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Geotechnical Analysis of Five Shelby Tube Samples from H-Area Retention Basin

by

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GEOTECHNICAL ANALYSIS OF FIVE SHELBY TUBE SAMPLES FROM THE H-AREA RETENTION BASIN (U)

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SUMMARY

Geotechnical and geochemical analyses were performed on five Shelby tube samples collected in the H-Area Retention Basin (HRB) during July and August of 1998. The samples were collected as part of the HRB characterization study. The test results, which are documented in this report, will be used to support the HRB contaminant fate and transport modeling/analysis and to evaluate remedial options. The results will also be used as a base line for future treatability studies.

The geotechnical testing was performed in the SRTC low-level radioactive soils characterization laboratory. WSRC/SRTC and Raytheon personnel conducted the test program. ASTM and EPA test protocols were used. Sample locations are indicated in Figure 1. The physical and chemical properties of the samples are consistent with the soil types, i.e., clayey sands to sandy clay. Details of the soil classifications are provided in Table 1. Test results are summarized in Tables 2 to 11. Data sheets are provided in the Appendices A-1 to A-6.

BACKGROUND

Descriptions of the HRB (281-3H) construction and operating history are provided elsewhere.[1, 2]

Samples analyzed in this task were collected as part of the 1998 HRB sampling and characterization program which was conducted to support the Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Work Plan (RFI/RI) for the H-Area Retention Basin (HRB) Operable Unit (OU). Results obtained in this study will be used to support fate and transport analysis, evaluate remedial action objectives, and support human health and ecological risk assessments involved in HRB remediation. They will also be used to support future treatability studies.
During the sampling campaign in 1998, Shelby tube samplers were used to collect undisturbed material from the basin at 3 locations (HRBS-04, -05, and -06) and from three wells (HR3-14C at

10.0 to 12.0 feet below land surface (ft bls), HR3-15C at 132.0 to 134.0 ft bls., and HR3-16 DL at 6.0 to 8.0 ft bls). Five Shelby tubes, which were identified by Environmental Restoration personnel for this series of tests, were relocated to SRTC, 773-A on 12-28-98. They included well samples, HRB-14C, HR3-15C and HR3-16DL, and samples collected from the basin bottom, HRBS-25-01, and HRBS-27-01. The samples were sealed and transported to building 772-7B for temporary refrigerated storage. Storage in SRTC was under ambient conditions.

L. A. Bagwell, SGS, provided a correlation between the sample locations and the Shelby tube labels. This information is provided below:

SHELBY TUBE I.D.	HR3-15C	HR3-16DL	HRBS-25-01	HRBS-27-01	HRB-14C
Corresponding well or bore hole	Well HR3-15C	Well HR3-16DL	Hole HRBS-05	Hole HRBS-06	Well HR3-14C
Date Sampled	5 Aug. 1998	30 June 1998	23 July 1998	27 July 1998	10 July 1998
Ground Elevation (ft above mean sea level)	263.3	254.9	~263	~263	264.5
Sample Depth (ft below land surface)	132 - 134	6 - 7	0 - 2.5	0 - 2.5	8 - 10
Sample Elevation (ft above mean sea level)	129.3 - 131.3	247.9 - 248.9	260.5 - 263	260.5 - 263	254.5 - 256.5
Approximate Core Length (inches)	12	16	20	15.5	26

The locations of these samples are shown in Figure 1.

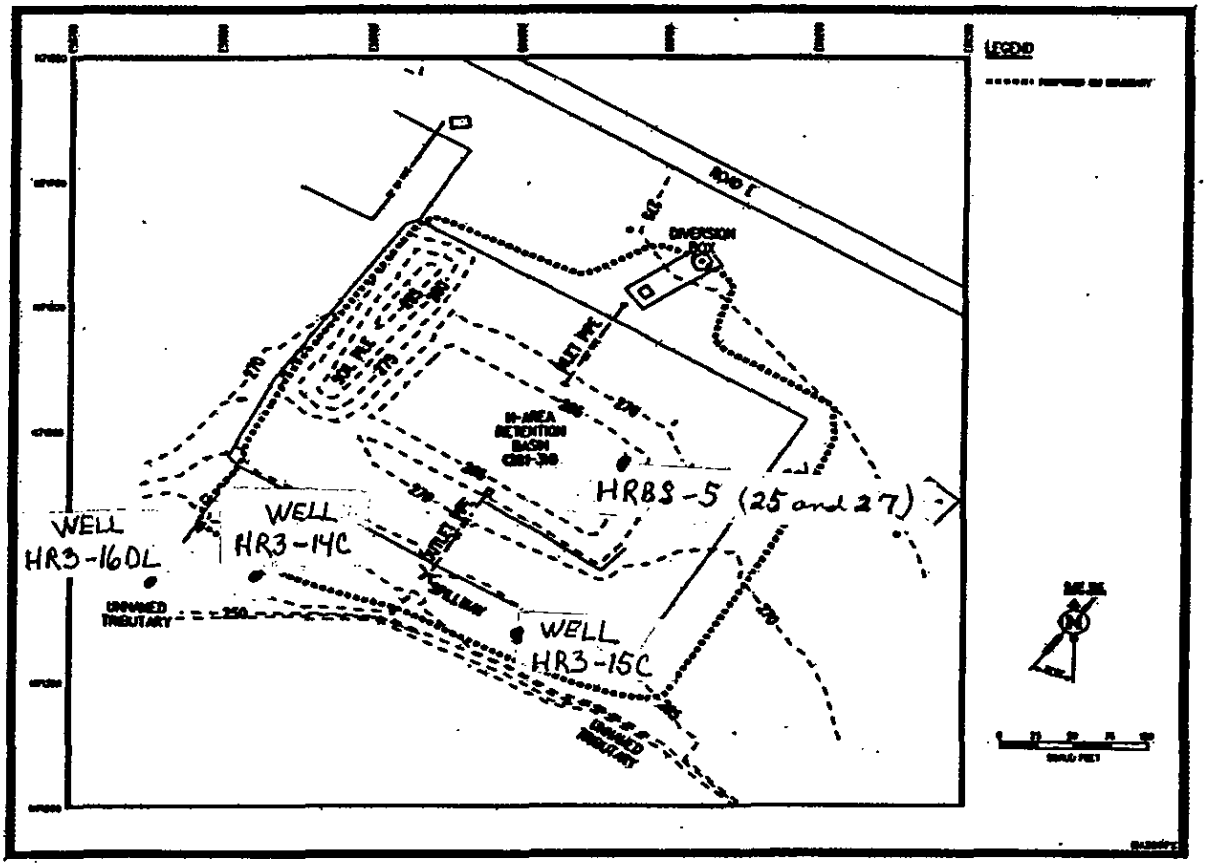


Figure 1. H-Area Retention Basin Sampling Locations

LABORATORY TESTING

Geochemcial properties of the soil samples were determined according to the United States Environmental Protection Agency (EPA) SW-846 methods. Physical and hydrological parameters were determined using American Society for Testing and Materials (ASTM) or United States Army Corps of Engineers (COE) procedures, as applicable. The following tests were conducted:

1. Core Logging
2. Particle Size
    a. #200 Sieve Analysis (ASTM D-1140)
    b. Sieve Analysis (ASTM D-421)
    c. Hydrometer Analysis (ASTM D-422)
3. Unit Weight and Moisture (SRTC Procedure)
4. Natural Moisture (ASTM D-2216)
5. Bulk Density (ASTM D-4531)
6. Specific Gravity ASTM D-854)
7. Porosity (calculation)
8. Falling Head Permeability - Vertical (ASTM D-5084)
9. pH (US EPA)
10. Exchangeable Acidity (US EPA 305.1)
11. Cation Exchange Capacity (US EPA 9081)

RESULTS AND DISCUSSION

Visual Description/Core Logging

The descriptions of the soil/sediment samples in the HRB Shelby tubes are given in Appendix A-1. The soils were clayey sands to sandy clays. The descriptions are consistent with the soil classifications based on the particle size data reported below.

Soil Classification Based on Particle Size Analyses

Particle size data generated by sieve analyses (ASTM D-421 and ASTM D-1140) and hydrometer analyses (ASTM D-422) were used to determine the soil classifications of samples from each of the HRB Shelby tubes. A summary of these results and the soil classifications is presented in Table 1. The Data sheets with the test results are given in Appendix 2.

Slight differences in the visual descriptions and the soil classifications were anticipated because only a small portion (about 3 inches) of the core was selected for the particle size analyses. This material was also judged to be the most representative of the core.

The most consolidated section of the core was selected for the hydraulic conductivity tests since the parameter of interest is related to the ability of the strata to act as a confining layer. Representative material was selected for the other tests. Gravel layers were not intentionally included since larger samples are necessary to accurately evaluate the amount and distribution of the gravel and/or cobbles on the physical properties of these soils.

Table 1. Soil Classification Based on Particle Size Analyses of the HRB Shelby Tube Samples.

	Gravel (wt. %)*	Coarse Sand (wt. %)	Mediu Sand (wt. %)	Fine Sand (wt. %)	Silt (wt. %	Clay (wt. %)	Colloid (wt. %)*	Classification***
Well Samples								
HRB-14C	1	1	9	49	3	37	(< 34)	Clayey Fine Sand
HR3-15C	8	9	8	52	8	15	(< 14)	Clayey Fine to Med. Sand
HR3-16DL	0	0	16	60	8	16	(< 14)	Clayey Fine Sand
Basin Samples								
HRBS-25-01	0	2	20	22	6	50	(< 45)	Sandy Clay or Clayey Fine to Med. Sand
HRBS-27-01	2	7	38	24	6	23	(< 20)	Clayey Med. Sand

* The gravel and larger cobble size fractions are under represented in this description because the small diameter (2 and 5/8 inch diameter) of the Shelby tubes excluded collection of any larger material which may be present in the strata.

* * The colloidal portion of the sample is a subset of the clay fraction.

*** ASTM D-422 provides the following definitions for the various size fractions.

Gravel: Material passing the 3 inch (7.62 cm) sieve and retained on the No. 4 sieve (4.75 mm).

Sand: Material passing the No.4 sieve (4.75 mm) and retained on the No.200 (75 mm) sieve.

a) Coarse sand = Material passing the No.4 (4.75 mm) sieve and retained on the No.10 (2.00 mm) sieve.
b) Medium Sand = Material passing the No. 10 (2.00 mm) sieve and retained on the No. 40 (425 μm) sieve.
c) Fine sand = Material passing the No. 40 sieve (425 μm) and retained on the No. 200 sieve (75 μm).

Silt Size: Material 0.074 to 0.005 mm in diameter.

Clay Size: Material smaller than 0.005 mm.

Colloids: Material smaller than 0.001 mm.

Unit Weights of the HRB Shelby Tube Samples As Received and Dried

The unit weights of the samples as received and the unit weights of the dry samples are reported in Tables 2 and 3, respectively.

Table 2. Unit Weights of As Received HRB Shelby Tube Samples.

Sample ID	Wt. Wet Soil (grams)	Length of Wet Soil (inches)	Diameter Soil Core (inches)	Volume Sample (ft^3)	Unit Wt. Wet (pcf)
Well Samples					
HRB-14C	782.4	3.652	2.875	0.01	125.52
HR3-15C	654.8	2.25	2.875	0.01	170.51
HR3-16DL	412.5	2.18	2.875	0.01	110.86
Basin Samples					
HRBS-25-01	672.6	3.125	2.875	0.01	126.10
HRBS-27-01	518.7	2	2.875	0.01	151.95

pcf = pounds per cubic feet

Table 3. Unit Weights of Dried HRB Shelby Tube Samples.

Sample ID	Wt. Dry Soil (grams)	Length of Dry Soil (inches)	Diameter Soil Core (inches)	Volume sample (ft3)	Unit Wt dry (pcf)
Well Samples					
HRB-14C	625.5	3.652	2.875	0.01	100.35
HR3-15C	460.1	2.25	2.875	0.01	119.81
HR3-16DL	349.5	2.18	2.875	0.01	93.93
Basin Samples					
HRBS-25-01	545.5	3.125	2.875	0.01	102.27
HRBS-27-01	463.9	2	2.875	0.01	135.90

pcf = pounds per cubic feet

Natural Moisture, Specific Gravity and Porosity

Natural moisture was calculated by determining the weight of water in each Shelby tube sample and calculating the moisture content relative to the dry weight of the sample (mass water/mass dry soil X 100). The natural moisture contents and the porosities of the samples are listed in Tables 3 and 4, respectively.

Table 4. Natural Moisture Content, Specific Gravity and Porosity of HRB Shelby Tube Samples.

Sample ID	Natural Moisture Content ASTM D-2216	Specific Gravity ASTM D-854	Porosity Pore Fraction
Well Samples			
HRB-14C	20.05	2.24	0.282
HR3-15C	29.73	2.60	0.262
HR3-16DL	15.27	2.62	0.426
Basin Samples			
HRBS-25-01	18.90	2.64	0.379
HRBS-27-01	10.56	2.61	0.166

Saturated Vertical Hydraulic Conductivity

Samples for the hydraulic conductivity tests were selected from portions of the core which were considered to be intact. The least fractured, most consolidated, highest clay content portions of the core were selected for the hydraulic conductivity tests because it was assumed that the parameter of interest was the ability of the soil to function as a confining layer. Since the sample length was at least that of the diameter, some of the samples contained gravel (up to ½ inch), which was apparent after the samples were removed from the cell, broken up and dried. Minor defects in the core surfaces (up to 3/8 inch deep and of limited surface extent) were patched with similar soil from the core. The samples were oriented in the permeability cell, such that, flow was parallel to the long axis of the core, i.e., vertical conductivities were measured.

Two samples, HR3-15C and HR3-16DL were remolded after no flow was observed after several hours in the cell. Sample HR3-15C had a very high water content and was compacted as the result of the cell and head pressure applied to the sample during testing.

The samples were saturated to β values of greater than 0.95 per the ASTM procedure. Saturation was accomplished in the permeability cell prior to the conductivity measurements. Results are presented in Table 5. In addition, the final water content after saturation and completion of the hydraulic conductivity test was determined and reported for each sample used for the hydraulic conductivity measurement. This information is listed in Table 6 along with the water content determined on the as received sample. Data sheets are presented in Appendix 4.

Table 5. Vertical Hydraulic Conductivities ($k_{saturated}$) of HRB Shelby Tube Samples.

	Falling Head Hydraulic Conductivity ASTM D-5084		
Sample ID	Run 1 (cm/sec)	Run 2 (cm/sec)	$k_{Ave.}$ (cm/sec)
Well Samples			
HRB-14C	1.67E-04	2.03E-04	1.85E-04
HR3-15C	1.06E-06	-	1.06E-06
HR3-16DL	2.67E-05	2.29E-05	2.48E-05
Basin Samples			
HRBS-25-01	4.02E-06	-	4.02E-06
HRBS-27-01	1.73E-05	1.78E-05	1.76E-05

Table 6. Comparison of Water Contents Of As Received and Saturated Samples From the HRB Shelby Tubes.

Sample ID	Water Content As Received (from Table 2) (wt. % of solid)	Water Content After Saturation (from hydraulic conductivity data sheets) (wt. % of solid)
Well Samples		
HRB-14C	20.05	25.2
HR3-15C	29.73	32.9
HR3-16DL	15.27	12.0
Basin Samples		
HRBS-25-01	18.90	29.2
HRBS-27-01	10.56	17.5

Soil pH

The pH of the soil is a measurement of the H^+ ion concentration in the pore fluid, which is in equilibrium with the soil, i.e., $pH = \log (1/C_{H+})$. The measurement determines the degree of acidity or alkalinity of the soil materials suspended in water. Deionized water was used to obtain these values per the EPA test method 9045A. Results for the HRB Shelby tube samples are listed in Table 7.

Table 7. ph Values for the HRB Shelby Tube Samples.

Sample ID	pH sample 1	pH sample 2	pH Average
Well Samples			
HRB-14C	8.7	8.2	8.45
HR3-15C	8	7.28	7.64
HR3-16DL	5.9	5.14	5.52
Basin Samples			
HRBS-25-01	8.7	7.88	8.29
HRBS-27-01	5.7	4.75	5.22

Exchangeable Acidity

Exchangeable acidities of the HRB Shelby tube samples were determined according to EPA Method 305.1. This test measures the mineral acidity of the sample plus the acidity resulting from oxidation and hydrolysis of polyvalent cations, such as, salts of iron and aluminum. Results are summarized in Table 8, and the data sheets are presented in Appendix 4.

Table 8. Exchangeable Acidity of the HRB Shelby Tube Samples.

Sample ID	Acidity (ueq/L) Sample A	Acidity (ueq/L) Sample B	Acidity (ueq/L) Average
Well Samples			
HRB-14C	90.3	170.5	130.4
HR3-15C	360.1	494.5	427.3
HR3-16DL	251.4	240.8	246.1
Basin Samples			
HRBS-25-01	170.0	180.1	160.5
HRBS-27-01	140.9	105.3	123.1

Cation Exchange Capacity

The cation exchange capacity (CEC) is a measure of the negative charges carried by the soil particles, organic matter and sesquioxides. US EPA Method 9081 was used for these determinations. Results are summarized in Table 9 and analytical data for sodium concentrations of tests solutions are presented in Appendix 5.

Table 9. Cation Exchange Capacity of the HRB Shelby Tube Samples.

Sample ID	CEC (C_{molc}/kg soil) Sample A	CEC (C_{molc}/kg soil) Sample B	CEC (C_{molc}/kg soil) Average
Well Samples			
HRB-14C	3.20	3.28	3.24
HR3-15C	4.76	3.47	4.12
HR3-16DL	1.95	1.17	1.56
Basin Samples			
HRBS-25-01	4.42	4.16	4.29
HRBS-27-01	3.36	2.71	3.04

CONCLUSIONS

The HRB Shelby tube samples analyzed in this study are clayey sands. One sample from the bottom of the basin, HRBS-25-01, is sandy clay. Geotechnical and geochemical test results obtained in the test program are consistent with the soil types and are summarized in Tables 10 and 11, respectively. Data sheets are included in the Appendices A-1 to A-6.

REFERENCES

1. WSRC-RP-97-122, Rev. 0, March 1997, "ASCAD™ Combined Feasibility Study Proposed Plan Document for the H-Area Retention Basin (281-3H) (U)," Westinghouse Savannah River Company, Aiken, SC.

2. WSRC-RP-98-00125, Rev. 0, March 1998, "281-3H Retention Basin Treatability Study Work Plan (U)," Westinghouse Savannah River Company, Aiken, SC.

3. WSRC-RP-99-121, Rev. 0., January 21, 1999, "Task Technical Plan for Geotechnical Analysis of Five H-Area Retention Basin (HRB) Shelby Tube Samples (U)," Westinghouse Savannah River Company, Aiken, SC.

4. WSRC-RP-99-122, Rev. 0., January 21,1999, "Task Quality Assurance Plan for Geotechnical Analysis of Five H-Area Retention Basin (HRB) Shelby Tube Samples (U)," Westinghouse Savannah River Company, Aiken, SC.

Table 10. Summary of the Geotechnical Properties of the HRB Shelby Tube Samples.

Sample ID	Ground Elevation Ft above MSL	Sample Depth Ft below land surface	Sample Elevation Ft above MSL	Specific Gravity ASTM D-854	Porosity Pore Fraction	Unit Wt as received (pcf)	Unit Wt dry (pcf)	Natural Moisture % H2O ASTM D-2216	Vertical Hydraulic Conductivity K ave. (cm/sec)
Well Samples									
HRB-14C	264.5	8 to 10	254.5 to 256.5	2.24	0.282	125.52	100.35	20.05	1.85E-04
HR3-15C	263.3	132 to 134	129.3 to 131.3	2.6	0.262	170.51	119.81	29.73	
HR3-16DL	254.9	6 to 7	247.9 to 248.9	2.62	0.426	110.86	93.93	15.27	2.48E-05
Basin Samples									
HRBS-25-01	~263	0 to 2.5	260.5 to 263	2.64	0.379	126.10	102.27	18.90	4.02E-06
HRBS-27-01	~263	0 to 2.5	260.5 to 263	2.61	0.166	151.95	135.90	10.56	1.76E-05

Table 11. Summary of the Geochemical Properties of the HRB Shelby Tube Samples.

Sample ID	pH (ave.)	Exchangeable Acidity (ave.)	Cation Exchange Capacity (ave.)
Well Samples			
HRB-14C	8.45	130.4	3.24
HR3-15C	7.64	427.1	4.12
HR3-16DL	5.52	246.1	1.56
Basin samples			
HRBS-25-01	8.29	160.5	4.29
HRBS-27-01	5.22	123.1	3.04

QUALITY ASSURANCE

Testing was conducted in accordance with ASTM standard practices and SRS procedures. Results are recorded in Laboratory Notebook WSRC-NB-98-00204. The Task Technical Plan and Task Quality Assurance Plan for this effort are documented in WSRC-RP-99-00122 and WSRC-RP-99-00121, respectively. The Chain of Custody documentation for the Shelby Tube Samples is provided in Appendix 6.

ACKNOWLEDGEMENTS

Wyman Pope Jr. and Clyde N. Shramek, Raytheon Engineers & Constructors, performed the geotechnical testing. Frances Wakefield and Cathey Coffey performed the geochemical testing. Cecil Woodard and Lynda Wingard opened the Shelby tubes and extracted the samples.

APPENDIX 1.

HRB Shelby Tube Sample Descriptions

Visual Descriptions of the HRB Shelby Tube Samples

HRB-14C

Approximately 26 inches of core was recovered from the Shelby tube. The upper 7 inches was disturbed and contained about 60 volume % large (up to 1.5 inches) quartzite gravel plus sand, silt and clay. The gravel is subangular, hard and dense. This section of core is mottled yellow/red/white.

The lower 19 inches is a silty clayey sand and contained no gravel. A few of the largest particles were less than 0.5 inches. The structure of this portion of the core is uniform and the color is mottled yellow/red/white.

HR3-15C

Approximately 12 inches of core was recovered from this Shelby tube. A few pieces of quartzite gravel were recovered from the top of the sample. The first 7 inches consisted of an organic rich silty sand which was grayish brown in color, mottled, and contained black charcoal particles (up to 3/8 inch), soft white agglomerates of white clay and clear quartz sand, light gray, dense quartzite (up to 3/8 inch).

The next 2 inches was a sandy silt which was similar to the material directly above it except this layer did not contain the carbon and the quartzite gravel was larger (up to 0.5 inches).

The bottom 3 inches of this core was very wet fine silty sand. It is greenish yellow and is not cohesive. This layer contains no gravel.

HR3-16DL

Approximately 16 inches of core was recovered from the Shelby tube. The upper 13 inches consists of wet mottled gray brown silty sand. It contains a small amount of light gray, dense, subangular quartzite gravel up to 1.5 inches in size. This section of core also contains a few root or twig fragments.

The bottom 3 inches of this core consists of wet, yellowish silty sand with orange mottling.

HRBS-25-01

Approximately 20 inches of core was recovered from the Shelby tube. Several pieces of quartzite gravel were present at the very top of the tube sample.

The remaining sample is a clayey, silty sand containing 5-10 volume % hard, dense light gray quartzite gravel up to 1.5 inches in size plus soft aggregates (less than 1 inch in size) of clear quartz sand. The quartz sand aggregates break/crumble very easily. The core is mottled red/yellow/orange and tends to fracture along the red mottling. Some layers have more sand than the others. The core fractured along the red (weathered) zones both perpendicular to and diagonal to the long axis of the core.

HRBS-27-01

Approximately 20 inches of core was recovered from the shelby tube. Black organic rich liquid was observed above the top plug in the tube. About 3 inches of sand and gravel coated with black organic material was recovered just below the plug. This material was not sampled.

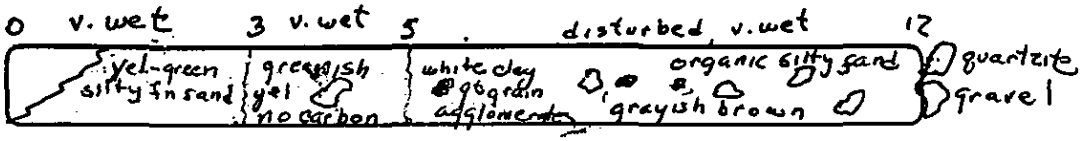
The next 5 inches of core contain fine clayey silty sand without gravel. It is mottled. This section is similar to the bottom 5 inches of this core except the sand is finer.

The next 4 inches of core consisted of a clayey, silty sand which contained about 20 volume % of the dense quartzite gravel and also about 20 volume % of the soft clear quartz sand agglomerates in a white clay matrix. The color of this core is mottled yellow/red/white.

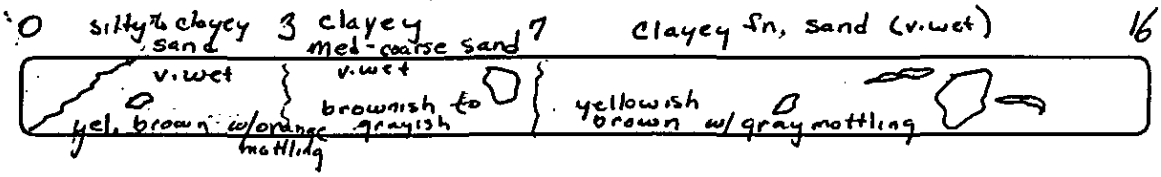
The next 2 inches consist of a few large quartzite gravel. This material was unconsolidated after removing it from the tube.

The bottom 5 inches of this core consisted of calyey, silty sand containing and soft clear quartz sand agglomerates up to 1.5 inches in size.

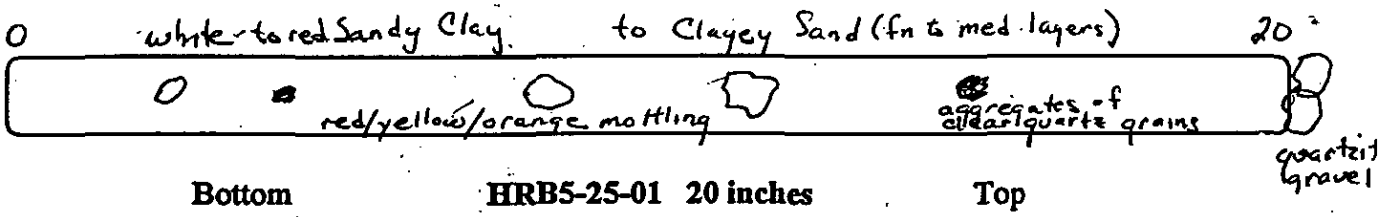
HRB Shelby Tube Samples



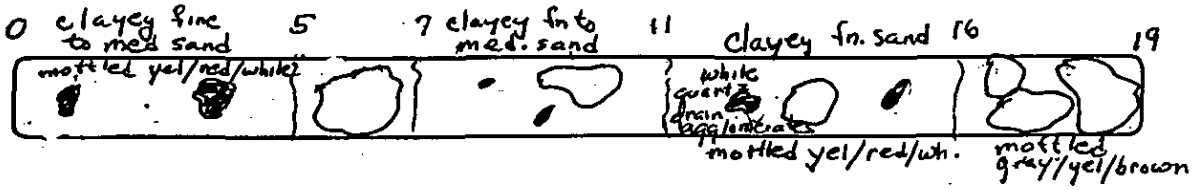
Bottom **HRB3-15C 12 inches** Top



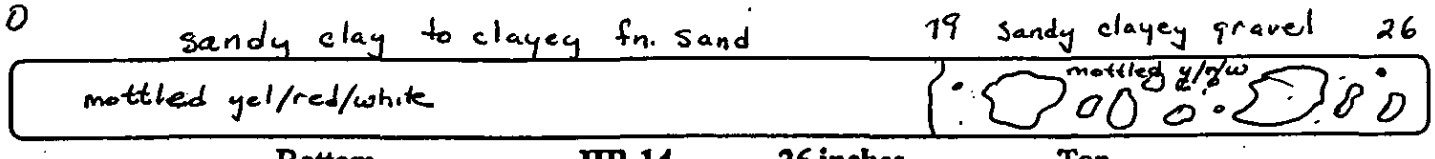
Bottom **HRB3-16DL 16 inches** Top



Bottom **HRB5-25-01 20 inches** Top



Bottom **HRB5-27-01 15.5 inches** Top



Bottom **HR-14 26 inches** Top

Sample: HR3 - 14C **Date:** 1-21-99 **Technician:** C. Langton + B. Mhyre

Distance from bottom of core		0-19+ in	19-26"			
1	Soil group name	Clayey sand to Sandy clay	Sandy clayey gravel			
2	Group Symbol					
3	Vol. % Cobbles fine/course	- 0	#4 Sand - 1½" 60%			
4	Vol % Sand fine/med/course	30-40 %	10% fine Sand			
5	Vol. % fines	60-70 %	30%			
6	Particle angularity Angular/subang/ subround/round	–	Sub-R			
7	Particle shape Flat, elongated, flat and elongated	–	Equant, - Irregular			
8	Maximum particle size	¼" except for occasional ½"	1½"			
9	Hardness of course sand and large particles	–	–			
10	Plasticity of fines	Plastic	Med Plastic			
11	Dry Strength None, low, med., high, v. high	High	High w/o rock gravel			
12	Dilatancy None, slow, rapid	–	–			
13	Toughness Low, med., high	–	–			
14	Color (in moist condition)	mottled yel, red, white sandy clay	mottled yel, red white			
15	Odor	None	None			
16	Moisture Dry, moist, wet	Moist	Wet			
17	Reaction with HCL none, weak, strong	–	–			
18	Consistency v. soft, soft, firm, hard, v. hard	V. Firm	Disturbed			
19	Structure	Uniform	Disturbed			
20	Cementation Weak, mod. strong	Mod-Strong	Weak in wet condition			
21	Local name					
23	Comments roots, root holes, mica, surface coatings on coarse grains, caving of hole, difficulty excavating	mottled	Disturbed but coarse/sand/fine ratio constant			

Sample: HR3-15C **Date:** 1-21-99 **Technician:** C. Langston & B. Mhyre

	Distance from bottom of core	0 - 3 inches	3 - 5	5 - 12	12 +	
1	Soil group name	Silty sand		organic silty sand	Gravel	
2	Group Symbol					
3	Vol. % Cobbles fine/course	0	20 %	25 %	100 %	
4	Vol % Sand fine/med/course	90 - 100	≤ 50 %	65 %	-	
5	Vol. % fines	Silt ≥ 10 %	10-5 %	5 %	—	
6	Particle angularity Angular/subang/ subround/round	—	Sub angular to sub rounded			
7	Particle shape Flat, elongated, flat and elongated	—	Irregular	flat to irregular		
8	Maximum particle size		≤ 1½"	≤ 3/8"		
9	Hardness of course sand and large particles	—	Quartzite hard	Quartzite hard	Quartzite hard	
10	Plasticity of fines	Not Plastic	same	same	NA same	
11	Dry Strength None, low, med., high, v. high	low	low	low	NA	
12	Dilatancy None, slow, rapid	—	—	—	—	
13	Toughness Low, med., high	—	—	—	—	
14	Color (in moist condition)	yellow to greenish	greenish yellow	same but contains black particles so it appears darker	(grayish greenish yellow)	
15	Odor	None	None	None		
16	Moisture Dry, moist, wet	Saturated	v. wet	v. wet	NA	
17	Reaction with HCL none, weak, strong	—	—	—	—	
18	Consistency v. soft, soft, firm, hard, v. hard	soft	soft	soft	NA	
19	Structure	uniform fng ss not cohesive	same	Disturbed	NA	
20	Cementation Weak, mod. strong	—				
21	Local name	—				
23	Comments roots, root holes, mica, surface coatings on coarse grains, caving of hole, difficulty excavating	bottom of Shelby tube Sampled in saturated fn. sand v. loose sand	—	black particles are charcoal. Sample = disturbed structure	—	

Sample: HR 3 - 16 DL **Date:** 1-21-99 **Technician:** C. Langton + B. Mhyre

Distance from bottom of core		0 - 3 inches	3 - 7 in	7 - 16		
1	Soil group name	silty, clayey sand	med to coarse clayey sand	clayey sand		
2	Group Symbol					
3	Vol. % Cobbles fine/course	< 2 %	–	< 5 %		
4	Vol % Sand fine/med/course	50 %	50 +	50 +		
5	Vol. % fines	50 %	50 -	50 -		
6	Particle angularity Angular/subang/ subround/round	Subangular Subrounded Quartzite	Same	same		
7	Particle shape Flat, elongated, flat and elongated	–		irregular & equant		
8	Maximum particle size	¼" - 3/8"	Same	same		
9	Hardness of course sand and large particles	Hard	same	same		
10	Plasticity of fines	–	–	–		
11	Dry Strength None, low, med., high, v. high	Med	same	same		
12	Dilatancy None, slow, rapid	–	–	–		
13	Toughness Low, med., high	–	–	–		
14	Color (in moist condition)	yellow to brown w/ orange mottling	Brownish	yellow brown		
15	Odor	None	None	None		
16	Moisture Dry, moist, wet	wet	wet	wet		
17	Reaction with HCL none, weak, strong	–	–	–		
18	Consistency v. soft, soft, firm, hard, v. hard	Firm	Firm	Firm		
19	Structure	mottled to uniform	more uniform	more uniform		
20	Cementation Weak, mod. strong	–	–	–		
21	Local name	–	–	–		
23	Comments roots, root holes, mica, surface coatings on coarse grains, caving of hole, difficulty excavating			few roots or twigs		

Sample: HRBS-25-01 **Date:** 1-21-99 **Technician:** C. Langton + B. Meyer

Distance from bottom of core		0-20"	20-21 Cobbles on top of core			
1	Soil group name	Clayey fn. Sand				
2	Group Symbol					
3	Vol. % Cobbles fine/course	1. Soft quartzite (inclusions) 2. quartzite-gravel } 45-10%				
4	Vol % Sand fine/med/course	60-70				
5	Vol. % fines	40-30				
6	Particle angularity Angular/subang/ subround/round	Sub A				
7	Particle shape Flat, elongated, flat and elongated	Equant - irregular				
8	Maximum particle size	1 1/2	1 1/2"			
9	Hardness of course sand and large particles	quartz = soft quartzite = hard	hard			
10	Plasticity of fines	Plastic				
11	Dry Strength None, low, med., high, v. high	High				
12	Dilatancy None, slow, rapid	-				
13	Toughness Low, med., high	-				
14	Color (in moist condition)	mottled red, yellow, lt gray				
15	Odor	None				
16	Moisture Dry, moist, wet	Moist				
17	Reaction with HCL none, weak, strong	-				
18	Consistency v. soft, soft, firm, hard, v. hard	Firm				
19	Structure	Horizontal parting planes				
20	Cementation Weak, mod. strong	Strong				
21	Local name					
23	Comments roots, root holes, mica, surface coatings on coarse grains, caving of hole, difficulty excavating	Horizontal Fractures along red zones More sand + hematite than 14C				

Sample: HRBS-27-01 **Date:** 1-21-99 **Technician:** C. Langton & B. Mayne

Distance from bottom of core		0-5"	5-7"	7-11"	11-16	16-19
1	Soil group name	clayey sand	gravel quartzite inclusion	clayey sand	fine clayey sand	sandy gravel
2	Group Symbol			w/quartz inclusions	Same as 0-5	
3	Vol. % Cobbles fine/course	Soft quartz sand inclusions 20%	80-90% one cobble	Soft quartz 20% quartzite rock 80%	except sand is	quartzite gr
4	Vol % Sand fine/med/course	60%	10-15	40-60	finer	1.
5	Vol. % fines	20%	5-10	10-20		
6	Particle angularity Angular/subang/ subround/round	Irregular Equant soft inclusions of clear quartz sand.	Sub ∠	Same as 0-5		Same
7	Particle shape Flat, elongated, flat and elongated	Soft sub ∠ inclusions of clear quartz grains				Same
8	Maximum particle size	1 1/2"	1 1/2	1 1/2		1 1/2"
9	Hardness of course sand and large particles	Sand grains = Hard Sandgrain inclusions = soft + porous	V. hard	1. quartz = soft 2. quartzite = hard		V. hard quartzite & Gray
10	Plasticity of fines	Plastic	—	Plastic		Plastic
11	Dry Strength None, low, med., high, v. high	Med	—	Med		Med
12	Dilatancy None, slow, rapid	—	—	—		—
13	Toughness Low, med., high	—	—	—		—
14	Color (in moist condition)	mottled y, red, white	matrix same as 0-5 w/thin quartzite = lt gray	quartz inclusions = white		gray-yellow-brown mottling
15	Odor	None	None	None		organic
16	Moisture Dry, moist, wet	Moist	—	SAME as 0-5		Moist
17	Reaction with HCL none, weak, strong	—	—			—
18	Consistency v. soft, soft, firm, hard, v. hard	Firm	Core fell apart with such a large cobble in this zone			Disturbed
19	Structure	Horizontal parting of red planes. Soft inclusions not uniform	—	Fractured horizontally along horizontal planes which are lt. weathered red.		Disturbed
20	Cementation Weak, mod. strong	Mod	weak			—
21	Local name	—	—			
23	Comments roots, root holes, mica, surface coatings on coarse grains, caving of hole, difficulty excavating		9" thick zone consisting of one large piece of quartzite and a few smaller pieces of quartzite in sand-clay matrix	horizontal fractures along horiz. weathered (red) layers		Contains organic material based on odor & black color

APPENDIX 2.

Particle Size Analyses (Sieve and Hydrometer),

Soil Classifications

and

Specific Gravity Data Sheet

C:FORMS.FMP
ASR 16-172 (7/99)

RAYTHEON Engineers & Constructors

Particle-Size Analysis

ASTM D 75-(N/A); ASTM D 422-(63)(90 #1; ASTM C 136-(N/A)

Report #: 99-PAR3100 3B-0001 Work Package No.: N/A

Project/WAD #: PAR 3100 3B QCIR No.: N/A

TWC: N/A Lab #: HRC-14C Date Tested: 2/01/99

Material Description: CLAYEY FINE SAND

Location: H RETENTION BASIN

Sieve Size	* Cumulative Wt. Retained, grams	* Cumulative % Retained	% Passing	Acceptance Criteria
3/8"	3.9	621.4	99	N/A
#4	2.1	619.3	99	
#10	3.7	615.6	98	
#20	1.0	69.1	97	
#40	5.9	63.2	89	
#100	6.5	56.7	80	
#140	19.4	37.3	52	
#200	8.8	28.5	40	
.03077 MM			39	
.01982			38	
.01162			37	
.00822	FROM HYDROMETER READINGS		37	#2
.00581			37	
.002901			35	
.001234MM			34	
		N/A		N/A

Pan Weight: 625.3 grams

Oven Dry Weight: 625.3/71.2 grams

Specific Gravity: 2.58

[X] Yes [ ] No

M&TE: IW-24 CAL DUE DATE: 11/17/99

NCR #: N/A

Test Result: [ ] Conforming [ ] Nonconforming [X] N/A #1

Remarks: *K.K.H. 2/08/99 *1 DATA SUBMITTED FOR FULL EVALUATION. K.K.H. 2/08/99
*2 PERCENT OF SOIL IN SUSPENSION

Procedure: C-CCF-021

Rev: 0

PCN's: N/A

Specs:

Rev: N/A

DCF's:

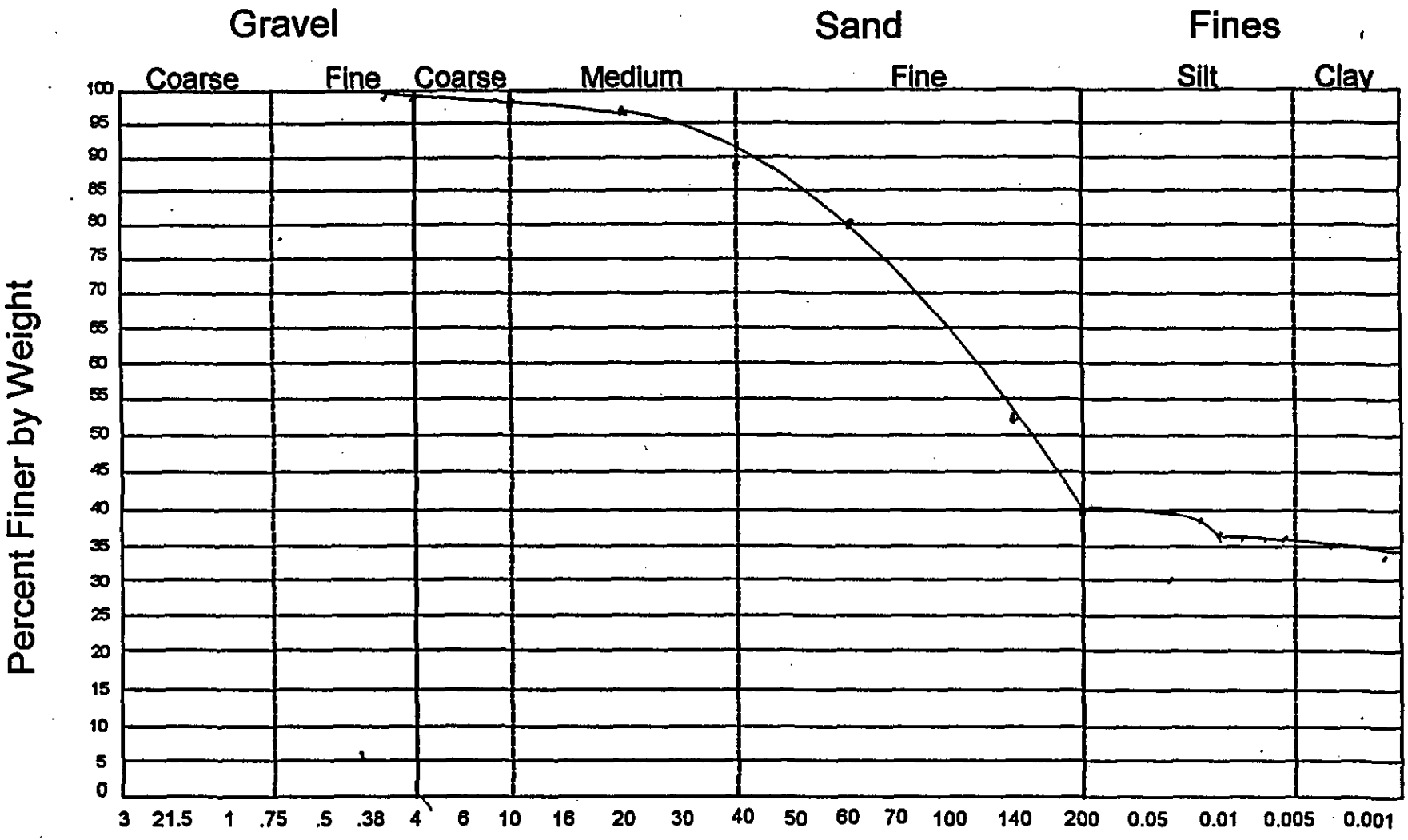
Design Category:

Inspector: [signature] Level: II Date: 2-3-99

Reviewer: K.K.Hodges Level: III Date: 3/3/99

RAYTHEON Engineers & Constructors

Grain Size Distribution Curve



Grain Size

Report #: 99-PAR3100353-0001 Project #: H RETENTION BASIN Lab #: HRC-14C

C:FORMS.FMP
ASR 16-172 (7/96)

RAYTHEON Engineers & Constructors

Particle-Size Analysis

ASTM D 75-(N/A); ASTM D 422-(63)(90)[E1]; ASTM C 136-(N/A)

Report #: 99-PAR3100 3B-0001 Work Package No.: N/A

Project/WAD #: PAR3100 3B QCIR No.: N/A

TWC: N/A Lab #: HR3-15C Date Tested: 2/02/99

Material Description: CLAYEY MED. SAND

Location: H RETENTION BASIN

Sieve Size	~~Cumulative~~ Wt. Retained, grams	~~Cumulative~~ ~~% Retained~~ MASS PASSING	% Passing	Acceptance Criteria
3/8"	9.5	450.1	98	N/A
#4	26.7	423.4	92	
10	43.2	380.2	83	
20	1.6	105.2	82	
40	8.0	97.2	75	
60	15.3	81.9	63	
140	44.5	37.4	29	
#200	7.6	29.8	23	
0.0329 MM			19	
0.0210 S			17	
0.0124 0			16	
0.0087 7	FROM HYDROMETER READINGS		16	*2
0.0062 2			15	
0.0030 9			15	
0.0113 MM			14	
				N/A

Pan Weight: 459.6 grams

Oven Dry Weight: 459.6/129.1 grams

Specific Gravity: 2.60

[X] Yes [ ] No

M&TE: IW-24 CAL DUE DATE: 11/17/99

NCR #: N/A

Test Result: [ ] Conforming [ ] Nonconforming [X] *1 N/A

Remarks: *1 N.C.M. 2/08/99; *1 DATA SUBMITTED FOR ENG. EVALUATION. *2 PERCENT OF SOIL IN SUSPENSION

Procedure: C-QCP-021

Rev: 0

PCN's: N/A

Specs:

Rev:

DCF's:

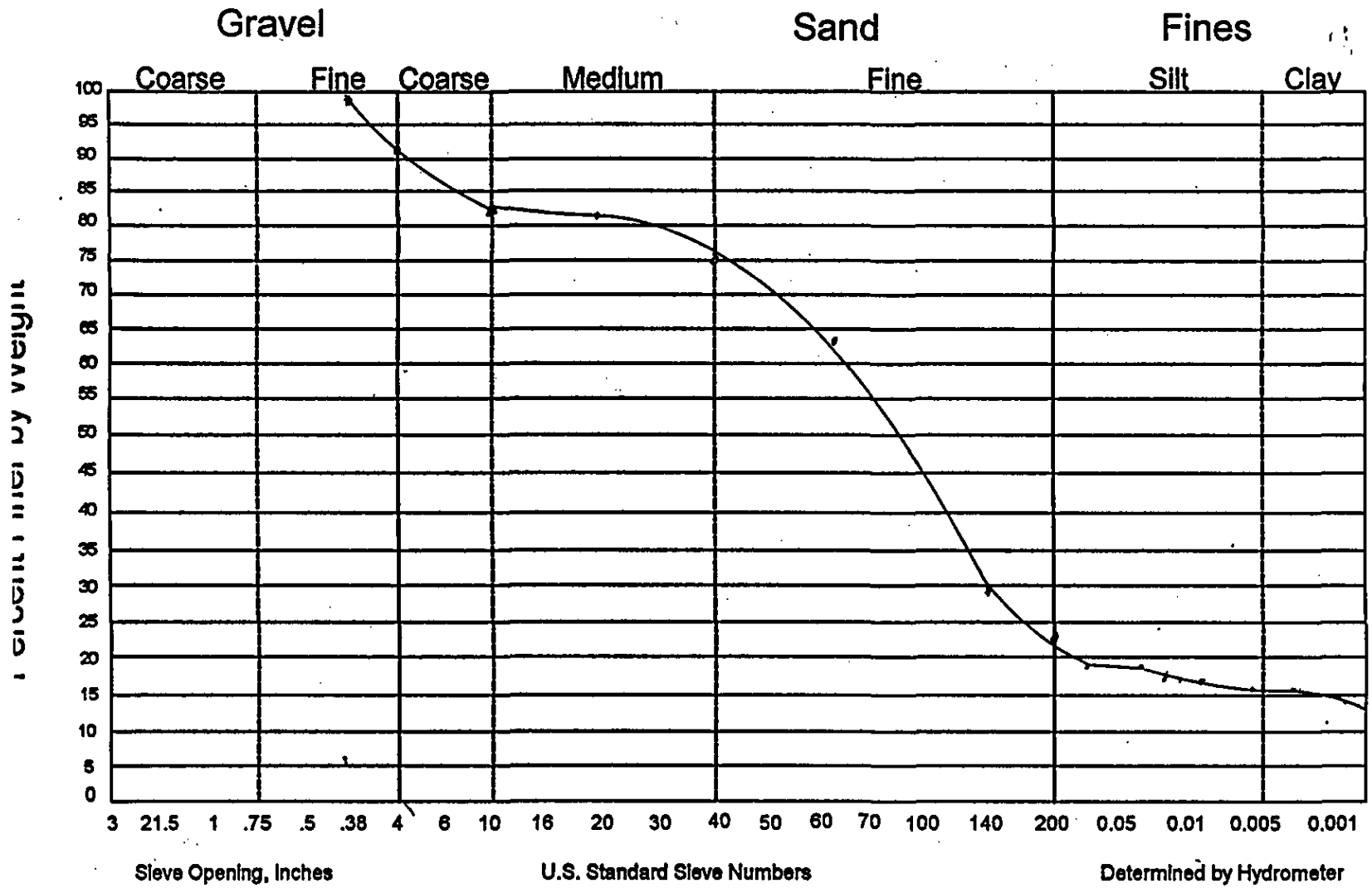
Design Category:

Inspector: [signature] Level: II Date: 3-3-99

Reviewer: [signature] Level: III Date: 3/3/99

RAYTHEON Engineers & Constructors

Grain Size Distribution Curve



Grain Size

Report #: 99-PAR3100 3B-0001 Project #: H RETENTION BASIN Lab #: HR3-15C

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ASR 18-172 (7/96)

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Particle-Size Analysis

ASTM D 75-(N/A); ASTM D 422-~~(63)~~ (90)?; ASTM C 136-(N/A)

Report #: 99-PAR31003B-0001 Work Package No.: N/A

Project/WAD #: PAR31003B QCIR No.: N/A

TWC: N/A Lab #: HR3-16DL Date Tested: 2/02/99

Material Description: ~~N/A~~ CLAYEY FINE SAND

Location: H RENTENTION BASIN

Sieve Size	*~~Cumulative Wt.~~ Retained, grams	~~Cumulative~~ MASS ~~% Retained~~ PASSING	% Passing	Acceptance Criteria
3/8"	0	463.4	100	N/A
#4	2.1	461.3	100	
10	17.6	443.7	100	
20	0.4	77.2	95	
40	9.1	68.1	84	
60	17.3	50.8	63	
140	25.0	25.8	32	
#200	6.0	19.8	24	
0.03411 mm	FROM HYDROMETER READINGS		21	#2
0.02173			20	
0.01224			17	
0.00871			17	
0.00647			16	
0.00321			16	
0.00136 mm			14	
		N/A		N/A

Pan Weight: 463.4 grams Specific Gravity: 2.62

Oven Dry Weight: 463.4/81.8 grams ☒ Yes ☐ No

M&TE: 1W-24 CAL DUE DATE: 11/17/99 Procedure: C-QCP-021

NCR #: N/A Rev: 0

Test Result: ☐ Conforming ☐ Nonconforming ☒ N/A *1 PCN's: N/A

Specs: N/A

Rev:

DCF's:

Design Category:

Remarks: * [initials] 2/08/99, *1 DATA SUBMITTED FOR ENG. EVALUATION.
*2 PERCENT OF SOIL IN SUSPENSION

Inspector: [signature] Level: II Date: 3-3-99

Reviewer: [signature] Level: III Date: 3/3/99

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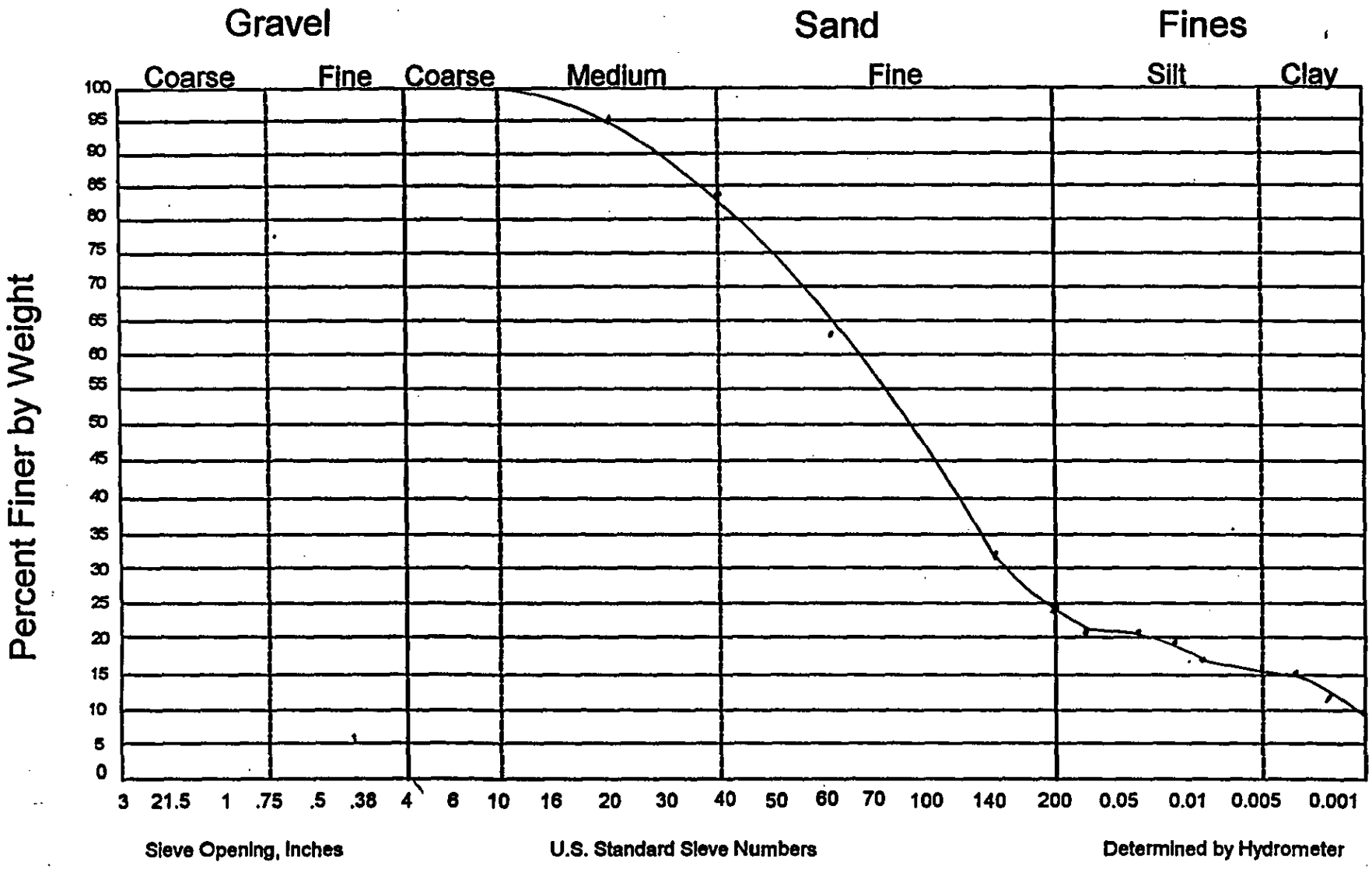
Grain Size Distribution Curve



Report #: 99-PAL310033B-0001 Project #: H RETENTION BASIN Lab #: HR3-16 DL

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ASR 18-172 (7/96)

RAYTHEON Engineers & Constructors

Particle-Size Analysis

ASTM D 75-(N/A); ASTM D 422-(63)(98)*1; ASTM C 136-(N/A)

Report #: 99-PAR3003B-0001 Work Package No.: N/A

Project/WAD #: PAR3003B QCIR No.: N/A

TWC: N/A Lab #: HRB-25-01 Date Tested: 2/01/99

Material Description: CLAYEY FINE SAND

Location: H RETENTION BASIN

Sieve Size	*~~Cumulative~~ Wt. Retained, grams	*~~Cumulative~~ % Retained	% Passing	Acceptance Criteria
3/8"	0	545.6	100	N/A
#4	7.0	543.6	100	
10	11.3	532.3	98	
20	1.5	60.9	95	
40	11.1	49.8	78	
100	7.6	42.2	66	
#140	5.5	36.7	57	
#200	1.2	35.5	56	
0.0305 mm			53	
0.0132			53	
0.0116			51	
0.00803	FROM HYDROMETER READINGS		50	#2
0.00568			50	
0.00283			48	
0.00120 mm			45	
		N/A		N/A

Pan Weight: 545.6 grams Specific Gravity: 2.64

Oven Dry Weight: 545.6/603.9 grams ☒ Yes ☐ No

M&TE: 1W.24	CAL DUE DATE: 11/17/99	Procedure: C-QCP-021
NCR #: N/A		Rev: 0
Test Result: ☐ Conforming ☐ Nonconforming ☒ N/A *1		PCN's: N/A
Remarks: *K.L.M. 2/08/99 *1 DATA SUBMITTED FOR ENG. EVALUATION. *2 PERCENT OF SOIL IN SUSPENSION		Specs:
		Rev: N/A
		DCF's:
		Design Category:

Inspector: [signature] Level: II Date: 2-2-99

Reviewer: K.L. Hastie Level: III Date: 2/5/99

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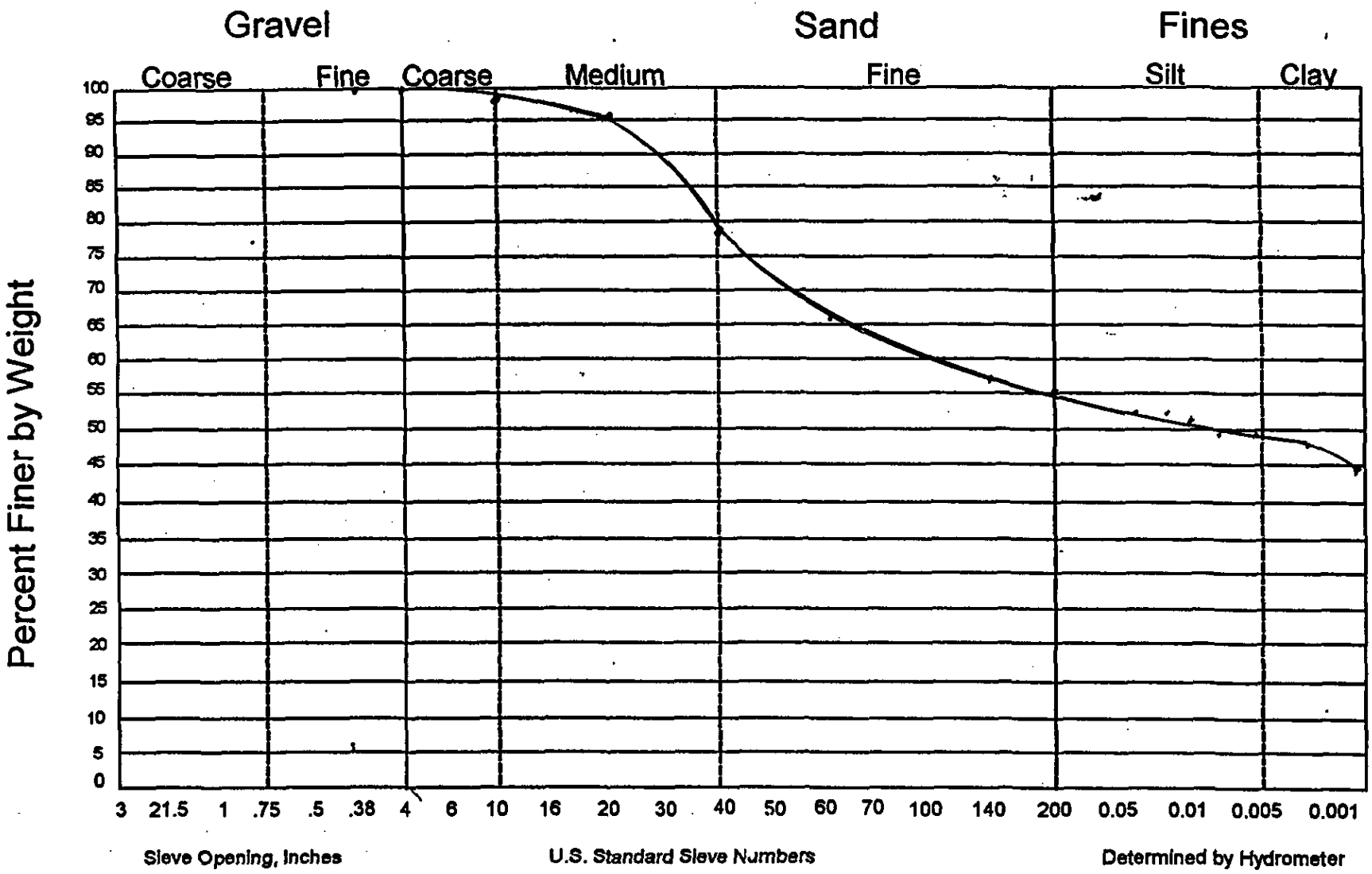
Grain Size Distribution Curve



Report #: 99-FAR3100BB-0001 Project #: H RETENTION BASIN Lab #: HRB-25-01

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ASR 18-172 (7/96)

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Particle-Size Analysis

ASTM D 75-(N/A); ASTM D 422-(63)(98)E1; ASTM C 136-(N/A)

Report #: 99-PAR310033B-0001 Work Package No.: N/A

Project/WAD #: PAR310033B QCIR No.: N/A

TWC: N/A Lab #: HRBS-27-01 Date Tested: 2/02/99

Material Description: CLAYEY MED. SAND

Location: H RETENTION BASINS

Sieve Size	* ~~Cumulative~~ Wt. Retained, grams	* ~~Cumulative~~ Mass % ~~Retained~~ Passing	% Passing	Acceptance Criteria
3/8	0	463.9 g.	100	N/A
#4	9.9	454.0	98	
10	33.6	420.3	91	
20	63.8	56.5	81	
40	19.2	37.3	53	
60	9.2	28.1	40	
140	6.4	21.7	31	
#200	1.2	20.5	29	
0.03425 mm			27	
0.02174			26	
0.01255			26	
0.00894	FROM HYDROMETER READINGS		24	*2
0.00637			23	
0.00317			21	
0.00134 mm			20	
	N/A			N/A

Pan Weight: 463.9 grams

Oven Dry Weight: 463.9/69.9 grams

Specific Gravity: 2.61

☒ Yes ☐ No

M&TE: IW-24	CAL DUE DATE: 11/17/99	Procedure: C-GOP-021
NCR #: N/A		Rev: 0
Test Result: ☐ Conforming ☐ Nonconforming ☒ N/A *1		PCN's: N/A
Remarks: *1 K.L.M., 2/08/99 *1 DATA SUBMITTED FOR ENG. EVALUATION *2 PERCENTAGE OF SOILS IN SUSPENSION		Specs:
		Rev: N/A
		DCF's:
		Design Category:

Inspector: [signature] Level: II Date: 3-3-99

Reviewer: K.L.M. Level: III Date: 3/3/99

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ASR 18-250 (7/96)

RAYTHEON Engineers & Constructors PAGE 13 OF 18

Summary Report of Testing Activities Continuation Sheet

Report Title: H RETENTION BASIN

Report No.: 99-PAR310038-0001

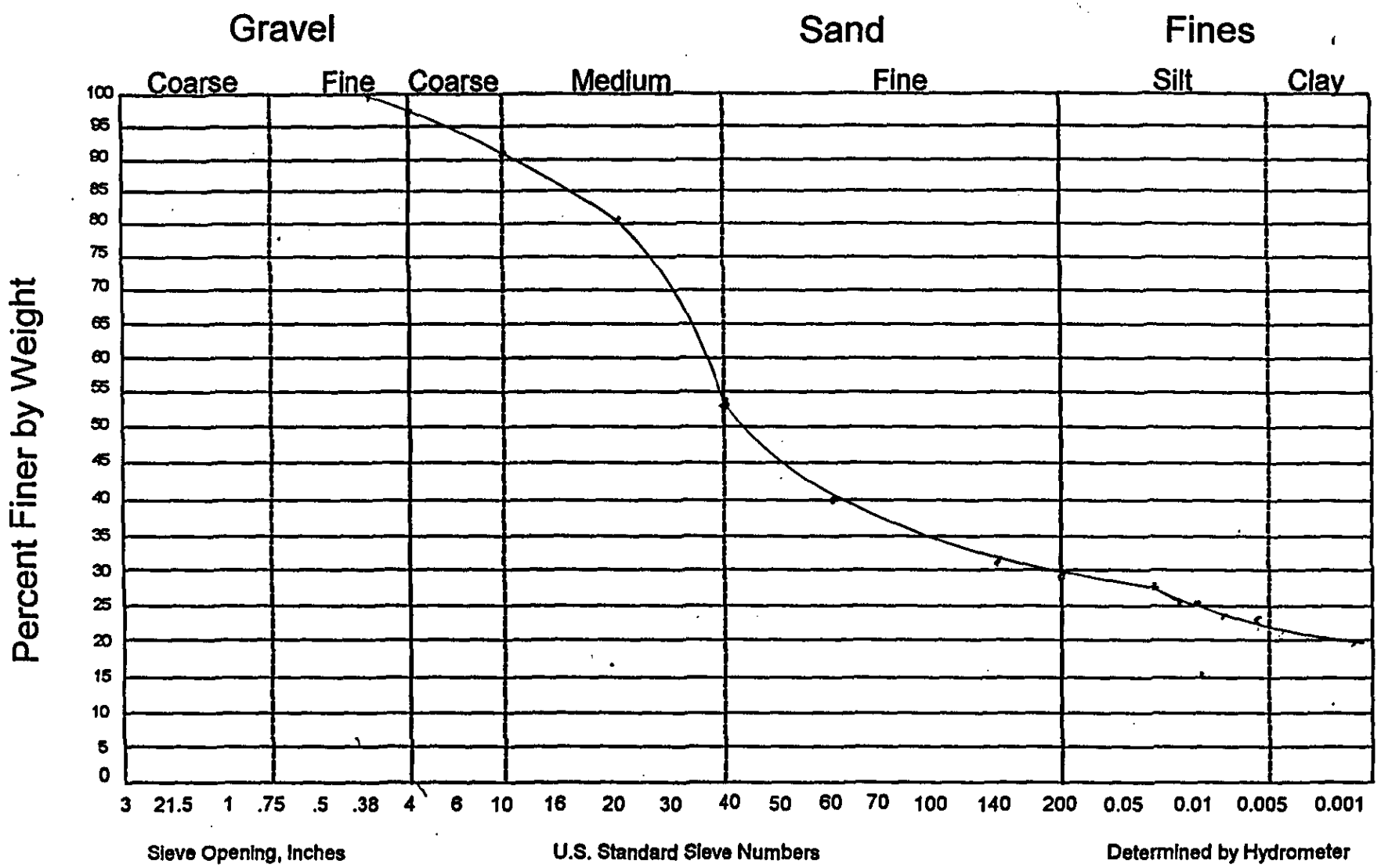
Item #	Remarks
	HYDRAULIC CONDUCTIVITY TESTS - ASTM D5084(90) FALLING HEAD. (REFER TO PAGES 14-18)

SAMPLE	AVG. HYDRAULIC CONDUCTIVITY
HRB-14C	1.85×10^{-4} cm/SEC.
HRB-25-01	4.02×10^{-6} cm/SEC
HRB5-21-01	1.93×10^{-5} cm/SEC.
HR3-16DL	2.16×10^{-5} cm/SEC.
HR3-15C	1.06×10^{-6} cm/SEC.

Remarks:

RAYTHEON Engineers & Constructors

Grain Size Distribution Curve



Report #: 99-PAC3100 3E-0001 Project #: H RETENTION BASIN Lab #: HRBS-27-01

WSRC-TR-00057
A242

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ASR 16-250 (7/96)

RAYTHEON Engineers & Constructors PAGE 2 OF ____

Summary Report of Testing Activities Continuation Sheet

Report Title: H AREA RETENTION BASIN Report No.: 99-PAR340036-0001

Item #	Remarks
~~HRB-99-01~~ Kidd, 2/2/99	RESULTS OF ASTM D422-63(90)$^{\varepsilon 1}$ STANDARD TEST FOR PARTICLE-SIZE ANALYSIS OF SOILS SAMPLE: HRC-14C MATERIAL DESCRIPTION: CLAYEY FINE SAND SPECIFIC GRAVITY: 2.58 ASTM D854-(92) REFER TO PAGE 3 AND 4 FOR PARTICLE-SIZE ANALYSIS SAMPLE: HRB-25-01 MATERIAL DESCRIPTION: CLAYEY FINE SAND SPECIFIC GRAVITY: 2.64, ASTM D854-(92) REFER TO PAGES 5 & 6 FOR PARTICLE-SIZE ANALYSIS SAMPLE: HRB5-27-01 MATERIAL DESCRIPTION: CLAYEY MED. SAND SPEC. GRAVITY: 2.61, ASTM D854-92 REFER TO PAGES 7 & 8 FOR PARTICLE-SIZE ANALYSIS SAMPLE: HR3-16DL MATERIAL DESCRIPTION: CLAYEY FINE SAND SPEC. GRAVITY: 2.62, ASTM D854-92 REFER TO PAGES 9 & 10 FOR PARTICLE SIZE ANALYSIS SAMPLE: HR3-16C MATERIAL DESCRIPTION: CLAYEY MED. SAND SPECIFIC GRAVITY: 2.60 REFER TO PAGES 11 & 12 FOR PARTICLE SIZE ANALYSIS

Remarks: ____

APPENDIX 3.

Vertical Hydraulic Conductivity Data Sheets for Saturated HRB Shelby Tube Samples

ASR 18-332 (7/98)

RAYTHEON Engineers & Constructors

Hydraulic Conductivity Test
ASTM D 5084-(90)

Report No.: 99-PAR31003B-00001	Project/WAD No.: PAR31003B	TWC: N/A
Date(s) of Test: 1/26 & 1/27/99	Sample Identification: HRB14C, H RETENTION BASIN	
Material Description: CLAYEY FINE SAND		Lab No.: HRB14C
Work Package No.: N/A	QCIR No.: N/A	
Special Selection/Preparation: NONE		
Method of Compaction: ☐ Standard Proctor (ASTM D 698) ☐ Modified Proctor (ASTM D 1557) ☒ Other: BULK DENSITY FIELD SAMPLE		
Initial Dimensions of Specimen	Height: 7.94 cm.	Diameter: 7.30 cm	Length: N/A
Initial Water Content: ~~29.4~~ 20.0 %	Initial Dry Unit Weight: ~~119.8 PCF~~ 100.4 PCF	
Type of Permeant Liquid Used: ☒ De-Aired Tap Water ☐ Other:		
Magnitude of Backpressure (psi): NO	Range of Hydraulic Gradient: 10	
Effective Consolidation Stress	Maximum: 1.5 psi	Minimum: 1.5 psi
Height of Specimen After Completion of Consolidation: ~~7.94 cm~~ NOT MEASURED		
Final Length of Specimen: ~~7.30 cm~~ 7.94 cm	Final Diameter: 7.30 cm	
Final Water Content: 25.2	Final Dry Unit Weight: 112.3 PCF	
Degree of Saturation: B VALUE ≥ 0.95 × SEE REMARKS	Average Hydraulic Conductivity: 1.85×10^{-4} cm/sec.	

Calculations

Methods A & D	Method B	Method C	
k = QL/Ath	k = (aL/At) ln (h1/h2)	k = [(a-in)(a-out)L / At(a-in + a-out] ln (h1/h2)	
If a-out = a-in = a	k = (aL / -2At) ln (h1/h2)	Correction to 20 Degrees C	k20 = RTk

Test Results: ☐ Conforming ☐ Nonconforming ☒ N/A *1	M&TE: IW-24	CAL DUE DATE: 11/17/99
NCR #:	Design Category: N/A	Procedure: C-QCP-021 Rev: 0 PCN's: N/A
Remarks: * VERIFIED PER PARA. 8.3.3.1 OF ASTM PROCEDURE. *1 DATA SUBMITTED FOR ENG. EVALUATION	Spec's: N/A	Rev: N/A DCF's: N/A
	Drawing(s): N/A	Rev: N/A DCF's: N/A

Inspector: [signature] Level: III Date: 3/3/99

Reviewer: [signature] Level: II Date: 3-3-99

ASR 18-332 (7/98)

RAYTHEON Engineers & Constructors

Hydraulic Conductivity Test
ASTM D 5084-(90)

Report No.: 99-PAR3100 3B	Project/WAD No.: PAR 3100 3B	TWC: N/A
Date(s) of Test: 2/04/99	Sample Identification: HR3-15C	
Material Description: CLAYEY MED. SAND		Lab No.: HR3-15C
Work Package No.: N/A	QCIR No.: N/A	
Special Selection/Preparation: N/A		
Method of Compaction: ☐ Standard Proctor (ASTM D 698) ☐ Modified Proctor (ASTM D 1557) ☒ Other: BULK DENSITY FIELD SAMPLE		
Initial Dimensions of Specimen	Height: 7.47 CM	Diameter: 7.30 CM / Length: N/A
Initial Water Content: 29.7%	Initial Dry Unit Weight: 119.8 PCF	
Type of Permeant Liquid Used: ☒ De-Aired Tap Water ☐ Other:		
Magnitude of Backpressure (psi): 0	Range of Hydraulic Gradient: 25	
Effective Consolidation Stress	Maximum: 1.5	Minimum: 0
Height of Specimen After Completion of Consolidation: 7.47 CM MEASURED 2/8/99		
Final Length of Specimen: 7.47 CM	Final Diameter: 7.30 CM	
Final Water Content: 32.9	Final Dry Unit Weight: 86.6 PCF	
Degree of Saturation: *SEE REMARKS B VALUE = 0.95	Average Hydraulic Conductivity: 1.002×10^{-6} CM/SEC.	

Calculations

Methods A & D	Method B	Method C	
k = QL/Ath	k = (aL/At) ln (h1/h2)	k = [(a-in)(a-out)L / At(a-in + a-out] ln (h1/h2)	
If a-out = a-in = a	k = (aL / -2At) ln (h1/h2)	Correction to 20 Degrees C	k20 = RTk

Test Results: ☐ Conforming ☐ Nonconforming ☒ *1 N/A	M&TE: IW-24	CAL DUE DATE: 11/17/99
NCR #: N/A / Design Category: N/A	Procedure: C-QCP-021	Rev: 0 PCN's: N/A
Remarks: *VERIFIED PER PARA. 8.3.3.1 OF ASTM PROCEDURE. *1 DATA SUBMITTED FOR ENG. EVALUATION	Spec's: N/A	Rev: N/A DCF's: N/A
	Drawing(s): N/A	Rev: N/A DCF's: N/A

Inspector: K. L. McKye Level: III Date: 2/3/99

Reviewer: [signature] Level: II Date: 3-3-99

ASR 18-332 (7/98)

RAYTHEON Engineers & Constructors

Hydraulic Conductivity Test
ASTM D 5084-(90)

Report No.: 99-PAR3100 3E-0001	Project/WAD No.: PAR 3100 3E	TWC: N/A
Date(s) of Test: 2/02/99	Sample Identification: HR3-16DL	
Material Description: CLAYEY FINE SAND		Lab No.: HR3-16DL
Work Package No.: N/A	QCIR No.: N/A	
Special Selection/Preparation: N/A		
Method of Compaction: ☐ Standard Proctor (ASTM D 698) ☐ Modified Proctor (ASTM D 1557) ☒ Other: BULK DENSITY FIELD SAMPLE		
Initial Dimensions of Specimen — Height: 7.62 CM	Diameter: 7.30 CM	Length: N/A
Initial Water Content: 15.3%	Initial Dry Unit Weight: 93.9 PCF	
Type of Permeant Liquid Used: ☒ De-Aired Tap Water ☐ Other:		
Magnitude of Backpressure (psi): N/A	Range of Hydraulic Gradient: 25	
Effective Consolidation Stress — Maximum: 1.5		Minimum: N/A
Height of Specimen After Completion of Consolidation: ~~6.98 CM~~ *SEE REMARKS, 2/8/99, NOT MEASURED		
Final Length of Specimen: 6.98 CM	Final Diameter: 7.30 CM	
Final Water Content: 12.0%	Final Dry Unit Weight: 126.0 PCF	
Degree of Saturation: *SEE REMARKS & VALUE = 0.95	Average Hydraulic Conductivity: 2.16×10^{-5} CM/SEC.	

Calculations

Methods A & D	Method B	Method C
k = QL/Ath	k = (aL/At) ln (h1/h2)	k = [(a-in)(a-out)L / At(a-in + a-out] ln (h1/h2)
If a-out = a-in = a	k = (aL / -2At) ln (h1/h2)	Correction to 20 Degrees C: k20 = RTk

Test Results: ☐ Conforming ☐ Nonconforming ☒ *1 N/A	M&TE: IW-24	CAL DUE DATE: 11/17/99
NCR #: N/A — Design Category: N/A	Procedure: C-QCP-021	Rev: 0 PCN's: N/A
Remarks: * VERIFIED PER PARA. 8.3.3.1	Spec's: N/A	Rev: N/A DCF's: N/A
OF ASTM PROCEDURE. *1 DATA	Drawing(s): N/A	Rev: N/A DCF's: N/A
SUBMITTED FOR ENG. EVALUATION.		

Inspector: [signature] Level: III Date: 2/3/99

Reviewer: [signature] Level: II Date: 3-3-99

ASR 18-332 (7/98)

RAYTHEON Engineers & Constructors

Hydraulic Conductivity Test
ASTM D 5084-(90)

Report No.: 99-PAR3400 3B-0001	Project/WAD No.: PAR3400 3B		TWC: N/A
Date(s) of Test: 1/28 & 1/29/99	Sample Identification: HRB-25-01, H RENTENTION BASIN		
Material Description: CLAYEY FINE SAND			Lab No.: HRB-25-01
Work Package No.: N/A		QCIR No.: N/A	
Special Selection/Preparation: NONE			
Method of Compaction: ☐ Standard Proctor (ASTM D 698) ☐ Modified Proctor (ASTM D 1557) ☒ Other:			BULK DENSITY FIELD SAMPLE
Initial Dimensions of Specimen	Height: 8.26 CM	Diameter: 7.30 CM	Length: N/A
Initial Water Content: 18.9%		Initial Dry Unit Weight: 102.3 PCF	
Type of Permeant Liquid Used: ☒ De-Aired Tap Water ☐ Other:			
Magnitude of Backpressure (psi): NO 0 [illegible] 1/28/99		Range of Hydraulic Gradient: 30	
Effective Consolidation Stress	Maximum: 1.5 PSI		Minimum: N/A
Height of Specimen After Completion of Consolidation: ~~8.26 CM~~ [illegible] 1/28/99, NOT MEASURED			
Final Length of Specimen: 8.26 CM		Final Diameter: 7.30 CM	
Final Water Content: 19.2%		Final Dry Unit Weight: 91.1 PCF	
Degree of Saturation: * SEE REMARKS B VALUE ≥ 0.95		Average Hydraulic Conductivity: 4.02×10^{-6} CM/SEC.	

Calculations

Methods A & D	Method B	Method C	
k = QL/Ath	k = (aL/At) ln (h1/h2)	k = [(a-in)(a-out)L / At(a-in + a-out] ln (h1/h2)	
If a-out = a-in = a	k = (aL / -2At) ln (h1/h2)	Correction to 20 Degrees C	k20 = RTk

Test Results: ☐ Conforming ☐ Nonconforming ☒ N/A *1	M&TE: IW-24	CAL DUE DATE: 11/17/99
NCR #: N/A Design Category: N/A	Procedure: C-GCP-021	Rev: 0 PCN's: N/A
Remarks: * VERIFIED PER PARA. 8.3.3.1	Spec's: N/A	Rev: N/A DCF's: N/A
OF ASTM PROCEDURE *1 DATA SUB-	Drawing(s): N/A	Rev: N/A DCF's: N/A
MITTED FOR ENG. EVALUATION		

Inspector: [signature] Level: III Date: 3/3/99

Reviewer: [signature] Level: III Date: 3-3-99

ASR 18-332 (7/98)

RAYTHEON Engineers & Constructors

Hydraulic Conductivity Test
ASTM D 5084-(90)

Report No.: 99-PAR31003B-0001	Project/WAD No.: PAR31003B	TWC: N/A
Date(s) of Test: 2/1/99	Sample Identification: HRBS-27-01	
Material Description: CLAYEY MED. SAND		Lab No.: HRBS-27-01
Work Package No.: N/A	QCIR No.: N/A	
Special Selection/Preparation: N/A		
Method of Compaction: ☐ Standard Proctor (ASTM D 698) ☐ Modified Proctor (ASTM D 1557) ☒ Other: BULK DENSITY FIELD SAMPLE		
Initial Dimensions of Specimen — Height: 7.94 CM	Diameter: 7.30 CM	Length: N/A
Initial Water Content: 10.6%	Initial Dry Unit Weight: 135.9 PCF	
Type of Permeant Liquid Used: ☒ De-Aired Tap Water ☐ Other:		
Magnitude of Backpressure (psi): 0	Range of Hydraulic Gradient: 20	
Effective Consolidation Stress — Maximum: 1.5 PSI		Minimum: N/A
Height of Specimen After Completion of Consolidation: 7.94CM K.K.M. 2/8/99 NOT MEASURED		
Final Length of Specimen: 7.94CM	Final Diameter: 7.30 CM	
Final Water Content: 17.5%	Final Dry Unit Weight: 105 PCF	
Degree of Saturation: * SEE REMARKS B VALUE ≥ 0.95	Average Hydraulic Conductivity: 1.93×10^{-5} CM/SEC.	

Calculations

Methods A & D	Method B	Method C
k = QL/Ath	k = (aL/At) ln (h1/h2)	k = [(a-in)(a-out)L / At(a-in + a-out] ln (h1/h2)
If a-out = a-in = a	k = (aL / -2At) ln (h1/h2)	Correction to 20 Degrees C: k20 = RTk

Test Results: ☐ Conforming ☐ Nonconforming ☒ N/A *1	M&TE: 1W-24	CAL DUE DATE: 11/17/99
NCR #: N/A — Design Category:	Procedure: C-QCP-021 Rev: 0 PCN's: N/A	
Remarks: * VERIFIED PER PARA. 8.3.3.1 OF ASTM PROCEDURE. *1 DATA SUBMITTED FOR ENG. EVALUATION	Spec's: N/A Rev: N/A DCF's: N/A	
	Drawing(s): N/A Rev: N/A DCF's: N/A	

Inspector: K.K. McKeon Level: III Date: 2/3/99

Reviewer: [signature] Level: III Date: 3-3-99

APPENDIX 4.

Exchangeable Acidity DATA Sheets

Summary of Data Sheet for Exchangeable Acidity Tests

Sample ID	Sample volume	Sample weight	Vol corrected for solids	Initial pH	Vol. 0.01N H2So3 (ml)	pH after addition of H2SO4	H2O2 Added (drops)	Boiling Time (min)	Vol. 0.02 N NaOH (ml)	Final pH	Exchangeable Acidity mg/L
HRB-14-C	50	50.1537	49.85	4.42	0.50	3.60	5	4	0.70	8.22	90.3
HR3-15C	50	50.019	49.98	6.24	4.00	4.00	55	38	3.80	8.22	360.1
HR3-16DL	50	50.2715	49.73	5.89	1.50	3.70	10	11	2.00	8.21	251.4
HRB5-25-01	50	50.001	50.00	8.23	8.50	4.01	30	30	5.10	8.21	170.0
HRB5-27-01	50	50.3164	49.69	8.56	4.80	4.00	30	30	3.10	8.20	140.9
Blank	50	50	50.00	5.41	0.10	4.01	5	4	0.20	8.2	30.0

Sample ID	Sample volume	Sample weight	Vol corrected for solids	Initial pH	Vol. 0.01N H2So3 (ml)	pH after addition of H2SO4	H2O2 Added (drops)	Boiling Time (min)	Vol. 0.02 N NaOH (ml)	Final pH	Exchangeable Acidity mg/L
HRB-14-C	50	50.1588	49.84	4.48	0.30	4.00	5	4	1.00	8.22	170.5
HR3-15C	50	50.05	49.95	6.46	3.30	4.01	10	13	2.80	8.22	494.5
HR3-16DL	50	50.1623	49.84	5.91	1.00	4.00	15	18	1.70	8.21	240.8
HRB5-25-01	50	50.0375	49.96	8.24	2.00	4.02	5	5	1.90	8.21	180.1
HRB5-27-01	50	50.1228	49.88	8.6	1.75	4.01	10	13	1.40	8.20	105.3

APPENDIX 5.

Sodium Concentrations for Cation Exchange Capacity Calculations

Unoffical Results Report By Submission By Operation
Tuesday February 09, 1999

Operation:
AANA

Method:AANA
Measure:ANALYST NAME
Units:PPM
Submission_id:200022330
Status:COMPLETE
Condition:APPROVED

User SampleId	Sample Id	COMPONENT	Text Value
15C-A	300122469	ANALYST NAME	SCG
15C-A	300122469	NA	190.1628
15C-B	300122470	ANALYST NAME	SCG
15C-B	300122470	NA	138.8043
14C-A	300122471	ANALYST NAME	SCG
14C-A	300122471	NA	128.0276
14C-B	300122472	ANALYST NAME	SCG
14C-B	300122472	NA	131.4818
25-A	300122473	ANALYST NAME	SCG
25-A	300122473	NA	176.6490
25-B	300122474	ANALYST NAME	SCG
25-B	300122474	NA	166.3470
27-A	300122475	ANALYST NAME	SCG
27-A	300122475	NA	135.0168
27-B	300122476	ANALYST NAME	SCG
27-B	300122476	NA	108.4336
16DL-A	300122477	ANALYST NAME	SCG
16DL-A	300122477	NA	78.1336
16DL-B	300122478	ANALYST NAME	SCG
16DL-B	300122478	NA	46.6014
BLANK	300122479	ANALYST NAME	SCG
BLANK	300122479	NA	1.9914

APPENDIX 6.

Chain of Custody for the HRB Shelby Tube Samples

OSR 24-E37A# (Rev 4-22-98)
Stores: 26-15298.04

CHRISTINE ~~LANGFORD~~ LANGTON
PHONE: 5-5806

WSRC-TR-0005
A6-

Savannah River Technology Center
Analytical Development Section (773-A)
Analysis Request

(Surcharge Applied For 24 And 48 Hours Turnaround Requests)

Approved by
Study
Datagroup
Submission ID
Online by

Requester (Print Name)	Requester Phone	Division/Department
Bob Lasswitz	2-6681	ESH&QA/EPD/EGG
Requester Address	**Date Submitted**	**Activity Code or LIMS Study Name**
730-2B, 2116	12/28/98	PAR20911J
Report Results To (Name)	**Phone**	**Address**
Bob Lasswitz	2-6681	730-2B, 2116
Analysis Reviewed With (Name)	**Comments**	
N/A	Soil samples are from H-Retention Basin and are radiologically contaminated	

Sample Matrix: ☐ Organic ☐ Aqueous ☐ Gas ☐ Solid ☒ Soil ☐ Sludge

Radioactive Material: ☒ Yes ☐ No

If radioactive identify type and estimate amount: ☒ Alpha 12,000 pCi/g ☒ Beta/Gamma 24,200 pCi/g ☐ Tritium n/a

Sample Description: Soil samples in Shelby Tubes from old H Retention Basin. Estimated rad amounts are in pCi/g.

Fissionable Material: ☐ Yes ☒ No

If yes specify Major Isotope(s) _____ Weights _____

Data used for EPA/SCDHEC Compliance: ☐ Yes ☒ No

SRWP Req ☐ Yes ☐ No

SRWP No. _____

Amount: 17.35 kg ☐ ML ☐ GM

QA Level: ☒ Routine ☐ Exploratory ☐ Customer Assisted

TTP No. _____

ASP No. _____

Sample Hazards—For Handling ☒ Yes ☐ No
List: Samples are radiologically contaminated

Sample Hazards—For Disposal ☒ Yes ☐ No
List: Samples are radiologically contaminated

Special Analysis Requirements for Customer Assisted QA Level

Requested Sample Turnaround Time
☐ 24 hrs for analysis no. _____
☐ 48 hrs for analysis no. _____
☐ Normal
☒ Other, specify date: soil study

Analysis Requested

1. Soil Study	2.	3.	4.
5.	6.	7.	8.

Sample ID	ADS Sample ID	List Analysis Requested for Each Sample by Number	Comments
HR3-16DL		☒ All	
HR3-14C		☒ All	
HRB-15C		☒ All	
HRB-25-01		☒ All	
HRB-27		☒ All	
		☐ All	
		☐ All	
		☐ All	
		☐ All	
		☐ All	

Required Sample Label: ☒ Red—Radioactive ☐ White—Nonradioactive

Samples contain less than reportable quantities of accountable nuclear materials as listed in L7.7 1.07: ☒ Yes ☐ No

Packaging: ☐ Blue Label ☐ Green Label ☐ HP Survey Label

Sample Disposal: ☒ Return to Customer ☐ Lab to Dispose—Sample is Not an EPA/SCDHEC Hazardous Waste

Job # [redacted]

ONSITE CHAIN - OF - CUSTODY (U)

Westinghouse Savannah River Company, Savannah River Site

Rev. 0, 12/21/95

Page # 1 of 1

Job Title: SOIL STUDY - SOIL FROM HRB

Sample Destination: 773-A

Org. Code	Activity Code	TWC Code
	PAR291IJ	

	Name	Dept.	Address	Phone	Pager
Customer	BRAD DAVIS	ER	730-2B	2-6518	15695
Customer Results	BRAD DAVIS	ER		2-6518	15695

SMP Customer Rep: BOB LASSWITZ

Matrix Key: S = Soil SO = Solid SL = Sludge O = Organic A = Aqueous

SAMPLE ANALYSIS REQUESTED

SAMPLE I.D.	TID NUMBER	COLLECTION DATE	COLLECTION TIME	MATRIX	NUMBER OF CONTAINERS	Alpha, Beta-Gamma & Tritium	Alpha	Alpha PHA	Beta-Gamma	Gamma PHA	Tritium	DOT Corrosivity (Corrositox)	Flash Point	pH	Specific Gravity	BTEX	Total Metals: 8 RCRA	Total Metals (specify):	TPH	TPH-Diesel	TPH-Gasoline	TSS - Total Suspended Solids	SRTC STUDY (CHRISTINE TANSFORD) LANGTON	Remarks:
HR3-16DL	—			S	1*																	X		
HR3-14C	—			S	1*																	X		
HRB-15C	—			S	1*																	X		
HRB-25-01	—			S	1*																	X		
HRB-27	—			S	1*																	X		
*SHELBY TUBE																								

1 Relinquished by:	Date / Time	Received by:	2 Relinquished by:	Date / Time	Received by:
(Print) BOB LASSWITZ	12/28/98	(Print) DJ Wheeler	(Print) E. Johnson	12/28/98	(Print) C A Langford 12/28/98
(Sign) R. Lasswitz	1000 hrs.	(Sign) DJ Wheeler	(Sign) E. Johnson	1030 hrs.	(Sign) Christine A Langford HDD
3 Relinquished by:	Date / Time	Received by:	4 Relinquished by:	Date / Time	Received by:
(Print)	/ /	(Print)	(Print)	/ /	(Print)
(Sign)	hrs.	(Sign)	(Sign)	hrs.	(Sign)
5 Relinquished by:	Date / Time	Received by:	6 Relinquished by:	Date / Time	Received by:
(Print)	/ /	(Print)	(Print)	/ /	(Print)
(Sign)	hrs.	(Sign)	(Sign)	hrs.	(Sign)

Requested Results TAT: 30 DA

Lab Report To:

- SMP, 773-62A, Fax 5-5154
- EMS, 773-58A, Fax 5-8041
- Other: [redacted]

WESTINGHOUSE SAVANNAH RIVER COMPANY
SAVANNAH RIVER TECHNOLOGY CENTER

February 11, 1999

To: B. K. Davis, 730-2B
cc: B. T. Butcher, 773-43A
W. E. Stevens, 773A
W. L. Tamosaitis, 773-A
L. Papouchado, 773-A
C. G. May, 773-43A
L. M. Nelson, 773-43A
P. E. Lowe, 773-41A
R. F. Blundy, 730-2B
L. A. Bagwell, 730-2B
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W. L. Mhyre, 717-5N
M. A. Ditullio, 717-5N
STI (4 Copies) 703-43A
File (2 copies)

OSR 14-357# (Rev 12-11-96)
Stores: 26-12801.00

Westinghouse Savannah River Company
Document Approval Sheet

Document No.
WSRC-TR-99-00057

Title
Geotechnical Analysis of Five Shelby Tube Samples from H-Area Retention Basin(U)

Primary Author/Contact (Must be WSRC)	Location	Phone No.	Position	User ID
C. A. Langton	773-43A	5-5806	Sr. Fellow Scientist	T6333

Organization Code	Organization (No Abbreviations)
L3230	Savannah River Technology Center

Other Authors
W. L. Mhyre

Deadline Date for Approval

Has an invention disclosure been submitted related to this information? ☐ Yes ☐ No

Disclosure No. (If Known) _____ Title _____ Date Submitted _____

Do you intend to submit an invention disclosure? ☐ Yes ☐ No If yes, projected date _____

Information Product Description

☒ Report Type
☐ Quarterly ☐ Annual ☐ Final ☐ Other_____
☐ Semiannual ☒ Technical ☐ Topical
Report Dates _____ thru _____

☐ Conference Type
☐ Abstract ☐ Published Proceedings
☐ Conf Paper ☐ Other_____
☐ Slides

☐ Journal Article (Journal Name) _____
☐ Videotape/Multimedia
☐ External Web Page
☐ Software (Additional forms are required (ESTSC F1 and F2)).

Conference/Meeting/Presentation

Meeting Title (No Abbreviations)

Meeting Address (City, State, Country)

Meeting Date(s)
_____ (m/d/y) thru _____ (m/d/y)

References ☐ In Public Literature ☐ Routing Concurrently
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Author's Signature: C. A. Langton — Date: 3-11-99

Approvals by Author's Organization

Derivative Classifier	Classification	Topic	Distribution
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Classification (Check One for Each)					Classification Guide Topics
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Abstract	☐ S	☐ C	☐ UCNI	☐ U	
Title	☐ S	☐ C	☐ UCNI	☐ U	

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58	Class/EC/DCE	

NOTE OSR 17-8 must be completed in addition to this form when submitting information for review and approval.

Keywords: See cover page

Westinghouse
Savannah River Company

P.O. Box 616
Aiken, SC 29802

March 18, 1999

WSRC-TR-99-00057
MSD-STI-97-4198

Ms. W. F. Perrin, Technical Information Officer
U. S. Department of Energy - Savannah River Operations Office

Dear Ms. Perrin:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for classification and technical approvals for the purpose of external release. Please complete Part II of this letter and return the letter to the undersigned by 4/30/99. The document has been reviewed for classification and export control by a WSRC Classification staff member and has been determined to be Unclassified.

Pat Domineq for
Kevin J. Schmidt, WSRC STI Program Manager

I. DETAILS OF REQUEST FOR RELEASE

Document Number: WSRC-TR-99-00057
Author's Name: C. A. Langton
Location: 773-43A Phone 5-5806
Department: SRTC
Document Title: Geotechnical Analysis of Five Shelby Tube Samples from H-Area Retention Basin

Presentation/Publication:
Meeting/Journal:
Location:
Meeting Date:

OSTI Reportable

II. DOE-SR ACTION

Date Received by TIO 03/19/99

☒ Approved for Release
☐ Approved Upon Completion of Changes
☐ Approved with Remarks
☐ Not Approved
☐ Revise and Resubmit to DOE-SR

Remarks: _____

W. F. Perrin
W. F. Perrin, Technical Information Officer, DOE-SR

6/2/99
Date

OSR 25-82-W# (4-89)
Stores: 26-15460.00

DOE F 241.1
(7-98) p. 1 of 2
(Formerly DOE F 1332.15)
(All other versions are obsolete)

US DEPARTMENT OF ENERGY

ANNOUNCEMENT OF U. S. DEPARTMENT OF ENERGY (DOE) SCIENTIFIC AND TECHNICAL INFORMATION (STI)

OMB Control No.
1910-1400

RECORD STATUS (select one):
X New ..... Revised Data ..... Revised STI Product

Part I: STI PRODUCT DESCRIPTION

A. STI PRODUCT TYPE (select one)

X 1. **Technical Report**
a. Type: ☐ **Topical** ☐ **Semiannual** ☐ **Annual** ☒ **Final** Other (**specify**) .....
b. Reporting Period *(mm/dd/yyyy)* ..... thru .....

..... 2. **Conference**
a. Product Type: ..... Conference Proceedings ..... Conference Paper or Other (*abstracts, excerpts, etc.*) ___
b. Conference Information (*title, location, dates*) _____

..... 3. **Software Manual** (*The actual software package should be made available simultaneously. Follow instructions provided with ESTSC F 1 and ESTSC F 2.*)

..... 4. **Journal Article**
a. Type: X Announcement citation only ___ *Preprint* ___ Postprint
b. Journal Name .....
c. Volume_____ d. Issue _____ e. Serial identifier (*e.g., ISSN or CODEN*) _____

..... 5. **S&T Accomplishment Report**

..... 6. **Book**

..... 7. **Patent Application**
a. Date Filed *(mm/dd/yyyy)* ___/___/___
b. Date Priority *(mm/dd/yyyy)* ___/___/___
c. Patent Assignee _____

..... 8. **Thesis/Dissertation**

B. STI PRODUCT TITLE Geotechnical Analysis of Five Shelby Tube Samples from H-Area Retention Basin

C. AUTHOR(s) C. A. Langton
E-mail Address(es):

D. STI PRODUCT IDENTIFIER
___ 1. Report Number(s) WSRC-TR-99-00057
___ 2. DOE Contract Number(s) DE-AC09-96SR18500
___ 3. R&D Project ID(s)
___ 4. *Other Identifying Number(s)*

E. ORIGINATING RESEARCH ORGANIZATION Savannah River Site

F. DATE OF PUBLICATION *(mm/dd/yyyy)* .....

G. LANGUAGE (***if non-English***) English

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Keywords H-Area Retention Basin, Geotechnical Analysis, Soil Characterization

K. DESCRIPTION/ABSTRACT

Geotechnical and geochemical analyses were performed on five Shelby tube samples collected in the H-Area Retention Basin (HRB) during July and August of 1998. The samples were collected as part of the HRB characterization study. The test results, which are documented in this report, will be used to support the HRB contaminant fate and transport modeling/analysis and to evaluate remedial options. The results will also be used as a base line for future treatability studies.

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