringers.
	30						CLAY TILL
		30.0 31.5	SS 12	18"	4.7.11 18		SILTY CLAY, medium plasticity, ~15% sand, mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1), damp, hard, (>4.5), CL-CH, spherical FeOx, MnOx stringers and blebs.
		32.5 35.0	ST 13	34			As above, pp=3.0, very stiff, CH.
	35						36.0
		35.0 36.5	SS 14	18"	3.9.50 59		GRAVEL fragments, chert, 10% clay, chert-yellowish brown (10YR 5/6), also clay with black MnOx, clay moist, hard, GC. RESIDUUM

Auger refusal at 37.0, T.D. 11:10 6/6/89
Apparent bedrock
Grouted hole with 2 bags of Volclay

Constant head test at 15.0'. Take = .25 oz. in 10 minutes.

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2
Project Number: 5121
Contract WP117
Hole Number: GTS-6

Project: Geotechnical Investigation Phase II	Location: Temporary Storage Area
Coordinates: N.98933.0 W.51035.7 (AEC)	Drilling Contractor: Hannibal Testing Laboratories
Drill Make and Model: CME-55 H.S. Auger 6 7/8", 3 1/4"	Depth Top of Rock: 47.0 / Depth Casing & Size: None / Hole Size: 6 - 7/8"
Elevation: G.S. 665.28 ft.	Angle from Vert. and Bearing: Vertical / Depth Bottom of Hole: 47.0
Water Level: Dry	Fluid & Additives: None / Date Start: 3:00 6/6/89 / Date Finish: 1:25 6/7/89 / Logger: A. Benfer

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	GTS-6 Bulk						(Bulk sample of cuttings, GTS-6, collected from 0 to 5.0 feet).
		2.5 4.0	SS 01	9"	3.6.8		SILT, nonplastic, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/2), damp, hard (4.5+), ML.
	5						
		5.0 7.5	ST 02	24"			FERRELVIEW As above, pp=4.5+, hard, light yellowish brown (10YR 6/4)
		7.5 9.0	SS 03	18"	3.5.7 12		SILTY CLAY, low to medium plasticity, mostly light yellowish brown (10YR 6/4) with yellowish brown (10YR 5/6), moist, very stiff to hard (4.0), CL. Up to 1/8" blebs MnOx.
	10						
		10.0 12.5	ST 04				FERRELVIEW As above, pp=4.1, hard, mottled yellowish brown (10YR 5/6) and lt. gray (10YR 7/1), abundant FeOx. 12.5
		12.5 14.0	SS 05	12"	2.3.5 8		CLAY, highly plastic, mottled yellowish brown (10YR 5/6) and light gray (10YR 7/1), moist, very stiff (2.5), CH. Slickensided, contains MnOx and FeOx.
'6/89 '7/89	15						
		15.0 17.5	ST 06	26"			As above, pp=3.1 FERRELVIEW
		17.5 19.0	SS 07	18	3.4.6 10		As above, pp=2.5, very stiff, slickensided with stringers and blebs of MnOx and spherical FeOx nodules.
	20						
		20.0 22.5	ST 08	30"			As above, pp=3.75, 5% white angular sand 22.5
		22.5 24.0	SS 09	18"	4.6.10 16		SILTY CLAY, highly plastic, 15% sand, 10% subrounded fine gravel, spherical FeOx, reddish yellow (7.5YR 6/6) with light gray (10YR 7/1), damp, hard (4.5+) CL-CH. Minor MnOx. CLAY TILL

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121
Contract WP117

Hole Number
GTS-6

Project: Geotechnical Investigation Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	25	25.0 27.5	ST 10	28"			As above, pp=4.5+, increase in MnOx
		27.5 29.0	SS 11	18"	4.6.8 14		As above, pp=3.0, very stiff, less sand and gravel
	30	30.0 31.5	SB 12	12"	3.8.10.13 23		SILTY CLAY, medium plasticity, 10% sand, 10% fine gravel, brownish yellow (10YR 6/6) with minor light gray (10YR 7/1), damp, very stiff (3.25), CL. FeOx and MnOx stringers.
		32.5 34.0	SS 13	15"	5.7.10 17		As above, pp=4.5+, hard, slickensided with MnOx
	35	35.0 36.5	SB 14	12"	9.18.24 42		As above, pp=4.3 CLAY TILL
							Hard drilling
		37.5 39.0	SS 15	18"	5.7.10 17		As above, pp=3.75, spherical FeOx, granitic rock fragments, some well rounded fine gravel.
	40	40.0 41.5	SB 16	12"	11.22.35 57		As above, at 40.5', mottled red (2.5YR 5/8) and light gray (10YR 7/1), moist, hard (4.5+).
	45	45.0 46.5	SS 17	18"	5.15.43 58		GRAVEL, 30% clay, predominantly chert, brownish yellow (10YR 6/6) and black (MnOx), damp, hard (4.5+) GC, bottom 2" chert, highly fractured. RESIDUUM
							Auger refusal 47.', T.D. 1:25 6/7/89 Probably bedrock Grouted hole with 2 bags Volclay

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 1 of 2

Project Number: 5121
Contract WP117

Hole Number: GTS-7

Project: Geotechnical Investigation Phase II	Location: Temporary Storage Area
Coordinates: N.98771.0 W.51381.8 (AEC)	Drilling Contractor: Hannibal Testing Laboratories
Drill Make and Model: CME-55 H.S Auger 6-7/8", 3-1/4"	Depth Top of Rock: 44.5 / Depth Casing & Size: None / Hole Size: 6-7/8"
Elevation: G.S. 662.07 ft.	Angle from Vert. and Bearing: Vertical / Depth Bottom of Hole: 44.5
Water Level: Dry	Fluid & Additives: None / Date Start: 8:45 6/8/89 / Date Finish: 2:00 6/8/89 / Logger: A. Benfer

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
	GTS-Bulk						(Bulk sample of cuttings GTS-7 Bulk, collected from 0 to 5.0 feet). FILL
		2.5 4.0	SS 01	4"	3.3.5 8		SILTY CLAY, low plasticity, dk yellowish brn (10YR 4/2) dry, hard (4.5+), CL, localized angular gravel. 3.5
5							SILTY CLAY, medium plasticity, mottled strong brown (7.5YR 5/6) and yellow (10 YR 7/3), moist, stiff to very stiff (2.0), CL. Contains black MnOx. FERRELVIEW
		5.0 7.5	ST 02	32"			CLAY, low plasticity, very silty, yellow (10YR 7/4) very stiff (3.0), CL. MnOx and FeOx blebs.
		7.5 9.0	SS 03	14"	1.3.5 8		9.0
10		10.0 12.5	ST 04	20"			CLAY, highly plastic, mottled yellowish red (5YR 6/6) and light gray (7.5YR 7/0). moist, very stiff (2.25), CH.
		12.5 14.0	SS 05	18"	3.4.5 9		As above, mostly light gray (10YR 7/1) with strong brown (7.5 YR 5/6) (FeOx), pp=2.75. As above, minor MnOx, spherical FeOx, pp=3.5.
15		15.0 17.5	ST 06	22"			FERRELVIEW As above, trace sand and fine gravel, pp=2.75. 17.5
		17.5 19.0	SS 07	18"	3.5.10		SILTY CLAY, 20% sand, mottled brownish yellow (10YR 6/6) and light gray (10YR 7/1), damp, hard (4.5+), CL-CH. Slickensided, MnOx blebs.
20		20.0 22.5	ST 08	20"			CLAY TILL As above, 15% sand, 5% subrounded gravel, pp=3.7, CH.
		22.5 24.0	SS 09	16"	3.5.6 11		As Above, pp=4.5+, MnOx stringers. trace gravel up to ½".

WELDON SPRING REMEDIAL ACTION PROJECT

BOREHOLE LOG

Sheet 2 of 2

Project Number: 5121
Contract WP117

Hole Number
GTS-7

Project: Geotechnical Investigation Phase II

Location: Temporary Storage Area

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25.0 26.5	SB 10	18"	7.15.27 42		As above, stiff (1.5), moist, CL, stringers of CaCO3 and MnOx, some well rounded coarse sand.
		27.5 29.0	SS 11	18"	4.7.9 16		As above, pp=4.5+, 10% fine gravel, vertical light gray clay stringers. CLAY TILL
		30.0 31.5	SB 12	12"	17.38.28 66		CLAY, silty, 10% sand, 10% gravel up to 1", brownish yellow (10YR 6/6) with light gray (10YR 6/6) stringers, spherical FeOx, damp hard (4.5), CL.
		32.5 34.0	SS 13	18"	4.7.11 18		As above, reddiwh yellow (7.5YR 6/8) at 33.5, pp=4.5, slickensided some with MnOx film.
	35	35.0 36.5	SB 14	12"	11.15.26 41		As above, yellowish brown (10YR 6/6) 37.0
		37.5 39.0	SS 15	18"	7.11.8 19		37.5-38.0 SAND, fine to coarse, 20% clay, strong brown (7.5YR 5/6), damp, medium dense, SC. 38.0-39.0 CLAY, medium plasticity, light gray (10YR 7/1) moist, medium stiff to stiff (1.0), CL-CH, with white lithographic limestone fragments.
	40	40.0 41.5	SB 16	12"	5.9.2 11		40.0-41.5 CLAY, low plasticity, speckled yellowish brown (10YR 7/1), moist, very stiff (2.5), CL, minor MnOx, abundant FeOx up to 1/4" nodules. CLAY TILL
							Auger refusal 44.5', T.D., 2:00 6/8/89 Probable bedrock Hole grouted with 2 bags Volclay.

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

SITE ID: _____ LOCATION ID: GT-73

COORDINATES (FT.): _____ E _____

GROUND ELEVATION (FT. MSL): _____

DRILLING METHOD: 3 3/4" ID Auger

DRILLING CONTR.: GEOTECHNOLOGY

DATE STARTED: 4/15/91 11:20

DATE COMPLETED: 4/15/91 16:10

FIELD GEOLOGIST/ENGINEER: E Renbat

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)
4/15/91	1510	DRY

LOCATION DESCRIPTION ~100' W of SW corner of Bldg 302

SITE CONDITION Grassy level

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	SAMPLE ~~CPM~~ ~~(OPT)~~ NO	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION	
						Top: Dk brown silt (ML) w/ organics contaminated (~400 cts/min), moist	
	2½-4' SPT	13"	7301	2-4-6		~3'+ Med brn silty clay (CL) moist plastic	11:40
5	5-7½ ST	28"	7302			AA, more silty; some gray color	
	7½-9 SPT	16"	7303	1-5-8		AA.	
10	10-12½ ST	4"	(7304) no sample			AA - single 1" angular chert clast	
	12½-14 SPT	16"	7305	1-4-7		AA mostly lt gray; clayey again	
15	15-17½ ST	23"	7306			AA stiff, Mn staining; some Fe staining lt brn & gray	
	17½-19 SPT	20"	7307	4-8-12		~7½'+ Lt Gray-brown silty Clay (CL) plastic, moist w/ ~5% subrounded med-cse chert qtz sand slight Mn & Fe staining	Clay Till
20	20-22½ ST	28"	7308			AA, more staining	
	22½-24 SPT	18"	7309	5-8-12		AA lt orange-brown color	13:25
25	25-27½ ST	27"	7310			AA lt gray & brown	
	27½-29 SPT	21"	7311	5-12-16		A.A. occl white Limestone mell - fizzes w/ HCl	
30	30-32½ ST	23"	7312			7312 - pushed 20", end bodly crimped	

COMMENTS: AA = As Above SPT = Std. Penetration Test ST = Shelby Tube

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

SITE ID: _____ LOCATION ID: GT-73
SITE COORDINATES (FT.): _____
N _____ E _____
GROUND ELEVATION (FT. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD GEOLOGIST/ENGINEER: _____

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	SAMPLE ~~CPM~~ ~~(OPT.)~~ No.	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION	
						A.A. occ'l gravel-size clasts	
	32½-34 SPT	21"	7313	6-10-11		A.A. - up to 10% fine gravel	
						33½ + softer gray clayey silt (ML) little sand	?
-35	35-36½ CS	19" (3 tubes)	7314	(7-11-15)		no gravel; some Fe staining	
						A.A.	
	37½-39 SPT	17"	7315	5-9-20		38'+ - Lt-dark brown clayey silty sand mostly med-cse	Basal
						w/ occ'l small angular gravel; Fe staining	Till ?
-40	40-41½ CS	15" (2 tubes)	7316	(24-37-100/4")		40'+ Whitish angular chert gravel (~60%) (GW-GM)	
	42½-44	7"	7317	34-50/2½"		w/ sandy clayey silt white-orange, slt Fe staining	
						AA more gravel, broken by pounding	
-45							15:00
						Auger refusal at 45½'	
						Grouted w/ 5 bags Volclay at 9.4; 9.6; 9.7 lbs/gal	

COMMENTS: CS = California sampler

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

SITE ID: _____ LOCATION ID: GT-74
TE COORDINATES (FT.): _____
_____ E _____
GROUND ELEVATION (FT. MSL): _____
DRILLING METHOD: 3 3/4" I.D. Auger
DRILLING CONTR.: GEOTECHNOLOGY
DATE STARTED: 4/12/91 14:00
DATE COMPLETED: 4/15/91 10:00
FIELD GEOLOGIST/ENGINEER: E. Rennat

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION ~150' NE of Bldg 434
SITE CONDITION Grassy, inclined to NE

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION
						Med brn silty Clay (CL) moist, plastic
	2 1/2-4 SPT	5"	7401	2-3-6		organics (dk brn) n. top, some grass occ'l chert clast (up to 1/2").
5	5-7 1/2 ST		7402			~6'+ Med gray silty Clay (CL) moist, plastic
	7 1/2-9 SPT	14"	7403	1-4-6		— Mottled lt brn - lt & med gray silty Clay (CL) moist, plastic
10	10-12 1/2 ST	27"	7404			~11'+ - lt brn - orange gray Clay (CL) moist, stiff, plastic, ~5% rounded med sand (chert) - subrounded occ'ly up to 1/4"
	12 1/2-14 SPT	18"	7405	1-5-7		
15	15-17 1/2 ST	[illegible]	7406			17 1/2' - ~10% subrdd fine gravel (dk gray)
	17 1/2-19 SPT	18"	7407	3-8-9		- AA stiff
20	20-22 1/2 ST	22"	7408			tube pushed 28"; end badly crimped AA!?
	22 1/2-24 SPT	22"	7409	3-8-9		AA
25	25-27 1/2 ST	24"	7410			- pushed 26" AA
	27 1/2-29 SPT	~14"	7411	9-23-25		28'+ ~60% angular chert gravel which ⇒ Fe stained
	30-32 1/2 CS	2"	═══	(100/5 1/2")		no sample kept 1-2" angular chert ~70% w/ sandy clay

Fvw

Clay Till

Fe, Mn [illegible]

COMMENTS: _____

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

ID: _____ LOCATION ID: GT-74
S. _ COORDINATES (FT.): _____
N _____ E _____
GROUND ELEVATION (FT. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD GEOLOGIST/ENGINEER: _____

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (FT.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH	SAMPLE INTERV.	SAMPLE RECOV.	CPM (OPT.)	BLOWS PER 6 IN.	N VALUE	VISUAL CLASSIFICATION
	32½-34 SPT		~~[illegible]~~	50/1½"		angular Chert Gravel w/ Limestone encrusted
35						TD = 34½" 15:50
						Grouted w/ 3 bags Volclay at 9.6 lbs/gal

MMENTS: _____

APPENDIX C

Request No.	Sample I.D.	Sample No.	Depth (ft)	Confining Pressure (ksf)	Reported Value Total Head (ft)	Reported Value Permeability (cm/sec)	Corrected Value Total Head (ft)	Corrected Value Permeability (cm/sec)
4	GT-60P	SB-15	40.5 - 41.0	4	64.3	$9x10^{-9}$	11.6	$7x10^{-8}$
	GT-60P	SB-15	41.0 - 41.5	7	112.5	$2x10^{-8}$	11.6	$2x10^{-7}$
	GT-60P	SB-17	48.5 - 49.0	4	64.3	$6x10^{-8}$	11.6	$3x10^{-7}$
	GT-60P	SB-17	48.5 - 49.0	7	112.5	$2x10^{-8}$	11.6	$2x10^{-7}$
	GT-62	ST-07	17.5 - 20.0	2	32.1	$2x10^{-8}$	11.6	$5x10^{-8}$
	GT-62	ST-07	17.5 - 20.0	4	32.1	No Flow	11.6	$<1x10^{-9}$
	GT-62S	SB-13	32.8 - 33.3	3	48.2	$6x10^{-6}$	11.6	$3x10^{-5}$
	GT-62S	SB-13	32.8 - 33.3	5	80.3	$7x10^{-9}$	11.6	$6x10^{-8}$
	GT-63P	ST-01	2.5 - 5.0	1	16.1	$5x10^{-9}$	11.6	$7x10^{-9}$
	GT-63P	ST-09	22.5 - 25.0	2	32.2	$3x10^{-9}$	11.6	$9x10^{-9}$
	GT-65S	SB-16	41.0 - 41.5	4	64.2	$2x10^{-7}$	11.6	$8x10^{-7}$
	GT-65S	SB-16	41.0 - 41.5	7	112.4	$3x10^{-8}$	11.6	$4x10^{-7}$
	GT-67P	ST-08	20.0 - 22.5	2	32.2	$4x10^{-8}$	11.6	$1x10^{-7}$
5	GTS-1	ST03	5.0 - 7.5	1	16.1	$1x10^{-7}$	11.6	$2x10^{-7}$
	GTS-3	ST02	5.0 - 7.5					
	GTS-2	ST02	2.5 - 5.0	1	16.1	$6x10^{-8}$	11.6	$8x10^{-8}$
	GTS-4	ST04	7.5 - 10.0					
	GTS-4	ST02	2.5 - 5.0	1	16.1	$2x10^{-7}$	11.6	$2x10^{-7}$
	GTS-4	ST04	7.5 - 10.0					
	GTS-5		0.0 - 5.0	1	16.1	$2x10^{-8}$	11.6	$2x10^{-8}$
	GTS-6		0.0 - 5.0	1	16.1	$9x10^{-8}$	11.6	$1x10^{-7}$
	GTS-7		0.0 - 5.0	1	16.1	$3x10^{-8}$	11.6	$5x10^{-8}$

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

Request #5

P.O. # 3589-1002-3445

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WJJ RAP

CHECKED BY: LAB 44

DATE: 11-9-89

TAC

LAB NAME: Geotechnology Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTS-1	ST03	TOP 5.0-7.5	26.7	N/A
GTS-1	ST03	MIDDLE 5.0-7.5	23.3	97.5
GTS-1	ST03	BOTTOM 5.0-7.5	22.8	N/A
GTS-2	ST02	TOP 2.5-5.0	29.2	N/A
GTS-2	ST02	MIDDLE 2.5-5.0	25.5	95.0
GTS-2	ST02	BOTTOM 2.5-5.0	26.6	N/A
GTS-2	ST04	TOP 7.5-10.0	20.5	103.0
GTS-2	ST04	BOTTOM 7.5-10.0	20.7	102.1
GTS-3	ST02	TOP 5.0-7.5	28.5	N/A
GTS-3	ST02	MIDDLE 5.0-7.5	29.6	89.9
GTS-3	ST02	BOTTOM 5.0-7.5	37.4	N/A
GTS-4	ST02	TOP 2.5-5.0	28.2	N/A
GTS-4	ST02	MIDDLE 2.5-5.0	28.4	92.3
GTS-4	ST02	BOTTOM 2.5-5.0	28.1	N/A
GTS-4	ST04	TOP 7.5-10.0	26.7	N/A

TEST PROCEDURE: ASTM D2216 & D2937

ATTACHMENT 6 59

MKF-AL-ENG-6 (4/87)

Request #5

P.O. # 3589-1002-3445

A MORRISON KNUDSEN COMPANY

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WWRAP

CHECKED BY: LAB 44

DATE: 11-9-89

TAC

LAB NAME: Geotechnology Inc

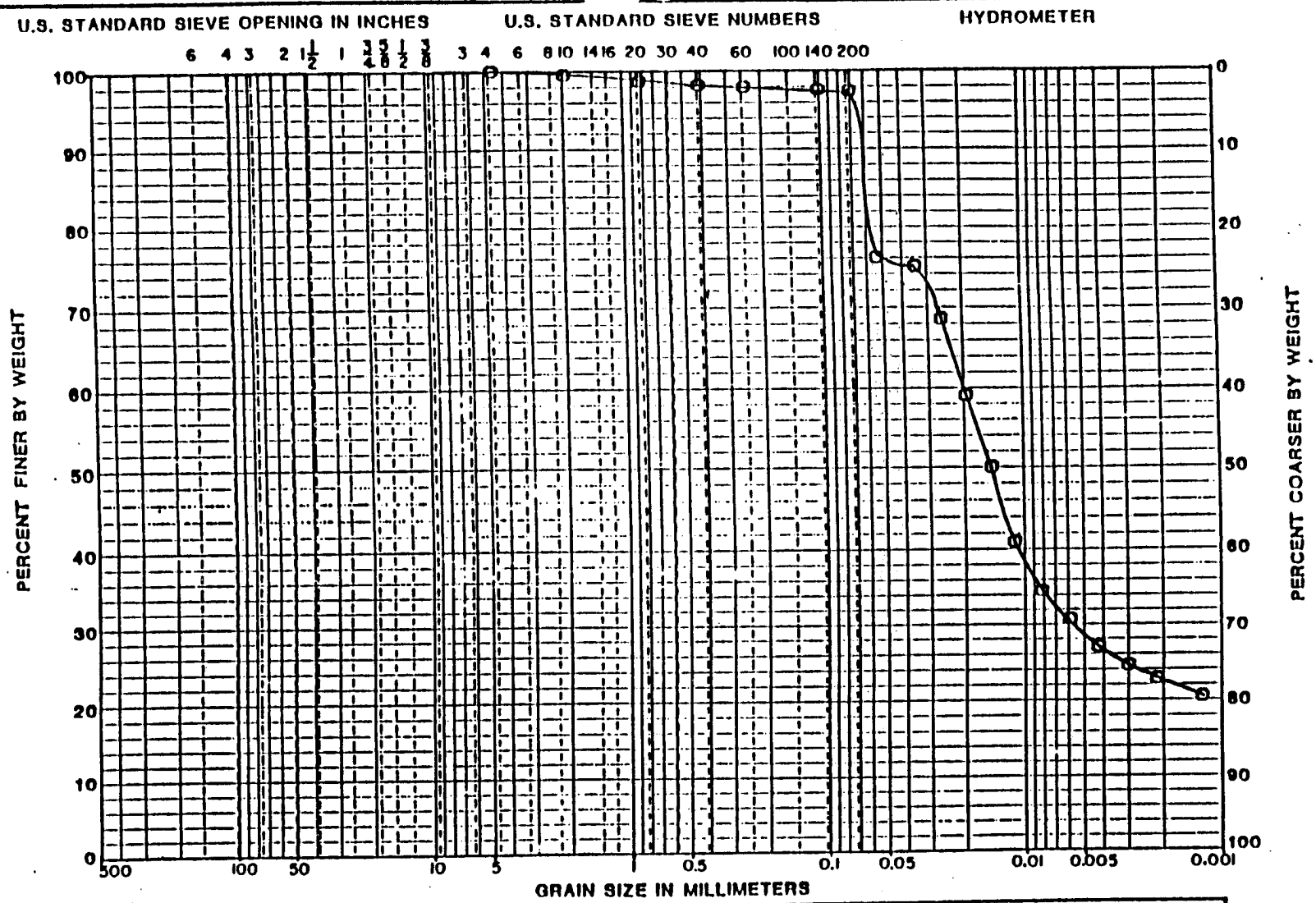
LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
GTS-4	ST04	MIDDLE 7.5-10.0	21.5	102.9
GTS-4	ST04	BOTTOM 7.5-10.0	21.5	N/A
GTS-5	BULK	0.0-5.0	21.7	N/A
GTS-6	BULK	0.0-5.0	19.7	N/A
GTS-7	BULK	0.0-5.0	23.8	N/A

TEST PROCEDURE: ASTM D2216 & D2937

MKF-AL-ENG-6 (4/87)

ATTACHMENT 6 #59

GRAD/ URVES



SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
ST-03	5.0-7.5	CL	25.2	40	20	20

PROJECT WSSRAP

BORING NO. GTS-1

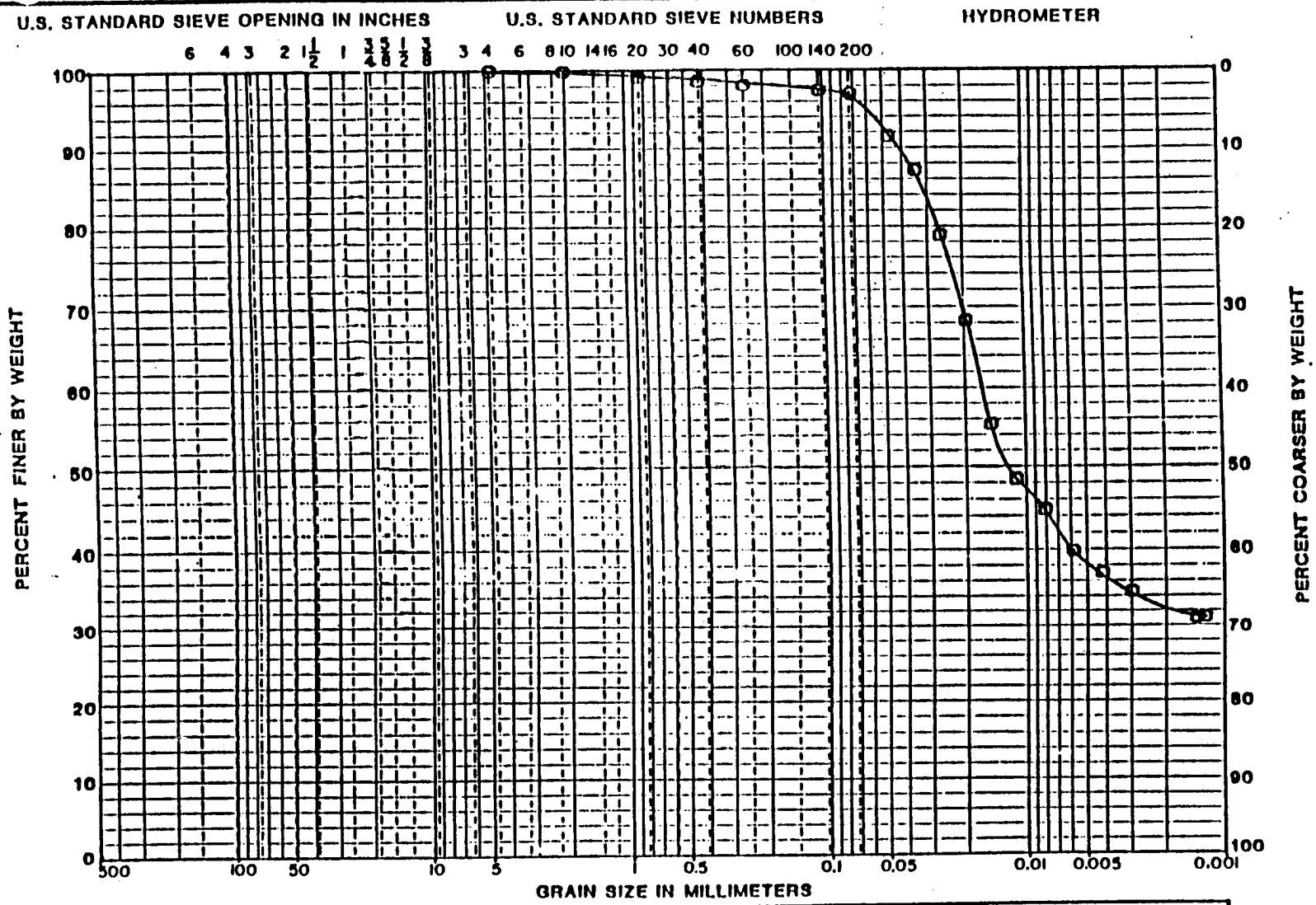
DATE 11-8-89

GEOTECHNOLOGY

11295

PLATE #82

GRAD C URVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
COMP.	2.5-10.0	CL	5.4	44	20	24

PROJECT WSSRAP

BORING NO. GTS-2

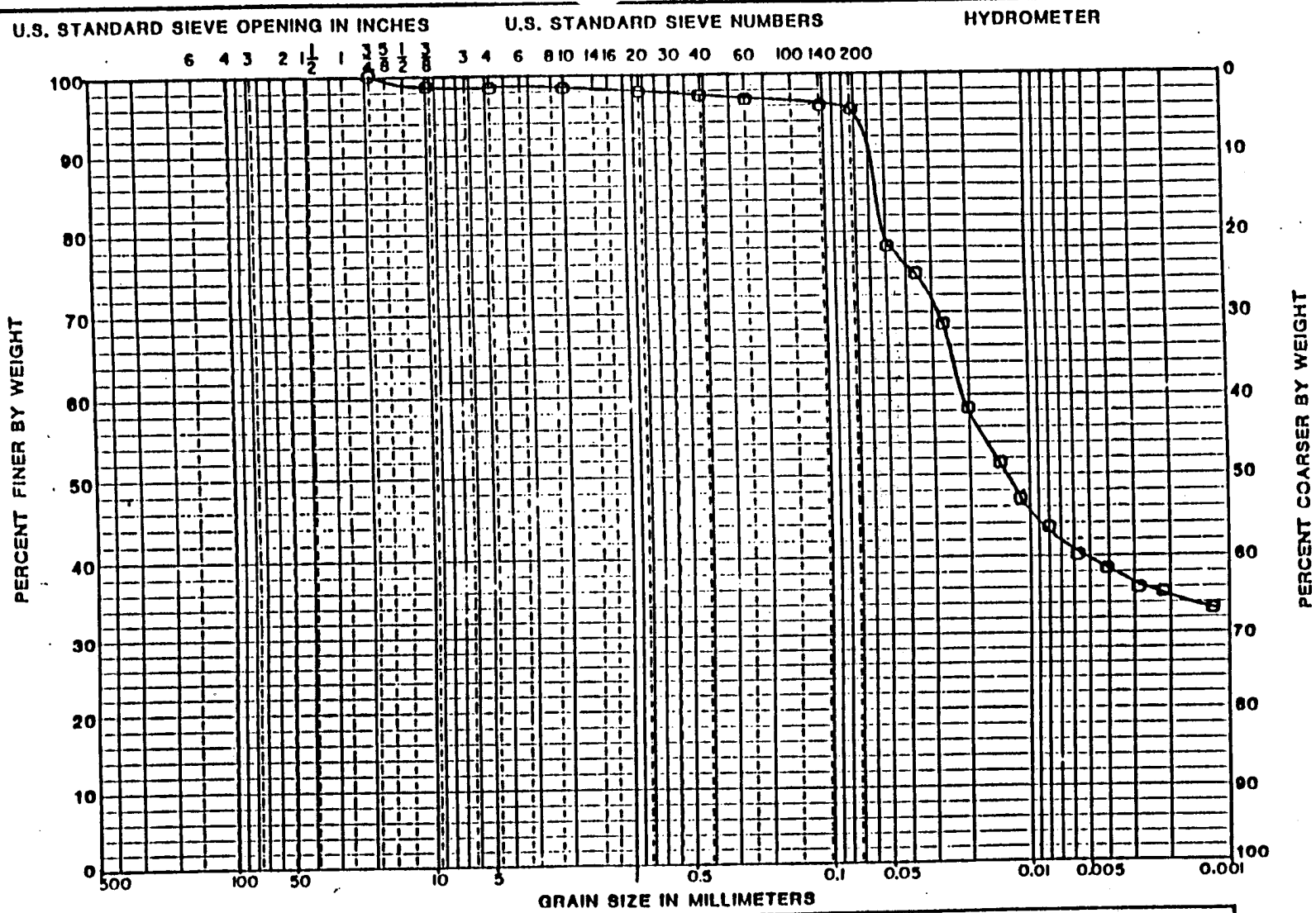
DATE 11-8-88

GEOTECHNOLOGY

11295

PLATE H 86

GRAD[illegible] CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
ST-02	5.0-7.5	CH	28.4	53	19	34

PROJECT WSSRAP

BORING NO. GTS-3

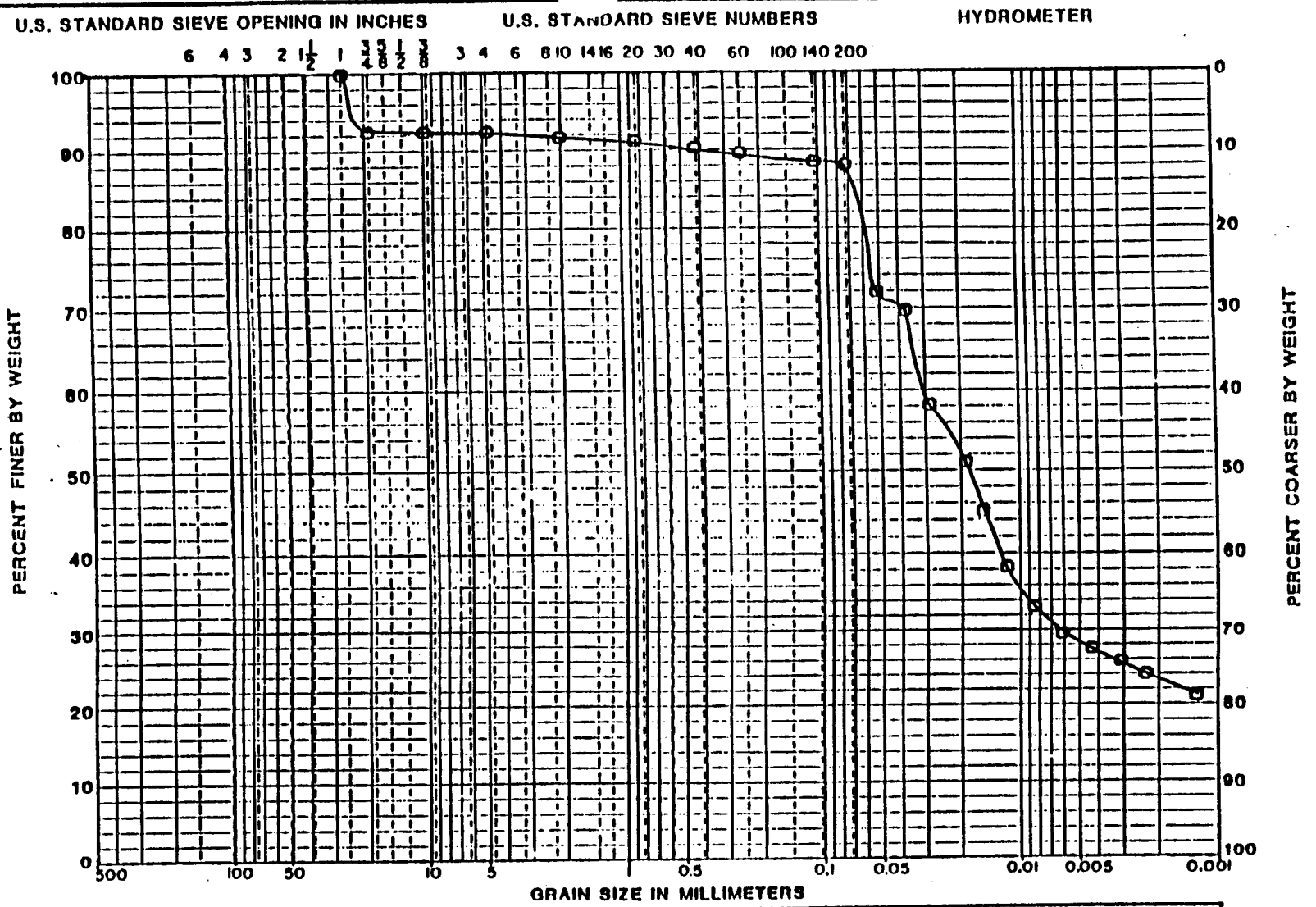
DATE 11-8-89

GEOTECHNOLOGY

11295

PLATE # 90

GRAI CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
ST-02	2.5-5.0	CH	27.1	51	23	28

PROJECT WSSRAP

BORING NO. GTS-4

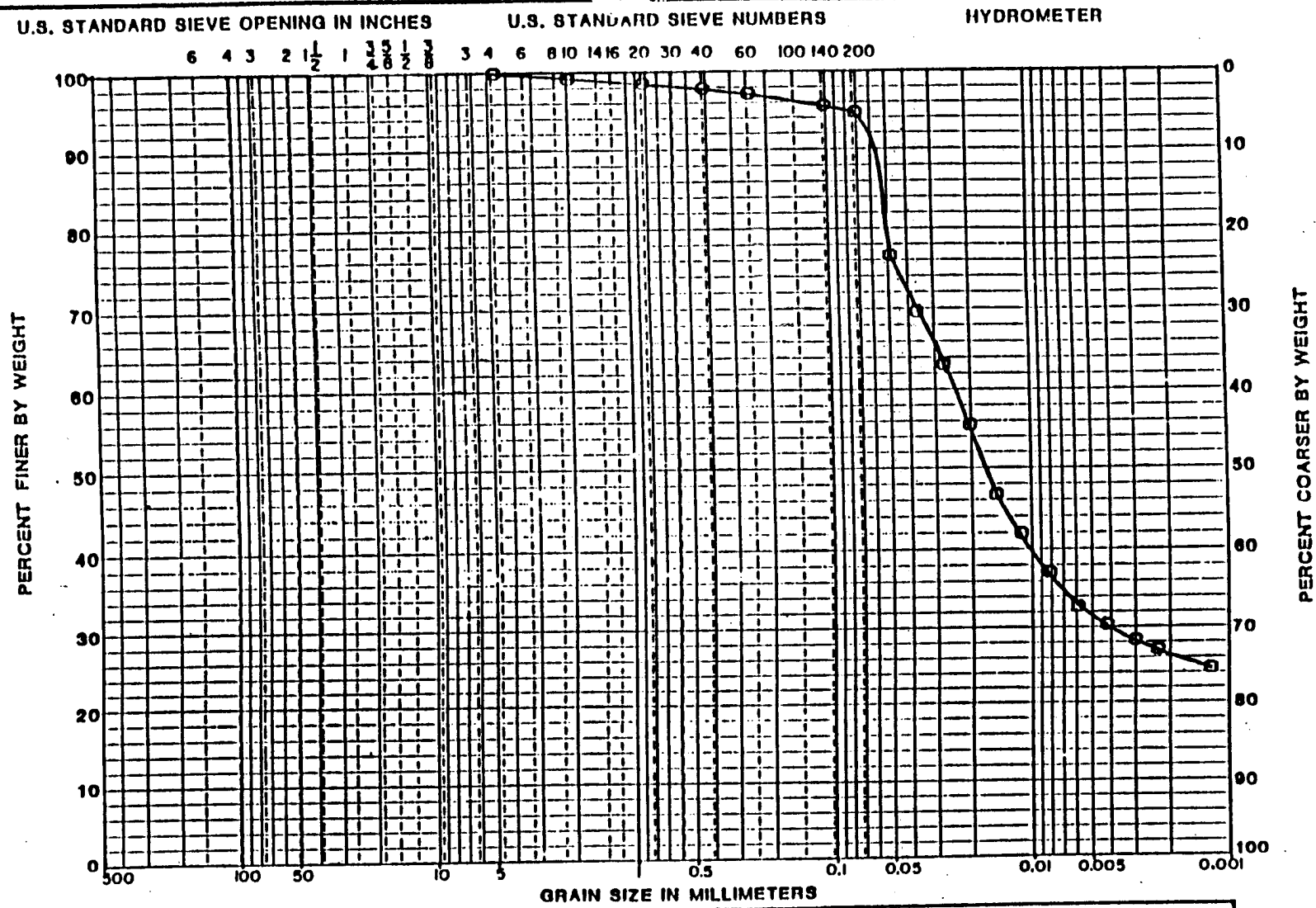
DATE 11-8-88

GEOTECHNOLOGY

11295

PLATE H 94

GRADA CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
ST-04	7.5-10.0	CL	22.4	41	20	21

PROJECT WSSRAP

BORING NO. GTS-4

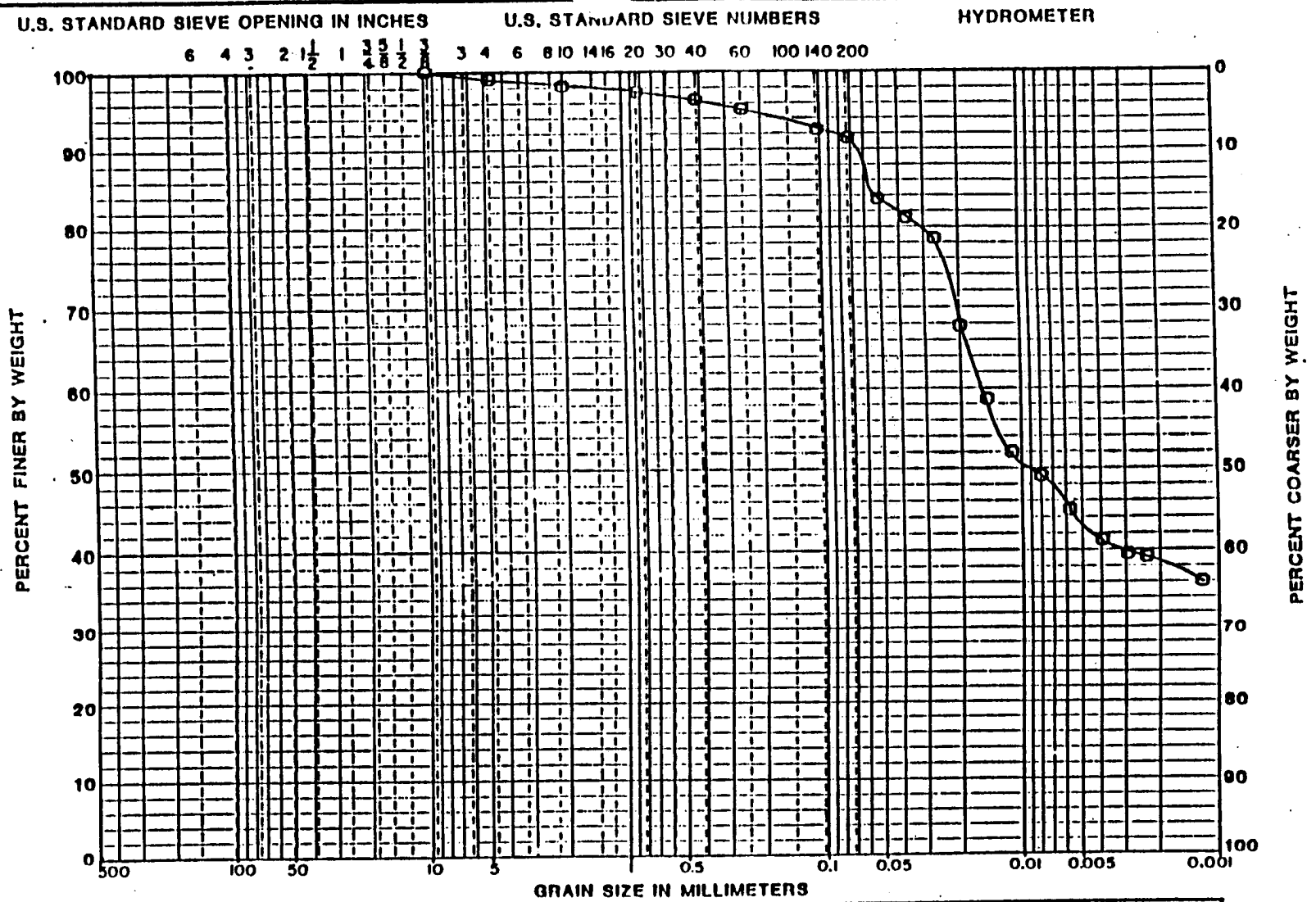
DATE 11-8-89

GEOTECHNOLOGY

PLATE H 98

11255

GRAD CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
BULK	0.0-5.0	CH	5.4	53	18	35

PROJECT WSSRAP

BORING NO. CTS-5

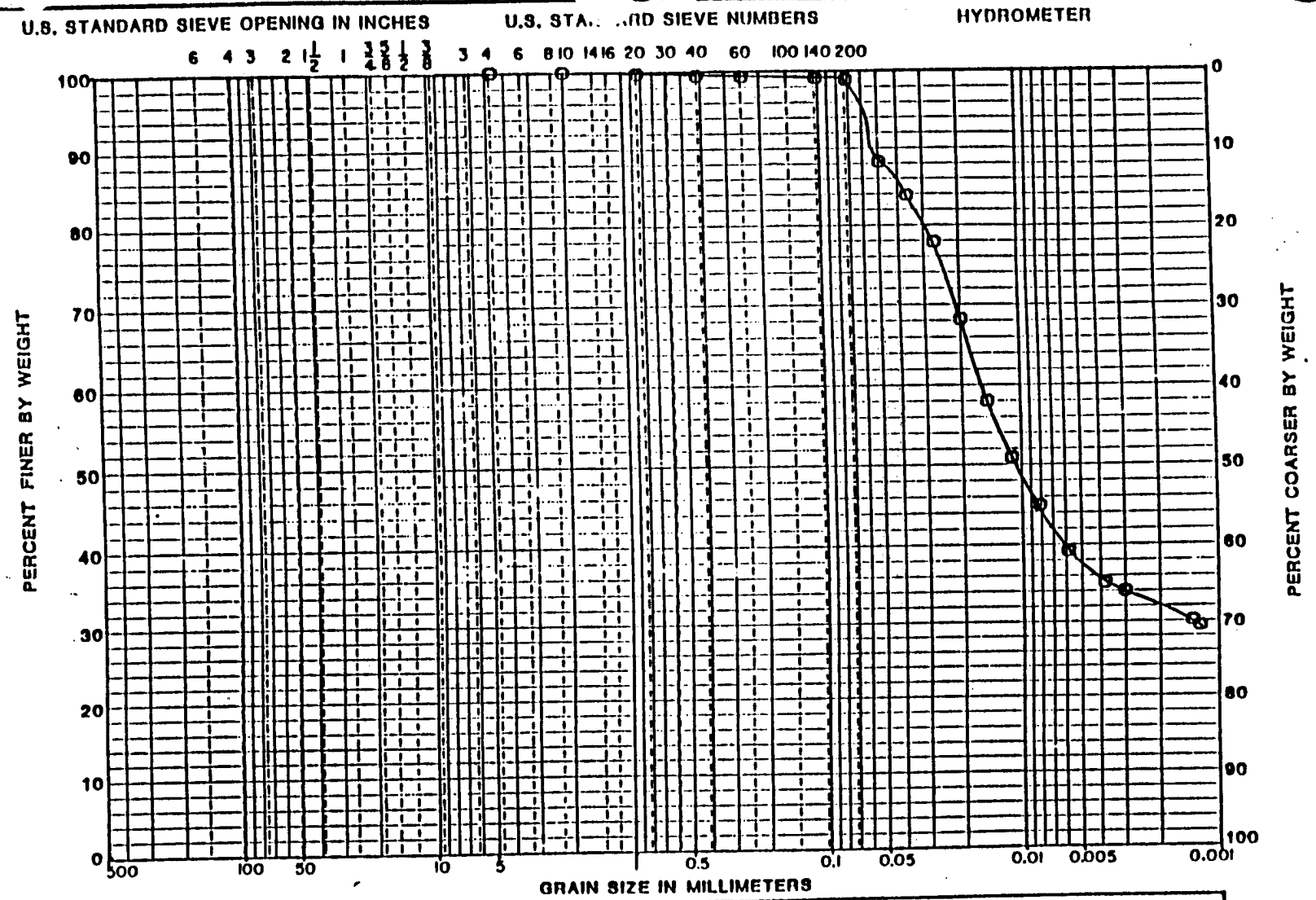
DATE 11-8-89

GEOTECHNOLOGY

PLATE H 102

1125

GRAD/ URVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
BULK	0.0-5.0	CL	6.1	43	22	21

PROJECT WSSRAP

BORING NO. CTS-6

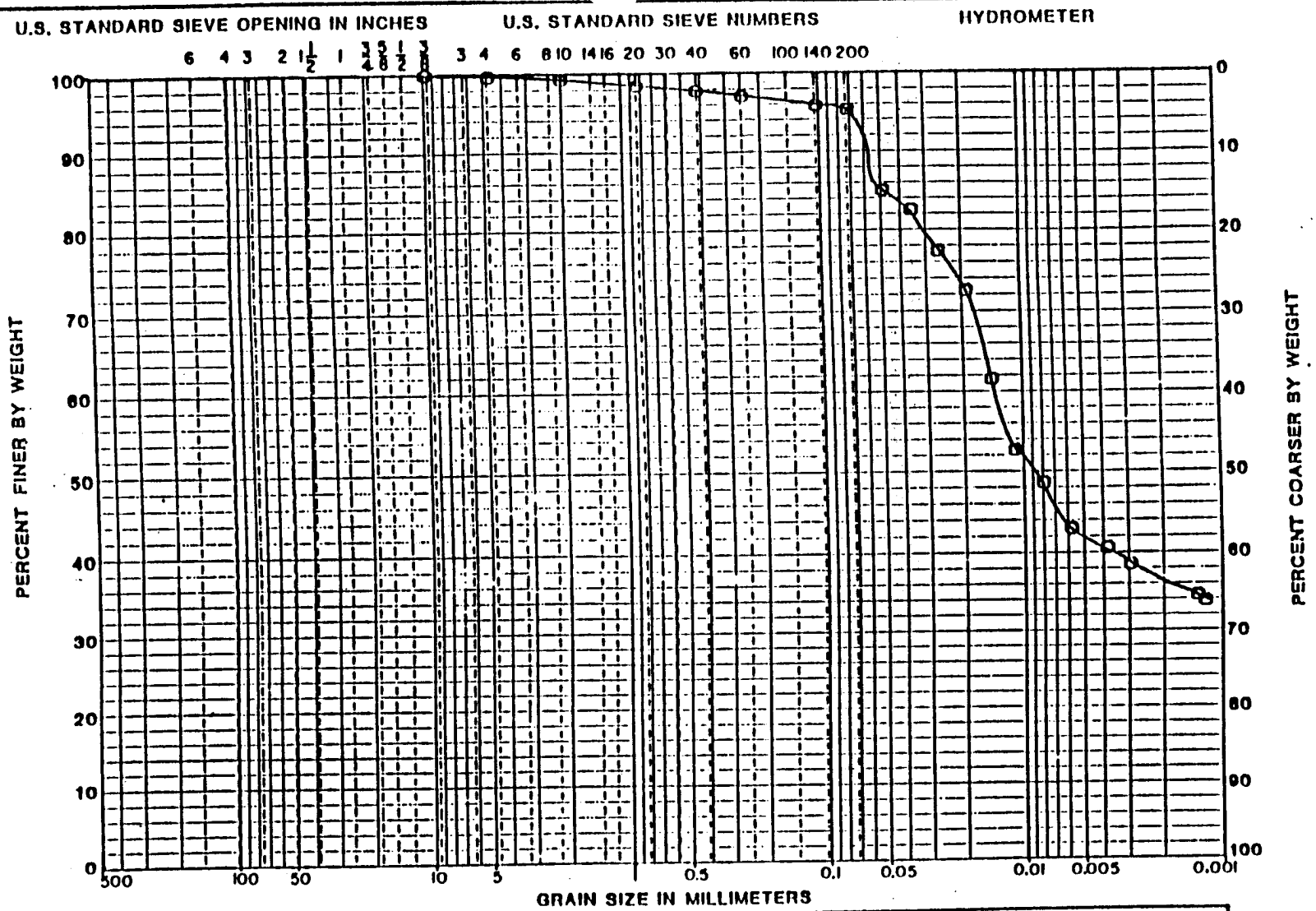
DATE 11-8-89

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS MISSOURI

PLATE # 106

11295

GRADA[illegible] JRVES



SAMPLE NO.	EL. or DEPTH	CLASSIFICATION	NAT.WT.%	LL	PL	PI
BULK	0.0-5.0	CH	3.8	59	24	35

PROJECT WSSRAP

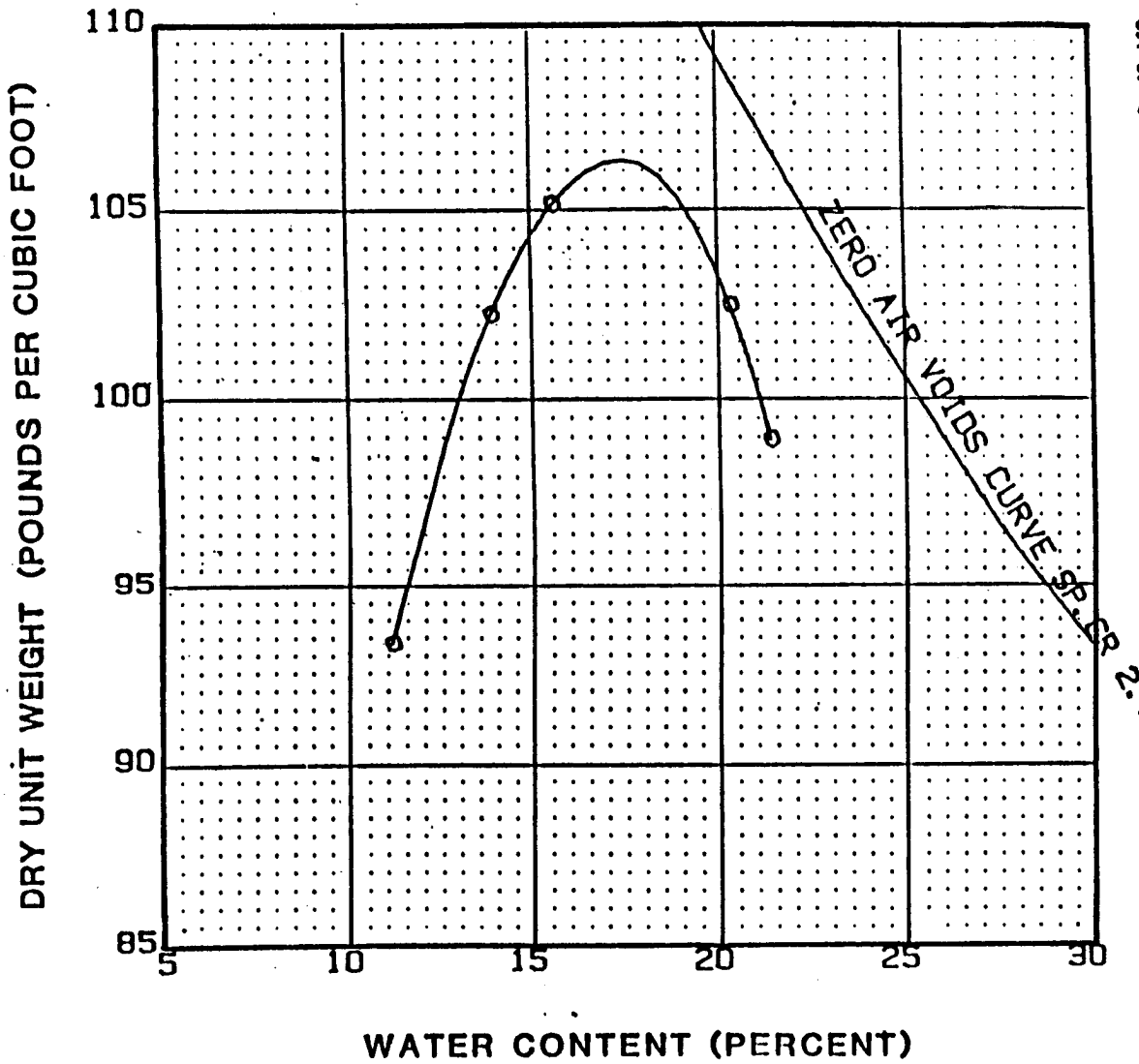
BORING NO. GTS-7

DATE 11-8-89

GEOTECHNOLOGY

PLATE H 110

Job # 11295
Date: 10-24-89



SPECIFICATIONS

STANDARD PROCTOR
AASHO T 99-70, ASTM D 698-70 (Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
106.4	17.5	21.7

DESCRIPTION

Brown CLAY

ATTERBERG LIMITS

LL- 53 PL- 18 PI- 35

CLASSIFICATION SYSTEM

UNIFIED : CH

AASHTO :

SAMPLE INFORMATION

GTS - 5
0.0-2.0 FT

WSSRAP

COMPACTION TEST

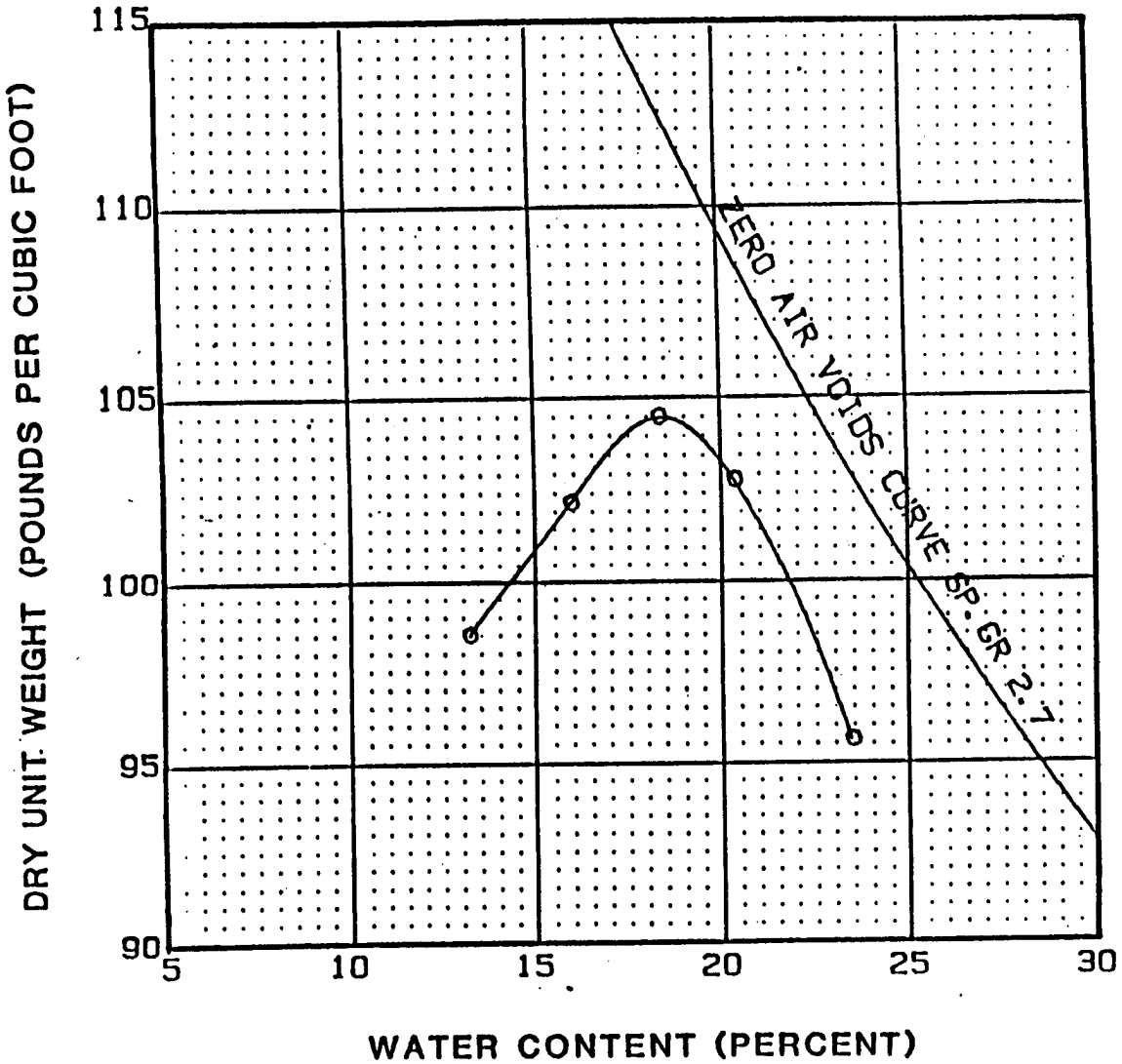
GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS MISSOURI

Checked by YY

DI ATE H 114

L-2 10/88

Job # 11295
Date: 10-18-89



SPECIFICATIONS

STANDARD PROCTOR
AASHO T 99-70, ASTM D 698-70

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
104.6	18.3	19.7

DESCRIPTION

Brown, silty CLAY

ATTERBERG LIMITS

LL- 43 PL- 22 PI- 21

CLASSIFICATION SYSTEM

UNIFIED : CL

AASHTO :

SAMPLE INFORMATION

CTS - 6 0.0-5.0 feet

WSSRAP

COMPACTION TEST

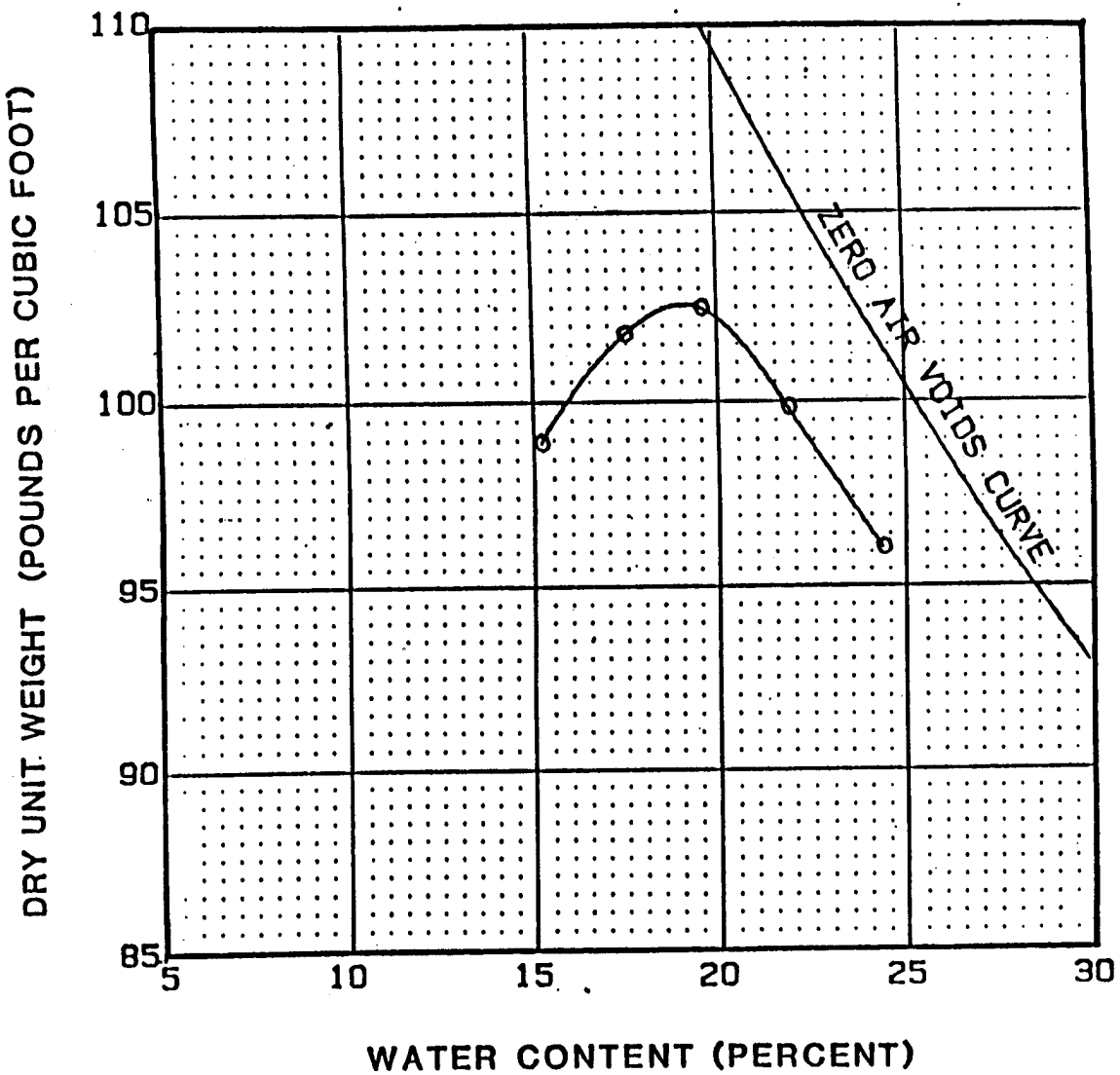
GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS MISSOURI

Checked by YY

PLATE H 116

L-2 10/88

Job # 11295
Date: 10-23-89



SPECIFICATIONS

STANDARD PROCTOR
AASHO T 99-70, ASTM D 698-70

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
102.7	19.2	23:8

DESCRIPTION

Brown Clay

ATTERBERG LIMITS

LL-59 PL-24 PI-35

CLASSIFICATION SYSTEM

UNIFIED : CI

AASHTO :

SAMPLE INFORMATION

GTS-7
0.0-5.0

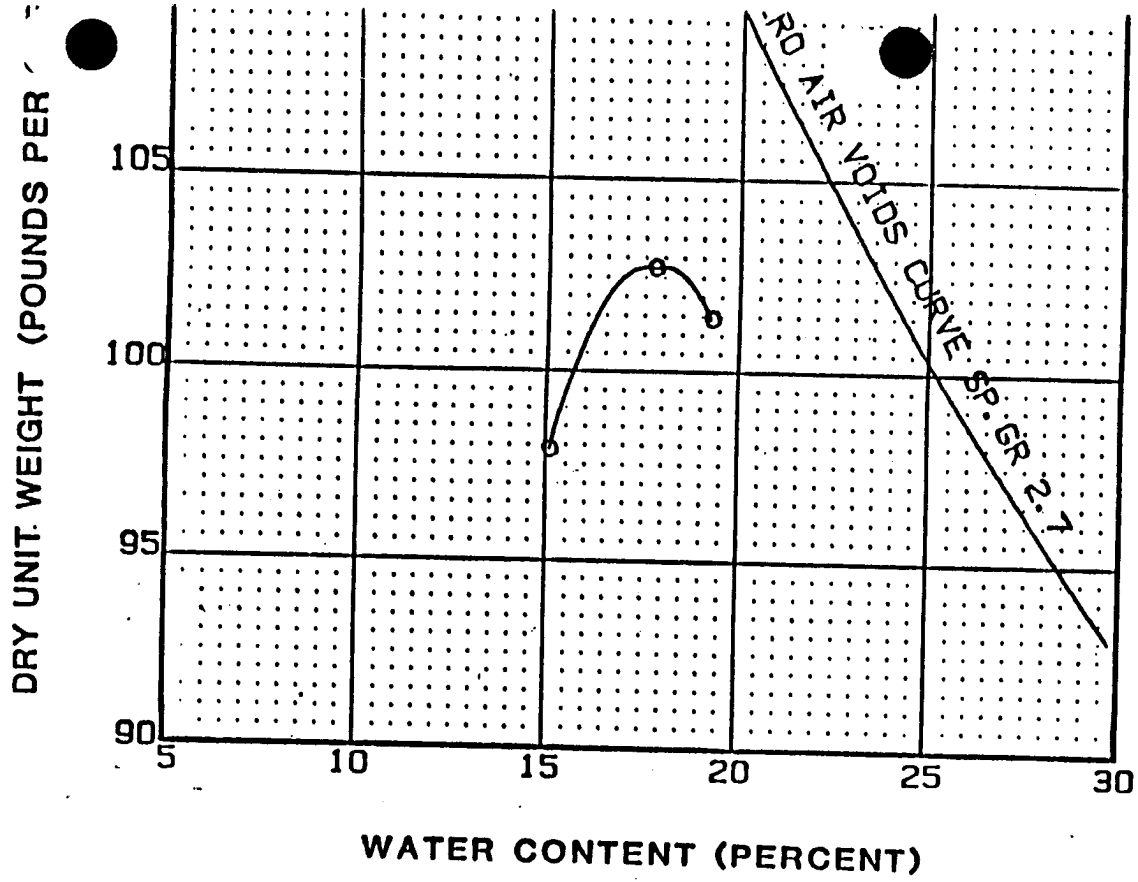
WSSRAP

COMPACTION TEST

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

Checked by yy

H 118



102.8	17.5

DESCRIPTION

Composite: Brownish gray mottled, silty CLAY and gray, brownish yellow and brown CLAY

ATTERBERG LIMITS

LL- PL- PI-

CLASSIFICATION SYSTEM

UNIFIED : CL and CH

AASHTO :

SAMPLE INFORMATION

GTS-1, ST03, 5-7.5 FT - LL-40, PL-20, PI-20 (CL)

GTS-3, ST02, 5-7.5 FT - LL-53, PL-19, PI-34 (CH)

WSSRAP

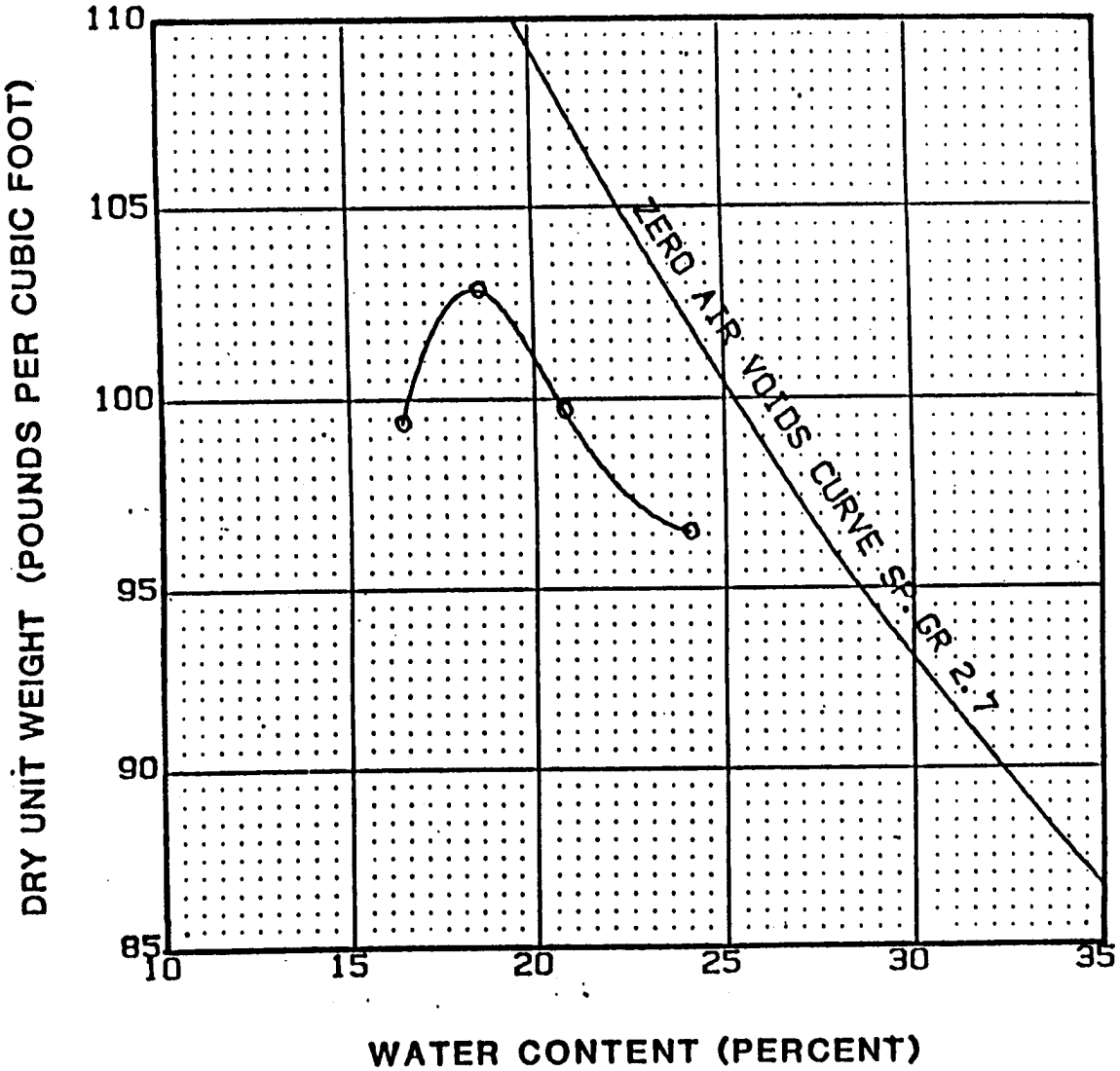
COMPACTION TEST

GEOTECHNOLOGY

Checked by 47

PLATE H 122

Job # 11295
Date: 11-11-89



SPECIFICATIONS

STANDARD PROCTOR
AASHO T 99-70, ASTM D 698-70 (Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
103.0	18.3	

DESCRIPTION

Composite: Brownish gray, silCLAY and brownish gray to grayish brown, clayey SILT to silty CLAY

ATTERBERG LIMITS

LL- 44 PL- 20 PI- 24

CLASSIFICATION SYSTEM

UNIFIED : CL

AASHTO :

SAMPLE INFORMATION

GTS-2, ST02, 2.5- 5.0 FT
~~GTS-4~~, ST04, 7.5-10.0 FT
2? GTS-2 COLLECTION MADE BY MKF SG 11/9/90

WSSRAP

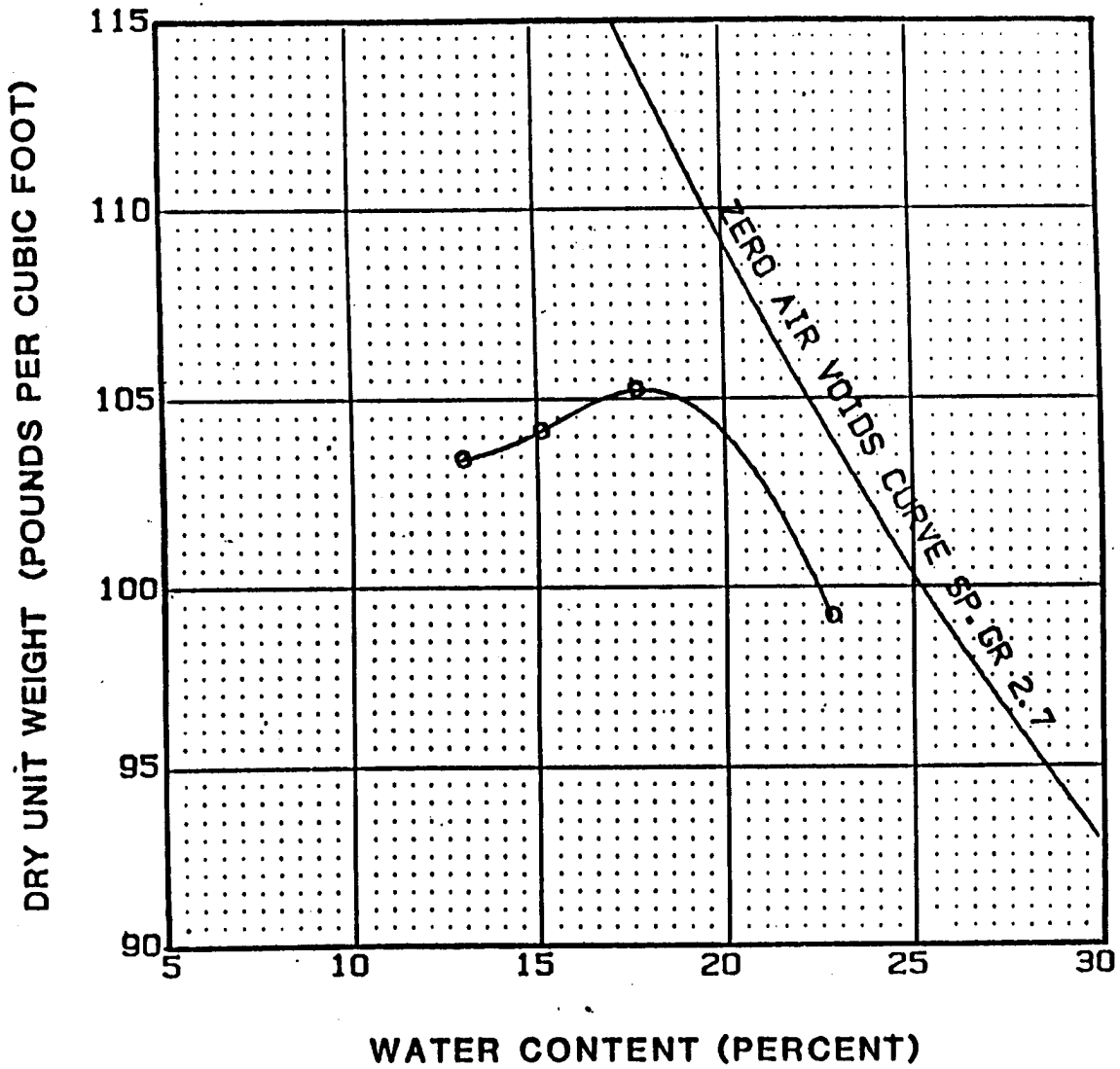
COMPACTION TEST

GEOTECHNOLOGY

Checked by 47

H 120

Job # 11295
Date: 11-11-89



SPECIFICATIONS

STANDARD PROCTOR
AASHO T 99-70, ASTM D 698-70 (Method A)

MAX DRY DENSITY (PCF)	WATER CONTENT %	
	OPTIMUM	NATURAL
105.3	17.7	

DESCRIPTION

Composite: Dark gray to brownish gray silty CLAY to CLAY and grayish brown and gray mottled, silty CLAY

ATTERBERG LIMITS

LL- PL- PI-

CLASSIFICATION SYSTEM

UNIFIED :

AASHTO :

SAMPLE INFORMATION

GTS-4, ST02, 2.5- 5.0 FT - LL-51, PL-23, PI-28 (CH)
GTS-4, ST04, 7.5-10.0 FT - LL-41, PL-20, PI-21 (CL)

WSSRAP

COMPACTION TEST

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

Checked by YY

DI ATE H 124

Request # 5
P.O. # 3509 -1002 -3445

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

PERMEABILITY TEST RESULTS

SITE ID: WSSRAP

CHECKED BY: LAB 77

DATE: 6-6-90

TAC

LAB NAME: Geotechnology, Inc

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	TEST METH.	COMPACTION (%)	MOISTURE CONTENT (%)		DRY DENSITY (PCF)		SATURATION (%)		TOTAL PRESSURE HEAD (FT)	PERMEABILITY (CM/SEC)
					INIT.	FINAL	INIT.	FINAL	INIT.	FINAL		
Temporary storage Area	GTJ-5	0-5	CH	94.9	20.7	23.6	101.0		85.1 *		16.1	~~2x10~~ 8
"	GTJ-6	0-5	CH	95.6	21.6	23.0	100.0		86.6 *		" 16.1	~~9x10~~ 8

TEST METHODS: CH - CONSTANT HEAD FH - FALLING HEAD TX - TRIAXIAL BACKPRESSURE FALLING HEAD TEST PROCEDURE: EM 1110-2-1906

* Assumed sp. Gravity 2

MKF - SG 11/04/90