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Saltstone, Concrete, Hydraulic Conductivity, Moisture Retention Characteristics

Retention: Permanent

HYDRAULIC AND PHYSICAL PROPERTIES OF SALTSTONE GROUTS AND VAULT CONCRETES

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NOVEMBER 2008

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Aiken, SC 29808

Prepared for the U.S. Department of Energy Under Contract Number DE-AC09-08SR22470

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REVIEWS AND APPROVALS

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LIST OF ACRONYMS

AEA	Air entraining admixture
ARP	Actinide Removal Process
CSSX	Caustic side solvent extraction
DDA	Deliquification, Dissolution, and Adjustment
INL	Idaho National Laboratory
ITP	In-Tank Precipitation Facility
LLW	Low Level Waste
MCT	Mactec Engineering and Consulting, Inc.
MCU	Modular Caustic Side Solvent Extraction Unit
PA	Performance Assessment
RETC	RETention Curve
SDF	Saltstone Disposal Facility
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SWPF	Salt Waste Processing Facility
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
w/pm	water to premix ratio
WRA	Water reducing admixture
WSRC	Washington Savannah River Company

1.0 EXECUTIVE SUMMARY

The Saltstone Disposal Facility (SDF), located in the Z-Area of the Savannah River Site (SRS), is used for the disposal of low-level radioactive salt solution. The SDF currently contains two vaults: Vault 1 (6 cells) and Vault 4 (12 cells). Additional disposal cells are currently in the design phase. The individual cells of the saltstone facility are filled with saltstone. Saltstone is produced by mixing the low-level radioactive salt solution, with blast furnace slag, fly ash, and cement (dry premix) to form a dense, micro-porous, monolithic, low-level radioactive waste form. The saltstone is pumped into the disposal cells where it subsequently solidifies. Significant effort has been undertaken to accurately model the movement of water and contaminants through the facility. Key to this effort is an accurate understanding of the hydraulic and physical properties of the solidified saltstone. To date, limited testing has been conducted to characterize the saltstone.

The primary focus of this task was to estimate the hydraulic and physical properties of three types of saltstone and two vault concretes. The saltstone formulations included saltstone premix batched with 1) Deliquification, Dissolution, and Adjustment (DDA) salt simulant (w/pm 0.60), 2) Actinide Removal Process (ARP)/Modular Caustic Side Solvent Extraction Unit (MCU) salt simulant (w/pm 0.60), and 3) Salt Waste Processing Facility (SWPF) salt simulant (w/pm 0.60). The vault concrete formulations tested included the Vault 1/4 concrete and two variations of the Vault 2 concrete (Mix 1 and Mix 2). Wet properties measured for the saltstone formulations included yield stress, plastic viscosity, wet unit weight, bleed water volume, gel time, set time, and heat of hydration. Hydraulic and physical properties measured on the cured saltstone and concrete samples included saturated hydraulic conductivity, moisture retention, compressive strength, porosity, particle density, and dry bulk density. These properties were determined following a minimum 28 day curing period. Additional testing of the three saltstone formulations was conducted following a minimum 90 day curing period. The compressive strength of each saltstone and concrete material was measured at approximately 14, 28, 56, and 90 days.

Recommended hydraulic property values for each saltstone grout and the vault concretes are provided. The hydraulic properties provided for each material include the saturated hydraulic conductivity, dry bulk density, particle density, and porosity. In addition, water retention data are presented for each material along with the van Genuchten transport parameters as determined using the RETC code.

2.0 INTRODUCTION

The Saltstone Disposal Facility (SDF), located in the Z-Area of the Savannah River Site (SRS), is used for the disposal of low-level radioactive salt solution. The SDF currently contains two vaults: Vault 1 and Vault 4. Additional disposal cells are currently in the design phase. Vault 4 is approximately 200 feet wide, 600 feet in length, and 26 feet in height. Vault 4 is divided into 12 cells with each cell measuring about 100 feet by 100 feet (Phifer et al., 2006). Vault 1 is half the size of Vault 4 measuring approximately 100 feet wide by 600 feet long with 6 cells. The individual cells of the saltstone facility are filled with saltstone. Saltstone is produced by mixing low-level radioactive salt solution, with blast furnace slag, fly ash, and cement to form a dense, micro-porous, monolithic, low-level radioactive waste form. The saltstone material contains no coarse or fine aggregate and is pumped into the disposal cells where it subsequently solidifies.

SRS is currently in the process of revising the Performance Assessment (PA) for the SDF as required by DOE Order 435.1, Radioactive Waste Management. As part of this revision, a significant effort will be undertaken to accurately model the movement of water and contaminants through the SDF. Key to this effort is an accurate understanding of the hydraulic and physical properties of the specific saltstone formulations to be placed in the SDF.

Initial testing of the saltstone grout was conducted by Yu et al. (1993). This characterization work indicated that intact saltstone had a saturated intrinsic permeability of 5.3×10^{-9} darcies using a brine solution; and a saturated hydraulic conductivity relative to water of 5.19×10^{-12} cm/s (Yu et al., 1993). These results have not been corroborated by subsequent testing and are now thought to be biased due to potential precipitation of the brine solution within the saltstone samples.

Langton (1986) measured the saturated hydraulic conductivity of "Reference Saltstone" samples containing 42.5% salt solution and 57.5% (by mass) blended cement. Langton (1986) reported saturated hydraulic conductivity of this material to be 1.1×10^{-8} cm/sec for a sample cured for 60 days. Additionally, Langton (1986) reported the results of previous hydraulic testing on saltstone samples (made with varying amounts of salt solution) with results ranging from 3.0×10^{-9} cm/sec to $<1.0 \times 10^{-11}$ cm/sec.

More recently, Harbour et al. (2007a) estimated the saturated hydraulic conductivity of a MCU saltstone using a beam bending technique. Harbour et al. (2007a) estimated the hydraulic conductivity of the saltstone ranged from 1.4 to 3.4×10^{-9} cm/sec, which is about three orders of magnitude more permeable than reported by Yu et al. (1993). Furthermore, Harbour et al. (2007a) reported a porosity of 0.62 which is substantially greater than that reported by Yu et al. (1993).

Dixon and Phifer (2007) estimated the saturated hydraulic conductivity of a MCU saltstone using standard geotechnical testing methods (ASTM 5084, flexible wall permeameter). Dixon and Phifer (2007) estimated the saturated hydraulic conductivity of the MCU saltstone relative to two different permeating fluids: groundwater equilibrated with vault concrete simulant and saltstone

pore fluid simulant. The saturated hydraulic conductivity of the saltstone relative to the groundwater equilibrated with vault concrete simulant was estimated to be 1.5 x 10^{-8} cm/sec. The saturated hydraulic conductivity of the saltstone relative to the saltstone pore fluid simulant was estimated to be 5.3 x 10^{-9} cm/sec. The dry bulk density of the saltstone was estimated to range from 0.95 to 1.06 g/cm^3 with an average of 0.99 g/cm^3. The porosity was estimated to range from 0.578 to 0.613 with an average of 0.596.

The purpose of this task was to measure the hydraulic and physical properties of three saltstone grout formulations and two vault concrete formulations. The saltstone formulations include saltstone premix batched with 1) Deliquification, Dissolution, and Adjustment (DDA) salt simulant (w/pm 0.60), 2) Actinide Removal Process (ARP)/ Modular Caustic Side Solvent Extraction Unit (MCU) salt simulant (w/pm 0.60), and 3) Salt Waste Processing Facility (SWPF) salt simulant (w/pm 0.60). The vault concretes tested include the Vault 1/4 concrete and the Vault 2 concretes (Mix 1 and Mix 2). Wet properties measured for the saltstone grout formulations include yield stress, plastic viscosity, wet unit weight, bleed water volume, gel time, set time, and heat of hydration. Hydraulic and physical properties measured on the cured samples included saturated hydraulic conductivity, moisture retention, porosity, and dry bulk density. These properties were determined following a minimum 28 day curing period. Additional testing was conducted on the saltstone samples following a minimum 90 day curing period. The sections that follow discuss the methods used to test samples of the saltstone and vault concretes and the results of the testing.

3.0 METHODS

The purpose of this task was to measure the hydraulic and physical properties of three saltstone grout formulations and two vault concrete formulations. The saltstone formulations tested were the DDA, ARP/MCU, and the SWPF formulations. The vault concrete formulations tested were the Vault 1/4 concrete and two variations of the Vault 2 concrete. All samples were tested for saturated hydraulic conductivity, moisture retention characteristics, compressive strength, dry bulk density, particle density, and porosity. The following samples of each material were tested to determine the hydraulic and physical properties using standard ASTM methods (or equivalent):

- 3 samples of DDA saltstone following a minimum 28 day curing period (w/pm 0.60)
- 3 samples of DDA saltstone following a minimum 90 day curing period (w/pm 0.60)
- 3 samples of ARP/MCU saltstone following a minimum 28 day curing period (w/pm 0.60)
- 3 samples of ARP/MCU saltstone following a minimum 90 day curing period (w/pm 0.60)
- 3 samples of SWPF saltstone following a minimum 28 day curing period (w/pm 0.60)
- 3 samples of SWPF saltstone following a minimum 90 day curing period (w/pm 0.60)
- 3 samples of Vault 1/4 concrete following a minimum 28 day curing period
- 3 samples of Vault 2, Mix 1 concrete following a minimum 28 day curing period
- 3 samples of Vault 2, Mix 2 concrete following a minimum 28 day curing period

3.1 SALTSTONE SAMPLE PREPARATION

Samples of three saltstone formulations were prepared for compressive strength and hydraulic and physical property testing. The cementitious materials used in the premix for each of the saltstone grout formulations were identical and were comprised of Class F fly ash (45 wt%), Grade 100 blast furnace slag (45 wt%), and Type II Portland cement (10 wt%) with an as-batched water to premix ratio (w/pm) of 0.60 (Table 1). The cementitious materials were received in 5 gallon containers from the vendors during truck delivery of the bulk materials to SPF. The cementitious materials are therefore part of one of the batches actually used in production of saltstone. For each saltstone grout formulation, the cementitious materials were mixed with a salt simulant representative of three types of decontaminated salt solution to be processed by the saltstone facility. The recipes for the simulants are presented in Table 2 through Table 4 and the physical properties of the simulants are presented in Table 5.

Wet properties measured for the saltstone formulations included yield stress, plastic viscosity, wet unit weight, bleed water volume, gel time, set time, and heat of hydration. The methods of Harbour et al. (2005) were followed to determine yield stress, plastic viscosity, gel time, bleed water volume, and wet unit weight. Porosity and heat of hydration were determined following the method of Harbour et al. 2007b and 2007c, respectively.

3.1.1 DDA Saltstone Sample Preparation

Three large batches of DDA Saltstone were batched (~ 5 kg each) to provide a sufficient amount of grout for all of the testing. Seven test cylinders (2.8 x 6 inch) were filled for hydraulic testing. The mold samples were capped, sealed, and allowed to cure in the laboratory at ambient temperature for a minimum of 28 or 90 days prior to testing. Bleed liquid leaked from the hydraulic test cylinders during the initial curing period. Compressive strength samples were cast in triplicate in 2-in. cube molds per ASTM C 109. A number of smaller vials were filled for bleed water volume, set time, gel time, wet unit weight, and porosity measurements. One additional 3 x 6 inch cylinder was filled and sealed for use in K_d measurements (Kaplan, 2008).

3.1.2 ARP/MCU Saltstone Sample Preparation

Three large batches of ARP/MCU Saltstone were batched (~ 5 kg each) to provide a sufficient amount of grout for all of the testing. Seven test cylinders (2.8 x 6 inch) were filled for hydraulic testing. The mold samples were capped, sealed, and allowed to cure in the laboratory at ambient temperature for a minimum of 28 or 90 days prior to testing. Bleed liquid leaked from the hydraulic test cylinders during the initial curing period. Compressive strength samples were cast in triplicate in 2-in. cube molds per ASTM C 109. A number of smaller vials were filled for bleed water volume, set time, gel time, wet unit weight, and porosity measurements. One additional 3 x 6 inch cylinder was filled and sealed for use in K_d measurements (Kaplan, 2008).

3.1.3 SWPF Saltstone Sample Preparation

Three large batches of SWPF Saltstone were batched (~ 5 kg each) to provide a sufficient amount of grout for all of the testing. Seven test cylinders (2.8 x 6 inch) were filled for hydraulic testing. The mold samples were capped, sealed, and allowed to cure in the laboratory at ambient

temperature for a minimum of 28 or 90 days prior to testing. Bleed liquid leaked from the hydraulic test cylinders during the initial curing period. Compressive strength samples were cast in triplicate in 2-in. cube molds per ASTM C 109. A number of smaller vials were filled for bleed water volume, set time, gel time, wet unit weight, and porosity measurements. One additional 3 x 6 inch cylinder was filled and sealed for use in K_d measurements (Kaplan, 2008).

3.1.4 Saltstone Permeant Preparation

Permeants for each of the three saltstone batches were prepared as required for use by the offsite testing laboratory. Additionally, the permeants were used to saturate the samples prior to testing. Geochemical modeling was conducted on each simulant to assess the potential for chemical reactions between the simulants and grout that could impact the hydraulic and physical property testing (Appendix A). The results of the modeling were used to develop permeants essentially equivalent to the simulants except for the exclusion of the minor phosphate and aluminate constituents. Aluminate and phosphate ions are reactive constituents in the hydration reactions and the intent was to preclude additional reactions which would not be representative of the disposal process at the SDF. Sodium hydroxide was adjusted for each permeant in order to maintain similar ionic strength and pH. The recipes for the permeants are given in Table 2 through Table 4.

3.2 CONCRETE SAMPLE PREPARATION

Sample preparation and strength testing of the Vault 1/4 and Vault 2 concretes were performed by The Washington Group at the SRS Civil Engineering Test Laboratory, Bldg. 717 – 5N. The mix design for the Vault 1/4 concrete is presented in Table 6. The Vault 2 mix designs are presented in Table 8 and Table 9. The Vault 2 concretes differ only in the amount of cementitious material with Mix 1 containing 670 lbs/yd^3 and Mix 2 containing 710 lbs/yd^3.

3.2.1 Vault 1/4 Concrete Preparation

Samples of the Vault 1/4 concrete were prepared according to ASTM C 192 and cured in a constant temperature (73°F) curing room at 100 % relative humidity. The ingredients and suppliers for this mix are given in Table 7. A three cubic foot concrete lab mixer was used to prepare the concrete. Prior to weighing the concrete sand, three cubic feet of the material was mixed in a wheelbarrow and its moisture content was determined. The moisture content of the coarse aggregate was also determined. These values were used to correct the batch mix water. The concrete was mixed in 2 batches of approximately 1.25 cubic feet each. The two batches were then combined in a wheelbarrow and shovel mixed for uniformity.

The laboratory mix of the Vault 1/4 concrete was prepared by placing approximately half the sand and stone and a portion of the batch water into the mixer. The mixer was then activated and the other half of the sand and stone, air entraining admixture (Microair) and water reducing agent (322 N, see footnote to Table 7) were added and mixed for five minutes. This was followed by the addition of the blast furnace slag and Portland cement. Batch water was added as needed. These ingredients were mixed for an additional five minutes then allowed to rest for five minutes. A slump test was performed and this sample was returned to the mixer. The remaining

batch water was added and the batch was mixed for an additional three minutes. The mix was allowed to rest for three minutes. The slump was re-checked, the unit weight determined, entrained air checked, and mix temperature was obtained. Samples were then cast for compressive strength testing, and hydraulic and physical property testing. Samples were tested for compressive strength at 14, 28, 56, and 90 days.

Six by twelve inch cylinders, four by eight inch cylinders, and three by six inch cylinders were cast from this mix. These cylinders were cast per ASTM C 31. The larger samples were prepared for permeability measurements (ASTM D 5084). The four by eight inch samples were prepared for compressive strength testing (ASTM C 39) and the three by six inch samples were prepared for water retention measurements (ASTM D 2325, 3152).

3.2.2 Vault 2 Concrete Preparation

Samples of the Vault 2 Mix 1 and Mix 2 concretes were prepared according to ASTM C 192 and cured in a constant temperature (73°F) curing room at 100 % relative humidity. The ingredients for each of the Vault 2 mixes were the same with the only difference being the amount of cementitious materials in each mix. The ingredients and suppliers for these mixes are given in Table 10. The method of preparation for each mix was the same and is as follows. A three cubic foot concrete lab mixer was used to prepare the Vault 2 concretes. Prior to weighing the concrete sand, three cubic feet of the material was mixed in a wheelbarrow and its moisture content was determined. The moisture content of the coarse aggregate was also determined. These values were used to correct the batch mix water. The concrete was mixed in 2 batches of approximately 1.25 cubic feet each. The two batches were then combined in a wheelbarrow and shovel mixed for uniformity.

The laboratory mix of each Vault 2 concrete was prepared by placing approximately half the sand and stone and a portion of the batch water into the mixer. The mixer was then activated and the other half of the sand and stone, air entraining admixture (Grace Darex II), and water reducing agent (Grace WRDA 35) were added and mixed for five minutes. This was followed by the addition of the blast furnace slag, fly ash, silica fume, and Portland cement. Batch water was added as needed to increase the slump within the required range (1 to 3 inches prior to adding super plasticizer). These ingredients were mixed for five minutes then allowed to rest for five minutes. A super plasticizer (Grace ADVA 380) was then added as needed to reach the final design slump for the mix (6 to 8 inches). With each addition of super plasticizer, the ingredients were mixed for five minutes then allowed to rest for five minutes prior to checking slump. After each slump test, the sample was returned to the mixer and the batch was mixed for three minutes. Once the slump was within the required range, the batch was allowed to rest for three minutes. The slump was re-checked, the wet unit weight determined, entrained air checked, and mix temperature was obtained. Samples were then cast for compressive strength testing, and hydraulic and physical property testing. Samples were tested for compressive strength at 14, 28, 56, and 90 days.

Six by twelve inch cylinders, four by eight inch cylinders, and three by six inch cylinders were cast from each mix. These cylinders were cast per ASTM C 31. The larger samples were prepared for permeability measurements (ASTM D 5084). The four by eight inch samples were

prepared for compressive strength testing (ASTM C 39) and the three by six inch samples were prepared for water retention measurements (ASTM D 2325, 3152).

3.3 HYDRAULIC AND GEOTECHNICAL TESTING

The saltstone and vault concrete samples were submitted for testing per standard ASTM methods (or equivalent) to Mactec Engineering and Consulting, Inc. (MCT), Atlanta, GA. Samples of the saltstone formulations were tested following 28 and 90 day minimum curing periods. All concrete samples were cured for a minimum of 28 days. Sample preparation and shipment to MCT was staggered so that each material was tested as closely as possible to the 28 or 90 day curing period.

3.3.1 Saltstone Grout Hydraulic and Physical Property Testing

Due to the high water to premix ratio (0.60) and low degree of hydration of each of the three types of saltstone grout, it was assumed that the samples were at or nearly saturated when received by the laboratory. This assumption is consistent with previous testing of various types of saltstone (Harbour et al., 2007a and Dixon and Phifer, 2007). Nonetheless, each saltstone grout sample was immersed in a permeant similar in composition to the simulant used to batch the grout (Section 3.1.4) to ensure that the samples were saturated. Laboratory measurements showed no significant weight gain during the saturation process, which suggests that the samples were saturated when received for testing.

For each of the three types of saltstone grout tested, the properties of the excess pore fluid remaining in the cured samples following hydration are not well documented. During hydration, a certain percentage of the water is consumed in producing the calcium silicate hydrate. Approximately 8 percent of the water used in the batching process is consumed during hydration in saltstone mixes. However, the salt is not consumed and therefore, the pore solution is concentrated as a result of this loss of water to the calcium silicate hydrate. This hydration and concentration process changes the ratio of water to simulant which is used to translate the mass of evaporable water to a mass of simulant. The density of the pore solution also increases as a result of this process. The resultant density in the pore space was determined from a graph of weight percent solids as function of simulant density for each of the three saltstone formulations (Figure 1). For each of the three saltstone formulations, the estimated properties of the concentrated pore fluid are given in Table 5.

The saturated hydraulic conductivity of each saltstone grout formulation was determined using method ASTM D 5084 (Method F, Constant Volume-Falling Head) using a flexible wall permeameter (mercury head). The laboratory tested cylinders approximately 2.8 inch diameter by 2.5 inch long cut from the original mold samples for each saltstone formulation. Each sample was tested with a permeant similar in composition to the simulant used to batch the samples (Section 3.1.4). Saturated hydraulic conductivity is a function of the porous medium and the properties of both the pore fluid and test fluid. Typically, the pore fluid and the permeating test fluid are the same; however, for the saltstone grouts, the pore fluid (concentrated simulant) and the permeating test fluid were slightly different. Since the samples were back pressure saturated with permeant, the resulting pore fluid is a combination of the concentrated simulant (as

described earlier) and the permeant used to test the sample. The differences between the simulants used to batch each type of saltstone, the resulting concentrated simulant contained within the pore spaces of the samples following curing, and the permeants used to test the samples are not believed to be significant (Table 5). Since the pore volume of each saltstone sample is large (about 150 cm^3) compared to the volume of permeant introduced to the sample during saturation and testing (< 1.0 cm^3), it is assumed that saturated hydraulic conductivity is relative to the concentrated simulant contained within the pore space following curing. Hence, the saturated hydraulic conductivity of each saltstone sample was converted to permeability using the following equation based on the properties of the concentrated simulant:

$$k = \frac{K \mu}{\rho g}$$

k = intrinsic permeability (darcy)
K = saturated hydraulic conductivity relative to concentrated simulant (cm/sec)
μ = dynamic viscosity of concentrated simulant (Table 5)
ρ = density of concentrated simulant (Table 5)
g = gravity (981 cm/sec^2)

The moisture retention characteristics, dry bulk density, and porosity of each of the three saltstone formulations were measured by the laboratory. Although assumed to be at or near saturation as received by the laboratory, each sample was immersed in the appropriate permeant to ensure saturation. The determination of each of the three aforementioned properties requires the removal of the evaporable water (at 105 ^oC) from each sample. As a result, each measurement was adjusted for the salt content of the pore fluid (which was precipitated during drying). Thus, the raw laboratory measurements presented in (Appendix C) differ from the final results presented in the tables of this report.

The moisture retention characteristics were measured using method ASTM D 2325 by pressure plate apparatus. This method provided the moisture retention properties of each grout sample to 15 bars. The laboratory tested 0.5 inch thick wafers cut from the original mold samples of each saltstone grout. Measurements were made at the following pressures: 0.1, 0.5, 1.0, 5.0, and 15.0 bars. For moisture retention analysis, the saturated samples were weighed to determine an initial weight. These samples were then subjected to increasing pressures in a pressure plate apparatus. Between each increase in pressure, the samples were weighed. Following the final pressure increase, the samples were weighed and then oven dried. The results from these measurements were subsequently adjusted for salt precipitation as illustrated in Appendix E. Porosity (initial moisture content) and dry bulk density were estimated for each water retention sample. These results were also adjusted for salt precipitation.

The laboratory determined dry bulk density and porosity of the three saltstone formulations using the samples from the saturated hydraulic conductivity testing. Dry bulk density was calculated by subtracting the evaporable water (from heating to 105 ^oC) and the known amount of salt present in the grout from the mass of the saturated saltstone. This mass was then divided by the measured volume of the saturated saltstone (obtained by measurement of the saturated saltstone) to obtain the dry bulk density. Example calculations are presented in Appendix E.

Porosity (η) of the saltstone grout samples was determined by subtracting the final dry weight of the sample from the saturated weight to yield the mass of evaporable water (from heating to 105 ^{o}C) in the sample. The amount of salt present in each grout was measured when batched and this mass (adjusted for sample weight) was added to the evaporable water mass to yield the simulant mass. The volume of simulant in the sample was then determined by dividing the simulant mass by the density of the concentrated salt simulant (Table 5). The volume of simulant contained within the sample was divided by the measured sample volume to obtain porosity. Example calculations are presented in Appendix E.

Particle density for each sample was calculated based on dry bulk density and porosity [$\rho_s = \rho_b/(1-\eta)$].

3.3.2 Vault Concrete Hydraulic and Physical Property Testing

Three samples each of the Vault 1/4, Vault 2 Mix 1, and Vault 2 Mix 2 concretes were tested for saturated hydraulic conductivity, water retention characteristics, porosity, and bulk density. Standard 6 x 12 inch cylinders of each material were submitted for use in the saturated hydraulic conductivity, dry bulk density, and porosity testing. Standard 3 x 6 inch cylinders were submitted for use in the water retention testing. Smaller diameter samples were necessary for the water retention testing due to the size of the testing equipment.

Saturated hydraulic conductivity was determined using method ASTM D 5084 (Method F, Constant Volume- Falling Head) using a flexible wall permeameter (mercury head). The laboratory tested 6 inch diameter by 5 inch long cylinders cut from the original 6 x 12 inch mold samples. These samples were tested with tap water. The saturated hydraulic conductivity of each concrete sample was converted to permeability using the following equation based on the properties of tap water:

$$k = \frac{K \mu}{\rho g}$$

k = intrinsic permeability
K = saturated hydraulic conductivity relative to tap water
μ = dynamic viscosity of concentrated simulant (1.002E-03 g/cm-sec)
ρ = density of concentrated simulant (1.00 g/cm^3)
g = gravity (981 cm/sec^2)

The water retention characteristics of each concrete sample were determined using method ASTM D 2325 by pressure plate apparatus. This method provided the water retention properties of each concrete sample to 15 bars. Measurements were made at the following pressures: 0.1, 0.5, 1.0, 5.0, and 15.0 bars. The laboratory tested wafers 0.5 inches thick which were cut from the 3 x 6 inch cylinders.

Porosity was estimated using the samples from the saturated hydraulic conductivity testing and the water retention testing following ASTM C 642. The samples were oven-dried (105 ^{o}C) to determine the final dry weight at the conclusion of testing. The final dry weight was subtracted

from the saturated weight to yield the mass of water contained within each sample. Then, using the density of water, the porosity of the each sample was determined by dividing the volume of water contained within the sample by the total volume of the sample ($\phi = ((M_{sat} - M_{dry})/\rho_w) / Vol$). The dry bulk density of the concrete samples were determined by dividing the dry weight of the sample by the measured volume. Dry bulk density was estimated using both the samples from the saturated hydraulic conductivity testing and from the water retention testing. Particle density for each sample was calculated based on dry bulk density and porosity [$\rho_s = \rho_b/(1-\eta)$].

3.4 DETERMINATION OF VAN GENUCHTEN TRANSPORT PARAMETERS

Direct measurement of the unsaturated hydraulic conductivity of large numbers of samples of cementitious materials is time consuming and cost prohibitive. An alternative to direct measurement is the use of theoretical methods to predict the unsaturated hydraulic conductivity based upon measured moisture retention data. These methods are generally based on pore-size distribution models, and have been shown to perform reasonably well for coarse textured soils and other porous media having relatively narrow pore-size distributions (USDA, 1998). Savage and Janssen (1997) compared measured drainage from concrete samples with predictive models produced from characteristic curves developed from van Genuchten curve fitting (i.e., RETC). They concluded that the van Genuchten method of predicting unsaturated hydraulic conductivity from moisture retention data was applicable to Portland cement concrete. This indicates that predictive models based on moisture retention data provide the most viable means of characterizing the hydraulic properties of large numbers of samples of cementitious materials. Therefore, this method was chosen to predict the unsaturated hydraulic conductivity of the saltstone grouts and the vault concrete samples based upon the measured moisture retention properties.

RETC (RETention Curve) (USDA, 1998), a U.S. Salinity Laboratory computer program designed for analyzing the hydraulic properties of unsaturated soils, was used to fit the measured moisture retention data for the saltstone and vault concrete samples. The program's curve fitting is based on van Genuchten's equation for soil moisture content as a function of pressure

$$\theta(h) = \theta_r + \frac{\theta_s - \theta_r}{\left[1 + (\alpha h)^n\right]^m} \qquad h \le 0$$

$$\theta(h) = \theta_s \qquad h > 0$$

where $\theta(h)$ is moisture content at the pressure head h, θ_r is residual moisture content, θ_s is the saturated moisture content, h is pressure head, α is a constant related to the inverse of the air-entry pressure, and n is a measure of the pore-size distribution. The constraint $m = 1 - 1/n$ was used as suggested by van Genuchten (van Genuchten, 1980; van Genuchten et al., 1991).

The generated moisture retention curves were based on moisture retention data only; no unsaturated hydraulic conductivity data were available for the samples. RETC's (USDA, 1998)

van Genuchten $m = 1 - 1/n$ retention curve model was used to estimate curve fitting parameters ($\theta_r, \theta_s, \alpha, n$) for each sample.

The curve fitting parameters ($\theta_r, \theta_s, \alpha, n$) from RETC (USDA, 1998) were used to calculate the effective saturation (or reduced water content), S_e, at incremental pressure heads according to

$$S_e = \frac{S - S_r}{1 - S_r} = \frac{1}{\left[1 + (\alpha h)^n\right]^m}$$

where S_r denotes residual saturation. Using S_e, the relative hydraulic conductivity was calculated at incremental pressure heads using the Mualem-van Genuchten type function

$K = S_e^L \left[1 - \left(1 - S_e^{1/m}\right)^m\right]^2$, where L is an empirical pore-connectivity parameter and assumed to be 0.5.

Saturation (S) was calculated at various pressure heads according to

$$S = S_r + \left(\frac{1 - S_r}{\left[1 + (\alpha h)^n\right]^m}\right)$$

where residual saturation, S_r, is equal to θ_r / θ_s (the residual moisture content divided by the saturated moisture content).

4.0 RESULTS

Samples of three saltstone grout formulations and two vault concrete formulations were tested to estimate hydraulic conductivity, moisture retention characteristics, porosity, and bulk density using standard ASTM methods (or equivalent). The saltstone formulations include: 1) DDA (w/pm 0.60), 2) ARP/MCU (w/pm 0.60), and 3) SWPF (w/pm 0.60). The vault concretes tested include the Vault 1/4 concrete and two variations of the Vault 2 concrete (Mix 1 and Mix 2). For saturated hydraulic conductivity, each saltstone grout sample was tested using a permeant similar in composition to the simulant used to batch the grout. The vault concrete samples were tested with tap water.

4.1 FRESH PROPERTIES OF THE SALTSTONE MIXES

The fresh properties of the three saltstone mixes were measured as part of this task and the results are summarized in Table 11. The results are in good agreement with previous measurements of these properties for the three mixes. The presence of bleed water in all of these samples reduces the actual water to premix (w/pm) ratio for these mixes from the as-batched 0.60 w/pm to 0.55 for the DDA mix and 0.58 for both the SWPF and MCU mixes. The DDA mixes have a 2 day set time compared to the 1 day set time for MCU and SWPF mixes.

4.2 HEAT OF HYDRATION OF THE SALTSTONE MIXES

The hydration reactions of the cement, slag, and fly ash generate heat (exothermic) in the process of producing the calcium silicate hydrates. The time dependence of the heat release was measured for the three saltstone mixes and these curves correspond to the development of the cured state of the grouts. Figure 2 reveals that hydration occurs over many days and that the SWPF mixes generate the most heat per gram of premix while the DDA and MCU mixes produce roughly the same amount of heat per gram of premix.

4.3 COMPRESSIVE STRENGTH TESTING

Mold samples of each material type were tested for compressive strength at 14, 28, 56, and 90 days by The Washington Group at the SRS Civil Engineering Test Laboratory, Bldg. 717 – 5N. The results of this testing are presented in Table 12 through Table 17. The detailed compressive strength test reports are presented in Appendix B. Compressive strength testing is of interest because an increase in strength over time for a specific material maybe associated with a decrease in hydraulic conductivity. Thus, a substantial increase in compressive strength for a specific material may be used as an indicator that additional hydraulic testing should be conducted to determine if the saturated hydraulic conductivity of the material has decreased.

Figure 3 shows the compressive strength results for the three saltstone materials. An increase in strength is observed for each material type with the SWPF saltstone exhibiting the greatest gain. The average compressive strength of the DDA saltstone at 28 and 90 days was 917 and 1023 psig, respectively. This represents approximately a 12 percent increase in compressive strength over the curing period. The average compressive strength of the ARP/MCU saltstone at 28 and 90 days was 1010 and 1213 psig, respectively. This represents approximately a 20 percent increase in compressive strength over the curing period. The average compressive strength of the SWPF saltstone at 28 and 90 days was 1213 and 1467 psig, respectively. This represents

approximately a 21 percent increase in compressive strength over the curing period. Based on the development of compressive strength between 28 and 90 days for each of the saltstone formulations, it was decided to test the 90 day samples of each material for hydraulic properties.

Figure 4 shows the compressive strength results for the Vault 1/4 and the Vault 2 concrete formulations. An increase in strength is noted for each material between 28 and 90 days. The average compressive strength of the Vault 1/4 concrete at 28 and 90 days was 8725 and 9430 psig, respectively. This represents approximately an 8 percent increase in compressive strength over the curing period. The average compressive strength of the Vault 2 Mix 1 concrete at 28 and 90 days was 7430 and 9285 psig, respectively. This represents approximately a 25 percent increase in compressive strength over the curing period. The strength of the mix easily exceeded the design strength of 5000 psig at 28 days and developed an additional 1855 psig of compressive strength between 28 and 90 days. The average compressive strength of the Vault 2 Mix 2 concrete at 28 and 90 days was 8255 and 10155 psig, respectively. This represents approximately an 19 percent increase in compressive strength over the curing period.

4.4 SALTSTONE AND VAULT CONCRETE HYDRAULIC AND PHYSICAL PROPERTIES

MCT estimated the hydraulic and physical properties of the saltstone and vault concrete samples using ASTM methods (or equivalent) following a minimum 28 or 90 day curing period. The supporting detailed test reports produced by MCT for the saltstone samples are provided in Appendix C, and the reports detailing the vault concrete results are included in Appendix D.

4.4.1 DDA Saltstone Hydraulic and Physical Properties

Six, 2.8 inch diameter samples of DDA saltstone were tested by MCT to estimate the saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity. Three samples each were tested following a minimum 28 and 90 day curing period. The saturated hydraulic conductivity of the 28 day DDA saltstone ranged from 5.9×10^{-10} to 1.4×10^{-8} cm/sec, with a logarithmic average of 2.5×10^{-9} cm/sec (Table 18). The saturated hydraulic conductivity of the 90 day DDA saltstone ranged from 7.2×10^{-11} to 1.1×10^{-10} cm/sec, with a logarithmic average of 9.6×10^{-11} cm/sec (Table 18). The saturated hydraulic conductivity results are assumed to be relative to the concentrated DDA simulant contained with the pore space of the samples. Hence, the saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of the concentrated DDA simulant as described in Section 3.3.1. The intrinsic permeability of the 28 day DDA saltstone ranged from 7.1×10^{-7} to 1.7×10^{-5} darcy, with a logarithmic average of 3.1×10^{-6} darcy (Table 18). The intrinsic permeability of the 90 day DDA saltstone ranged from 8.7×10^{-8} to 1.3×10^{-7} darcy, with an logarithmic average of 1.1×10^{-7} darcy (Table 18). These results are summarized in Table 30.

The moisture retention properties of the DDA saltstone were also determined by MCT and are presented in Table 32. These results are adjusted for salt precipitation as described in Section 3.3.1. As stated earlier, the samples were considered to be saturated with the DDA simulant used to batch the saltstone samples. MCT tested each DDA saltstone sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_2O (15 bars), Table 32. MCT tested wafers approximately 2.8 inches in diameter and ½ inch thick from each sample using a pressure plate

apparatus. Moisture retention curves were prepared for both the 28 day and 90 day wafers taken from each sample as shown in Figure 5 and Figure 6, respectively.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 19 and Table 32). After adjusting for salt precipitation, the dry bulk density of the 28 day DDA saltstone ranged from 1.04 to 1.07 g/cm^3 with an arithmetic average of 1.05 g/cm^3. The dry bulk density of the 90 day DDA saltstone ranged from 1.04 to 1.08 g/cm^3 with an arithmetic average of 1.06 g/cm^3. The porosity of the 28 day DDA saltstone ranged from 0.54 to 0.56 with an arithmetic average of 0.56. The porosity of the 90 day DDA saltstone ranged from 0.55 to 0.57 with an arithmetic average of 0.55. The high total porosity and low bulk density observed for the DDA saltstone samples may be attributed to the high water to cementitious material ratio (w/pm = 0.6) and low degree of cementitious material reaction. The particle density of the DDA saltstone was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day DDA saltstone ranged from 2.32 to 2.43 g/cm^3 with an arithmetic average of 2.37 g/cm^3. The particle density of the 90 day DDA saltstone ranged from 2.33 to 2.48 g/cm^3 with an arithmetic average of 2.37 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.4.2 ARP/MCU Saltstone Hydraulic and Physical Properties

Six, 2.8 inch diameter samples of ARP/MCU saltstone were tested by MCT to estimate the saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity. Three samples each were tested following a minimum 28 and 90 day curing period. The saturated hydraulic conductivity of the 28 day ARP/MCU saltstone ranged from 2.7 x 10^{-10} to 5.4 x 10^{-9} cm/sec, with a logarithmic average of 2.6 x 10^{-9} cm/sec (Table 20). The saturated hydraulic conductivity of the 90 day ARP/MCU saltstone ranged from 6.4 x 10^{-10} to 1.1 x 10^{-9} cm/sec, with a logarithmic average of 8.5 x 10^{-10} cm/sec (Table 20). The saturated hydraulic conductivity results are assumed to be relative to the concentrated ARP/MCU simulant contained with the pore space of the samples. Hence, the saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of the concentrated ARP/MCU simulant as described in Section 3.3.1. The intrinsic permeability of the 28 day ARP/MCU saltstone ranged from 4.9 x 10^{-7} to 9.8 x 10^{-6} darcy, with a logarithmic average of 2.6 x 10^{-6} darcy (Table 20). The intrinsic permeability of the 90 day ARP/MCU saltstone ranged from 1.2 x 10^{-6} to 2.0 x 10^{-6} darcy, with a logarithmic average of 1.6 x 10^{-6} darcy (Table 20). These results are summarized in Table 30.

The moisture retention properties of the ARP/MCU saltstone were also determined by MCT and are presented in Table 33. These results are adjusted for salt precipitation as described in Section 3.3.1. As stated earlier, the samples were considered to be saturated with the ARP/MCU simulant used to batch the saltstone samples. MCT tested each ARP/MCU saltstone sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 33. MCT tested wafers approximately 2.8 inches in diameter and ½ inch thick from each sample using a pressure plate apparatus. Moisture retention curves were prepared for both the 28 day and 90 day wafers taken from each sample as shown in Figure 7 and Figure 8, respectively.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 21 and Table 33). After adjusting for salt precipitation, the dry bulk density of the 28 day ARP/MCU saltstone ranged from 0.98 to 0.99 g/cm^3 with an arithmetic average of 0.98 g/cm^3. The dry bulk density of the 90 day ARP/MCU saltstone ranged from 0.95 to 1.01 g/cm^3 with an arithmetic average of 0.97 g/cm^3. The porosity of the 28 day ARP/MCU saltstone ranged from 0.58 to 0.59 with an arithmetic average of 0.58. The porosity of the 90 day ARP/MCU saltstone ranged from 0.58 to 0.61 with an arithmetic average of 0.59. The high total porosity and low bulk density observed for the ARP/MCU saltstone samples may be attributed to the high water to cementitious material ratio (w/pm = 0.6) and low degree of cementitious material reaction. The particle density of the ARP/MCU saltstone was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day ARP/MCU saltstone ranged from 2.30 to 2.41 g/cm^3 with an arithmetic average of 2.35 g/cm^3. The particle density of the 90 day ARP/MCU saltstone ranged from 2.30 to 2.49 g/cm^3 with an arithmetic average of 2.38 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.4.3 SWPF Saltstone Hydraulic and Physical Properties

Six, 2.8 inch diameter samples of SWPF saltstone were tested by MCT to estimate the saturated hydraulic conductivity, water retention characteristics, dry bulk density, and porosity. Three samples each were tested following a minimum 28 and 90 day curing period. The saturated hydraulic conductivity of the 28 day SWPF saltstone ranged from 2.0 x 10^{-9} to 3.4 x 10^{-8} cm/sec, with a logarithmic average of 9.3 x 10^{-9} cm/sec (Table 22). The saturated hydraulic conductivity of the 90 day SWPF saltstone ranged from 1.2 x 10^{-9} to 8.8 x 10^{-8} cm/sec, with a logarithmic average of 6.0 x 10^{-9} cm/sec (Table 22). Of the three samples of 90 day SWPF saltstone tested for saturated hydraulic conductivity, two were slightly more than 10^{-9} cm/sec and the third was almost 10^{-7} cm/sec. The saturated hydraulic conductivity of the most permeable sample was almost two orders of magnitude greater than the other two samples whereas the difference between the minimum and maximum saturated hydraulic conductivity values for the 90 day DDA and ARP/MCU samples was less than a factor of two. Additionally, MCT reported that a prolonged power failure complicated testing of the most permeable 90 day SWPF sample. Thus, this sample may be an outlier. If this sample is excluded from the data set, the logarithmically averaged saturated hydraulic conductivity of the 90 day SWPF is 1.5 x 10^{-9} cm/sec.

The saturated hydraulic conductivity results are assumed to be relative to the concentrated SWPF simulant contained with the pore space of the samples. Hence, the saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of the concentrated SWPF simulant as described in Section 3.3.1. The intrinsic permeability of the 28 day SWPF saltstone ranged from 4.0 x 10^{-6} to 6.8 x 10^{-5} darcy, with a logarithmic average of 1.9 x 10^{-5} darcy (Table 22). The intrinsic permeability of the 90 day SWPF saltstone ranged from 2.4 x 10^{-6} to 1.8 x 10^{-4} darcy, with a logarithmic average of 1.2 x 10^{-5} darcy (Table 22). If the potential outlier is excluded, the logarithmically averaged intrinsic permeability of the 90 day SWPF saltstone is 3.1 x 10^{-6} darcy. These results are summarized in Table 30.

The moisture retention properties of the SWPF saltstone were also determined by MCT and are presented in Table 34. These results are adjusted for salt precipitation as described in Section

3.3.1. As stated earlier, the samples were considered to be saturated with the SWPF simulant used to batch the saltstone samples. MCT tested each SWPF saltstone sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars), Table 34. MCT tested wafers approximately 2.8 inches in diameter and ½ inch thick from each sample using a pressure plate apparatus. Moisture retention curves were prepared for both the 28 day and 90 day wafers taken from each sample as shown in Figure 9 and Figure 10, respectively.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 23 and Table 34). After adjusting for salt precipitation, the dry bulk density of the 28 day SWPF saltstone ranged from 1.00 to 1.05 g/cm^3 with an arithmetic average of 1.03 g/cm^3. The dry bulk density of the 90 day SWPF saltstone ranged from 1.00 to 1.03 g/cm^3 with an arithmetic average of 1.01 g/cm^3. The porosity of the 28 day SWPF saltstone ranged from 0.56 to 0.60 with an arithmetic average of 0.58. The porosity of the 90 day SWPF saltstone ranged from 0.57 to 0.59 with an arithmetic average of 0.59. The high total porosity and low bulk density observed for the SWPF saltstone samples may be attributed to the high water to cementitious material ratio (w/pm = 0.6) and low degree of cementitious material reaction. The particle density of the SWPF saltstone was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day SWPF saltstone ranged from 2.39 to 2.53 g/cm^3 with an arithmetic average of 2.44 g/cm^3. The particle density of the 90 day SWPF saltstone ranged from 2.35 to 2.53 g/cm^3 with an arithmetic average of 2.42 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.4.4 Vault 1/4 Concrete Hydraulic and Physical Properties

Three, 6 inch diameter samples of the Vault 1/4 concrete were tested by MCT to estimate the saturated hydraulic conductivity, dry bulk density, and porosity following a minimum 28 day curing period. The saturated hydraulic conductivity of the 28 day Vault 1/4 concrete ranged from 1.1 x 10^{-10} to 2.1 x 10^{-9} cm/sec, with a logarithmic average of 3.1 x 10^{-10} cm/sec (Table 24). The saturated hydraulic conductivity results are relative to tap water. The saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of tap water as described in Section 3.3.2. The intrinsic permeability of the 28 day Vault 1/4 concrete ranged from 1.1 x 10^{-8} to 2.2 x 10^{-7} darcy, with a logarithmic average of 3.2 x 10^{-8} darcy (Table 24). These results are summarized in Table 30.

The moisture retention properties of the Vault 1/4 concrete were determined by MCT using three inch diameter samples and are presented in Table 35. MCT tested each Vault 1/4 concrete sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars). MCT tested wafers approximately 3 inches in diameter and ½ inch thick from each sample using a pressure plate apparatus. Moisture retention curves were prepared for the wafers taken from each sample, Figure 11.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 25 and Table 35). The dry bulk density of the 28 day Vault 1/4 concrete ranged from 2.15 to 2.31 g/cm^3 with an arithmetic average of 2.24 g/cm^3. The porosity of the 28 day Vault 1/4 concrete ranged from

0.10 to 0.12 with an arithmetic average of 0.11. The particle density of the Vault 1/4 concrete was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day Vault 1/4 concrete ranged from 2.44 to 2.58 g/cm^3 with an arithmetic average of 2.53 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.4.5 Vault 2 Mix 1 Concrete Hydraulic and Physical Properties

Three, 6 inch diameter samples of the Vault 2 Mix 1 concrete were tested by MCT to estimate the saturated hydraulic conductivity, dry bulk density, and porosity following a minimum 28 day curing period. The saturated hydraulic conductivity of the 28 day Vault 2 Mix 1 concrete ranged from 6.0 x 10^{-11} to 2.8 x 10^{-10} cm/sec, with a logarithmic average of 1.1 x 10^{-10} cm/sec (Table 26). The saturated hydraulic conductivity results are relative to tap water. The saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of tap water as described in Section 3.3.2. The intrinsic permeability of the 28 day Vault 2 Mix 1 concrete ranged from 6.2 x 10^{-9} to 2.9 x 10^{-8} darcy, with a logarithmic average of 1.1 x 10^{-8} darcy (Table 26). These results are summarized in Table 30.

The moisture retention properties of the Vault 2 Mix 1 concrete were determined by MCT using three inch diameter samples and are presented in Table 36. MCT tested each Vault 2 Mix 1 concrete sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars). MCT tested wafers approximately 3 inches in diameter and ½ inch thick from each sample using a pressure plate apparatus. Moisture retention curves were prepared for the wafers taken from each sample, Figure 12.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 27 and Table 36). The dry bulk density of the 28 day Vault 2 Mix 1 concrete ranged from 2.16 to 2.21 g/cm^3 with an arithmetic average of 2.19 g/cm^3. The porosity of the 28 day Vault 2 Mix 1 concrete ranged from 0.08 to 0.13 with an arithmetic average of 0.12. The particle density of the Vault 2 Mix 1 concrete was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day Vault 2 Mix 1 concrete ranged from 2.39 to 2.50 g/cm^3 with an arithmetic average of 2.48 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.4.6 Vault 2 Mix 2 Concrete Hydraulic and Physical Properties

Three, 6 inch diameter samples of the Vault 2 Mix 2 concrete were tested by MCT to estimate the saturated hydraulic conductivity, dry bulk density, and porosity following a minimum 28 day curing period. The saturated hydraulic conductivity of the 28 day Vault 2 Mix 2 concrete ranged from 5.0 x 10^{-11} to 3.2 x 10^{-10} cm/sec, with a logarithmic average of 9.3 x 10^{-11} cm/sec (Table 28). The saturated hydraulic conductivity results are relative to tap water. The saturated hydraulic conductivity results were converted to intrinsic permeability based on the properties of tap water as described in Section 3.3.2. The intrinsic permeability of the 28 day Vault 2 Mix 2 concrete ranged from 5.2 x 10^{-9} to 3.3 x 10^{-8} darcy, with a logarithmic average of 9.6 x 10^{-9} darcy (Table 28). These results are summarized in Table 30.

The moisture retention properties of the Vault 2 Mix 2 concrete were determined by MCT using three inch diameter samples and are presented in Table 37. MCT tested each Vault 2 Mix 2 concrete sample at pressures ranging from 102 cm H_2O (0.1 bars) to 15,296 cm H_20 (15 bars). MCT tested wafers approximately 3 inches in diameter and ½ inch thick from each sample using a pressure plate apparatus. Moisture retention curves were prepared for the wafers taken from each sample, Figure 13.

Dry bulk density and porosity were measured on the samples used in the saturated hydraulic conductivity testing and on the samples used in the water retention testing (Table 29 and Table 36). The dry bulk density of the 28 day Vault 2 Mix 2 concrete ranged from 2.16 to 2.26 g/cm^3 with an arithmetic average of 2.22 g/cm^3. The porosity of the 28 day Vault 2 Mix 2 concrete ranged from 0.09 to 0.14 with an arithmetic average of 0.11. The particle density of the Vault 2 Mix 2 concrete was calculated based on the results from the dry bulk density and porosity measurements. The particle density of the 28 day Vault 2 Mix 2 concrete ranged from 2.43 to 2.55 g/cm^3 with an arithmetic average of 2.50 g/cm^3. The dry bulk density, porosity, and particle density results are summarized in Table 31.

4.5 ANALYSIS OF MOISTURE RETENTION CHARACTERISTICS

The measured moisture retention data for the three saltstone formulations, the Vault 1/4 concrete, and the two Vault 2 concretes (Mix 1 and Mix 2) as determined by MCT were analyzed to determine the van Genuchten transport parameters and the relative hydraulic conductivity function. For the saltstone materials, the 90 day moisture retention data was used for the analysis. Measured moisture retention data was available for three samples of each material. These data were averaged to produce a single data set for each of the three types of saltstone tested. Initially, the moisture retention data were analyzed using the RETC model (USDA, 1998). However, it was not possible to obtain a good fit of the data using RETC. Thus, a visual curve matching procedure was employed in a spreadsheet where the curve fitting parameters of the van Genuchten model (α and n) were manipulated to obtain an acceptable fit of the moisture retention data. The residual and saturated moisture content (θ_r and θ_s) used to fit each set of data was loosely constrained by the measured minimum and maximum porosities for each material. It was found that an acceptable fit could be obtained by fixing α for each material to a value of 0.15. The curve fitting parameter, α, represents the inverse of the air entry pressure and given the similarity of the three saltstone materials would not be expected to vary significantly. For each saltstone material, the standard Mualem relationship between n and m (i.e., $m = 1 - 1/n$) was used. The resulting characteristic curves are presented in Figure 14 through Figure 16 and the transport parameters are given in Table 38. The results for all three types of saltstone are similar to those reported by Dixon and Phifer (2007).

Previously, Idaho National Laboratory (INL) tested samples of MCU saltstone for moisture retention characteristics (Dixon and Phifer, 2007). INL measured the moisture retention characteristics of the saltstone samples by testing sub-cores of the saltstone over a range of pressures from 0 to approximately 56,086 cm of H_2O (~55 bars). This is a significantly wider range than Mactec tested the current saltstone samples. A combination of methods was used to establish the moisture retention curve including hanging column analysis (for the wet end of the

curve), pressure plate apparatus (for the middle portion of the curve), and chilled mirror analysis (for the dry end of the curve). The INL moisture retention data were analyzed to determine the van Genuchten transport parameters and the relative hydraulic conductivity function. The results from this analysis are presented in Table 38 (adjusted for salt precipitation) and Figure 17. Results from this analysis provide a comparison for the current analysis.

The RETC model was used to fit the moisture retention data for each concrete material. All parameters in the RETC model were fitted including the saturated moisture content (θ_s). All moisture retention values were given a weight of 1. The standard Mualem relationship between n and m (i.e., $m = 1 - 1/n$) was used. The characteristic curves for each material are presented in Figure 18 through Figure 20 and the transport parameters are given in Table 38. As with the saltstone samples, it is important to note the limited range over which moisture retention data was obtained. Beyond the range of the moisture retention data (15 bars), the characteristic curves are extrapolated. Data beyond 15 bars suction may significantly affect the shape of the characteristic curves since these low permeability materials exhibit minimal drainage at lower pressures.

4.6 RECOMMENDED HYDRAULIC AND PHYSICAL PROPERTIES

The recommended hydraulic and physical properties for each material tested are presented in Table 39. For the concretes, the logarithmic average of the 28 day saturated hydraulic conductivity is presented as the recommended value. For the saltstone grouts, the logarithmic average of the 90 day saturated hydraulic conductivity data is presented as the recommended value. For the SWPF saltstone, the recommended saturated hydraulic conductivity value may be influenced by an outlying value. Sample SWPF-TR451-3 had a saturated hydraulic conductivity almost two orders of magnitude greater than that of the other two 90 day samples whereas the difference between the minimum and maximum saturated hydraulic conductivity values for the 90 day DDA and ARP/MCU samples was less than a factor of two. The testing laboratory reported that a prolonged power failure complicated the testing of this sample. Thus, it may be appropriate to exclude this sample from the data set for saturated hydraulic conductivity.

The recommended values for porosity and dry bulk density for each saltstone material were determined based on the arithmetic average of the 90 day data. The recommended value for particle density was calculated from the porosity and dry bulk density data [$\rho_s = \rho_b/(1-\eta)$]. Recommended transport parameters were determined from the 90 day moisture retention data and presented in Table 38. The data for the characteristic curves are given in Appendix F including that for the MCU saltstone as determined by INL and reported by Dixon and Phifer (2007).

The recommended values for porosity and dry bulk density for each concrete material were determined based on the arithmetic average of the 28 day data. The recommended value for particle density was calculated from the porosity and dry bulk density data [$\rho_s = \rho_b/(1-\eta)$]. Recommended transport parameters were determined from the 28 day moisture retention data and presented in Table 38. The data for the characteristic curves are given in Appendix F.

5.0 SUMMARY

The primary focus of this task was to determine the hydraulic and physical properties of three different saltstone formulations and two vault concretes. The saltstone formulations included saltstone premix batched with 1) Deliquification, Dissolution, and Adjustment (DDA) salt simulant (premix at w/pm 0.60), 2) Actinide Removal Process (ARP)/Modular Caustic Side Solvent Extraction Unit (MCU) salt simulant (premix at w/pm 0.60), and 3) Salt Waste Processing Facility (SWPF) salt simulant (premix at w/pm 0.60). The vault concrete formulations tested included the Vault 1/4 mix and two variations of the Vault 2 concrete (Mix 1 and Mix 2).

Mold samples of each saltstone formulation were prepared for hydraulic and physical property testing. These samples were 2.8 by 6 inch cylinders. Preparation of the samples were staggered so that each formulation could be tested as closely as possible to a 28 and 90 day cure. Wet properties measured for the saltstone formulations included yield stress, plastic viscosity, wet unit weight, bleed water volume, gel time, set time, and heat of hydration. The results of these measurements are presented in Table 11.

The saltstone samples were submitted to Mactec Engineering and Consulting, Inc. (MCT) for testing per ASTM standards (or equivalent). Each saltstone formulation was tested with a permeant similar in composition to the simulant used to batch the grout. The hydraulic conductivity of a porous medium is related to the properties of the medium and the permeating fluid (density and viscosity). Each of the saltstone formulations was batched with a salt simulant (w/pm 0.60) specific to the formulation. Due to the low degree of hydration for saltstone grouts in general, it is assumed that the saltstone samples remained saturated with simulant throughout the curing process (Harbour et al., 2007a). Additionally, some of the water in the simulant is consumed during hydration (about 8 percent) which results in a slightly concentrated solution in the pore space of the saltstone compared to the initial simulant used to batch the samples. Although each type of saltstone grout was tested with a permeant similar in composition to the simulant used to batch the grout, the saturated hydraulic conductivity measurements are assumed to be relative to the concentrated simulant that comprises the pore fluid following hydration. This is a reasonable assumption due to the low permeability of the saltstone materials and the small volume of permeant that actually penetrates each sample. The saturated hydraulic conductivity data reported by the lab for each formulation were subsequently converted to intrinsic permeability using the density and viscosity estimated for the concentrated simulants. Intrinsic permeability is independent of the test fluid and is solely a function of the porous medium.

The saturated hydraulic conductivity (relative to the concentrated DDA simulant) and intrinsic permeability data for the DDA saltstone are presented in Table 18. The dry bulk density, porosity, and particle density data for the DDA saltstone are presented in Table 19 and Table 32. The saturated hydraulic conductivity (relative to the concentrated ARP/MCU simulant) and intrinsic permeability data for the ARP/MCU saltstone are presented in Table 20. The dry bulk density, porosity, and particle density data for the ARP/MCU saltstone are presented in Table 21 and Table 33. The saturated hydraulic conductivity (relative to the concentrated SWPF simulant)

and intrinsic permeability data for the SWPF saltstone are presented in Table 22. The dry bulk density, porosity, and particle density data for the SWPF saltstone are presented in Table 23 and Table 34.

The moisture retention properties of all three saltstone formulations were measured by MCT and are presented in Table 32, Table 33, and Table 34. Although the samples were assumed to be saturated, prior to testing they were immersed in a permeant similar in composition to the simulant used to batch the samples. The MCT measurements were made using pressure plate apparatus. The data for each saltstone formulation were analyzed to determine the van Genuchten transport parameters using a visual curve matching method. These parameters may be used to implicitly determine the relationship between unsaturated hydraulic conductivity and moisture content. The results from these analyses are presented in Table 38. Also included in Table 38 are previous results for MCU saltstone as determined by INL which includes data over a broader range of pressures (Dixon and Phifer, 2007).

In addition to the saltstone samples, mold samples of the two vault concrete formulations were also prepared for testing. These formulations included the Vault 1/4 mix and two variations of the Vault 2 formulation (Mixes 1 and 2). The samples used to estimate hydraulic conductivity were 6 by 12 inch cylinders. Samples prepared for moisture retention analysis were 3 by 6 inch cylinders. These samples were submitted to MCT for testing per ASTM specifications (or equivalent). These samples were tested using tap water as the permeating fluid.

The saturated hydraulic conductivity and intrinsic permeability data for the Vault 1/4 concrete are presented in Table 24. The dry bulk density, porosity, and particle density data for the Vault 1/4 concrete are presented in Table 25 and Table 35. The saturated hydraulic conductivity and intrinsic permeability data for the Vault 2 Mix 1 concrete are presented in Table 26. The dry bulk density, porosity, and particle density data for the Vault 2 Mix 1 concrete is presented in Table 27 and Table 36. The saturated hydraulic conductivity and intrinsic permeability data for the Vault 2 Mix 2 concrete are presented in Table 28. The dry bulk density, porosity, and particle density data for the Vault 2 concrete are presented in Table 29 and Table 37.

The moisture retention properties of the Vault 1/4, Vault 2 Mix 1, and Vault 2 Mix 2 concrete formulations were also measured by MCT and are presented in Table 35, Table 36, and Table 37. Prior to testing, samples of each concrete formulation were saturated with tap water. The MCT measurements were made using pressure plate apparatus. The data for the Vault 1/4, Vault 2 Mix 1, and Vault 2 Mix 2 concrete formulations were analyzed to determine the van Genuchten transport parameters using the RETC code (USDA, 1998). These parameters may be used to implicitly determine the relationship between unsaturated hydraulic conductivity and moisture content. The results from these analyses are presented in Table 38. The data for the characteristic curves are presented in Appendix F. As noted previously, the characteristic curves are extrapolated beyond the range of the moisture retention data (15 bars).

Summary hydraulic properties for all materials tested are presented in Table 30. Summary physical properties for all materials tested are presented in Table 31. Recommended hydraulic and physical properties for each material tested are presented in Table 39.

6.0 REFERENCES

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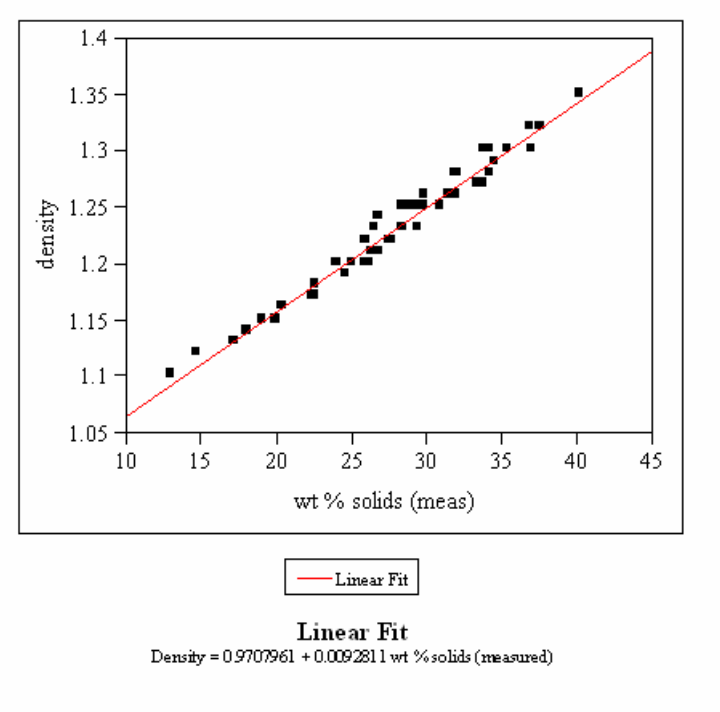


Figure 1. Bivariate fit of simulant density as a function of measured weight percent solids.

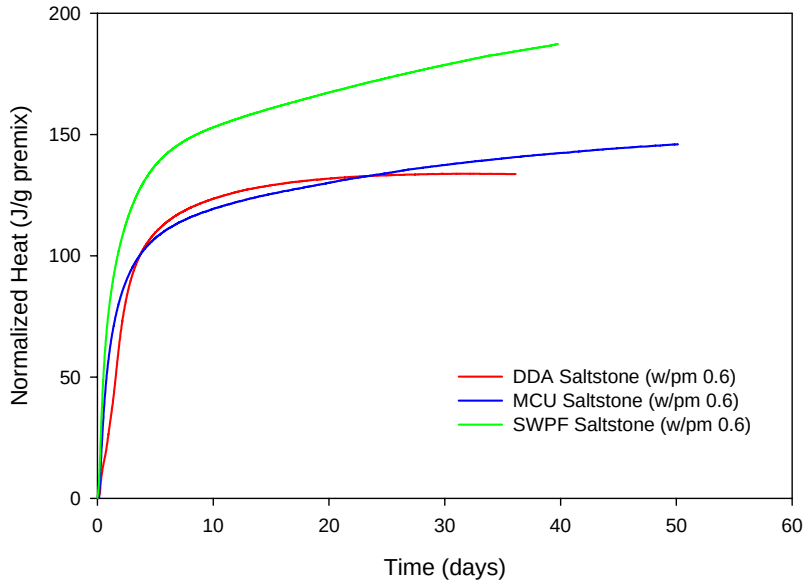


Figure 2. Normalized Heat (J/g of premix) from DDA, ARP/MCU, and SWPF saltstone at 0.60 w/pm ratio.

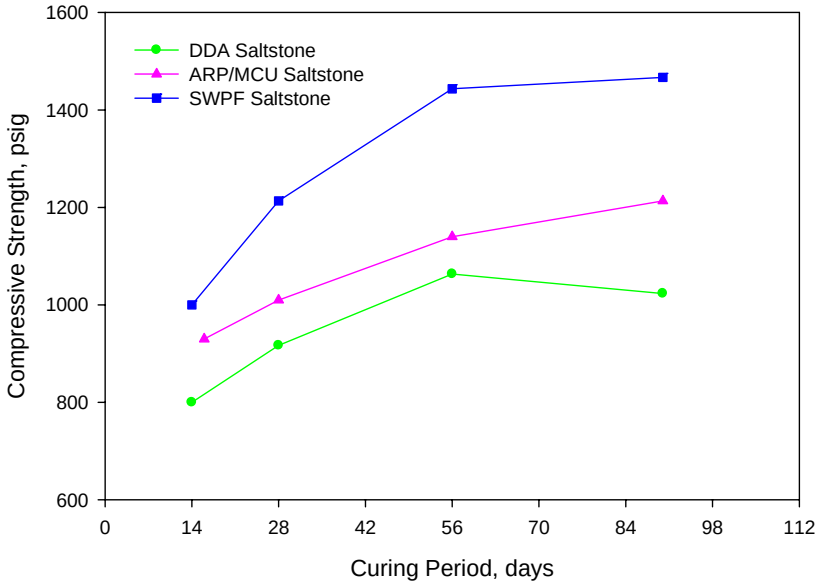


Figure 3. Compressive strength as a function of curing period for DDA, ARP/MCU, and SWPF Saltstone.

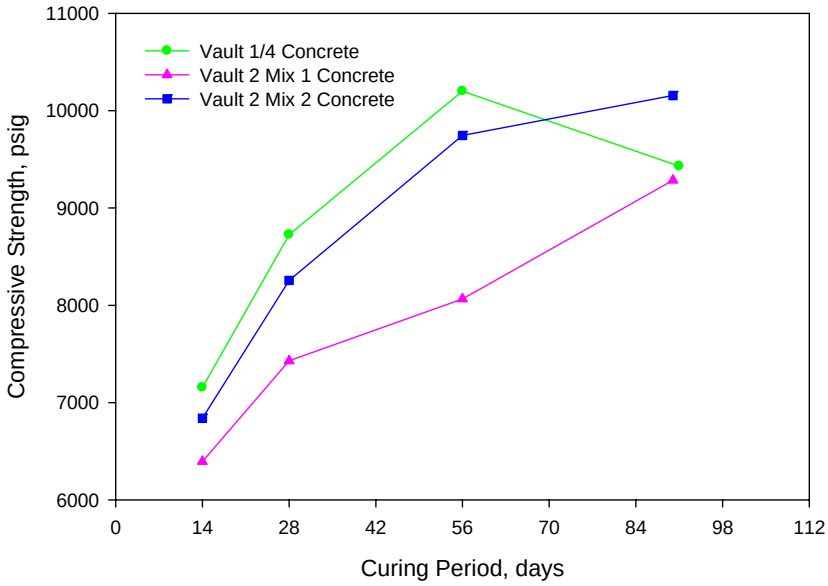


Figure 4. Compressive strength as a function of curing period for Vault 1/4, Vault 2 Mix 1, and Vault 2 Mix 2.

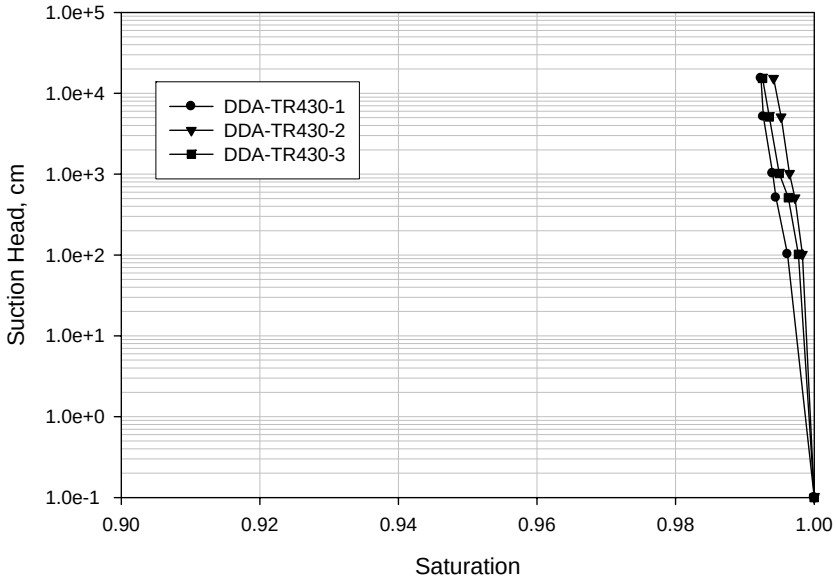


Figure 5. Moisture retention curves for the 28 day DDA saltstone samples.

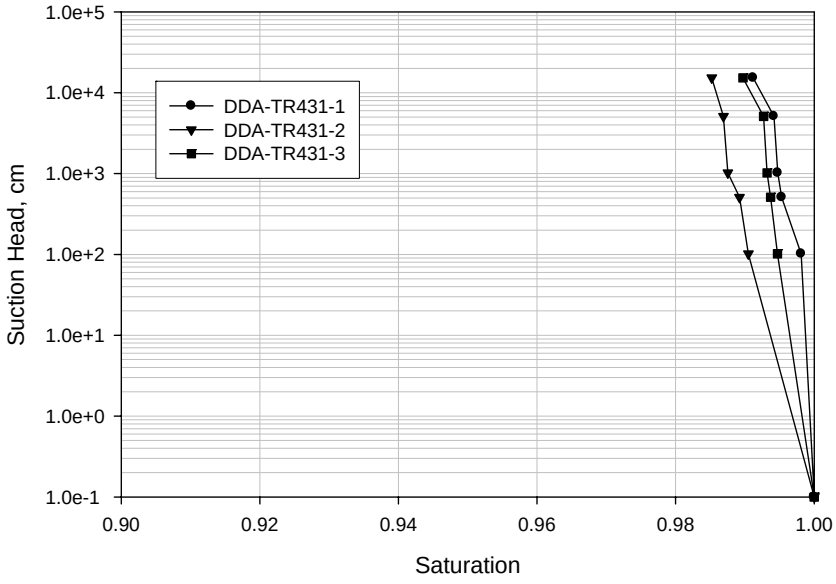


Figure 6. Moisture retention curves for the 90 day DDA saltstone samples.

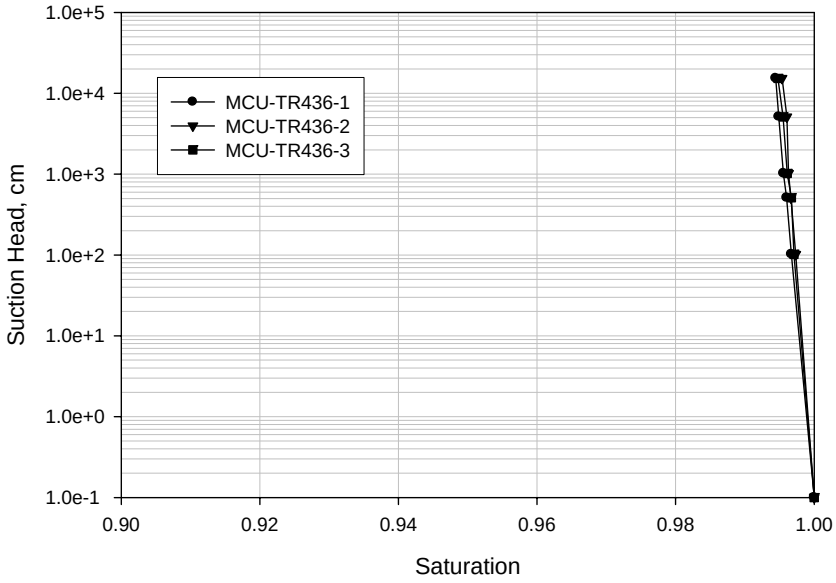


Figure 7. Moisture retention curves for the 28 day ARP/MCU saltstone samples.

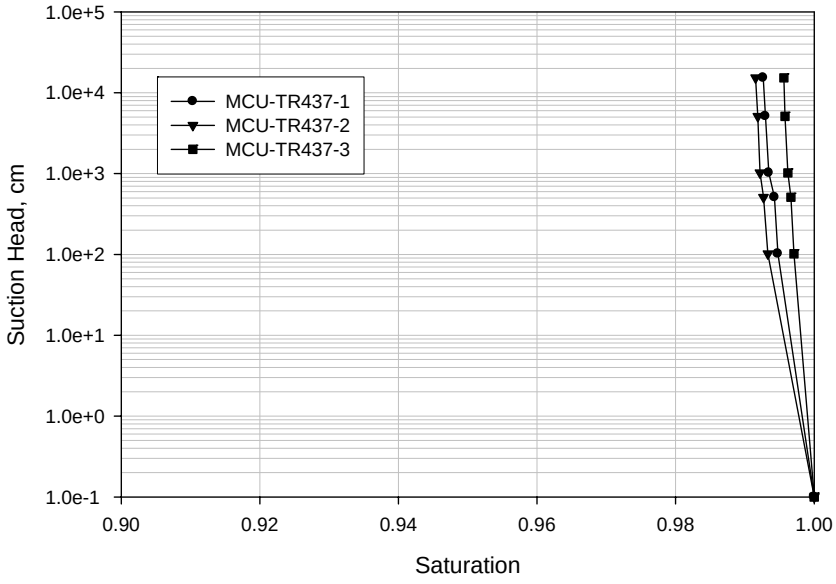


Figure 8. Moisture retention curves for the 90 day ARP/MCU saltstone samples.

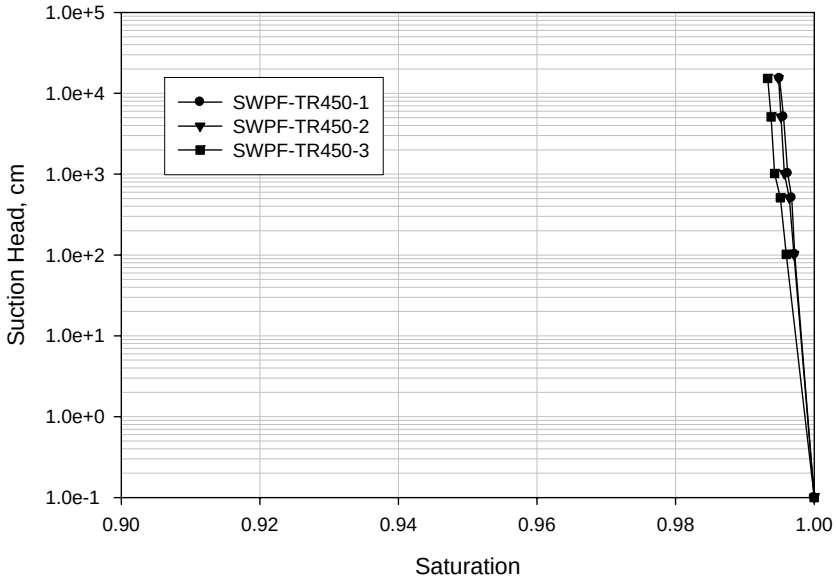


Figure 9. Moisture retention curves for the 28 day SWPF saltstone samples.

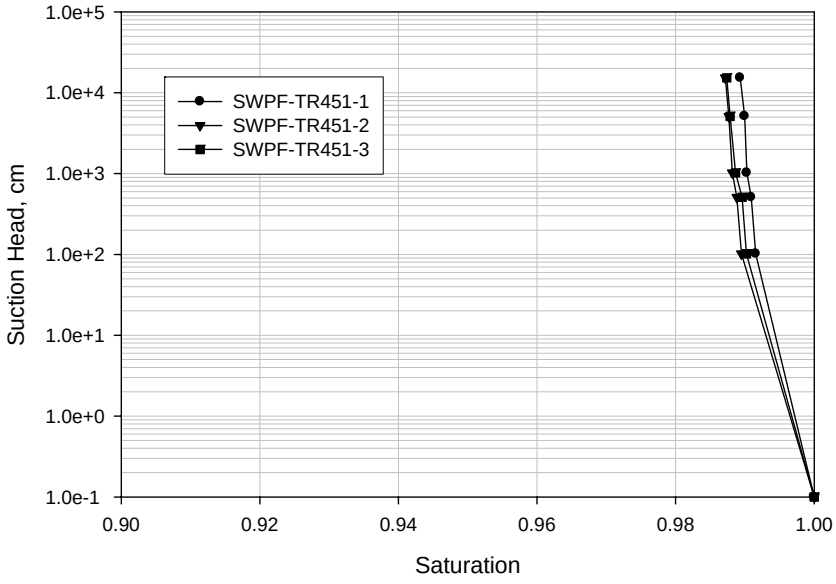


Figure 10. Moisture retention curves for the 90 day SWPF saltstone samples.

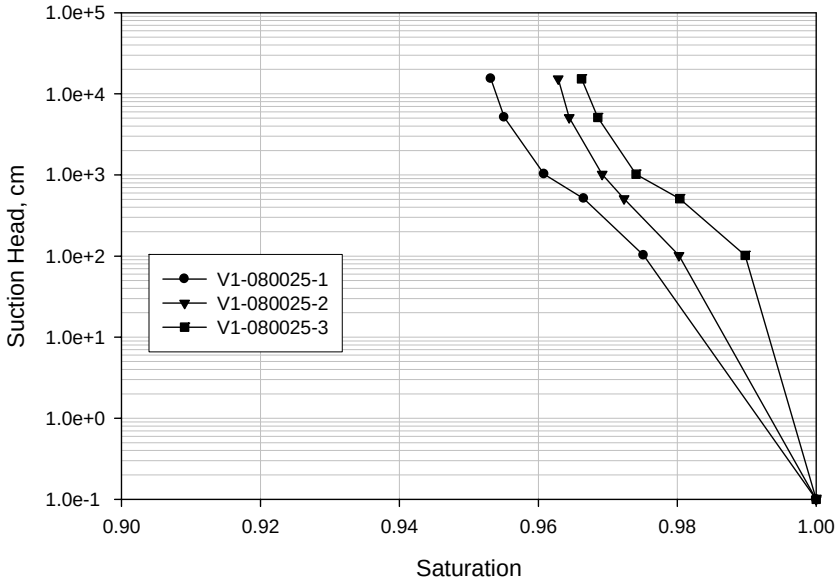


Figure 11. Moisture retention curves for the 28 day Vault 1/4 concrete samples.

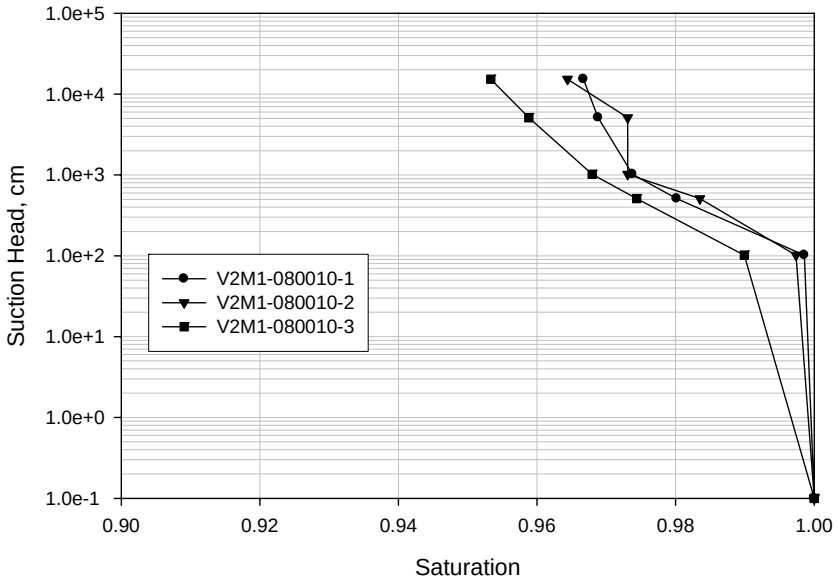


Figure 12. Moisture retention curves for the 28 day Vault 2 Mix 1 concrete samples.

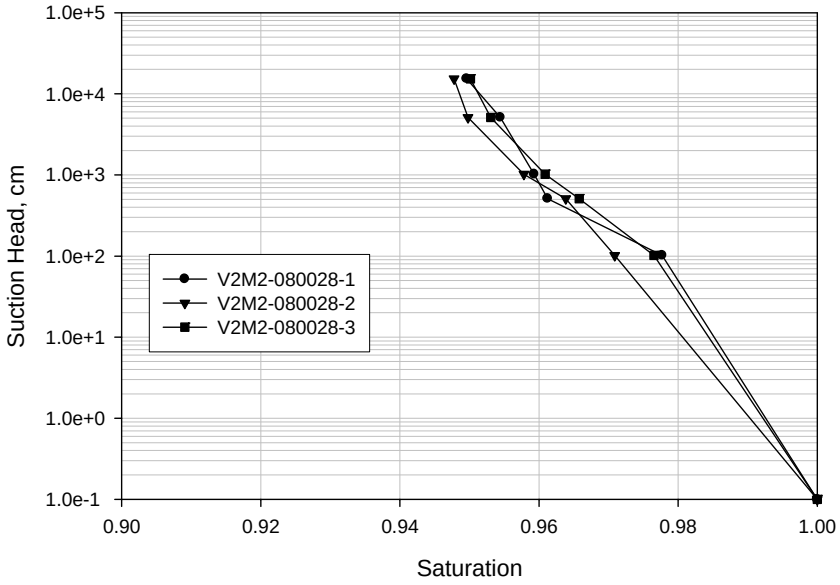


Figure 13. Moisture retention curves for the 28 day Vault 2 Mix 2 concrete samples.

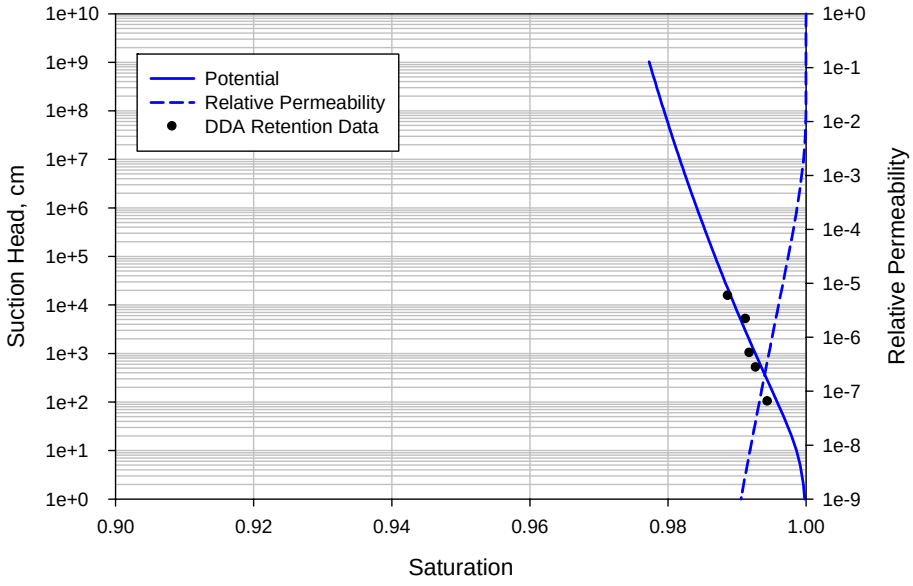


Figure 14. Characteristic Curves for the DDA Saltstone (using 28 and 90 day retention data).

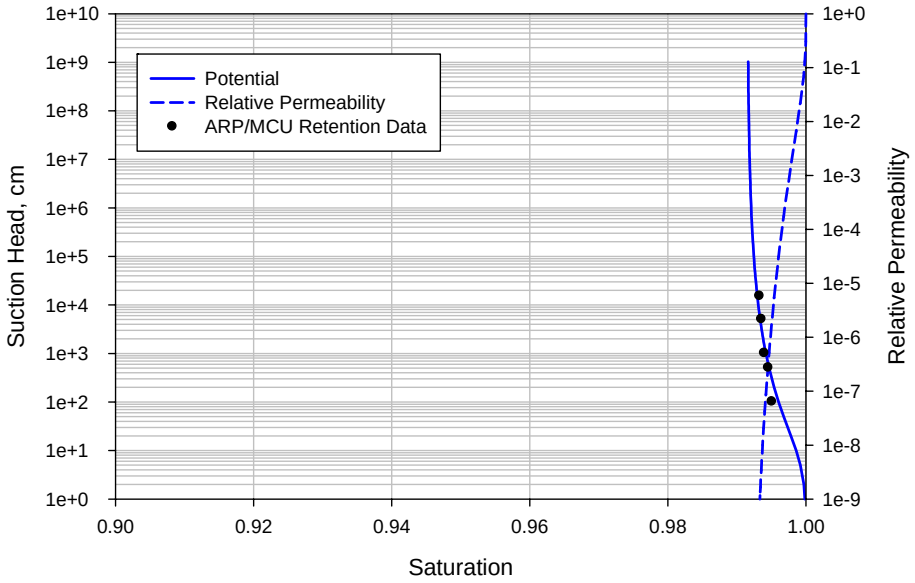


Figure 15. Characteristic Curves for the ARP/MCU Saltstone (using 28 and 90 day retention data).

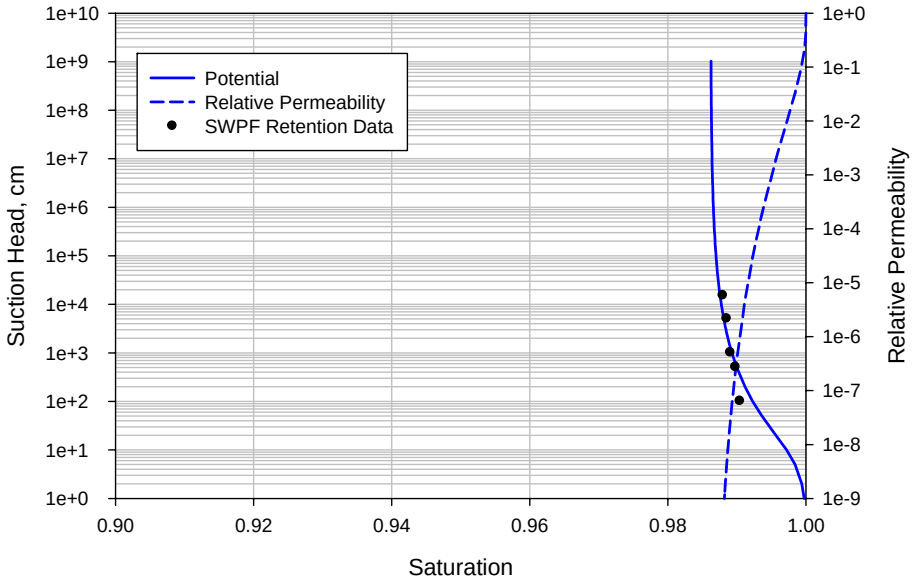


Figure 16. Characteristic Curves for the SWPF Saltstone (using 28 and 90 day retention data).

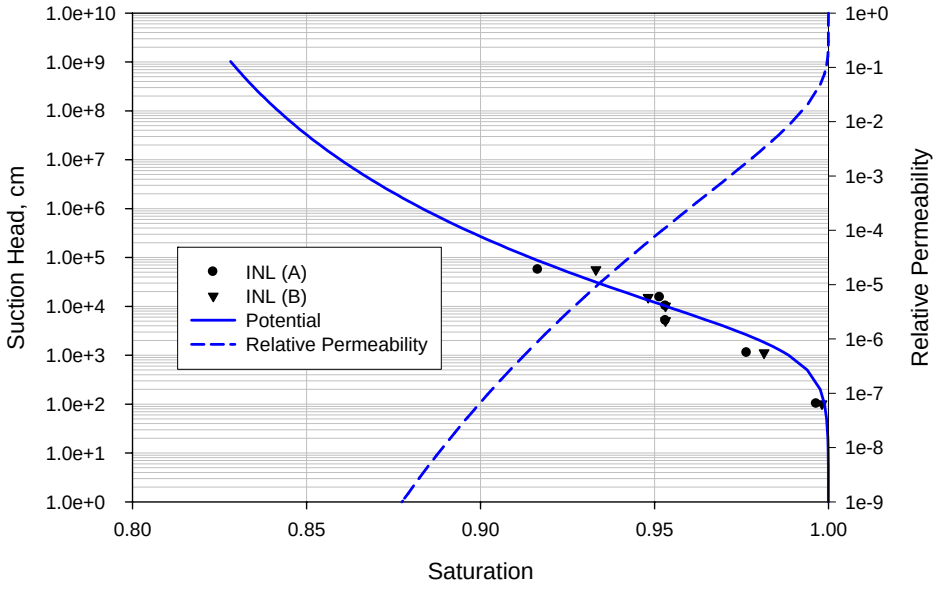


Figure 17. Characteristic curves for MCU saltstone samples as determined by INL reported by Dixon and Phifer (2007).

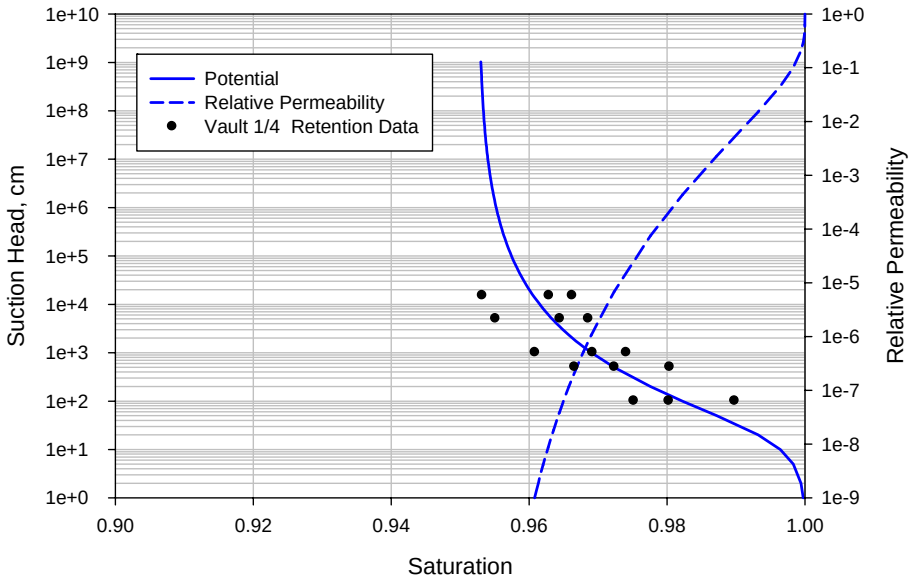


Figure 18. Characteristic Curves for the Vault 1/4 Concrete (based on 28 day minimum curing period).

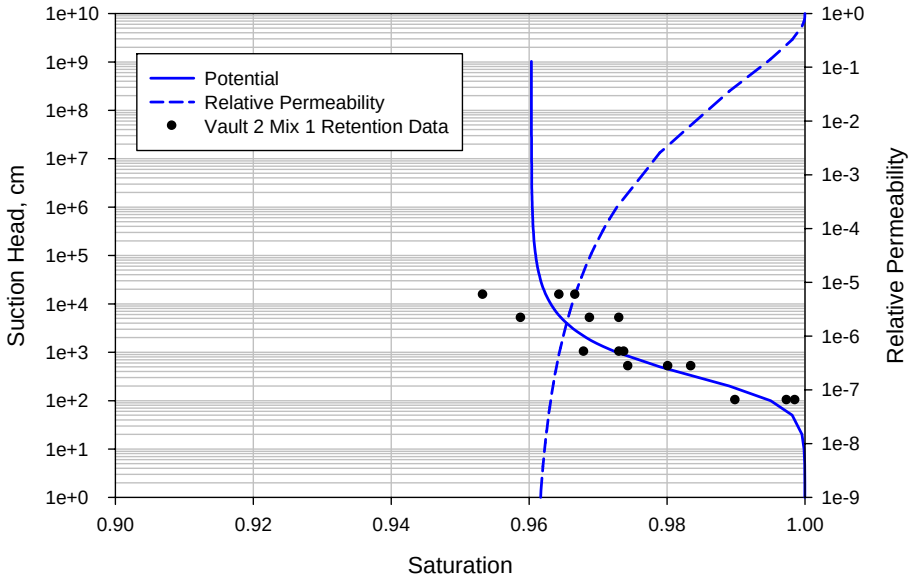


Figure 19. Characteristic Curves for the Vault 2 Mix 1 Concrete (based on 28 day minimum curing period).

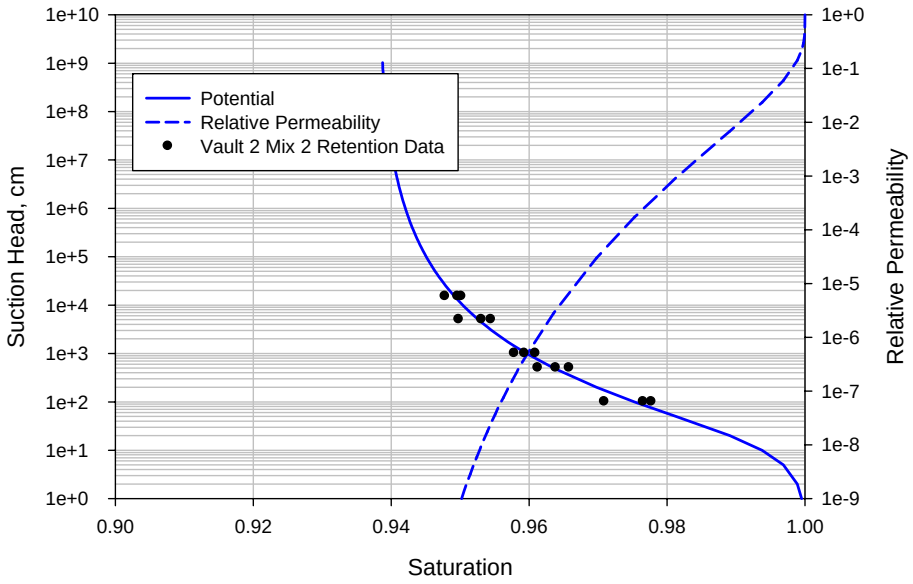


Figure 20. Characteristic Curves for the Vault 2 Mix 2 Concrete (based on 28 day minimum curing period).

Table 1. Saltstone Cementitious Materials (premix).

Ingredient[1]	Vendor	Premix Blend (wt%)
Portland Cement (Type II)	Holcim	10
Blast Furnace Slag (Grade 100)	Holcim	45
Fly Ash (Class F)	Cross Station	45

[1]All materials were received from the Saltstone Disposal Facility. The as-batched water to premix ratio for all three mixes was 0.60.

Table 2. Recipe for DDA Simulant used to Prepare Simulated Saltstone Grout Samples and the Permeant used for Hydraulic and Physical Testing.

Ingredient	DDA Simulant[1]		DDA Permeant[2]	
	Molarity (Moles/Liter)	Mass (g/Liter H_2O)	Molarity (Moles/Liter)	Mass (g/Liter H_2O)
Sodium Hydroxide, NaOH (50 % by weight)	0.769	61.52	0.485	38.80
Sodium Nitrate, $NaNO_3$	2.202	187.15	2.202	187.15
Sodium Nitrite, $NaNO_2$	0.110	7.56	0.110	7.56
Sodium Carbonate, Na_2CO_3	0.145	15.36	0.145	15.36
Sodium Sulfate. Na_2SO_4	0.044	6.31	0.044	6.31
Aluminum Nitrate (9 H^20)	0.071	26.63	0.000	0.000
Sodium Phosphate (12 H_2O)	0.008	3.22	0.000	0.000

[1]The simulant was used to batch the grout samples.
[2]The permeant was used to test the grout samples for hydraulic and physical properties.

Table 3. Recipe for ARP/MCU Simulant used to Prepare Simulated Saltstone Grout Samples and the Permeant used for Hydraulic and Physical Testing.

Ingredient	ARP/MCU Simulant[1]		ARP/MCU Permeant[2]	
	Molarity (Moles/Liter)	Mass (g/Liter H_2O)	Molarity (Moles/Liter)	Mass (g/Liter H_2O)
Sodium Hydroxide, NaOH (50 % by weight)	1.594	127.50	1.377	110.16
Sodium Nitrate, $NaNO_3$	3.159	268.48	3.159	268.48
Sodium Nitrite, $NaNO_2$	0.368	25.39	0.368	25.39
Sodium Carbonate, Na_2CO_3	0.176	18.65	0.176	18.65
Sodium Sulfate. Na_2SO_4	0.059	8.37	0.059	8.37
Aluminum Nitrate (9 H^20)	0.054	20.33	0.000	0.000
Sodium Phosphate (12 H_2O)	0.012	4.67	0.000	0.000

[1]The simulant was used to batch the grout samples.
[2]The permeant was used to test the grout samples for hydraulic and physical properties.

Table 4. Recipe for SWPF Simulant used to Prepare Simulated Saltstone Grout Samples and the Permeant used for Hydraulic and Physical Testing.

Ingredient	SWPF Simulant[1]		SWPF Permeant[2]	
	Molarity (Moles/Liter)	Mass (g/Liter H_2O)	Molarity (Moles/Liter)	Mass (g/Liter H_2O)
Sodium Hydroxide, NaOH (50 % by weight)	2.866	229.28	2.409	192.69
Sodium Nitrate, $NaNO_3$	1.973	167.66	1.973	167.66
Sodium Nitrite, $NaNO_2$	0.485	33.43	0.485	33.43
Sodium Carbonate, Na_2CO_3	0.118	12.46	0.118	12.46
Sodium Sulfate. Na_2SO_4	0.055	7.84	0.055	7.84
Aluminum Nitrate (9 H^20)	0.114	42.90	0.000	0.000
Sodium Phosphate (12 H_2O)	0.007	2.76	0.000	0.000

[1]The simulant was used to batch the grout samples.
[2]The permeant was used to test the grout samples for hydraulic and physical properties.

Table 5. Simulant and Permeant Properties

	Density (g/ml)	Dynamic Viscosity (cP)	Water to Simulant Ratio (g H_2O/g simulant)	Weight Percent Solids (%)	Salt Content (g/100g wet grout)
DDA Simulant	1.173	1.50	0.777	22.33	9.28
ARP/MCU Simulant	1.261	2.46	0.685	31.54	14.50
SWPF Simulant	1.248	2.78	0.711	28.88	13.00
DDA Concentrated Simulant[1]	1.190	-	0.762	-	9.28
ARP/MCU Concentrated Simulant[1]	1.273	-	0.664	-	14.50
SWPF Concentrated Simulant[1]	1.260	-	0.691		13.00
DDA Permeant	1.156	1.39	0.780	20.45	-
ARP/MCU Permeant	1.248	2.25	0.680	30.20	-
SWPF Permeant	1.224	2.46	0.710	26.08	-

[1]During hydration, approximately 8% of the water contained within the simulant is consumed. This concentrates the pore fluid relative to the simulant used to batch the samples. The properties of the concentrated pore fluids were determined as described in Section 3.3.1.

Table 6. Saltstone Vault 1/4 Concrete Formulations.

Ingredient[1]	**Quantity (lbs/cu yd)**
Type II cement (ASTM C 150)	419
Grade 100 Blast furnace slag (ASTM C 989)[2]	278
Sand (ASTM C 33)	1133
No. 67 aggregate (maximum ¾ in) (ASTM C 33)	1798
Microair AEA (oz/yd^3)	5.9
Master Builders 320 N WRA (oz/yd^3)[3]	40
Water (maximum)	268 (32.1 gal/cu yd)
Water to cementitious material ratio	0.385
Minimum compressive strength at 28 days	4000 psig
Maximum slump	3 in

[1]Taken from Phifer et al. 2006 Tables 4-5 and 4-6).
[2]The original formulation called for Grade 120 Blast furnace slag. Currently, only Grade 100 Blast furnace slag is available.
[3]This product line is now supplied by BASF and 320 N has been replaced with 322 N.

Table 7. Ingredients Used to Prepare the Vault 1/4 Concrete Samples.

Material	Specification	Supplier / Address	Phone Number
Portland cement (Type I/II)	ASTM C 150	LaFarge Cement P.O. Box 326 463 Judge St. Harleyville, S.C, 29448 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(803) 462-7651 (706) 798-3676
Slag cement (Grade 100)	ASTM C 989	Holcim, US Inc. 1555 Hartman Industrial Blvd. Birmingham, AL 35221	(205) 929-6813
Concrete sand	ASTM C 33	Foster Dixiana 3308 Charleston Hwy. Columbia, SC, 29172 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(803) 794-2872 (706) 798-3676
No. 67 stone 3/4 inch gravel (granite)	ASTM C 33	USA Aggregates Dogwood Quarry Appling GA, 30802 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(706) 541-0187 (706) 798-3676
Admixtures			
Microair (air entraining admixture)	ASTM C 260	BASF Corporation 106 Macon St. Reynolds, GA, 31076	(864) 607-4160
322 N (mid range water reducer)[1]	ASTM C 494		

[1]322 N has replaced 320 N in the BASF AEA product line.

Table 8. Saltstone Vault 2, Mix 1 Concrete Formulation (670 lbs/cu yd Cementitious Material, Class 3 Sulfate Resistant Concrete).

Ingredient[1]	**Quantity (lbs/cu yd)**
Type V cement (Lehigh T-V #2 ; ASTM C 150)	201
Grade 100 Blast furnace slag (Holcim Grade 100 Slag; ASTM C 989)	268
Silica Fume (W. R. Grace Silica Fume; ASTM C 1240)	44.7
Type F Fly ash (SEFA Class "F" Fly Ash; ASTM C 618)	156.3
sand (Rinker Aggregates Company - Augusta Sand - Natural Washed Sand); ASTM C 33)	911
aggregate (Rinker Aggregates Company - Dogwood Quarry - #67 Granite; ASTM C 33)	1850
Water (maximum)	254.6
Water (maximum; gal/ cu yd)	30.5
Maximum water to cementitious material ratio	0.38
Grace WRDA 35 (oz/cwt c+p)	5
Grace Darex II (oz/cwt c+p)	0.4 to 0.5
Grace Adva 380 (oz/cwt c+p)	3 to 4
Minimum compressive strength of at 28 days	5000 psig
Slump range/target of before Super-P	1 – 3 inches / 2 inches
Slump range/target of after Super-P	6 – 8 inches / 7 inches

[1]Taken from Phifer et al. 2006 Tables 4-6, DCR: AC51636A-001 Supplier Document, and personal correspondence with Carlos Chiappetto.

Table 9. Saltstone Vault 2, Mix 2 Concrete Formulation (710 lbs/cu yd Cementitious Material, Class 3 Sulfate Resistant Concrete).

Ingredient[1]	**Quantity (lbs/cu yd)**
Type V cement (Lehigh T-V #2 ; ASTM C 150)	213
Grade 100 Blast furnace slag (Holcim Grade 100 Slag; ASTM C 989)	284
Silica Fume (W. R. Grace Silica Fume; ASTM C 1240)	47.3
Type F Fly ash (SEFA Class "F" Fly Ash; ASTM C 618)	165.7
sand (Rinker Aggregates Company - Augusta Sand - Natural Washed Sand); ASTM C 33)	911
aggregate (Rinker Aggregates Company - Dogwood Quarry - #67 Granite; ASTM C 33)	1850
Water (maximum)	269.8
Water (maximum; gal/ cu yd)	32.3
Maximum water to cementitious material ratio	0.38
Grace WRDA 35 (oz/cwt c+p)	5
Grace Darex II (oz/cwt c+p)	0.4 to 0.5
Grace Adva 380 (oz/cwt c+p)	3 to 4
Minimum compressive strength of at 28 days	5000 psig
Slump range/target of before Super-P	1 – 3 inches / 2 inches
Slump range/target of after Super-P	6 – 8 inches / 7 inches

[1]Taken from Phifer et al. 2006 Tables 4-6, DCR: AC51636A-001 Supplier Document, and personal correspondence with Carlos Chiappetto.

Table 10. Ingredients Used to Prepare the Vault 2 Mix 1 and Mix 2 Concrete Samples.

Material	Specification	Supplier / Address	Phone Number
Portland cement (Type V)	ASTM C 150	Lehigh Portland Cement Co., 8401 2nd Ave. Leeds, AL., 35094 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(205) 699-2231 (706) 798-3676
Slag cement (Grade 100)	ASTM C 989	Holcim US Inc. 1555 Hartman Industrial Blvd. Birmingham, AL 35221	(205) 929-6813
Fly ash (Class F)	ASTM C 618	SEFA Group, 217 Cedar Rd., Lexington, SC, 29073	(803) 520-9000
Concrete sand	ASTM C 33	Foster Dixiana 3308 Charleston Hwy. Columbia, SC, 29172 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(803) 794-2872 (706) 798-3676
No. 67 stone 3/4 inch gravel (granite)	ASTM C 33	USA Aggregates Dogwood Quarry Appling GA, 30802 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(706) 541-0187 (706) 798-3676
Admixtures			
DAREX II (air entraining admixture)	ASTM C 260	Grace Construction Products, 6606 Marshall Blvd., Lithonia, GA, 30058 sampled from Lafarge Ready Mix Plant, 109 Laney Walker Blvd., Augusta, GA, 30909	(877) 423-6491 (706) 798-3676
WRDA 35 (mid range water reducer)	ASTM C 494		
Adva 380 (super plasticizer)	ASTM C 494 Type F		

Table 11. Fresh Properties of the DDA, ARP/MCU, and SWPF Saltstone.

Sample Id	Yield Stress (Pa)	Plastic Viscosity (cP)	Gel Time (minutes)	One Day Bleed (volume %)	Set Time (days)
DDA-TR430	6.3	89	> 90	5.0	2
MCU-TR436	3.4	79	40	1.5	1
SWPF-TR450	3.3	83	> 100	2.5	1

Table 12. Compressive Strength for the DDA Saltstone Grout (Cast 3/18/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)			
		Measured			Average
14	4/01/2008	820	790	790	800
28	4/15/2008	910	940	900	917
56	5/13/2008	1060	1070	1060	1063
90	6/16/2008	1020	1010	1040	1023

[1]Samples were 2-in cube mold samples and were tested per ASTM C 109.
[2]Lab Batch ID 080013.

Table 13. Compressive Strength for the ARP/MCU Saltstone Grout (Cast 3/31/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)			
		Measured			Average
16	4/16/2008	970	1000	820	930
28	4/28/2008	1000	1000	1030	1010
56	5/26/2008	1130	1120	1170	1140
90	6/29/2008	1200	1230	1210	1213

[1]Samples were 2-in cube mold samples and were tested per ASTM C 109.
[2]Lab Batch ID 080014.

Table 14. Compressive Strength for the SWPF Saltstone Grout (Cast 4/22/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)			
		Measured			Average
14	5/06/2008	1020	1000	980	1000
28	5/20/2008	1210	1200	1230	1213
56	6/17/2008	1420	1420	1490	1443
90	7/21/2008	1480	1450	1470	1467

[1]Samples were 2-in cube mold samples and were tested per ASTM C 109.
[2]Lab Batch ID 080021.

Table 15. Compressive Strength for the Vault 1/4 Concrete (Cast 5/05/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)		
		Measured		Average
14	5/19/2008	7440	6870	7155
28	6/02/2008	8700	8750	8725
56	6/30/2008	10170	10230	10200
90	8/03/2008	9570	9290	9430

[1]Samples were 4 x 8 inch cylinders and were tested per ASTM C 39.
[2]Lab Batch ID 080025.

Table 16. Compressive Strength for the Vault 2 Mix 1 Concrete (Cast 3/25/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)		
		Measured		Average
14	4/08/2008	6390	6400	6395
28	4/22/2008	7550	7310	7430
56	5/20/2008	8050	8080	8065
90	6/23/2008	9450	9120	9285

[1]Samples were 4 x 8 inch cylinders and were tested per ASTM C 39.
[2]Lab Batch ID 080010.

Table 17. Compressive Strength for the Vault 2 Mix 2 Concrete (Cast 6/24/2008).

Days Aged	Date Tested	Compressive Strength[1,2] (psig)		
		Measured		Average
14	7/08/2008	6880	6800	6840
28	7/22/2008	8170	8340	8255
56	8/19/2008	9930	9560	9745
90	9/22/2008	10050	10260	10155

[1]Samples were 4 x 8 inch cylinders and were tested per ASTM C 39.
[2]Lab Batch ID 080028.

Table 18. Hydraulic Properties of DDA Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution[1]	Saturated Hydraulic Conductivity[2] (cm/s)	Permeability[3] (darcy)
DDA-TR430-1	2.8" Mold	28	DDA	1.4×10^{-8}	1.7×10^{-5}
DDA-TR430-2	2.8" Mold	28	DDA	5.9×10^{-10}	7.1×10^{-7}
DDA-TR430-3	2.8" Mold	28	DDA	2.0×10^{-9}	2.4×10^{-6}
DDA-TR431-1	2.8" Mold	90	DDA	1.1×10^{-10}	1.3×10^{-7}
DDA-TR431-2	2.8" Mold	90	DDA	7.2×10^{-11}	8.7×10^{-8}
DDA-TR431-3	2.8" Mold	90	DDA	1.1×10^{-10}	1.3×10^{-7}

[1]DDA permeant (Table 2) used as permeating solution.
[2]Saturated hydraulic conductivity relative to concentrated DDA simulant.
[3]Permeability is independent of the pore fluid and can be converted to saturated hydraulic conductivity for any solution using the equation in Section 3.3.1

Table 19. Physical Properties of DDA Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)[1]	Particle Density (g/cm^3)[2]	Porosity[3]
DDA-TR430-1	2.8" Mold	28	1.04	2.36	0.56
DDA-TR430-2	2.8" Mold	28	1.05	2.39	0.56
DDA-TR430-3	2.8" Mold	28	1.04	2.40	0.56
DDA-TR431-1	2.8" Mold	90	1.05	2.34	0.55
DDA-TR431-2	2.8" Mold	90	1.08	2.48	0.57
DDA-TR431-3	2.8" Mold	90	1.06	2.38	0.56

[1]Dry bulk density corrected for salt precipitation as described in Section 3.3.1.
[2]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.
[3]Porosity corrected for salt precipitation as described in Section 3.3.1.

Table 20. Hydraulic Properties of ARP/MCU Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution[1]	Saturated Hydraulic Conductivity[2] (cm/s)	Permeability[3] (darcy)
MCU-TR436-1	2.8" Mold	28	ARP/MCU	5.4×10^{-9}	9.8×10^{-6}
MCU-TR436-2	2.8" Mold	28	ARP/MCU	2.1×10^{-9}	3.8×10^{-6}
MCU-TR436-3	2.8" Mold	28	ARP/MCU	2.7×10^{-10}	4.9×10^{-7}
MCU-TR437-1	2.8" Mold	90	ARP/MCU	1.1×10^{-9}	2.0×10^{-6}
MCU-TR437-2	2.8" Mold	90	ARP/MCU	8.8×10^{-10}	1.6×10^{-6}
MCU-TR437-3	2.8" Mold	90	ARP/MCU	6.4×10^{-10}	1.2×10^{-6}

[1]ARP/MCU permeant (Table 3) used as permeating solution.
[2]Saturated hydraulic conductivity relative to the concentrated ARP/MCU simulant.
[3]Permeability is independent of the pore fluid and can be converted to saturated hydraulic conductivity for any solution using the equation in Section 3.3.1.

Table 21. Physical Properties of ARP/MCU Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)[1]	Particle Density (g/cm^3)[2]	Porosity[3]
MCU-TR436-1	2.8" Mold	28	0.98	2.30	0.58
MCU-TR436-2	2.8" Mold	28	0.98	2.33	0.58
MCU-TR436-3	2.8" Mold	28	0.98	2.34	0.58
MCU-TR437-1	2.8" Mold	90	0.95	2.35	0.59
MCU-TR437-2	2.8" Mold	90	0.96	2.39	0.60
MCU-TR437-3	2.8" Mold	90	0.97	2.49	0.61

[1]Dry bulk density corrected for salt precipitation as described in Section 3.3.1.
[2]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.
[3]Porosity corrected for salt precipitation as described in Section 3.3.1.

Table 22. Hydraulic Properties of SWPF Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution[1]	Saturated Hydraulic Conductivity[2] (cm/s)	Permeability[3] (darcy)
SWPF-TR450-1	2.8" Mold	28	SWPF	1.2×10^{-8}	2.4×10^{-5}
SWPF-TR450-2	2.8" Mold	28	SWPF	3.4×10^{-8}	6.8×10^{-5}
SWPF-TR450-3	2.8" Mold	28	SWPF	2.0×10^{-9}	4.0×10^{-6}
SWPF-TR451-1	2.8" Mold	90	SWPF	1.2×10^{-9}	2.4×10^{-6}
SWPF-TR451-2	2.8" Mold	90	SWPF	2.0×10^{-9}	4.0×10^{-6}
SWPF-TR451-3[4]	2.8" Mold	90	SWPF	8.8×10^{-8}	1.8×10^{-8}

[1]SWPF permeant (Table 4) used as permeating solution.
[2]Saturated hydraulic conductivity relative to the concentrated SWPF simulant.
[3]Permeability is independent of the pore fluid and can be converted to saturated hydraulic conductivity for any solution using the equation in Section 3.3.1.
[4]This sample may be an outlier.

Table 23. Physical Properties of SWPF Saltstone as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)[1]	Particle Density (g/cm^3)[2]	Porosity[3]
SWPF-TR450-1	2.8" Mold	28	1.01	2.40	0.58
SWPF-TR450-2	2.8" Mold	28	1.00	2.43	0.59
SWPF-TR450-3	2.8" Mold	28	1.02	2.53	0.60
SWPF-TR451-1	2.8" Mold	90	1.00	2.45	0.59
SWPF-TR451-2	2.8" Mold	90	1.01	2.42	0.58
SWPF-TR451-3	2.8" Mold	90	1.00	2.46	0.59

[1]Dry bulk density corrected for salt precipitation as described in Section 3.3.1.
[2]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.
[3]Porosity corrected for salt precipitation as described in Section 3.3.1.

Table 24. Hydraulic Properties of Vault 1/4 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution	Saturated Hydraulic Conductivity (cm/s)	Permeability (darcy)
V1-080025-4	6" Mold	28	Water	1.3×10^{-10}	1.3×10^{-8}
V1-080025-5	6" Mold	28	Water	2.1×10^{-9}	2.2×10^{-7}
V1-080025-6	6" Mold	28	Water	1.1×10^{-10}	1.1×10^{-8}

Table 25. Physical Properties of Vault 1/4 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)	Particle Density (g/cm^3)[1]	Porosity
V1-080025-4	6" Mold	28	2.27	2.57	0.12
V1-080025-5	6" Mold	28	2.31	2.58	0.10
V1-080025-6	6" Mold	28	2.27	2.55	0.10

[1]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.

Table 26. Hydraulic Properties of Vault 2 Mix 1 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution	Saturated Hydraulic Conductivity (cm/s)	Permeability (darcy)
V2M1-080010-4	6" Mold	28	Water	7.8×10^{-11}	8.0×10^{-9}
V2M1-080010-5	6" Mold	28	Water	2.8×10^{-10}	2.9×10^{-8}
V2M1-080010-6	6" Mold	28	Water	6.0×10^{-11}	6.2×10^{-9}

Table 27. Physical Properties of Vault 2 Mix 1 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)	Particle Density (g/cm^3)[1]	Porosity
V2M1-080010-4	6" Mold	28	2.18	2.47	0.12
V2M1-080010-5	6" Mold	28	2.21	2.39	0.08
V2M1-080010-6	6" Mold	28	2.16	2.49	0.13

[1]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.

Table 28. Hydraulic Properties of Vault 2 Mix 2 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Permeating Solution	Saturated Hydraulic Conductivity (cm/s)	Permeability (darcy)
V2M2-080028-4	6" Mold	28	Water	5.0×10^{-11}	5.2×10^{-9}
V2M2-080028-5	6" Mold	28	Water	5.0×10^{-11}	5.2×10^{-9}
V2M2-080028-6	6" Mold	28	Water	3.2×10^{-10}	3.3×10^{-8}

Table 29. Physical Properties of Vault 2 Mix 2 Concrete as Measured by MCT.

Sample Id	Sample Type	Minimum Curing Period (days)	Dry Bulk Density (g/cm^3)	Particle Density (g/cm^3)[1]	Porosity
V2M2-080028-4	6" Mold	28	2.16	2.50	0.14
V2M2-080028-5	6" Mold	28	2.17	2.43	0.09
V2M2-080028-6	6" Mold	28	2.21	2.46	0.10

[1]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity.

Table 30. Summary Hydraulic Properties for Saltstone and Vault Concrete Samples.

Description	Minimum Curing Period (days)	Saturated Hydraulic Conductivity[1] (cm/sec)				Permeability (darcy)			
		Minimum	Maximum	Arithmetic Average	Logarithmic Average	Minimum	Maximum	Arithmetic Average	Logarithmic Average
DDA Saltstone	28	5.9×10^{-10}	1.4×10^{-08}	5.5×10^{-09}	2.5×10^{-09}	7.1×10^{-07}	1.7×10^{-05}	6.7×10^{-06}	3.1×10^{-06}
	90	7.2×10^{-11}	1.1×10^{-10}	9.7×10^{-11}	9.6×10^{-11}	8.7×10^{-08}	1.3×10^{-07}	1.2×10^{-07}	1.1×10^{-07}
ARP/MCU Saltstone	28	2.7×10^{-10}	5.4×10^{-09}	2.6×10^{-09}	2.6×10^{-09}	4.9×10^{-07}	9.8×10^{-06}	4.7×10^{-06}	2.6×10^{-06}
	90	6.4×10^{-10}	1.1×10^{-09}	8.7×10^{-10}	8.5×10^{-10}	1.2×10^{-06}	2.0×10^{-06}	1.6×10^{-06}	1.6×10^{-06}
SWPF Saltstone[2]	28	2.0×10^{-09}	3.4×10^{-08}	1.6×10^{-08}	9.3×10^{-09}	4.0×10^{-06}	6.8×10^{-05}	3.2×10^{-05}	1.9×10^{-05}
	90	1.2×10^{-09}	8.8×10^{-08}	3.0×10^{-08} (1.6×10^{-09})	6.0×10^{-09} (1.5×10^{-09})	2.4×10^{-06}	1.8×10^{-04}	6.1×10^{-05} (3.2×10^{-06})	1.2×10^{-05} (3.1×10^{-06})
Vault 1/4 Concrete	28	1.1×10^{-10}	2.1×10^{-09}	7.8×10^{-10}	3.1×10^{-10}	1.1×10^{-08}	2.2×10^{-07}	8.0×10^{-08}	3.2×10^{-08}
Vault 2 Mix 1 Concrete	28	6.0×10^{-11}	2.8×10^{-10}	1.4×10^{-10}	1.1×10^{-10}	6.2×10^{-09}	2.9×10^{-08}	1.4×10^{-08}	1.1×10^{-08}
Vault 2 Mix 2 Concrete	28	5.0×10^{-11}	3.2×10^{-10}	1.4×10^{-10}	9.3×10^{-11}	5.2×10^{-09}	3.3×10^{-08}	1.4×10^{-08}	9.6×10^{-09}

[1]Saturated hydraulic conductivity values for saltstone materials are relative to the concentrated simulants as given in Table 5. The saturated hydraulic conductivity of the vault concretes are relative to tap water.

[2]The 90 day saturated hydraulic conductivity data may be influenced by an outlying value. If this value is excluded, the arithmetically averaged saturated hydraulic conductivity is 1.6×10^{-9} cm/sec and the logarithmically averaged saturated hydraulic conductivity is 1.5×10^{-9} cm/sec. If the value is also excluded for permeability, arithmetically averaged permeability is 3.2×10^{-6} darcy and the logarithmically averaged permeability is 3.1×10^{-6} darcy.

Table 31. Summary Physical Properties for Saltstone and Vault Concrete Samples.

Description	Minimum Curing Period (days)	Bulk Density (g/cm^3)			Particle Density (g/cm^3)			Porosity (fraction)		
		Minimum	Maximum	Arithmetic Average	Minimum	Maximum	Arithmetic Average	Minimum	Maximum	Arithmetic Average
DDA Saltstone	28	1.04	1.07	1.05	2.32	2.43	2.37	0.54	0.56	0.56
	90	1.04	1.08	1.06	2.33	2.48	2.37	0.55	0.57	0.55
ARP/MCU Saltstone	28	0.98	0.99	0.98	2.30	2.41	2.35	0.58	0.59	0.58
	90	0.95	1.01	0.97	2.30	2.49	2.38	0.58	0.61	0.59
SWPF Saltstone	28	1.00	1.05	1.03	2.40	2.53	2.45	0.56	0.60	0.58
	90	1.00	1.03	1.01	2.35	2.53	2.44	0.57	0.59	0.59
Vault 1/4 Concrete	28	2.15	2.31	2.24	2.44	2.58	2.53	0.10	0.12	0.11
Vault 2 Mix 1 Concrete	28	2.16	2.21	2.19	2.39	2.50	2.48	0.08	0.13	0.12
Vault 2 Mix 2 Concrete	28	2.16	2.26	2.22	2.43	2.55	2.50	0.09	0.14	0.11

Table 32. Moisture Retention Data for DDA Saltstone as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density[1] (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content[1] (cm^3/cm^3)					
DDA-TR430-1	28	1.07	0.560	0.558	0.557	0.557	0.556	0.556
DDA-TR430-2	28	1.06	0.545	0.544	0.544	0.543	0.542	0.542
DDA-TR430-3	28	1.06	0.545	0.544	0.543	0.542	0.541	0.541
DDA-TR431-1	90	1.06	0.551	0.550	0.549	0.548	0.548	0.546
DDA-TR431-2	90	1.06	0.550	0.545	0.544	0.543	0.543	0.542
DDA-TR431-3	90	1.04	0.553	0.550	0.549	0.549	0.549	0.547

[1]Dry bulk density and volumetric moisture content corrected for salt precipitation as described in Section 3.3.1.

Table 33. Moisture Retention Data for the ARP/MCU Saltstone as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density[1] (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content[1] (cm^3/cm^3)					
MCU-TR436-1	28	0.98	0.582	0.580	0.580	0.580	0.579	0.579
MCU-TR436-2	28	0.98	0.590	0.588	0.588	0.588	0.588	0.587
MCU-TR436-3	28	0.99	0.592	0.590	0.590	0.590	0.589	0.589
MCU-TR437-1	90	1.01	0.584	0.580	0.580	0.580	0.579	0.579
MCU-TR437-2	90	0.98	0.585	0.581	0.580	0.580	0.580	0.580
MCU-TR437-3	90	0.95	0.587	0.586	0.585	0.585	0.585	0.585

[1]Dry bulk density and volumetric moisture content corrected for salt precipitation as described in Section 3.3.1.

Table 34. Moisture Retention Data for the SWPF Saltstone as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density[1] (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content[1] (cm^3/cm^3)					
SWPF-TR450-1	28	1.05	0.576	0.575	0.575	0.574	0.574	0.574
SWPF-TR450-2	28	1.05	0.570	0.568	0.568	0.567	0.567	0.567
SWPF-TR450-3	28	1.05	0.566	0.563	0.563	0.562	0.562	0.562
SWPF-TR451-1	90	1.00	0.579	0.574	0.574	0.573	0.573	0.573
SWPF-TR451-2	90	1.03	0.599	0.593	0.592	0.592	0.592	0.591
SWPF-TR451-3	90	1.02	0.588	0.582	0.582	0.581	0.581	0.581

[1]Dry bulk density and volumetric moisture content corrected for salt precipitation as described in Section 3.3.1.

Table 35. Moisture Retention Data for Vault 1/4 Concrete as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content (cm^3/cm^3)					
V1-080025-x	28	2.25	0.117	0.114	0.113	0.112	0.111	0.111
V1-080025-x	28	2.15	0.122	0.120	0.119	0.118	0.118	0.117
V1-080025-x	28	2.19	0.124	0.122	0.121	0.120	0.120	0.119

Table 36. Moisture Retention Data for Vault 2 Mix 1 Concrete as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content (cm^3/cm^3)					
V2M1-080010-1	28	2.18	0.128	0.128	0.125	0.125	0.124	0.124
V2M1-080010-2	28	2.21	0.116	0.116	0.114	0.113	0.113	0.112
V2M1-080010-3	28	2.19	0.127	0.125	0.123	0.123	0.122	0.121

Table 37. Moisture Retention Data for Vault 2 Mix 2 Concrete as measured by MCT.

Sample Id	Minimum Curing Period (days)	Bulk Density (g/cm3)	Potential (cm) 0 (0.00 bars)	-101.97 (-0.10 bars)	-509.87 (-0.50 bars)	-1,019.74 (-1.0 bars)	-5,098.72 (-5.0 bars)	-15,296.16 (-15.0 bars)
			Volumetric Moisture Content (cm^3/cm^3)					
V2M2-080028-1	28	2.26	0.113	0.110	0.109	0.108	0.108	0.107
V2M2-080028-2	28	2.25	0.111	0.108	0.107	0.106	0.105	0.105
V2M2-080028-3	28	2.26	0.109	0.106	0.105	0.105	0.104	0.104

Table 38. Van Genuchten Transport Parameters.

Material	θ_s (cm^3/cm^{-3})	θ_r (cm^3/cm^3)	α (1/cm)	n	m[1]
DDA Saltstone	0.570	0.540	0.150	1.03	0.0291
ARP/MCU Saltstone	0.590	0.585	0.150	1.23	0.1870
MCU Saltstone – INL[2]	0.700	0.550	0.0007	1.12	0.1071
SWPF Saltstone	0.580	0.572	0.150	1.30	0.2308
Vault 1/4 Concrete	0.121	0.115	0.054	1.27	0.2099
Vault 2 Mix 1 Concrete	0.124	0.119	0.006	1.65	0.3951
Vault 2 Mix 2 Concrete	0.111	0.104	0.077	1.24	0.1952

[1]Data analyzed using Mualem relationship between n and m where m = 1 – 1/n.
[2]Analysis of MCU saltstone previously reported by Dixon and Phifer (2007).

Table 39. Recommended Saltstone and Vault Concrete Hydraulic and Physical Parameter Values

Saltstone	Saturated Hydraulic Conductivity [1,2] (cm/s)	Particle Density[2] (g/cm^3)	Dry Bulk Density[3] (g/cm^3)	Porosity[3]	Van Genuchten Transport Parameters[4]
DDA	9.6×10^{-11}	2.37	1.06	0.55	Appendix F
ARP/MCU	8.5×10^{-10}	2.38	0.97	0.59	Appendix F
SWPF[5]	6.0×10^{-09} (1.5×10^{-09})	2.42	1.01	0.58	Appendix F
Vault 1/4	3.1×10^{-10}	2.53	2.24	0.12	Appendix F
Vault 2 Mix 1	1.1×10^{-10}	2.50	2.21	0.12	Appendix F
Vault 2 Mix 2	9.3×10^{-11}	2.50	2.22	0.11	Appendix F

[1]Saturated hydraulic conductivity values for saltstone materials are relative to the concentrated simulants as given in Table 5. The saturated hydraulic conductivity of the vault concretes are relative to tap water.
[2]Logarithmically averaged saturated hydraulic conductivity from Tables 20, 22, 24, 26, 28, and 30. Used 90 day data for saltstone and 28 day data for concrete.
[2]Particle density calculated as $\rho_s = \rho_b/(1-\eta)$ where ρ_b is dry bulk density and η is porosity using 90 day data for saltstone and 28 day for concretes.
[3]Average dry bulk density and porosity from Tables 21, 23, 25, 27, 29, and 31. Used 90 day data for saltstone and 28 day data for concretes.
[4]Characteristic curve data is contained in Appendix F.
[5]The SWPF saturated hydraulic conductivity value provided in parenthesis is the recommended value excluding a potential outlying value. Sample SWPF-TR451-3 had a saturated hydraulic conductivity almost two orders of magnitude greater than that of the other two 90 day samples whereas the difference between the minimum and maximum saturated hydraulic conductivity values for the 90 day DDA and ARP/MCU samples was less than a factor of two. The testing laboratory reported that a prolonged power failure complicated the testing of this sample. Thus, it may be appropriate to exclude this sample from the data set for saturated hydraulic conductivity.

APPENDIX A. DEVELOPMENT OF SALTSTONE PERMEANTS

Miles Denham/SRNL/Srs
03/27/2008 04:45 PM

To Kenneth Dixon/SRNL/Srs@srs
cc Mark Phifer/SRNL/Srs@Srs, John Harbour/SRNL/Srs@Srs, Vickie Williams/SRNL/Srs@Srs, Frances Williams/SRNL/Srs@Srs
bcc
Subject Permeant Simulant for Saltstone Tests

History: This message has been replied to and forwarded.

Ken,

Sorry for the delay in these calculations. I have spent a fair amount of time trying to find appropriate Pitzer parameters to deal with aluminum at such high ionic strengths and trying other calculations to try and get around the lack of appropriate data. I finally gave up and ran calculations with and without aluminum in the original permeant simulant. The following is a summary of the calculations:

1) Saturation Indices in simulant

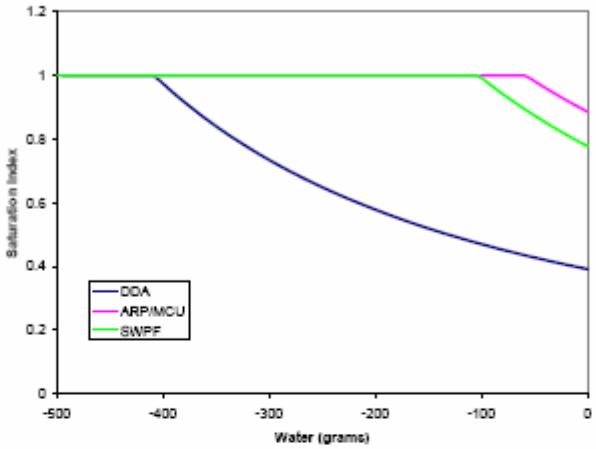
NaNO3	SI (1=saturated)
DDA	0.35
ARP/MCU	0.83
SWPF	0.79

Several aluminum phases are oversaturated according to these calculations, but I have little faith in these because of the lack of appropriate thermdynamic data.

2) Reaction of simulant with simulated cement

Several aluminum-bearing phases precipitate at the expense of CSH -- the net porosity difference being minimal. Again, I am not sure I have faith in this because of the aluminum problem.

3) Removal of water from simulant (no aluminum present) -- this is meant to test whether water removed from any further hydration of the cement will drive NaNO3 to precipitate. The figure below shows that over 40% of the water (400 grams/kg solution) would have to be removed from the DDA simulant to exceed NaNO3 saturation. For the ARP/MCU and the SWPF simulants the amounts are smaller, 10% for SWPF and 6% for ARP/MCU.



Conclusions

1) If John has seen no evidence of aluminum phases precipitating in these simulants, it suggests we can be pretty skeptical of the prediction that aluminum phases will precipitate. If we wanted to be sure, we could leave the aluminum out of the simulants used in the tests. The solution would remain about the same ionic strength and pH.

2) NaNO3 should not precipitate if the DDA simulant is used -- 40% of the water will not be removed even if some cement hydration occurs. This is probably true for the other simulants as well, but they are much closer to saturation with NaNO3.

Recommendation

If John sees no harm in it, remove the aluminum from the simulants. Otherwise, I think they should be fine.

I hope this helps,

Miles

Kenneth Dixon/SRNL/Srs
03/31/2008 01:38 PM

To Miles Denham/SRNL/Srs@Srs, John Harbour/SRNL/Srs@Srs, Mark Phifer/SRNL/Srs@Srs
cc Heather Burns/SRNL/Srs@Srs
bcc
Subject Re: Permeant Simulant for Saltstone Tests

Pursuant to our phone conversation this afternoon, we will eliminate aluminum nitrate nonahydrate and trisodium phosphate dodecahydrate from the DDA, ARP/MCU, and SWPF simulants. Sodium hydroxide will be adjusted as necessary for each simulant based on the elimination of these compounds. These modifications will only be made to the permeants and not to the solution used to batch the samples. Based on calculations performed by Miles Denham, these adjustments appear to be necessary to prevent precipitation issues which could adversely affect our permeability data (see attached e-mail from Denham).

Additionally, we agreed that we should test one DDA sample for hydraulic conductivity with the high pressure head system simultaneous to testing the remaining samples using the standard method. This appears to be prudent based on recent hydraulic conductivity data from John Harbour which suggests that the standard method may not be capable of measuring conductivity values much less than $1X10^{-8}$ cm/sec. If a significant discrepancy is noted between the two methods for the DDA saltstone, we will need to discuss having all samples testing using the high pressure system. If this is necessary, then the schedule will be delayed as the lab can only test one sample at the time with this method.

Ken
5-5205

APPENDIX B. STRENGTH REPORTS

DDA Saltstone Strength Report Page 1

ASR 18-203 (11/07)

Washington Group
Savannah River Site

Summary Report of Testing Activities

Page 1 of 2

[X] Report [ ] Cover Sheet

Approvals (If required)	Work Package No.: N/A
Civil Materials Testing Supervisor: W. L. Mhyre	QCIR No.: N/A
	Project No.: LWIISVOPW
Quality Programs & Civil Materials Testing Manager: W. Pope	Design Category: N/A
	Report No.: 2008-LWIISVOPW-0001 Date: 6-16-08

Lab No.:	080013	Test Method:	N/A
Discipline:	Civil Testing	Description:	Grout Mix Designs
Location:	Bldg. 717-5N	Reported to:	J. Harbour, 819-8420

Summary: The following is a list of the compressive strength test results from 12, 2" X 2" cubes cast from mix DDA. The samples were cast by SRNL at their ACTL facility on 3-18-08.

Mix Design,	Lab. No.,	Cast Date,	Days aged,	Date Tested,	Load, lbs.,	Unit Load, psi
DDA	080013a	3-18-08	14	4-1-08	3,107	820
	080013b		14		3,161	790
	080013c		14		3,046	790
14 Day Average = 800 psi						
DDA	080013d	3-18-08	28	4-15-08	3,621	910
	080013e		28		3,665	940
	080013f		28		3,551	900
28 Day Average = 920 psi						
			N/A			
			N/A			

M&TE: See Coments Page 2	Cal. Due Date: See Coments Page 2	Procedure:	C-QCP-020[1]
NCR No.: N/A		Rev:	0
Test Results: [ ] Conforming [ ] Nonconforming [*X] N/A		PCNs:	N/A
		Specs:	N/A
Remarks: *Data submitted for Engineering Review.		Rev:	N/A
[1]Cubes tested 4-1-08 and 4-15-08 were tested per Procedure C-QCP-020 Rev. 1		DCFs:	N/A
PCN 2.			
N/A			
Inspector (Print/Sign): Charles A. Barkhamer / Charles A. Barkhamer		Level: II	Date: 6-16-08
Reviewer (Print/Sign): W.L. MHYRE W. L. Mhyre		Level: III	Date: 6/16/08

AB 6/23/08

DDA Saltstone Strength Report Page 2

ASR 18-250 (11/07)

Washington Group
Savannah River Site

Page 2 of 2

Summary Report of Testing Activities (Continuation Sheet)

Report Title: Grout Mix Designs Report No.: 2008-LWIISVOPW-0001

Item #	Summary

N/A

Mix Design	Lab No.	Date Cast	Days aged	Date Tested	Load, lbs.	Unit Load, psi
DDA	080013g	3-18-08	56	5-13-08	4145	1060
	080013h		56		4148	1070
	080013i		56		4137	1060
56 Day Average = 1060 psi						
DDA	080013j	3-18-08	90	6-16-08	4065	1020
	080013k		90		4031	1010
	080013l		90		4160	1040
90 Day Average = 1020 psi						

N/A

N/A

Comments: M & TE: TM-4, due 12-28-08; CM-50, due8-30-08; CM-59, due7-26-08; CM-49, due7-28-08; CM-60, due 7-26-08; CDS-167, 9-12-08

N/A

ARP/MCU Saltstone Strength Report Page 1

ASR 18-203 (11/07)

Washington Group
Savannah River Site
Summary Report of Testing Activities

Page 1 of 2

[X] Report [ ] Cover Sheet

Approvals (If required)	Work Package No.: N/A
Civil Materials Testing Supervisor: W. L. Mhyre	QCIR No.: N/A
	Project No.: LWIISVOPW
Quality Programs & Civil Materials Testing Manager: W. Pope	Design Category: N/A
	Report No.: 2008-LWIISVOPW-0002 Date: 7-01-08
Lab No.: 080014	Test Method: N/A
Discipline: Civil Testing	Description: Grout Mix Designs
Location: Bldg. 717-5N	Reported to: J. Harbour, 819-8420

Summary: The following is a list of the compressive strength test results from 12, 2" X 2" cubes cast from mix MCU. The samples were cast by SRNL at their ACTL facility on 3-31-08.

Mix Design	Lab. No.	Cast Date	Days aged	Date Tested	Load, lbs.	Unit Load, psi
MCU	080014a	3-31-08	21	4-21-08	3,720	970
	080014b				3,880	1,000
	080014c				3,636	820
21 Day Average = 960 psi						
MCU	080014d	3-18-08	28	4-28-08	3,956	1,000
	080014e				3,950	1,000
	080014f				3,965	1,030
28 Day Average = 1,010 psi						

N/A

M&TE: See Coments Page 2	Cal. Due Date: See Coments Page 2	Procedure:	C-QCP-020[1]
NCR No.: N/A		Rev:	0
Test Results: [ ] Conforming [ ] Nonconforming [*X] N/A		PCNs:	N/A
		Specs:	N/A
Remarks: *Data submitted for Engineering Review.		Rev:	N/A
[1]Cubes tested 4-21-08 and 4-28-08 were tested per Procedure C-QCP-020 Rev. 1		DCFs:	N/A
PCN 2.			

Inspector (Print/Sign): Charles A. Bookhamer/Charles A. Bookhamer Level: II Date: 7-1-08

Reviewer (Print/Sign): W.L. MHYRE/W. L. Mhyre Level: III Date: 7/01/08

7-2-08

ARP/MCU Saltstone Strength Report Page 2

ASR 18-250 (11/07)

Washington Group
Savannah River Site

Page 2 of 2

Summary Report of Testing Activities (Continuation Sheet)

Report Title: Grout Mix Designs Report No.: 2008-LWIISVOPW-0002

Item #	Summary						
N/A	Mix Design	Lab No.	Date Cast	Days aged	Date Tested	Load, lbs.	Unit Load, psi
	MCU	080014g	3-31-08	57	5-27-08	4,483	1,130
		080014h				4,471	1,120
		080014i				4,696	1,170
	57 Day Average = 1,140 psi						
	MCU	080014j	3-31-08	90	6-30-08	4,758	1,200
		080014k				4,835	1,230
		080014l				4,802	1,210
	90 Day Average = 1,210 psi						

Comments: M & TE: TM-4, due 12-28-08; CM-50, due8-30-08; CM-59, due7-26-08; CM-49, due7-28-08; CM-60, due 7-26-08

7-2-08

SWPF Saltstone Strength Report Page 1

ASR 18-203 (11/07)

Washington Group
Savannah River Site
Summary Report of Testing Activities

Page 1 of 2

☒ Report ☐ Cover Sheet

Approvals (If required)	Work Package No.: N/A
Civil Materials Testing Supervisor: W. L. Mhyre	QCIR No.: N/A
	Project No.: LWIISVOPW
Quality Programs & Civil Materials Testing Manager: W. Pope	Design Category: N/A
	Report No.: 2008-LWIISVOPW-0003 Date: 7/21/08

Lab No.:	080021	Test Method:	N/A
Discipline:	CIVIL TESTING	Description:	GROUT - MIX DESIGNS
Location:	BLDG. 717-5N	Reported to:	J. HARBOUR, 819-8420

Summary: The following is a list of the compressive strength test results from the 12, 2" X 2" cubes cast from mix SWPF. The samples were cast by SRNL at their ACTL facility on 4/22/08.

Mix No.	Lab. No.	Date Cast	Age, days	Date Tested	Load, lb.	Unit Load, psi
SWPF	080021a	4/22/08	14	5/06/08	4,126	1,020
	080021b				4,022	1,000
	080021c				3,967	980
14 Day Average = 1,000 psi						
SWPF	080021d	4/22/08	28	5/20/08	4,870	1,210
	080021e				4,837	1,200
	080021f				4,982	1,230
28 Day Average = 1,210 psi						

M&TE: Refer to comments pg.2	Cal. Due Date: Refer to comments pg.2	Procedure:	C-QCP-020
NCR No.: N/A		Rev:	0
Test Results: ☐ Conforming ☐ Nonconforming ☒ N/A		PCNs:	N/A
		Specs:	N/A
Remarks: *Data submitted for Engineering Review.		Rev:	N/A
		DCFs:	N/A

Inspector (Print/Sign): W.L. MHYRE / W. L. Mhyre Level: III Date: 7/21/08

Reviewer (Print/Sign): Michael Koval / Michael Koval Level: II Date: 7/23/08

7-23-08

SWPF Saltstone Strength Report Page 2

ASR 18-250 (11/07)

Washington Group
Savannah River Site

Page 2 of 2

Summary Report of Testing Activities (Continuation Sheet)

Report Title: Grout Mix Designs Report No.: 2008-LWIISVOPW-0003

Item #	Summary						
N/A	Mix Design	Lab No.	Date Cast	Days aged	Date Tested	Load, lbs.	Unit Load, psi
	SWPF	080021g	4-22-08	56	6-17-08	5,633	1,420
		080021h				5,645	1,420
		080021i				5,925	1,490
	56 Day Average = 1,440 psi						
	SWPF	080021j	4-22-08	90	7-21-08	6,056	1,480
		080021k				5,913	1,450
		080021l				5,947	1,470
	90 Day Average = 1,470 psi						

Comments: M & TE: TM-4, due 12-28-08; CM-50, due8-30-08; CM-59, due7-26-08; CM-49, due7-28-08; CM-60, due 7-26-08

7-23-08

Vault 1/4 Strength Report Page 1

ASR 18-335 (11/07)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 39-(05[e1]) ASTM C 31-(06) ASTM C 143-(05a)
ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a)
ASTM C 192-(07) ASTM C 617-(98(03))
ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(N/A) Page 1 of 2

Report No.:	2008-LWPASR000-0002	Date Molded:	5-5-2008	Work Package No.:	N/A
Report Date:	5-5-2008	Time Molded:	1430	QCIR No.:	N/A
Project No.:	LWPASR000	Mix Design:	Saltstone Vault 1, Mix 4	Design Strength:	5000 psi @ 28 days
Design Category:	N/A	Batch Ticket Number:	N/A	Placement Method:	N/A Contractor: SRNL
Supplier:	LaFarge	Type Admixture(s), (if known):	WRDA35,ADVA380,DAREX II	Acceptance Criteria:	Slump, in. 1-3 / 4-8; Air Content, % 3 to 6 +/- 1; CLSM Flow, in. N/A; Conc./CLSM Temp.,°F Max. 90
Placement Location:	717-5N Civil Lab				2 / 3.0 / N/A / 70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge		Batch Size, yds.	Water Allow. / Water Added, gals.			
N/A	1000	1020	/ N/A	1	N/A	/ N/A	Weather: N/A	Ambient Temp., °F: 68

Inspector (Print/Sign): Michael Koval / Michael Koval Level II Initial Curing: Conforming CDS-167 / 9-12-08
Inspector (Print/Sign): Charles A. Bookhamer / Charles A. Bookhamer Level II Laboratory Curing: Conforming CDS-167 / 9-12-08
Pick-up Date : N/A Time: N/A Initials: N/A Cast in Lab.: Yes [X] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Conc	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080025	14	5/19/2008	8.13	4.00	12.56	93460	7440				X		CAB / II
	14	5/19/2008	8.16	4.00	12.56	86310	6870		X				CAB / II
	28	6/2/2008	8.13	4.00	12.56	109240	8700			X			CAB / II
	28	6/2/2008	8.13	4.00	12.56	109920	8750				X		CAB / II
	56	6/30/2008	8.17	4.00	12.56	127770	10170				X		CAB / II
	56	6/30/2008	8.15	4.00	12.56	128460	10230				X		CAB / II
	90	8/3/2008	8.19	4.00	12.56	120140	9570		X				MK / II

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
44.56	8.28	4.02	145.85	710	2761	32.35	0	33.5	2.8	21.3	3744.75	25.68	.95

M& TE Cal.: SC- 01 10-18-08 TG- 337 7-10-08 AM- 04 7-28-08 UWB- 04 7-28-08 S- 48 6-27-08 CDS- 167 9-12-08 TM- 5 12-27-08

Remarks: 14 Day Avg. = 7160 psi; 28 Day Avg. =8720 psi; 56Day Avg. =10190 psi; 90 Day Avg. =9420 psi.
**Information for Engineering evaluation only.
N/A WSRC-TR-2008-00037

Procedure No. : C-QCP-020 Drawing No.: N/A Specification No.: MK8.14.08 ~~C-SPS-G-00005~~
Rev.: 0 PCN: N/A Rev.: N/A DCF: N/A Rev.: 0 DCF: N/A
Inspector (Print/Sign): Michael Koval / Michael Koval Level II Date: 8-3-08 NCR No.: N/A
Reviewer (Print/Sign): William L. Wilmore / W. L. Wilmore Level III Date: 8/14/08 Test Results: **

8-19-08

Vault 1/4 Concrete Strength Report Page 2

ASR 18-335 (11/07)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 39-(05[e1]) ASTM C 31-(06) ASTM C 143-(05a)
ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a)
ASTM C 192-(07) ASTM C 617-(98(03))
ASTM C 231-(04) ASTM C 1064-(05) MK 8.14.08
ASTM D 6103-(N/A) Page 12 of 2

Report No.:	2008-LWPASR000-0002	Date Molded:	5-5-2008	Work Package No.:	N/A
Report Date:	5-5-2008	Time Molded:	1430	QCIR No.:	N/A
Project No.:	LWPASR000	Mix Design:	Saltstone Vault 1, Mix 4	Design Strength:	5000 psi @ 28 days
Design Category:	N/A	Batch Ticket Number:	N/A	Placement Method:	N/A Contractor: SRNL
Supplier:	LaFarge	Type Admixture(s), (if known):	WRDA35,ADVA380,DAREX II	Acceptance Criteria:	Slump, in. / Air Content, % / CLSM Flow, in. / Conc./CLSM Temp.,°F
Placement Location:	717-5N Civil Lab				1-3 / 4-8 / N/A / Max. 90
					2½ / 3.0 / N/A / 70 68

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.	Weather:	Ambient Temp., °F:
N/A	1000	1020 / N/A	1	N/A / N/A	N/A	~~N/A~~ MK 8.14.08

Inspector (Print/Sign): Michael Koval / Michael Koval Level II Initial Curing: Conforming CDS-167 / 9-12-08
Inspector (Print/Sign): Charles A Beckhamer / Charles A Beckhamer Level II Laboratory Curing: Conforming CDS-167 / 9-12-08
Pick-up Date : N/A Time: N/A Initials: N/A Cast in Lab.: Yes [X] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080025	90	8/3/2008	8.21	4.00	12.56	116640	9290		X				MK/II
	90 spare	8/3/2008	Discard	←								→	Discard
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
44.56	8.28	4.02	145.85	710	2761	32.35	0	33.5	2.8	21.3	3744.75	25.68	.95

M& TE Cal.: SC- 01 10-18-08 TG- 337 7-10-08 AM- 04 7-28-08 UWB- 04 7-28-08 S- 48 6-27-08 CDS- 167 9-12-08 TM- 5 12-27-08

Remarks: 14 Day Avg. = 7160 psi; 28 Day Avg. =8720 psi; 56Day Avg. = 10190 psi; 90 Day Avg. = 9420 psi.
**Information for Engineering evaluation only.
N/A WSRC-TR-2008-00037

Procedure No. :	C-QCP-020	Drawing No.:	N/A	Specification No.:	MK 8.14.08 ~~CSPS-C-00005~~
Rev.: 0 PCN:	N/A	Rev.: N/A DCF:	N/A	Rev.: 0 DCF:	N/A
Inspector (Print/Sign):	Michael Koval / Michael Koval	Level II	Date: 8.3.08	NCR No.:	N/A
Reviewer (Print/Sign):	[illegible]	Level III	Date: 8/4/08	Test Results:	**

8-19-08

Vault 2 Mix 1 Concrete Strength Report Page 1

ASR 18-33.3 (11/07)

ASTM C 39-(05[e1]) ASTM C 31-(06) ASTM C 143-(05a)
ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 192-(07) ASTM C 617-(98(03))
ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(N/A)

Page 1 of 2

Report No.:	2008-LWPASR000-0001	Date Molded:	3-25-2008	Work Package No.:	N/A
Report Date:	3-25-2008	Time Molded:	1600	QCIR No.:	N/A
Project No.:	LWPASR000	Mix Design:	Saltstone Vault 2, Mix 1	Design Strength:	5000 psi @ 28 days
Design Category:	N/A	Batch Ticket Number:	N/A	Placement Method:	N/A Contractor: SRNL
Supplier:	Lehigh, Type V	Type Admixture(s), (if known):	WRDA35,ADVA380,DAREX II	Acceptance Criteria:	Slump, in. 1-3 / 4-8; Air Content, % 3 to 6 +/- 1; CLSM Flow, in. N/A; Conc./CLSM Temp.,°F Max. 90
Placement Location:	717-5N Civil Lab				2 / 7 ; 3.2 ; N/A ; 72

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.	Weather:	Ambient Temp., °F:
N/A	1540	1545 / N/A	1.0	N/A / N/A	N/A	70

Inspector (Print/Sign): Charles A. Bookhamer / Charles A. Bookhamer Level II Initial Curing: Conforming CDS-167 / 9-12-08
Inspector (Print/Sign): Michael Koval / Michael Koval Level II Laboratory Curing: Conforming CDS-167 / 9-12-08
Pick-up Date : N/A Time: N/A Initials: N/A Cast in Lab.: Yes [X] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080010	14	4/8/2008	8.17	4.00	12.56	80220	6390				X		CAB/II
	14	4/8/2008	8.25	4.00	12.56	80330	6400				X		CAB/II
	28	4/22/2008	8.25	4.00	12.56	94880	7550				X		CAB/II
	28	4/22/2008	8.32	4.00	12.56	91800	7310				X		CAB/II
	56	5/20/2008	8.17	4.00	12.56	101100	8050		X				MK/II
	56	5/20/2008	8.09	4.00	12.56	101480	8080		X				MK/II
	90	6/23/2008	8.20	4.00	12.56	118720	9450				X		CAB/II

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
43.12	8.11	4.02	140.74	670	2761	30.5	0	33	3.5	2.5	3689.62	26.22	.97

M& TE Cal.: SC- 01 10-18-08 TG- 337 4-9-08 AM- 04 4-28-08 UWB- 04 4-28-08 S- 80 2-7-09 CDS- 167 9-12-08 TM- 5 12-27-08

Remarks: **14 Day Avg. = 6380 psi; **28 Day Avg. = 7430 psi; **56Day Avg. = 8060 psi; **90 Day Avg. = 9280 psi.
**Information for Engineering evaluation only.
N/A

Procedure No. :	C-QCP-020	Drawing No.:	N/A	Specification No.:	WSRC-TR-2008-00037		
Rev.: 0	PCN: N/A	Rev.: N/A	DCF: N/A	Rev.: 0	DCF: N/A		
Inspector (Print/Sign):	Charles A. Bookhamer / Charles A. Bookhamer	Level II	Date: 6-23-08	NCR No.:	N/A		
Reviewer (Print/Sign):	William L. Mahaffey / William L. Mahaffey	Level III	Date: 7/2/08	Test Results:	**		

7-2-08

Vault 2 Mix 1 Concrete Strength Report Page 2

ASR 18 .33 (11/07)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 39-(05[1]) ASTM C 31-(06) ASTM C 143-(05a)
ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a)
ASTM C 192-(07) ASTM C 617-(98(03))
ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(N/A) Page 2 of 2

Report No.:	2008-LWPASR000-0001	Date Molded:	3-25-2008	Work Package No.:	N/A
Report Date:	3-25-2008	Time Molded:	1600	QCIR No.:	N/A
Project No.:	LWPASR000	Mix Design:	Saltstone Vault 2, Mix 1	Design Strength:	5000 psi @ 28 days
Design Category:	N/A	Batch Ticket Number:	N/A	Placement Method:	N/A Contractor: SRNL
Supplier:	Lehigh, Type V	Type Admixture(s), (if known):	WRDA35,ADVA380,DAREX II	Acceptance Criteria:	Slump, in.: 1-3 / 4-8; 2 / 7 — Air Content, %: 3 to 6 +/- 1; 3.2 — CLSM Flow, in.: N/A; N/A — Conc./CLSM Temp.,°F: Max. 90; 72
Placement Location:	717-5N Civil Lab				

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.	Weather:	Ambient Temp., °F:
N/A	1540	1545 / N/A	1.0	N/A / N/A	N/A	70

Inspector (Print/Sign): Charles A. Bookhamer / Charles A. Bookhamer Level II Initial Curing: Conforming CDS-167 / 9-12-08
Inspector (Print/Sign): Michael Koval / Michael Koval Level II Laboratory Curing: Conforming CDS-167 / 9-12-08
Pick-up Date : N/A Time: N/A Initials: N/A Cast in Lab.: Yes [X] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080010	90	6/23/2008	8.20	4.00	12.56	114530	9120				X		CAB/II
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						
		N/A			N/A		N/A						

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
43.12	8.11	4.02	140.74	670	2778.3	28.5	0	33	3.5	25	3690.26	26.22	.97

M& TE Cal.: SC- 01 10-18-08 TG- 337 4-9-08 AM- 04 4-28-08 UWB- 04 4-28-08 S- 80 2-7-09 CDS- 167 9-12-08 TM- 5 12-27-08

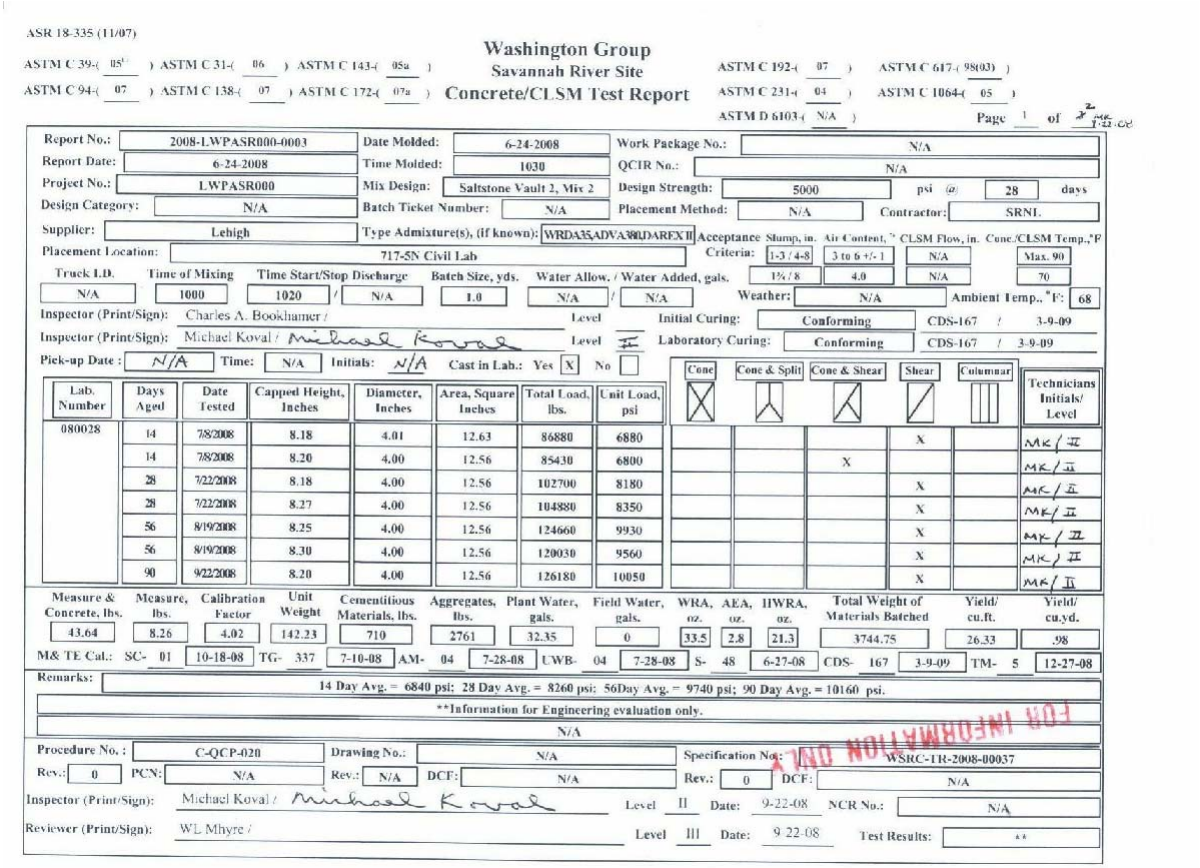
Remarks: **14 Day Avg. = 6380 psi; **28 Day Avg. = 7430 psi; **56Day Avg. = 8060 psi; **90 Day Avg. = 9280 psi.
**Information for Engineering evaluation only.
N/A

Procedure No. :	C-QCP-020	Drawing No.:	N/A	Specification No.:	WSRC-TR-2008-00037		
Rev.:	0	PCN:	N/A	Rev.:	N/A	DCF:	N/A	Rev.:	0	DCF:	N/A

Inspector (Print/Sign): Charles A. Bookhamer / Charles A. Bookhamer Level II Date: 6-23-08 NCR No.: N/A
Reviewer (Print/Sign): William L. Mahaffey / William L. Mahaffey Level III Date: 7/02/08 Test Results: **

7-2-08

Vault 2 Mix 2 Concrete Strength Report Page 1



ASR 18-335 (11/07)

ASTM C 39-(05) ASTM C 31-(06) ASTM C 143-(05a) ASTM C 192-(07) ASTM C 617-(98(03))
ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a) ASTM C 231-(04) ASTM C 1064-(05)
ASTM D 6103-(N/A) Page 1 of 2

Washington Group
Savannah River Site
Concrete/CLSM Test Report

Report No.:	2008-LWPASR000-0003	Date Molded:	6-24-2008	Work Package No.:	N/A		
Report Date:	6-24-2008	Time Molded:	1030	QCIR No.:	N/A		
Project No.:	LWPASR000	Mix Design:	Saltstone Vault 2, Mix 2	Design Strength:	5000 psi @	28	days
Design Category:	N/A	Batch Ticket Number:	N/A	Placement Method:	N/A	Contractor:	SRNL
Supplier:	Lehigh	Type Admixture(s), (if known):	WRDA35,ADVA380,DARFX II	Acceptance Criteria:	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp.,°F
Placement Location:	717-5N Civil Lab				1-3 / 4-8	3 to 6 +/- 1	N/A	Max. 90
					1¾ / 8	4.0	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.	Weather:	Ambient Temp., °F:
N/A	1000	1020 / N/A	1.0	N/A / N/A	N/A	68

Inspector (Print/Sign): Charles A. Bookhamer / Level
Inspector (Print/Sign): Michael Koval / Michael Koval Level II
Pick-up Date: N/A Time: N/A Initials: N/A Cast in Lab.: Yes [X] No [ ]

Initial Curing: Conforming CDS-167 / 3-9-09
Laboratory Curing: Conforming CDS-167 / 3-9-09

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080028	14	7/8/2008	8.18	4.01	12.63	86880	6880				X		MK / II
	14	7/8/2008	8.20	4.00	12.56	85430	6800			X			MK / II
	28	7/22/2008	8.18	4.00	12.56	102700	8180				X		MK / II
	28	7/22/2008	8.27	4.00	12.56	104880	8350				X		MK / II
	56	8/19/2008	8.25	4.00	12.56	124660	9930				X		MK / II
	56	8/19/2008	8.30	4.00	12.56	120030	9560				X		MK / II
	90	9/22/2008	8.20	4.00	12.56	126180	10050				X		MK / II

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
43.64	8.26	4.02	142.23	710	2761	32.35	0	33.5	2.8	21.3	3744.75	26.33	.98

M& TE Cal.: SC- 01 10-18-08 TG- 337 7-10-08 AM- 04 7-28-08 UWB- 04 7-28-08 S- 48 6-27-08 CDS- 167 3-9-09 TM- 5 12-27-08

Remarks: 14 Day Avg. = 6840 psi; 28 Day Avg. = 8260 psi; 56Day Avg. = 9740 psi; 90 Day Avg. = 10160 psi.
**Information for Engineering evaluation only.
N/A

FOR INFORMATION ONLY

Procedure No.: C-QCP-020 Drawing No.: N/A Specification No.: WSRC-TR-2008-00037
Rev.: 0 PCN: N/A Rev.: N/A DCF: N/A Rev.: 0 DCF: N/A
Inspector (Print/Sign): Michael Koval / Michael Koval Level II Date: 9-22-08 NCR No.: N/A
Reviewer (Print/Sign): WL Mhyre / Level III Date: 9-22-08 Test Results:

Vault 2 Mix 2 Concrete Strength Report Page 2

ASR 18-335 (11/07)

ASTM C 39-(05') ASTM C 31-(06) ASTM C 143-(05a) ASTM C 94-(07) ASTM C 138-(07) ASTM C 172-(07a)

Washington Group
Savannah River Site
Concrete/CLSM Test Report

ASTM C 192-(07) ASTM C 617-(98(03)) ASTM C 231-(04) ASTM C 1064-(05) ASTM D 6103-(N/A)

Page 2 of 2

Report No.: 2008-LWPASR000-0003 | Date Molded: 6-24-2008 | Work Package No.: N/A

Report Date: 6-24-2008 | Time Molded: 1030 | QCIR No.: N/A

Project No.: LWPASR000 | Mix Design: Saltstone Vault 2, Mix 2 | Design Strength: 5000 psi @ 28 days

Design Category: N/A | Batch Ticket Number: N/A | Placement Method: N/A | Contractor: SRNL

Supplier: Lehigh | Type Admixture(s), (if known): WRDA35,ADVA380,DAREX II

Placement Location: 717-5N Civil Lab

Acceptance Criteria	Slump, in.	Air Content, %	CLSM Flow, in.	Conc./CLSM Temp.,°F
Criteria	1-3 / 4-8	3 to 6 +/- 1	N/A	Max. 90
Measured	1¾ / 8	4.0	N/A	70

Truck I.D.	Time of Mixing	Time Start/Stop Discharge	Batch Size, yds.	Water Allow. / Water Added, gals.
N/A	1000	1020 / N/A	1.0	N/A / N/A

Weather: N/A | Ambient Temp., °F: 68

Inspector (Print/Sign): Charles A. Bookhamer/ Level

Inspector (Print/Sign): Michael Koval/ Michael Koval Level II

Initial Curing: Conforming CDS-167 / 3-9-09

Laboratory Curing: Conforming CDS-167 / 3-9-09

Pick-up Date: N/A | Time: N/A | Initials: N/A | Cast in Lab.: Yes [X] No [ ]

Lab. Number	Days Aged	Date Tested	Capped Height, Inches	Diameter, Inches	Area, Square Inches	Total Load, lbs.	Unit Load, psi	Cone	Cone & Split	Cone & Shear	Shear	Columnar	Technicians Initials/ Level
080028	90	9/22/2008	8.18	4.00	12.56	128880	10260				X		MK/II
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Measure & Concrete, lbs.	Measure, lbs.	Calibration Factor	Unit Weight	Cementitious Materials, lbs.	Aggregates, lbs.	Plant Water, gals.	Field Water, gals.	WRA, oz.	AEA, oz.	HWRA, oz.	Total Weight of Materials Batched	Yield/ cu.ft.	Yield/ cu.yd.
43.64	8.26	4.02	142.23	710	2761	32.35	0	33.5	2.8	21.3	3744.75	26.33	.98

M& TE Cal.: SC- 01 10-18-08 TG- 337 4-9-08 AM- 04 4-28-08 UWB- 04 4-28-08 S- 80 2-7-09 CDS- 167 3-9-09 TM- 5 12-27-08

Remarks:

**Information for Engineering evaluation only.

N/A

FOR INFORMATION ONLY

Procedure No.: C-QCP-020 | Drawing No.: N/A | Specification No.: WSRC-TR-2008-00037

Rev.: 0 | PCN: N/A | Rev.: N/A | DCF: N/A | Rev.: 0 | DCF: N/A

Inspector (Print/Sign): Michael Koval / Michael Koval Level II Date: 9-22-08 NCR No.: N/A

Reviewer (Print/Sign): WL Mhyre / Level III Date: 9-22-08 Test Results: **

APPENDIX C. MCT DATA SHEETS ON SALTSTONE

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*4/18/2008*
Boring No.	*TR430-1 (DDA)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8584*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.4*
Wet Unit Weight, pcf:	*106.5*
Dry Unit Weight, pcf:	*74.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.4E-08***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 04/18/08
Boring No. TR430-1 (DDA) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8584
Sample Description Grout

Initial Sample Data			Final Sample Data		
Length, in		Diameter, in	Pan No.		T-25
Location 1	3.021	Location 1	2.861	Wet Soil+Pan, grams	554.27
Location 2	3.021	Location 2	2.860	Dry Soil + Pan, grams	389.53
Location3	3.021	Location 3	2.861	Pan Weight, grams	8.23
Average	3.021	Average	2.861	Moisture Content, %	43.2
Volume, in^3	19.42	Wet Soil + Tare, grams	542.85	Dry Unit Weight, pcf	74.8
SG Measured	2.36	Tare Weight, grams	0.00	Saturation,%	105.2
Soil Sample Wt., g	542.85	Dry Soil +Tare, grams	381.30	Diameter, in.	2.861
Dry UW, pcf	74.8	Moisture Content, %	42.4	Length, in.	3.021
Saturation, %	103.2			Volume, in^3	19.42

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used DDA Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Inital Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
1200	1.70	22.40	21.00	1.40	23.3	33.9	31.5	2.70E-08	2.50E-08
3720	1.70	21.00	18.60	2.40	23.3	31.6	27.5	1.66E-08	1.53E-08
10200	1.70	21.00	15.85	5.15	23.3	31.6	22.8	1.42E-08	1.31E-08
21000	1.70	21.00	12.70	8.30	23.3	31.6	17.5	1.26E-08	1.16E-08
30300	1.70	21.00	10.80	10.20	23.3	31.6	14.2	1.17E-08	1.08E-08
84840	1.70	21.00	4.60	16.40	23.9	31.6	3.7	1.13E-08	1.03E-08

Avg. k at 20 °C **1.4E-08 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 41.47 cm^2
L = 7.67 cm
S=L/A= 0.18505 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(2_{sg}-1)$ = 0.0004443 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR430-1 (DDA)
Lab No:	8584	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	04/18/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.021			Tare No.	T-25	
2	3.021	Top	2.861	Tare Weight	0.00	*grams*
3	3.021	Bottom	2.860	Wet Weight + Tare	542.85	*grams*
Average	3.02	Average	2.861	Dry Weight + Tare	381.30	*grams*
				Moisture Content	42.4	%

Total Weight of Soil + Tube Section	542.85	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.20	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	**42.4**	**%**
Wet Density	**106.5**	***pcf***
Dry Density	**74.8**	***pcf***
Specific Gravity	**2.3611**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13-2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*4/18/2008*
Boring No.	*TR430-2 (DDA)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8585*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.3*
Wet Unit Weight, pcf:	*107.1*
Dry Unit Weight, pcf:	*75.2*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***5.9E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 Tested By HJ
Project Name Saltstone Grout & Vault Concrel Test Date 04/18/08
Boring No. TR430-2 (DDA) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8585
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, in		Pan No.	R-64
Location 1	3.049	Location 1	2.875	Wet Soil+Pan, grams	567.38
Location 2	3.040	Location 2	2.878	Dry Soil + Pan, grams	399.17
Location3	3.041	Location 3	2.880	Pan Weight, grams	8.23
Average	3.043	Average	2.878	Moisture Content, %	43.0
Volume, in^3	19.79	Wet Soil + Tare, grams	556.43	Dry Unit Weight, pcf	75.2
SG Measured	2.39	Tare Weight, grams	0.00	Saturation, %	104.6
Soil Sample Wt., g	556.43	Dry Soil +Tare, grams	390.94	Diameter, in.	2.878
Dry UW, pcf	75.2	Moisture Content, %	42.3	Length, in.	3.043
Saturation, %	102.9			Volume, in^3	19.79

Consolidation	
Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used DDA Simulant

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
2400	1.70	22.10	22.05	0.05	24.4	33.2	33.1	4.71E-10	4.24E-10
7800	1.70	22.10	21.85	0.25	24.4	33.2	32.7	7.28E-10	6.56E-10
76080	1.70	22.10	19.60	2.50	23.6	33.2	28.9	7.93E-10	7.29E-10
93600	1.70	22.10	19.10	3.00	23.9	33.2	28.1	7.85E-10	7.16E-10
328740	1.70	22.10	15.40	6.70	23.9	33.2	21.8	5.63E-10	5.13E-10
348060	1.70	22.10	15.15	6.95	23.6	33.2	21.4	5.6E-10	5.11E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 5.9E-10 cm/sec

a_s = 0.76712 cm^2
A = 41.96 cm^2
L = 7.73 cm
S=L/A= 0.18422 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0004423 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR430-2 (DDA)
Lab No:	8585	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	04/18/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.049			Tare No.	R-64	
2	3.04	Top	2.875	Tare Weight	0.00	*grams*
3	3.041	Bottom	2.880	Wet Weight + Tare	556.43	*grams*
Average	3.04	Average	2.878	Dry Weight + Tare	390.94	*grams*
				Moisture Content	42.3	%

Total Weight of Soil + Tube Section	556.43	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.23	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

Moisture Content	**42.3**	**%**
Wet Density	**107.1**	***pcf***
Dry Density	**75.3**	***pcf***
Specific Gravity	**2.392145**	
Porosity	**0.50**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*4/18/2008*
Boring No.	*TR430-3 (DDA)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8586*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.5*
Wet Unit Weight, pcf:	*107.1*
Dry Unit Weight, pcf:	*75.1*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concreti Test Date 04/18/08
Boring No. TR430-3 (DDA) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8586
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, in		Pan No.	T-7
Location 1	2.908	Location 1	2.854	Wet Soil+Pan, grams	535.05
Location 2	2.902	Location 2	2.858	Dry Soil + Pan, grams	375.80
Location3	2.908	Location 3	2.860	Pan Weight, grams	8.31
Average	2.906	Average	2.857	Moisture Content, %	43.3
Volume, in^3	18.63	Wet Soil + Tare, grams	523.84	Dry Unit Weight, pcf	75.1
SG Measured	2.40	Tare Weight, grams	0.00	Saturation, %	104.8
Soil Sample Wt., g	523.84	Dry Soil +Tare, grams	367.49	Diameter, in.	2.857
Dry UW, pcf	75.1	Moisture Content, %	42.5	Length, in.	2.906
Saturation, %	102.9			Volume, in^3	18.63

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used DDA Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
2100	1.70	22.20	21.80	0.40	23.8	34.9	34.2	4.19E-09	3.83E-09
6210	1.70	21.80	21.00	0.80	23.8	34.2	32.8	2.92E-09	2.67E-09
15120	1.70	21.80	20.50	1.30	23.8	34.2	31.9	1.97E-09	1.80E-09
20220	1.70	21.80	20.30	1.50	23.8	34.2	31.6	1.71E-09	1.57E-09
27480	1.70	21.80	20.00	1.80	23.8	34.2	31.0	1.53E-09	1.39E-09
81060	1.70	21.80	18.50	3.30	23.3	34.2	28.4	9.90E-10	9.16E-10

Avg. k at 20 °C **2.0E-09 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 41.37 cm^2
L = 7.38 cm
S=L/A= 0.17842 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0004284 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR430-3 (DDA)
Lab No:	8586	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	04/18/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.908			Tare No.	T-7	
2	2.902	Top	2.854	Tare Weight	0.00	*grams*
3	2.908	Bottom	2.860	Wet Weight + Tare	523.84	*grams*
Average	2.91	Average	2.857	Dry Weight + Tare	367.49	*grams*
				Moisture Content	42.5	%

Total Weight of Soil + Tube Section	523.84	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.15	*lbs*
Volume of Sample	0.011	ft^3

RESULT SUMMARY

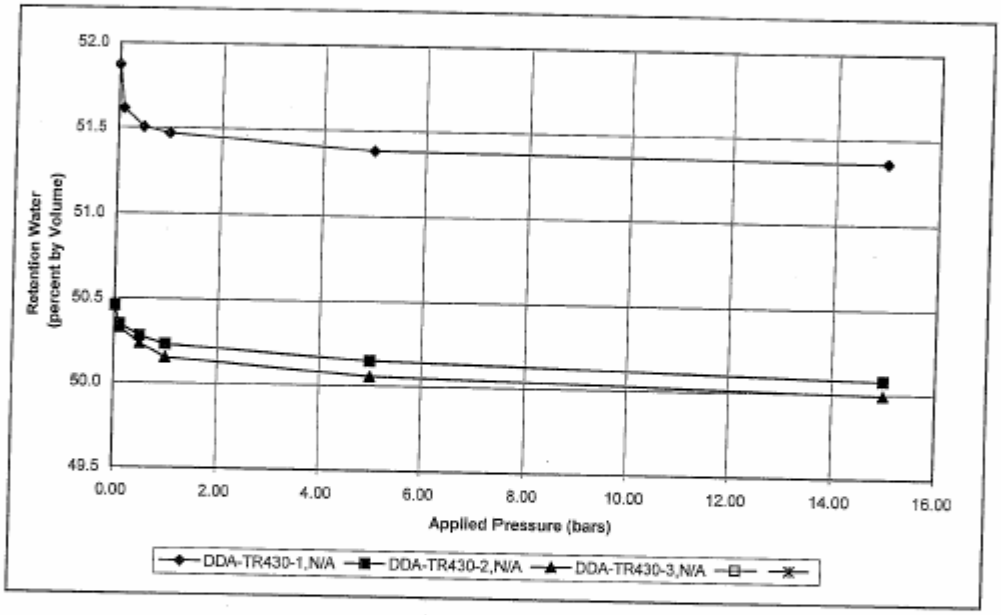
Moisture Content	**42.5**	**%**
Wet Density	**107.1**	***pcf***
Dry Density	**75.1**	***pcf***
Specific Gravity	**2.396608**	
Porosity	**0.50**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	5/21/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
DDA-TR430-1,N/A	51.9	76.1	51.9	51.6	51.5	51.5	51.4	51.4
DDA-TR430-2,N/A	50.5	75.3	50.5	50.3	50.3	50.2	50.1	50.1
DDA-TR430-3,N/A	50.5	74.8	50.5	50.3	50.2	50.2	50.1	50.0

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	5/21/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	DDA-TR430-1	DDA-TR430-2	DDA-TR430-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8584	8585	8586		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.224	7.328	7.303		
Container Height, (cm)	2.198	2.373	2.273		
Container Volume (cm^3)	90.09	100.08	95.21		
Wt. of Wet Soil + Container (g)	156.54	171.31	162.21		
Wt. of Dry Soil + Container (g)	109.81	120.81	114.15		
Moisture Content (%)	42.6	41.8	42.1		
Dry Unit Weight (pcf)	76.06	75.32	74.81		
Initial Wt.Wet Soil + Container (g)	156.54	171.31	162.21		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	51.9	50.5	50.5		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure	psi	0	1.45	7.25	14.5	72.5	217.5				
		bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By											
8584	Weight of Soil + Ring		156.54	156.31	156.21	156.18	156.1	156.08				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		51.9	51.6	51.5	51.5	51.4	51.4				
8585	Weight of Soil + Ring		171.31	171.2	171.13	171.08	171	170.93				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		50.5	50.3	50.3	50.2	50.1	50.1				
8586	Weight of Soil + Ring		162.21	162.07	161.98	161.9	161.81	161.75				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		50.5	50.3	50.2	50.2	50.1	50.0				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*7/24/2008*
Boring No.	*TR431-1 (DDA)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8878*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*41.0*
Wet Unit Weight, pcf:	*106.6*
Dry Unit Weight, pcf:	*75.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.1E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 07/24/08
Boring No. TR431-1 (DDA) Reviewed By JW
Sample No. Core Age 90 Days Review Date 10/14/08
Sample Depth n/a Lab No. 8878
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, in		Pan No.	LJ-20
Location 1	2.430	Location 1	2.894	Wet Soil+Pan, grams	456.34
Location 2	2.431	Location 2	2.893	Dry Soil + Pan, grams	325.50
Location3	2.431	Location 3	2.894	Pan Weight, grams	8.34
Average	2.431	Average	2.894	Moisture Content, %	41.3
Volume, in^3	15.98	Wet Soil + Tare, grams	447.21	Dry Unit Weight, pcf	75.6
SG Measured	2.34	Tare Weight, grams	0.00	Saturation, %	103.5
Soil Sample Wt., g	447.21	Dry Soil +Tare, grams	317.16	Diameter, in.	2.894
Dry UW, pcf	75.6	Moisture Content, %	41.0	Length, in.	2.431
Saturation, %	102.9			Volume, in^3	15.99

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used DDA Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Initial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
10800	1.70	23.30	23.20	0.10	23.2	44.0	43.8	1.56E-10	1.45E-10
65820	1.70	23.30	22.90	0.40	23.2	44.0	43.1	1.03E-10	9.58E-11
95640	1.70	23.30	22.70	0.60	23.2	44.0	42.7	1.07E-10	9.93E-11
161760	1.70	23.30	22.30	1.00	23.2	44.0	41.9	1.07E-10	9.89E-11
239280	1.70	23.30	21.65	1.65	25.5	44.0	40.5	1.21E-10	1.06E-10

Avg. k at 20 °C 1.1E-10 cm/sec

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2 n_p = 0.031416 cm^2
A = 42.42 cm^2 M_1 = 0.03018
L = 6.17 cm M_2 = 1.04095
S=L/A= 0.14552 1/cm $C_c = M_1 S/(G_{Hg}-1)$ = 0.0003494 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR431-1 (DDA)
Lab No:	8878	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	07/24/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.43			Tare No.	LJ-20	
2	2.431	Top	2.894	Tare Weight	0.00	*grams*
3	2.431	Bottom	2.894	Wet Weight + Tare	447.21	*grams*
Average	2.43	Average	2.894	Dry Weight + Tare	317.16	*grams*
				Moisture Content	41.0	%

Total Weight of Soil + Tube Section	447.21	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.99	*lbs*
Volume of Sample	0.009	ft^3

RESULT SUMMARY

Moisture Content	**41.0**	**%**
Wet Density	**106.6**	***pcf***
Dry Density	**75.6**	***pcf***
Specific Gravity	**2.341953**	
Porosity	**0.48**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concreti Test Date 07/24/08
Boring No. TR431-2 (DDA) Reviewed By JW
Sample No. Core Age 90 Days Review Date 10/14/08
Sample Depth n/a Lab No. 8879
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, in		Pan No.	DB-14
Location 1	2.485	Location 1	2.868	Wet Soil+Pan, grams	458.24
Location 2	2.485	Location 2	2.768	Dry Soil + Pan, grams	326.80
Location3	2.485	Location 3	2.868	Pan Weight, grams	8.24
Average	2.485	Average	2.834	Moisture Content, %	41.3
Volume, in^3	15.67	Wet Soil + Tare, grams	449.80	Dry Unit Weight, pcf	77.4
SG Measured	2.48	Tare Weight, grams	0.00	Saturation, %	102.3
Soil Sample Wt., g	449.80	Dry Soil +Tare, grams	318.56	Diameter, in.	2.4845
Dry UW, pcf	77.4	Moisture Content, %	41.2	Length, in.	2.8675
Saturation, %	102.1			Volume, in^3	24.51

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used DDA Simulant

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
77400	1.70	25.10	24.70	0.40	23.2	46.6	45.8	8.64E-11	8.00E-11
105420	1.70	25.10	24.60	0.50	23.2	46.6	45.6	7.94E-11	7.36E-11
164580	1.70	25.10	24.35	0.75	23.2	46.6	45.1	7.68E-11	7.11E-11
195360	1.70	25.10	24.20	0.90	23.2	46.6	44.7	7.79E-11	7.22E-11
261060	1.70	25.10	24.00	1.10	23.2	46.6	44.3	7.15E-11	6.63E-11
283260	1.70	25.10	23.90	1.20	23.2	46.6	44.1	7.21E-11	6.68E-11

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 7.2E-11 cm/sec

a_s = 0.76712 cm^2
A = 40.70 cm^2
L = 6.31 cm
S=L/A= 0.15505 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0003723 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR431-2 (DDA)
Lab No:	8879	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	07/24/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.485			Tare No.	DB-14	
2	2.485	Top	2.868	Tare Weight	0.00	*grams*
3	2.485	Bottom	2.800	Wet Weight + Tare	449.80	*grams*
Average	2.49	Average	2.834	Dry Weight + Tare	318.56	*grams*
				Moisture Content	41.2	%

Total Weight of Soil + Tube Section	449.80	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.99	*lbs*
Volume of Sample	0.009	ft^3

RESULT SUMMARY

Moisture Content	**41.2**	*%*
Wet Density	**109.3**	*pcf*
Dry Density	**77.4**	*pcf*
Specific Gravity	**2.484399**	
Porosity	**0.50**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/21/2008*
Boring No.	*TR431-3 (DDA)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*N/A*	Lab No.	*8880*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*41.4*
Wet Unit Weight, pcf:	*107.2*
Dry Unit Weight, pcf:	*75.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.1E-10***

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*7/24/2008*
Boring No.	*TR431-2 (DDA)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8879*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*41.2*
Wet Unit Weight, pcf:	*109.3*
Dry Unit Weight, pcf:	*77.4*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***7.2E-11***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number	6155-08-0031 DO 2	Tested By	HJ
Project Name	Saltstone Grout & Vault Concrete	Test Date	08/21/08
Boring No.	TR431-3 (DDA)	Reviewed By	JW
Sample No.	Core Age 90 Days	Review Date	10/14/08
Sample Depth	N/A	Lab No.	8880
Sample Description	Grout		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	T-3
Location 1	2.479	Location 1	2.861	Wet Soil+Pan, grams	496.25
Location 2	2.461	Location 2	2.859	Dry Soil + Pan, grams	368.78
Location3	2.508	Location 3	2.864	Pan Weight, grams	51.11
Average	2.483	Average	2.861	Moisture Content, %	40.1
Volume, in^3	15.96	Wet Soil + Tare, grams	449.19	Dry Unit Weight, pcf	75.8
SG Measured	2.37	Tare Weight, grams	0.00	Saturation, %	100.0
Soil Sample Wt., g	449.15	Dry Soil +Tare, grams	317.67	Diameter, in.	2.861
Dry UW, pcf	75.8	Moisture Content, %	41.4	Length, in.	2.483
Saturation, %	103.2			Volume, in^3	15.96

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used: DDA Simulant

Elapsed Time (sec)	z_e (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
16200	1.70	21.90	21.80	0.10	23.2	40.3	40.1	1.16E-10	1.08E-10
70440	1.70	21.90	21.50	0.40	23.2	40.3	39.4	1.08E-10	1.00E-10
100560	1.70	21.90	21.20	0.70	23.2	40.3	38.8	1.33E-10	1.24E-10
230760	1.70	24.40	22.80	1.60	23.2	45.3	41.9	1.21E-10	1.12E-10
316680	1.70	24.40	22.40	2.00	23.2	45.3	41.1	1.11E-10	1.03E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C **1.1E-10** **cm/sec**

a_s = 0.76712 cm^2
A = 41.47 cm^2
L = 6.31 cm
S=L/A= 0.15205 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0003651 for 15° to 25°

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR431-3 (DDA)
Lab No:	8880	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	08/21/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.479			Tare No.	T-3	
2	2.461	Top	2.861	Tare Weight	0.00	*grams*
3	2.508	Bottom	2.861	Wet Weight + Tare	449.19	*grams*
Average	2.48	Average	2.861	Dry Weight + Tare	317.67	*grams*
				Moisture Content	41.4	*%*

Total Weight of Soil + Tube Section	449.19	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.99	*lbs*
Volume of Sample	0.009	ft^3

RESULT SUMMARY

Moisture Content	**41.4**	**%**
Wet Density	**107.2**	***pcf***
Dry Density	**75.8**	***pcf***
Specific Gravity	**2.371823**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	TR431-1	TR431-2	TR431-3		
Depth (ft)	[illegible](DOA)	90 dyes(DOA)	[illegible](DOA)		
Lab No.	8878	8879	8880		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.340	7.292	7.246		
Container Height, (cm)	1.921	1.733	2.228		
Container Volume (cm^3)	81.28	72.37	91.88		
Wt. of Wet Soil + Container (g)	139.19	123.89	156.27		
Wt. of Dry Soil + Container (g)	97.68	86.93	109.20		
Moisture Content (%)	42.5	42.5	43.1		
Dry Unit Weight (pcf)	74.99	74.95	74.17		
Initial Wt.Wet Soil + Container (g)	139.19	129.89	156.27		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	51.1	59.4	51.2		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

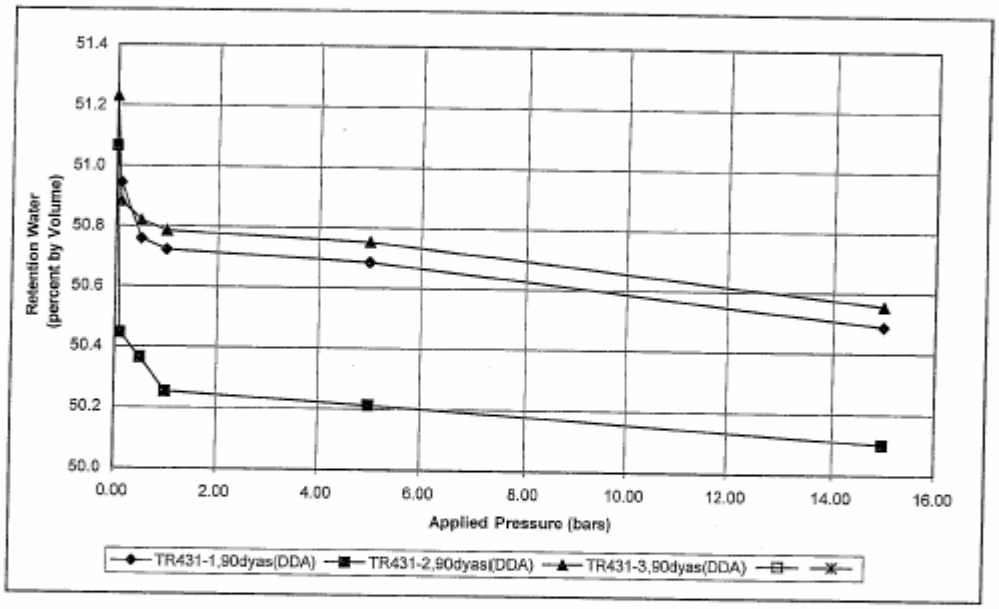
Lab No.	Pressure psi	0	1.45	7.25	14.5	72.5	217.5				
	bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By										
8878	Weight of Soil + Ring	139.19	139.09	138.94	138.91	138.88	138.72				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.1	50.9	50.8	50.7	50.7	50.5				
8879	Weight of Soil + Ring	123.89	123.44	123.38	123.3	123.27	123.19				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.1	50.4	50.4	50.3	50.2	50.1				
8880	Weight of Soil + Ring	156.27	155.95	155.89	155.88	155.83	155.65				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.2	50.9	50.8	50.8	50.8	50.6				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
TR431-1,90dyas(DDA)	51.1	75.0	51.1	50.9	50.8	50.7	50.7	50.5
TR431-2,90dyas(DDA)	59.4	75.0	51.1	50.4	50.4	50.3	50.2	50.1
TR431-3,90dyas(DDA)	51.2	74.2	51.2	50.9	50.8	50.8	50.8	50.6

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*5/5/2008*
Boring No.	*TR436-1 (MCU)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8591*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*39.6*
Wet Unit Weight, pcf:	*106.8*
Dry Unit Weight, pcf:	*76.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***5.4E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 05/05/08
Boring No. TR436-1 (MCU) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8591
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, in		Pan No.	AD-1
Location 1	3.638	Location 1	2.894	Wet Soil+Pan, grams	792.00
Location 2	3.636	Location 2	2.887	Dry Soil + Pan, grams	592.38
Location3	3.640	Location 3	2.887	Pan Weight, grams	113.4
Average	3.638	Average	2.889	Moisture Content, %	41.7
Volume, in^3	23.85	Wet Soil + Tare, grams	668.47	Dry Unit Weight, pcf	76.5
SG Measured	2.30	Tare Weight, grams	0.00	Saturation, %	109.2
Soil Sample Wt., g	668.47	Dry Soil +Tare, grams	478.98	Diameter, in.	2.889
Dry UW, pcf	76.5	Moisture Content, %	39.6	Length, in.	3.638
Saturation, %	103.7			Volume, in^3	23.85

Consolidation

Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used MCU Simulant

Elapsed Time (sec)	z_o (cm)	z_a (cm)	z_b (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
2880	1.70	24.20	23.50	0.70	23.3	30.6	29.6	6.00E-09	5.54E-09
6960	1.70	24.20	22.90	1.30	23.3	30.6	28.8	4.67E-09	4.32E-09
13260	1.70	24.20	21.55	2.65	23.3	30.6	26.9	5.17E-09	4.78E-09
71220	1.70	24.20	9.90	14.30	23.9	30.6	10.4	7.98E-09	7.28E-09
9540	1.70	10.80	10.00	0.80	23.3	12.4	11.2	5.28E-09	4.88E-09

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C **5.4E-09 cm/sec**

a_s = 0.76712 cm^2
A = 42.30 cm^2
L = 9.24 cm
S=L/A= 0.21845 1/cm

a_p = 0.031416 cm^2
M_i = 0.03018
M_f = 1.04095
$C = M_i S/(G_{Hg}-1)$ = 0.0005245 for 15° to 25°

Remarks:

Subcontract No. ACS4317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR436-1 (MCU)
Lab No:	8591	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	05/05/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.638			Tare No.	AD-1	
2	3.636	Top	2.894	Tare Weight	0.00	*grams*
3	3.64	Bottom	2.884	Wet Weight + Tare	668.47	*grams*
Average	3.64	Average	2.889	Dry Weight + Tare	478.98	*grams*
				Moisture Content	39.6	*%*

Total Weight of Soil + Tube Section	668.47	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.47	*lbs*
Volume of Sample	0.014	ft^3

RESULT SUMMARY

Moisture Content	**39.6**	*%*
Wet Density	**106.8**	*pcf*
Dry Density	**76.5**	*pcf*
Specific Gravity	**2.30378**	
Porosity	**0.47**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*5/5/2008*
Boring No.	*TR436-2 (MCU)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8592*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*40.0*
Wet Unit Weight, pcf:	*107.1*
Dry Unit Weight, pcf:	*76.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.1E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 05/05/08
Boring No. TR436-2 (MCU) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8592
Sample Description Grout

Initial Sample Data			
Length, in		Diameter, in	
Location 1	3.902	Location 1	2.884
Location 2	3.903	Location 2	2.887
Location3	3.900	Location 3	2.888
Average	3.902	Average	2.886
Volume, in^3	25.52	Wet Soil + Tare, grams	717.48
SG Measured	2.33	Tare Weight, grams	0.00
Soil Sample Wt., g	717.48	Dry Soil +Tare, grams	512.52
Dry UW, pcf	76.5	Moisture Content, %	40.0
Saturation, %	103.6		

Final Sample Data		
Pan No.		X-19
Wet Soil+Pan, grams		771.35
Dry Soil + Pan, grams		560.26
Pan Weight, grams		47.74
Moisture Content, %		41.2
Dry Unit Weight, pcf		76.5
Saturation, %		106.7
Diameter, in.		2.886
Length, in.		3.902
Volume, in^3		25.52

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used MCU Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Initial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
3480	1.70	23.60	22.90	0.70	23.6	27.8	26.9	5.48E-09	5.03E-09
7920	1.70	22.90	22.30	0.60	23.6	26.9	26.1	2.13E-09	1.95E-09
65400	1.70	22.90	19.30	3.60	23.6	26.9	22.1	1.68E-09	1.54E-09
97500	1.70	22.90	18.10	4.80	23.6	26.9	20.6	1.55E-09	1.43E-09
158760	1.70	22.90	16.15	6.75	23.3	26.9	18.0	1.43E-09	1.32E-09
175500	1.70	22.90	15.65	7.25	23.3	26.9	17.3	1.41E-09	1.31E-09

Avg. k at 20 °C **2.1E-09 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 42.20 cm^2
L = 9.91 cm
S=L/A= 0.23481 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
C = $M_2S/(G_{sg}-1)$ = 0.0005638 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR436-2 (MCU)
Lab No:	8592	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	05/05/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.902			Tare No.	X-19	
2	3.903	Top	2.884	Tare Weight	0.00	*grams*
3	3.9	Bottom	2.888	Wet Weight + Tare	717.48	*grams*
Average	3.90	Average	2.886	Dry Weight + Tare	512.52	*grams*
				Moisture Content	40.0	*%*

Total Weight of Soil + Tube Section	717.48	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.58	*lbs*
Volume of Sample	0.015	ft^3

RESULT SUMMARY

Moisture Content	**40.0**	**%**
Wet Density	**107.1**	***pcf***
Dry Density	**76.5**	***pcf***
Specific Gravity	**2.327971**	
Porosity	**0.47**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*5/5/2008*
Boring No.	*TR436-3 (MCU)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8593*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*39.6*
Wet Unit Weight, pcf:	*105.4*
Dry Unit Weight, pcf:	*75.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.7E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concreti Test Date 05/05/08
Boring No. TR436-3 (MCU) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8593
Sample Description Grout

Initial Sample Data			
Length, in		Diameter, in	
Location 1	3.705	Location 1	2.880
Location 2	3.703	Location 2	2.883
Location3	3.701	Location 3	2.885
Average	3.703	Average	2.882
Volume, in³	24.16	Wet Soil + Tare, grams	681.38
SG Measured	2.34	Tare Weight, grams	0.00
Soil Sample Wt., g	681.38	Dry Soil +Tare, grams	488.11
Dry UW, pcf	77.0	Moisture Content, %	39.6
Saturation, %	103.3		

Final Sample Data	
Pan No.	AB-3
Wet Soil+Pan, grams	776.15
Dry Soil + Pan, grams	573.23
Pan Weight, grams	85.12
Moisture Content, %	41.6
Dry Unit Weight, pcf	77.0
Saturation, %	108.5
Diameter, in.	2.882
Length, in.	3.703
Volume, in³	24.16

Consolidation	
Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used MCU Simulant

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Initial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
225600	1.70	27.75	24.90	2.85	23.3	34.8	30.9	2.87E-10	2.66E-10
15960	1.70	24.90	24.70	0.20	23.3	31.0	30.7	3.03E-10	2.80E-10
20040	1.70	24.90	24.65	0.25	23.3	31.0	30.7	3.02E-10	2.79E-10
84240	1.70	24.90	24.00	0.90	23.9	31.0	29.8	2.62E-10	2.39E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
4	Core	N/A	N/A	Vertical

Avg. k at 20 °C **2.7E-10 cm/sec**

a_s = 0.76712 cm²
A = 42.10 cm²
L = 9.41 cm
S=L/A= 0.22342 1/cm

a_p= 0.031416 cm²
M_1= 0.03018
M_2= 1.04095
$C = M_1S/(G_{tg}-1)$= 0.0005364 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR436-3 (MCU)
Lab No:	8593	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	05/05/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.705			Tare No.	AB-3	
2	3.703	Top	2.880	Tare Weight	0.00	*grams*
3	3.701	Bottom	2.885	Wet Weight + Tare	681.38	*grams*
Average	3.70	Average	2.883	Dry Weight + Tare	488.11	*grams*
				Moisture Content	39.6	%

Total Weight of Soil + Tube Section	681.38	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.50	*lbs*
Volume of Sample	0.014	ft^3

RESULT SUMMARY

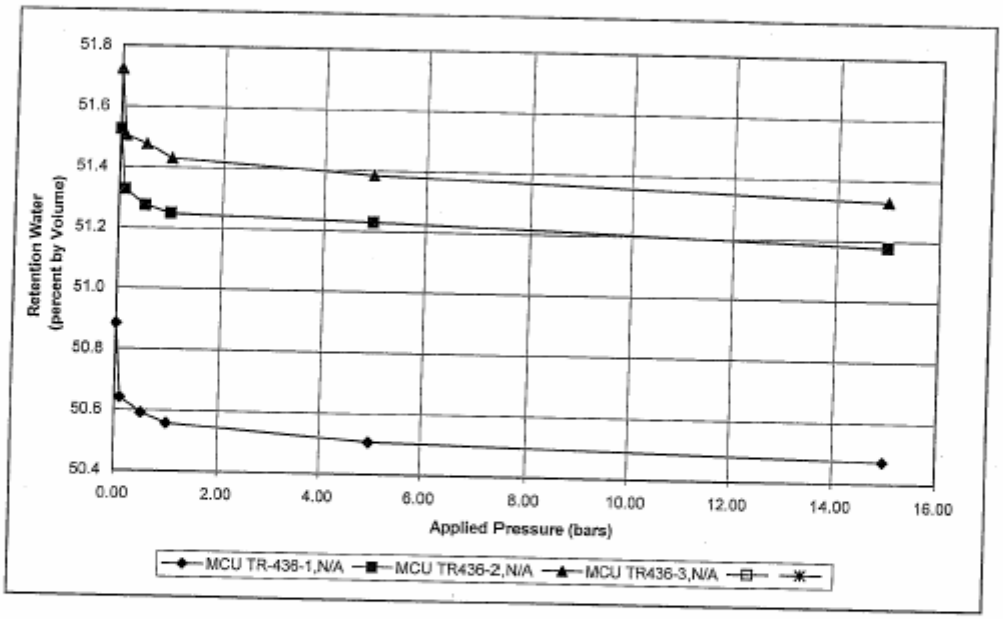
Moisture Content	**39.6**	*%*
Wet Density	**107.4**	*pcf*
Dry Density	**76.9**	*pcf*
Specific Gravity	**2.338571**	
Porosity	**0.47**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	5/21/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
MCU TR-436-1,N/A	50.9	75.7	50.9	50.6	50.6	50.6	50.5	50.5
MCU TR436-2,N/A	51.5	75.7	51.5	51.3	51.3	51.2	51.2	51.2
MCU TR436-3,N/A	51.7	76.2	51.7	51.5	51.5	51.4	51.4	51.3

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No 6155-08-0031 DO2
Tested By HJ/JW
Reviewed By JW

Project Name Saltstone Grout & Vault Concrete
Test Date 5/21/2008
Review Date 10/14/2008

Sample No.	MCU TR-436-1	MCU TR436-2	MCU TR436-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8591	8592	9583		
Ring No.	N/A	N/A	N/A		
Container Weight (g)	0	0	0		
Container Diameter (cm)	7.339	7.318	7.317		
Container Height (cm)	2.812	2.739	2.595		
Container Volume (cm^3)	118.95	115.20	109.12		
Wt. of Wet Soil + Container (g)	204.75	199.12	189.77		
Wt. of Dry Soil + Container (g)	144.22	139.76	133.33		
Moisture Content (%)	42.0	42.5	42.3		
Dry Unit Weight (pcf)	75.65	75.70	76.25		
Initial Wt.Wet Soil + Container (g)	204.75	199.12	189.77		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	50.9	51.5	51.7		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure psi	0	1.45	7.25	14.5	72.5	217.5				
	bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By										
8591	Weight of Soil + Ring	204.75	204.46	204.4	204.36	204.3	204.26				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	50.9	50.8	50.8	50.8	50.5	50.5				
8592	Weight of Soil + Ring	199.12	198.89	198.83	198.8	198.78	198.72				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.5	51.3	51.3	51.2	51.2	51.2				
9583	Weight of Soil + Ring	189.77	189.53	189.5	189.45	189.4	189.34				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.7	51.5	51.5	51.4	51.4	51.3				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*BM*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/19/2008*
Boring No.	*TR437-1 (MCU)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8884*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.4*
Wet Unit Weight, pcf:	*106.7*
Dry Unit Weight, pcf:	*75.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.1E-09***

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By BM

Project Name Saltstone Grout & Vault Concrete Test Date 08/19/08

Boring No. TR437-1 (MCU) Reviewed By JW

Sample No. Core Age 90 Days Review Date 10/14/08

Sample Depth n/a Lab No. 8884

Sample Description Grout

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	AB-11
Location 1	2.203	Location 1	2.902	Wet Soil+Pan, grams	496.68
Location 2	2.217	Location 2	2.889	Dry Soil + Pan, grams	372.82
Location3	2.226	Location 3	2.893	Pan Weight, grams	85.95
Average	2.215	Average	2.895	Moisture Content, %	43.2
Volume, in^3	14.58	Wet Soil + Tare, grams	408.39	Dry Unit Weight, pcf	75.0
SG Measured	2.35	Tare Weight, grams	0.00	Saturation, %	106.2
Soil Sample Wt., g	408.39	Dry Soil +Tare, grams	286.87	Diameter, in.	2.895
Dry UW, pcf	75.0	Moisture Content, %	42.4	Length, in.	2.215
Saturation, %	104.2			Volume, in^3	14.58

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used MCU

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
7800	1.70	24.20	23.50	0.70	22.5	50.3	48.6	1.34E-09	1.27E-09
18060	1.70	24.20	22.70	1.50	22.5	50.3	46.8	1.27E-09	1.19E-09
72180	1.70	24.20	19.50	4.70	22.0	50.3	39.3	1.08E-09	1.03E-09
102900	1.70	24.20	18.00	6.20	23.0	50.3	35.9	1.05E-09	9.73E-10
159540	1.70	24.20	15.70	8.50	23.0	50.3	30.5	9.96E-10	9.28E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C **1.1E-09 cm/sec**

a_s = 0.76712 cm^2 a_p = 0.031416 cm^2

A = 42.45 cm^2 M_1 = 0.03018

L = 5.63 cm M_2 = 1.04095

S=L/A= 0.13253 1/cm $C = M_1S/(G_{fg}-1)$ = 0.0003182 for 15° to 25°

Remarks:

Subcontract No. AC54317N

Specification No. K-SPC-G-0013

Revision 10 08-13-2007

Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By BM
Project Name Saltstone Grout & Vault Concrete Test Date 08/19/08
Boring No. TR437-1 (MCU) Reviewed By JW
Sample No. Core Age 90 Days Review Date 10/14/08
Sample Depth n/a Lab No. 8884
Sample Description Grout

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	AB-11
Location 1	2.203	Location 1	2.902	Wet Soil+Pan, grams	496.68
Location 2	2.217	Location 2	2.889	Dry Soil + Pan, grams	372.82
Location3	2.226	Location 3	2.893	Pan Weight, grams	85.95
Average	2.215	Average	2.895	Moisture Content, %	43.2
Volume, in^3	14.58	Wet Soil + Tare, grams	408.39	Dry Unit Weight, pcf	75.0
SG Measured	2.35	Tare Weight, grams	0.00	Saturation, %	106.2
Soil Sample Wt., g	408.39	Dry Soil +Tare, grams	286.87	Diameter, in.	2.895
Dry UW, pcf	75.0	Moisture Content, %	42.4	Length, in.	2.215
Saturation, %	104.2			Volume, in^3	

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used MCU

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
7800	1.70	24.20	23.50	0.70	22.5	50.3	48.6	1.34E-09	1.27E-09
18060	1.70	24.20	22.70	1.50	22.5	50.3	46.8	1.27E-09	1.19E-09
72180	1.70	24.20	19.50	4.70	22.0	50.3	39.3	1.08E-09	1.03E-09
102900	1.70	24.20	18.00	6.20	23.0	50.3	35.9	1.05E-09	9.73E-10
159540	1.70	24.20	15.70	8.50	23.0	50.3	30.5	9.96E-10	9.28E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C 1.1E-09 cm/sec

a_s = 0.76712 cm^2
A = 42.45 cm^2
L = 5.63 cm
S=L/A= 0.13253 1/cm

a_p= 0.031416 cm^2
M_i= 0.03018
M_g= 1.04095
C = $M_i S/(G_{bg}-1)$= 0.0003182 for 15° to 25°

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR437-1 (MCU)
Lab No:	8884	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	08/19/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.203			Tare No.	AB-11	
2	2.217	Top	2.900	Tare Weight	0.00	*grams*
3	2.226	Bottom	2.890	Wet Weight + Tare	408.39	*grams*
Average	2.22	Average	2.895	Dry Weight + Tare	286.87	*grams*
				Moisture Content	42.4	%

Total Weight of Soil + Tube Section	408.39	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.90	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

Moisture Content	**42.4**	%
Wet Density	**106.7**	*pcf*
Dry Density	**74.9**	*pcf*
Specific Gravity	**2.348237**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*BM*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/19/2008*
Boring No.	*TR437-2 (MCU)*	Reviewed By	*JW*
Sample No.	*Core Age 90 days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8885*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.0*
Wet Unit Weight, pcf:	*107.6*
Dry Unit Weight, pcf:	*75.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***8.8E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By BM
Project Name Saltstone Grout & Vault Concrete Test Date 08/19/08
Boring No. TR437-2 (MCU) Reviewed By JW
Sample No. Core Age 90 days Review Date 10/14/08
Sample Depth n/a Lab No. 8885
Sample Description Grout

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	T-19
Location 1	2.147	Location 1	2.902	Wet Soil+Pan, grams	450.34
Location 2	2.151	Location 2	2.889	Dry Soil + Pan, grams	330.83
Location3	2.144	Location 3	2.883	Pan Weight, grams	50.43
Average	2.147	Average	2.891	Moisture Content, %	42.6
Volume, in^3	14.10	Wet Soil + Tare, grams	398.19	Dry Unit Weight, pcf	75.8
SG Measured	2.39	Tare Weight, grams	0.00	Saturation, %	105.2
Soil Sample Wt., g	398.19	Dry Soil +Tare, grams	280.40	Diameter, in.	2.891
Dry UW, pcf	75.8	Moisture Content, %	42.0	Length, in.	2.147
Saturation, %	103.7			Volume, in^3	14.09

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used MCU

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
5760	1.70	22.80	22.30	0.50	23.2	48.6	47.4	1.34E-09	1.24E-09
318960	1.70	22.80	9.80	13.00	23.2	48.6	17.4	9.94E-10	9.21E-10
13320	1.70	23.50	22.55	0.95	22.5	50.2	48.0	1.08E-09	1.02E-09
24600	1.70	23.50	22.00	1.50	22.5	50.2	46.6	9.34E-10	8.80E-10
79680	1.70	23.50	20.15	3.35	22.5	50.2	42.2	6.76E-10	6.37E-10
164760	1.70	23.50	17.70	5.80	22.5	50.2	36.3	6.08E-10	5.73E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 8.8E-10 cm/sec

a_s = 0.76712 cm^2 a_p = 0.031416 cm^2
A = 42.35 cm^2 M_1 = 0.03018
L = 5.45 cm M_2 = 1.04095
S=L/A= 0.12876 1/cm $C = M_1 S/(G_{Hg}-1)$ = 0.0003092 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR437-2 (MCU)
Lab No:	8885	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	08/19/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.147			Tare No.	T-19	
2	2.151	Top	2.900	Tare Weight	0.00	*grams*
3	2.144	Bottom	2.881	Wet Weight + Tare	398.19	*grams*
Average	2.15	Average	2.891	Dry Weight + Tare	280.40	*grams*
				Moisture Content	42.0	%

Total Weight of Soil + Tube Section	398.19	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.88	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

Moisture Content	**42.0**	*%*
Wet Density	**107.7**	*pcf*
Dry Density	**75.8**	*pcf*
Specific Gravity	**2.389783**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*BM*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/19/2008*
Boring No.	*TR437-3 (MCU)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8886*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.2*
Wet Unit Weight, pcf:	*108.9*
Dry Unit Weight, pcf:	*76.1*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***6.4E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By BM
Project Name Saltstone Grout & Vault Concrete Test Date 08/19/08
Boring No. TR437-3 (MCU) Reviewed By JW
Sample No. Core Age 90 Days Review Date 10/14/08
Sample Depth n/a Lab No. 8886
Sample Description Grout

Initial Sample Data			
Length, in		Diameter, in	
Location 1	2.231	Location 1	2.870
Location 2	2.239	Location 2	2.872
Location3	2.224	Location 3	2.884
Average	2.231	Average	2.875
Volume, in^3	14.49	Wet Soil + Tare, grams	414.21
SG Measured	2.49	Tare Weight, grams	0.00
Soil Sample Wt., g	414.21	Dry Soil +Tare, grams	289.26
Dry UW, pcf	76.1	Moisture Content, %	43.2
Saturation, %	103.2		

Final Sample Data		
Pan No.	AB-25	
Wet Soil+Pan, grams	499.16	
Dry Soil + Pan, grams	373.42	
Pan Weight, grams	84.16	
Moisture Content, %	43.5	
Dry Unit Weight, pcf	76.1	
Saturation, %	103.9	
Diameter, in.	2.875	
Length, in.	2.231	
Volume, in^3	14.48	

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used MCU

Elapsed Time (sec)	z_a (cm)	z_a (cm)	z_b (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
57540	1.70	15.80	14.40	1.40	22.5	31.3	28.0	6.16E-10	5.80E-10
92160	1.70	15.80	13.50	2.30	22.5	31.3	26.0	6.56E-10	6.18E-10
251520	1.70	15.30	9.70	5.60	22.5	30.2	17.2	7.23E-10	6.81E-10
165160	1.70	15.30	11.20	4.10	22.5	30.2	20.7	7.41E-10	6.98E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
4	Core	N/A	N/A	Vertical

Avg. k at 20 °C 6.4E-10 cm/sec

a_s = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 41.89 cm^2 M_1= 0.03018
L = 5.67 cm M_2= 1.04095
S=L/A= 0.13530 1/cm $C = M_1S/(G_{ss}\cdot1)$= 0.0003248 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR437-3 (MCU)
Lab No:	8886	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	08/19/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.231			Tare No.	AB-25	
2	2.239	Top	2.870	Tare Weight	0.00	*grams*
3	2.224	Bottom	2.880	Wet Weight + Tare	414.21	*grams*
Average	2.23	Average	2.875	Dry Weight + Tare	289.26	*grams*
				Moisture Content	43.2	%

Total Weight of Soil + Tube Section	414.21	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.91	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

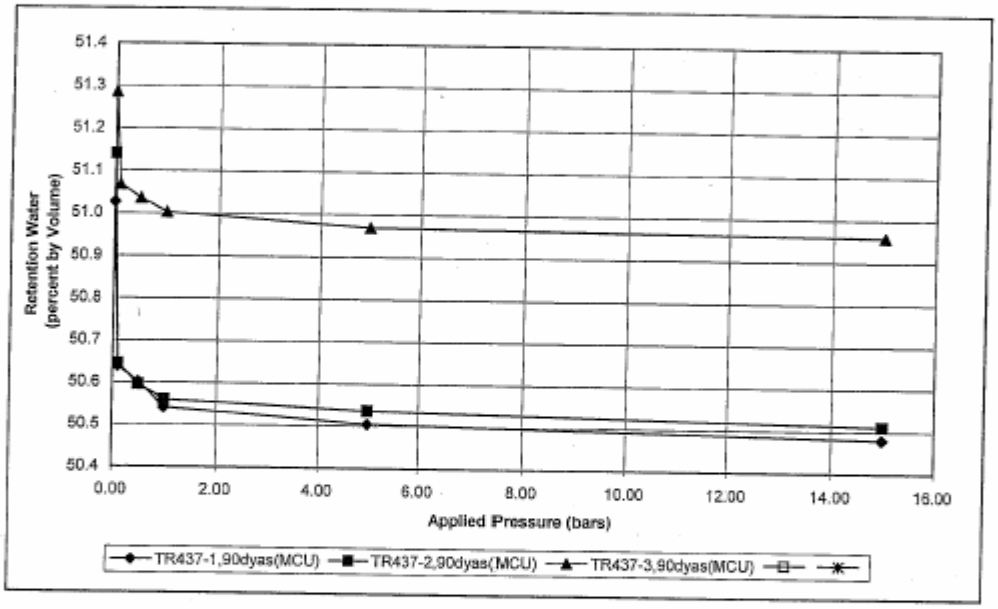
Moisture Content	**43.2**	**%**
Wet Density	**108.9**	***pcf***
Dry Density	**76.1**	***pcf***
Specific Gravity	**2.488207**	
Porosity	**0.51**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
TR437-1,90dyas(MCU)	51.0	77.8	51.0	50.6	50.6	50.5	50.5	50.5
TR437-2,90dyas(MCU)	51.1	75.8	51.1	50.6	50.6	50.6	50.5	50.5
TR437-3,90dyas(MCU)	51.3	74.1	51.3	51.1	51.0	51.0	51.0	51.0

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	TR437-1	TR437-2	TR437-3		
Depth (ft)	90days(MCU)	90days(MCU)	90days(MCU)		
Lab No.	8884	8885	8886		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.300	7.320	7.342		
Container Height, (cm)	1.968	1.965	2.172		
Container Volume (cm^3)	82.37	82.69	91.96		
Wt. of Wet Soil + Container (g)	144.73	142.7	156.29		
Wt. of Dry Soil + Container (g)	102.70	100.41	109.13		
Moisture Content (%)	40.9	42.1	43.2		
Dry Unit Weight (pcf)	77.80	76.77	74.05		
Initial Wt.Wet Soil + Container (g)	144.73	142.70	156.29		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	51.0	51.1	51.3		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure psi	0	1.45	7.25	14.5	72.5	217.5				
	bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By										
8884	Weight of Soil + Ring	144.73	144.41	144.38	144.33	144.3	144.28				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.0	50.6	50.6	50.5	50.5	50.5				
8885	Weight of Soil + Ring	142.7	142.29	142.25	142.22	142.2	142.18				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.1	50.6	50.6	50.6	50.5	50.5				
8885	Weight of Soil + Ring	156.29	156.09	156.06	156.03	156	155.99				
	Weight of Ring	0	0	0	0	0	0				
	Retained Water (%)	51.3	51.1	51.0	51.0	51.0	51.0				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*6/4/2008*
Boring No.	*TR450-1 (SWPF)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8727*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*40.8*
Wet Unit Weight, pcf:	*108.6*
Dry Unit Weight, pcf:	*77.1*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.2E-08***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 06/04/08
Boring No. TR450-1 (SWPF) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8727
Sample Description Grout

Initial Sample Data			Final Sample Data	
Length, in	Diameter, In		Pan No.	R-20
Location 1	3.536	Location 1	2.884	Wet Soil+Pan, grams	673.74
Location 2	3.537	Location 2	2.884	Dry Soil + Pan, grams	477.30
Location3	3.576	Location 3	2.882	Pan Weight, grams	8.19
Average	3.550	Average	2.883	Moisture Content, %	41.9
Volume, in^3	23.17	Wet Soil + Tare, grams	660.60	Dry Unit Weight, pcf	77.1
SG Measured	2.39	Tare Weight, grams	0.00	Saturation, %	107.4
Soil Sample Wt., g	660.60	Dry Soil +Tare, grams	469.11	Diameter, in.	2.883
Dry UW, pcf	77.1	Moisture Content, %	40.8	Length, in.	3.55
Saturation, %	104.7			Volume, in^3	23.17

Consolidation

Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used SWPF Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
4320	1.70	25.60	22.50	3.10	25.3	33.3	28.8	1.73E-08	1.52E-08
17580	1.70	25.60	15.40	10.20	25.3	33.3	18.5	1.72E-08	1.52E-08
72720	1.70	25.60	6.90	18.70	25.0	33.3	6.2	1.19E-08	1.06E-08
18240	1.70	24.20	17.30	6.90	25.0	31.4	21.4	1.08E-08	9.63E-09
28680	1.70	24.20	14.10	10.10	25.0	31.4	16.7	1.13E-08	1.00E-08
82920	1.70	24.20	7.00	17.20	25.0	31.4	6.4	9.84E-09	8.75E-09

Avg. k at 20 °C **1.2E-08 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2 a_p = 0.031416 cm^2
A = 42.12 cm^2 M_1 = 0.03018
L = 9.02 cm M_2 = 1.04095
S=L/A= 0.21404 1/cm $C = M_1 S/(G_{Hg}-1)$ = 0.0005139 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR450-1 (SWPF)
Lab No:	8727	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	06/04/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.536			Tare No.	R-20	
2	3.537	Top	2.884	Tare Weight	0.00	*grams*
3	3.576	Bottom	2.882	Wet Weight + Tare	660.60	*grams*
Average	3.55	Average	2.883	Dry Weight + Tare	469.11	*grams*
				Moisture Content	40.8	%

Total Weight of Soil + Tube Section	660.60	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.46	*lbs*
Volume of Sample	0.013	ft^3

RESULT SUMMARY

Moisture Content	**40.8**	**%**
Wet Density	**108.6**	***pcf***
Dry Density	**77.1**	***pcf***
Specific Gravity	**2.385699**	
Porosity	**0.48**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*6/12/2008*
Boring No.	*TR450-2 (SWPF)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8728*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*41.9*
Wet Unit Weight, pcf:	*108.7*
Dry Unit Weight, pcf:	*76.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.4E-08***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concreti Test Date 06/12/08
Boring No. TR450-2 (SWPF) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8728
Sample Description Grout

Initial Sample Data			Final Sample Data		
Length, in	Diameter, in		Pan No.	R-21	
Location 1	3.132	Location 1	2.873	Wet Soil+Pan, grams	584.85
Location 2	3.049	Location 2	2.881	Dry Soil + Pan, grams	412.92
Location3	3.084	Location 3	2.885	Pan Weight, grams	8.27
Average	3.088	Average	2.880	Moisture Content, %	42.5
Volume, in^3	20.11	Wet Soil + Tare, grams	574.00	Dry Unit Weight, pcf	76.7
SG Measured	2.43	Tare Weight, grams	0.00	Saturation, %	105.6
Soil Sample Wt., g	574.00	Dry Soil +Tare, grams	404.65	Diameter, in.	2.88
Dry UW, pcf	76.7	Moisture Content, %	41.9	Length, in.	3.088
Saturation, %	104.0			Volume, in^3	20.11

Consolidation

Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used SWPF Simulant

Elapsed Time (sec)	z_0 (cm)	za (cm)	zb (cm)	Δz_0 (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
3780	1.70	17.90	9.90	8.00	25.0	26.0	12.6	8.56E-08	7.61E-08
3720	1.70	24.80	19.60	5.20	25.0	37.0	28.3	3.22E-08	2.86E-08
10620	1.70	24.80	13.10	11.70	25.0	37.0	17.5	3.16E-08	2.81E-08
16620	1.70	24.80	10.55	14.25	25.0	37.0	13.2	2.77E-08	2.46E-08
6180	1.70	23.40	16.80	6.60	25.0	34.8	23.8	2.76E-08	2.46E-08
28800	1.70	23.40	6.70	16.70	25.0	34.8	6.9	2.51E-08	2.24E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 3.4E-08 cm/sec

a_s = 0.76712 cm^2
A = 42.01 cm^2
L = 7.84 cm
S=L/A= 0.18670 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0004483 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8728
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 06/12/08

Boring No.: TR450-2 (SWPF)
Depth: n/a
Sample ID: Core
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.132			Tare No.	R-21	
2	3.049	Top	2.885	Tare Weight	0.00	*grams*
3	3.084	Bottom	2.873	Wet Weight + Tare	574.00	*grams*
Average	3.09	Average	2.879	Dry Weight + Tare	404.65	*grams*
				Moisture Content	41.9	%

Total Weight of Soil + Tube Section	574.00	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.27	*lbs*
Volume of Sample	0.012	ft^3

RESULT SUMMARY

Moisture Content	**41.9**	%
Wet Density	**108.8**	*pcf*
Dry Density	**76.7**	*pcf*
Specific Gravity	**2.428175**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*6/4/2008*
Boring No.	*TR450-3 (SWPF)*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8729*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*41.6*
Wet Unit Weight, pcf:	*110.7*
Dry Unit Weight, pcf:	*78.2*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 06/04/08
Boring No. TR450-3 (SWPF) Reviewed By JW
Sample No. Core Review Date 10/14/08
Sample Depth n/a Lab No. 8729
Sample Description Grout

Initial Sample Data			
Length, in		Diameter, in	
Location 1	3.814	Location 1	2.873
Location 2	3.738	Location 2	2.863
Location3	3.799	Location 3	2.880
Average	3.784	Average	2.872
Volume, in^3	24.51	Wet Soil + Tare, grams	712.50
SG Measured	2.53	Tare Weight, grams	0.00
Soil Sample Wt., g	712.50	Dry Soil +Tare, grams	503.26
Dry UW, pcf	78.2	Moisture Content, %	41.6
Saturation, %	103.1		

Final Sample Data		
Pan No.	BG-1	
Wet Soil+Pan, grams	722.28	
Dry Soil + Pan, grams	511.50	
Pan Weight, grams	8.28	
Moisture Content, %	41.9	
Dry Unit Weight, pcf	78.2	
Saturation, %	103.9	
Diameter, in.	2.872	
Length, in.	3.784	
Volume, in^3	24.51	

Consolidation	
Chamber Pressure, psi	75
Back Pressure, psi	65
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used SWPF Simulant

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
5400	1.70	24.00	23.30	0.70	27.2	29.2	28.2	3.40E-09	2.87E-09
11340	1.70	24.00	22.75	1.25	27.2	29.2	27.5	2.93E-09	2.48E-09
69900	1.70	24.00	19.40	4.60	25.0	29.2	22.9	1.91E-09	1.70E-09
101280	1.70	24.00	18.20	5.80	25.0	29.2	21.3	1.72E-09	1.53E-09
156540	1.70	24.00	16.50	7.50	24.4	29.2	19.0	1.52E-09	1.37E-09

Avg. k at 20 °C **2.0E-09 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 41.80 cm^2
L = 9.61 cm
S=L/A= 0.22994 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0005521 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR450-3 (SWPF)
Lab No:	8729	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core
Tested By:	HJ	Reviewed By:	JW
Date:	06/04/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	3.814			Tare No.	BG-1	
2	3.738	Top	2.863	Tare Weight	0.00	*grams*
3	3.799	Bottom	2.880	Wet Weight + Tare	712.50	*grams*
Average	3.78	Average	2.872	Dry Weight + Tare	503.26	*grams*
				Moisture Content	41.6	%

Total Weight of Soil + Tube Section	712.50	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	1.57	*lbs*
Volume of Sample	0.014	ft^3

RESULT SUMMARY

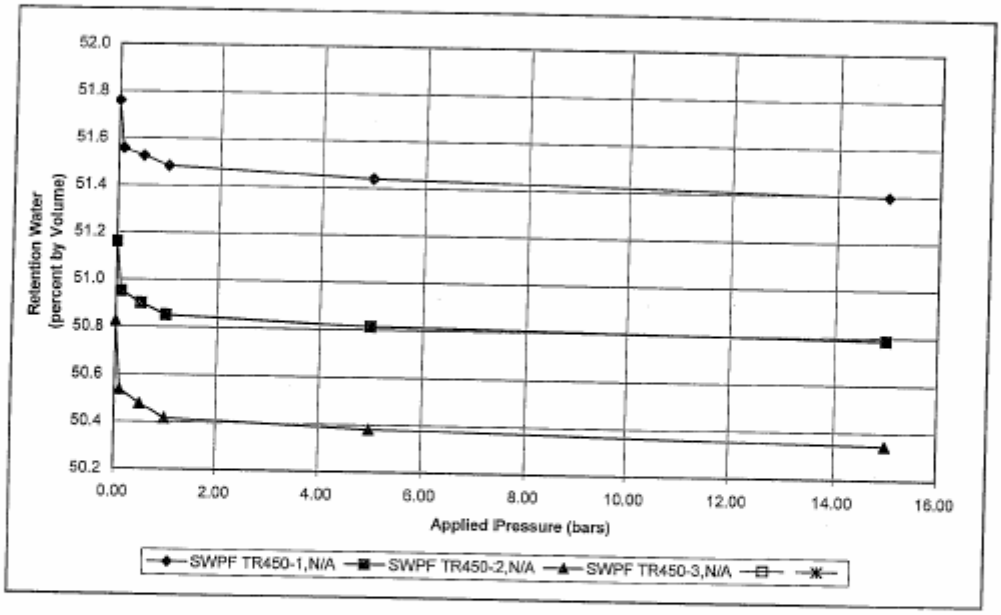
Moisture Content	**41.6**	**%**
Wet Density	**110.8**	***pcf***
Dry Density	**78.2**	***pcf***
Specific Gravity	**2.533665**	
Porosity	**0.51**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	6/18/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
SWPF TR450-1,N/A	51.8	78.8	51.8	51.6	51.5	51.5	51.4	51.4
SWPF TR450-2,N/A	51.2	78.7	51.2	50.9	50.9	50.9	50.8	50.8
SWPF TR450-3,N/A	50.8	78.2	50.8	50.5	50.5	50.4	50.4	50.3

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	6/18/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	SWPF TR450-1	SWPF TR450-2	SWPF TR450-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8727	8728	8729		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.305	7.31	7.323		
Container Height, (cm)	2.238	1.938	1.984		
Container Volume (cm^3)	93.80	81.34	83.56		
Wt. of Wet Soil + Container (g)	167.02	144.14	147.2		
Wt. of Dry Soil + Container (g)	118.47	102.53	104.73		
Moisture Content (%)	41.0	40.6	40.6		
Dry Unit Weight (pcf)	78.81	78.66	78.21		
Initial Wt.Wet Soil + Container (g)	167.02	144.14	147.20		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	51.8	51.2	50.8		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
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Lab No.	Pressure	psi	0	1.45	7.25	14.5	72.5	217.5				
		bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By											
8727	Weight of Soil + Ring		167.02	166.83	166.8	166.76	166.72	166.68				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		51.8	51.6	51.5	51.5	51.4	51.4				
8728	Weight of Soil + Ring		144.14	143.97	143.93	143.89	143.86	143.84				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		51.2	50.9	50.9	50.9	50.8	50.8				
8729	Weight of Soil + Ring		147.2	146.96	146.91	146.86	146.83	146.8				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		50.8	50.5	50.5	50.4	50.4	50.3				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*BM*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/10/2008*
Boring No.	*TR451-1 (SWPF)*	Reviewed By	*HJ*
Sample No.	*Core Age 90 Days*	Review Date	*10/6/2008*
Sample Depth	*n/a*	Lab No.	*8881*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.3*
Wet Unit Weight, pcf:	*109.1*
Dry Unit Weight, pcf:	*76.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.2E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number	6155-08-0031 DO 2	Tested By	BM
Project Name	Saltstone Grout & Vault Concrete	Test Date	09/10/08
Boring No.	TR451-1 (SWPF)	Reviewed By	HJ
Sample No.	Core Age 90 Days	Review Date	10/06/08
Sample Depth	n/a	Lab No.	8881
Sample Description	Grout		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	
Location 1	2.025	Location 1	2.850	Wet Soil+Pan, grams	372.00
Location 2	2.028	Location 2	2.849	Dry Soil + Pan, grams	261.06
Location3	2.045	Location 3	2.855	Pan Weight, grams	0
Average	2.033	Average	2.851	Moisture Content, %	42.5
Volume, in^3	12.98	Wet Soil + Tare, grams	371.56	Dry Unit Weight, pcf	76.6
SG Measured	2.39	Tare Weight, grams	0.00	Saturation, %	107.5
Soil Sample Wt., g	371.56	Dry Soil +Tare, grams	261.06	Diameter, in.	2.851
Dry UW, pcf	76.6	Moisture Content, %	42.3	Length, in.	2.033
Saturation, %	107.1			Volume, in^3	12.98

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used: SWPF

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
73080	1.70	24.40	19.80	4.60	23.2	55.3	43.6	9.75E-10	9.04E-10
10620	1.70	22.70	22.00	0.70	23.2	51.1	49.4	1.00E-09	9.27E-10
23040	1.70	22.70	19.80	2.90	23.2	51.1	43.8	2.03E-09	1.88E-09

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
3	Core	N/A	N/A	Vertical

Avg. k at 20 °C 1.2E-09 cm/sec

a_s = 0.76712 cm^2
A = 41.20 cm^2
L = 5.16 cm
S=L/A= 0.12533 1/cm

a_p = 0.031416 cm^3
M_1 = 0.03018
M_2 = 1.04095
$C = M_1S/(G_{Hg}-1)$ = 0.0003009 for 15° to 25°

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR451-1 (SWPF)
Lab No:	8881	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	09/10/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.025			Tare No.		
2	2.028	Top	2.850	Tare Weight	0.00	*grams*
3	2.045	Bottom	2.852	Wet Weight + Tare	371.56	*grams*
Average	2.03	Average	2.851	Dry Weight + Tare	261.06	*grams*
				Moisture Content	42.3	%

Total Weight of Soil + Tube Section	371.56	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.82	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

Moisture Content	**42.3**	%
Wet Density	**109.1**	*pcf*
Dry Density	**76.6**	*pcf*
Specific Gravity	**2.385699**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*BM*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/10/2008*
Boring No.	*TR451-2 (SWPF)*	Reviewed By	*JW*
Sample No.	*Core Age 90 Days*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8882*
Sample Description	*Grout*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*40.7*
Wet Unit Weight, pcf:	*109.0*
Dry Unit Weight, pcf:	*77.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 — Tested By BM
Project Name Saltstone Grout & Vault Concrete — Test Date 09/10/08
Boring No. TR451-2 (SWPF) — Reviewed By JW
Sample No. Core Age 90 Days — Review Date 10/14/08
Sample Depth n/a — Lab No. 8882
Sample Description Grout

Initial Sample Data				Final Sample Data		
Length, in		Diameter, in		Pan No.	N-11	
Location 1	2.157	Location 1	2.887	Wet Soil+Pan, grams	445.96	
Location 2	2.073	Location 2	2.873	Dry Soil + Pan, grams	330.94	
Location3	2.152	Location 3	2.882	Pan Weight, grams	51.11	
Average	2.127	Average	2.881	Moisture Content, %	41.1	
Volume, in^3	13.86	Wet Soil + Tare, grams	396.66	Dry Unit Weight, pcf	77.5	
SG Measured	2.42	Tare Weight, grams	0.00	Saturation, %	104.8	
Soil Sample Wt., g	396.66	Dry Soil +Tare, grams	282.00	Diameter, in.	2.881	
Dry UW, pcf	77.5	Moisture Content, %	40.7	Length, in.	2.127	
Saturation, %	103.7			Volume, in^3	13.87	

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used SWPF

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
6360	1.70	21.10	20.10	1.00	23.2	45.1	42.7	2.68E-09	2.48E-09
12780	1.70	21.10	19.30	1.80	23.2	45.1	40.8	2.45E-09	2.27E-09
21360	1.70	21.10	18.30	2.80	23.2	45.1	38.4	2.35E-09	2.18E-09
74880	1.70	21.10	15.00	6.10	23.2	45.1	30.4	1.63E-09	1.51E-09
98160	1.70	21.10	14.20	6.90	23.2	45.1	28.4	1.45E-09	1.35E-09

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C **2.0E-09 cm/sec**

a_s = 0.76712 cm^2 — a_p = 0.031416 cm^2
A = 42.04 cm^2 — M_1 = 0.03018
L = 5.40 cm — M_2 = 1.04095
S=L/A= 0.12851 1/cm — C = $M_1 S/(G_{Hg}-1)$ = 0.0003086 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	TR451-2 (SWPF)
Lab No:	8882	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 90 Days
Tested By:	HJ	Reviewed By:	JW
Date:	09/10/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.157			Tare No.	N-11	
2	2.073	Top	2.887	Tare Weight	0.00	*grams*
3	2.152	Bottom	2.875	Wet Weight + Tare	396.66	*grams*
Average	2.13	Average	2.881	Dry Weight + Tare	282.00	*grams*
				Moisture Content	40.7	%

Total Weight of Soil + Tube Section	396.66	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.87	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

Moisture Content	**40.7**	**%**
Wet Density	**109.0**	***pcf***
Dry Density	**77.5**	***pcf***
Specific Gravity	**2.420541**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By BM
Project Name Saltstone Grout & Vault Concrete Test Date 09/10/08
Boring No. TR451-3 (SWPF) Reviewed By JW
Sample No. Core Age 90 Days Review Date 10/14/08
Sample Depth n/a Lab No. 8883
Sample Description Grout

Initial Sample Data			
Length, in		Diameter, in	
Location 1	2.040	Location 1	2.880
Location 2	2.017	Location 2	2.869
Location3	2.010	Location 3	2.904
Average	2.022	Average	2.884
Volume, in^3	13.21	Wet Soil + Tare, grams	378.54
SG Measured	2.40	Tare Weight, grams	0.00
Soil Sample Wt., g	378.54	Dry Soil +Tare, grams	266.52
Dry UW, pcf	76.8	Moisture Content, %	42.0
Saturation, %	106.2		

Final Sample Data	
Pan No.	
Wet Soil+Pan, grams	379.00
Dry Soil + Pan, grams	266.52
Pan Weight, grams	
Moisture Content, %	42.2
Dry Unit Weight, pcf	76.8
Saturation, %	106.6
Diameter, in.	2.884
Length, in.	2.022
Volume, in^3	13.21

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used SWPF

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Initial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
3480	1.70	25.10	10.40	14.70	22.5	57.3	19.8	8.92E-08	8.41E-08
6480	1.70	25.10	5.00	20.10	22.5	57.3	6.1	1.01E-07	9.55E-08
2760	1.70	26.90	13.10	13.80	22.5	61.7	26.5	8.95E-08	8.43E-08
5400	1.70	26.90	6.70	20.20	22.5	61.7	10.2	9.74E-08	9.18E-08
3600	1.70	26.60	10.40	16.20	22.5	60.9	19.7	9.19E-08	8.66E-08
4620	1.70	24.30	7.50	16.80	22.5	55.3	12.5	9.41E-08	8.87E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 8.8E-08 cm/sec

a_o = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 42.15 cm^2 M_1= 0.03018
L = 5.14 cm M_2= 1.04095
S=L/A= 0.12187 1/cm $C = M_1 S/(G_{Hg}-1)$= 0.00029266 for 15° to 25°

Remarks:

Subcontract No. AC34317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8883
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 09/10/08

Boring No.: TR451-3 (SWPF)
Depth: n/a
Sample ID: Core Age 90 Days
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	2.04			Tare No.		
2	2.017	Top	2.880	Tare Weight	0.00	*grams*
3	2.01	Bottom	2.888	Wet Weight + Tare	378.54	*grams*
Average	2.02	Average	2.884	Dry Weight + Tare	266.52	*grams*
				Moisture Content	42.0	%

Total Weight of Soil + Tube Section	378.54	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	0.83	*lbs*
Volume of Sample	0.008	ft^3

RESULT SUMMARY

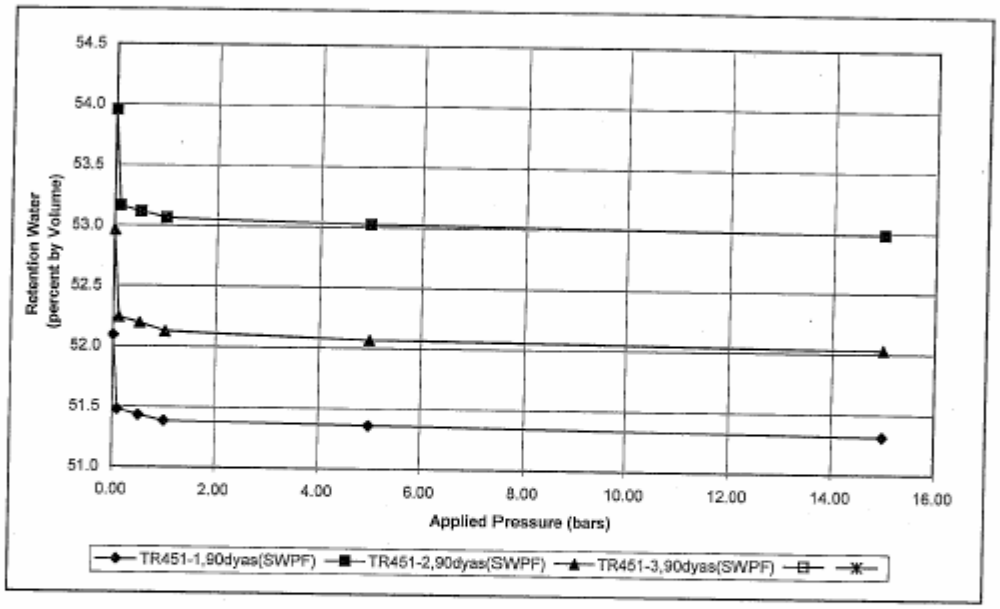
Moisture Content	**42.0**	**%**
Wet Density	**109.2**	***pcf***
Dry Density	**76.9**	***pcf***
Specific Gravity	**2.402716**	
Porosity	**0.49**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0				
			Retained Water (percent by volume)									
TR451-1,90dyas(SWPF)	44.0	75.6	52.1	51.5	51.4	51.4	51.4	51.3				
TR451-2,90dyas(SWPF)	54.0	77.7	54.0	53.2	53.1	53.1	53.0	53.0				
TR451-3,90dyas(SWPF)	53.0	76.8	53.0	52.2	52.2	52.1	52.1	52.0				

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	8/19/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	TR451-1	TR451-2	TR451-3		
Depth (ft)	90days(SWPF)	90days(SWPF)	90days(SWPF)		
Lab No.	8881	8882	8883		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.263	7.237	7.318		
Container Height, (cm)	2.079	1.936	2.037		
Container Volume (cm^3)	86.13	79.64	85.68		
Wt. of Wet Soil + Container (g)	149.22	142.13	150.77		
Wt. of Dry Soil + Container (g)	104.35	99.16	105.39		
Moisture Content (%)	43.0	43.3	43.1		
Dry Unit Weight (pcf)	75.60	77.70	76.78		
Initial Wt.Wet Soil + Container (g)	142.22	142.13	150.77		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	44.0	54.0	53.0		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure										
	psi		0	1.45	7.25	14.5	72.5	217.5			
	bars		0.0	0.10	0.5	1.0	5.0	15.0			
	Date / Read By										
8881	Weight of Soil + Ring		149.22	148.89	148.65	148.61	148.59	148.55			
	Weight of Ring		0	0	0	0	0	0			
	Retained Water (%)		52.1	51.5	51.4	51.4	51.4	51.3			
8882	Weight of Soil + Ring		142.13	141.5	141.46	141.42	141.39	141.36			
	Weight of Ring		0	0	0	0	0	0			
	Retained Water (%)		54.0	53.2	53.1	53.1	53.0	53.0			
8883	Weight of Soil + Ring		150.77	150.15	150.11	150.05	150	149.97			
	Weight of Ring		0	0	0	0	0	0			
	Retained Water (%)		53.0	52.2	52.2	52.1	52.1	52.0			

No. of Samples 3
No. of Tests per Sample 6

APPENDIX D. MCT DATA SHEETS ON VAULT CONCRETES

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/5/2008*
Boring No.	*VI-080025-4*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*N/A*	Lab No.	*8969*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*5.2*
Wet Unit Weight, pcf:	*148.7*
Dry Unit Weight, pcf:	*141.4*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.3E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 08/05/08
Boring No. V1-080025-4 Reviewed By JW
Sample No. Core 28 days (6x12) Review Date 10/14/08
Sample Depth N/A Lab No. 8969
Sample Description Concrete

Initial Sample Data				Final Sample Data		
Length, in		Diameter, in		Pan No.		
Location 1	5.709	Location 1	6.005	Wet Soil+Pan, grams	6279.80	
Location 2	5.674	Location 2	6.010	Dry Soil + Pan, grams	5966.70	
Location3	5.623	Location 3	6.012	Pan Weight, grams	0	
Average	5.669	Average	6.009	Moisture Content, %	5.2	
Volume, in^3	160.76	Wet Soil + Tare, grams	6276.20	Dry Unit Weight, pcf	141.4	
SG Measured	2.57	Tare Weight, grams	0.00	Saturation, %	100.4	
Soil Sample Wt., g	6276.20	Dry Soil +Tare, grams	5966.70	Diameter, in.	6.009	
Dry UW, pcf	141.4	Moisture Content, %	5.2	Length, in.	5.669	
Saturation, %	99.2			Volume, in^3	160.77	

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used Water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
6000	1.70	23.60	23.30	0.30	23.2	19.1	18.8	4.52E-10	4.19E-10
61380	1.70	23.60	23.10	0.50	23.2	19.1	18.7	7.40E-11	6.86E-11
94920	1.70	23.60	22.75	0.85	23.2	19.1	18.3	8.21E-11	7.61E-11
148800	1.70	23.60	22.40	1.20	23.2	19.1	18.0	7.46E-11	6.91E-11
181500	1.70	23.60	22.20	1.40	23.2	19.1	17.8	7.17E-11	6.64E-11
235500	1.70	23.60	22.00	1.60	23.2	19.1	17.7	6.35E-11	5.88E-11

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C **1.3E-10 cm/sec**

a_s = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 182.96 cm^2 M_1= 0.03018
L = 14.40 cm M_2= 1.04095
S=L/A= 0.07870 1/cm $C = M_1 S/(G_{HS}-1)$= 0.00001889 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8969
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 08/19/08

Boring No.: V1-080025-4
Depth: n/a
Sample ID: Core Age 28 Days (6x12)
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	5.709			Tare No.		
2	5.674	Top	6.005	Tare Weight	0.00	*grams*
3	5.623	Bottom	6.013	Wet Weight + Tare	6276.20	*grams*
Average	5.67	Average	6.009	Dry Weight + Tare	5966.70	*grams*
				Moisture Content	5.2	*%*

Total Weight of Soil + Tube Section	6276.20	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	13.84	*lbs*
Volume of Sample	0.093	ft^3

RESULT SUMMARY

Moisture Content	**5.2**	*%*
Wet Density	**148.7**	*pcf*
Dry Density	**141.4**	*pcf*
Specific Gravity	**2.57043**	
Porosity	**0.12**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/10/2008*
Boring No.	*V1-080025-5*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*N/A*	Lab No.	*8970*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*4.5*
Wet Unit Weight, pcf:	*151.0*
Dry Unit Weight, pcf:	*144.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.1E-09***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 09/10/08
Boring No. V1-080025-5 Reviewed By JW
Sample No. Core 28 days (6x12) Review Date 10/14/08
Sample Depth N/A Lab No. 8970
Sample Description Concrete

Initial Sample Data											
Length, in		Diameter, in									
Location 1	5.580	Location 1	6.025								
Location 2	5.600	Location 2	6.020								
Location3	5.540	Location 3	6.021								
Average	5.573	Average	6.022								
Volume, in^3	158.74	Wet Soil + Tare, grams	6291.40								
SG Measured	2.57	Tare Weight, grams	0.00								
Soil Sample Wt., g	6291.40	Dry Soil +Tare, grams	6020.50								
Dry UW, pcf	144.5	Moisture Content, %	4.5								
Saturation, %	105.0										

Final Sample Data	
Pan No.	
Wet Soil+Pan, grams	6291.40
Dry Soil + Pan, grams	6020.50
Pan Weight, grams	0
Moisture Content, %	4.5
Dry Unit Weight, pcf	144.5
Saturation, %	105.0
Diameter, in.	6.022
Length, in.	5.573
Volume, in^3	158.73

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used Water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
5100	1.70	24.10	21.80	2.30	23.2	19.9	17.8	4.10E-09	3.80E-09
11040	1.70	24.10	19.80	4.30	23.2	19.9	15.9	3.73E-09	3.46E-09
3000	1.70	25.30	24.70	0.60	23.2	21.0	20.4	1.65E-09	1.53E-09
14100	1.70	25.30	23.10	2.20	23.2	21.0	18.9	1.34E-09	1.24E-09
28500	1.70	25.30	21.30	4.00	23.2	21.0	17.3	1.26E-09	1.17E-09
83100	1.70	25.30	15.60	9.70	23.2	21.0	12.0	1.24E-09	1.15E-09

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C **2.1E-09 cm/sec**

a_s = 0.76712 cm^2
A = 183.75 cm^2
L = 14.16 cm
S=L/A= 0.07704 1/cm

a_p= 0.031416 cm^2
M_1= 0.03018
M_2= 1.04095
$C = M_1 S/((G_{Hg}-1)$= 0.0001850 for 15° to 25°

Remarks:

Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8970
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 09/10/08

Boring No.: V1-080025-5
Depth: n/a
Sample ID: Core Age 28 Days (6x12)
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	5.58			Tare No.		
2	5.6	Top	6.026	Tare Weight	0.00	*grams*
3	5.54	Bottom	6.020	Wet Weight + Tare	6291.40	*grams*
Average	5.57	Average	6.023	Dry Weight + Tare	6020.50	*grams*
				Moisture Content	4.5	%

Total Weight of Soil + Tube Section	6291.40	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	13.87	*lbs*
Volume of Sample	0.092	ft^3

RESULT SUMMARY

Moisture Content	**4.5**	*%*
Wet Density	**150.9**	*pcf*
Dry Density	**144.4**	*pcf*
Specific Gravity	**2.57043**	
Porosity	**0.10**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/10/2008*
Boring No.	*V1-080025-6*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*N/A*	Lab No.	*8971*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*4.5*
Wet Unit Weight, pcf:	*149.2*
Dry Unit Weight, pcf:	*142.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.1E-10***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 09/10/08
Boring No. V1-080025-6 Reviewed By JW
Sample No. Core 28 days (6x12) Review Date 10/14/08
Sample Depth N/A Lab No. 8971
Sample Description Concrete

Initial Sample Data			
Length, in		Diameter, in	
Location 1	5.520	Location 1	6.013
Location 2	5.548	Location 2	6.009
Location3	5.637	Location 3	6.017
Average	5.568	Average	6.013
Volume, in^3	158.12	Wet Soil + Tare, grams	6191.60
SG Measured	2.57	Tare Weight, grams	0.00
Soil Sample Wt., g	6191.60	Dry Soil +Tare, grams	5926.80
Dry UW, pcf	142.8	Moisture Content, %	4.5
Saturation, %	93.1		

Final Sample Data	
Pan No.	
Wet Soil+Pan, grams	6191.60
Dry Soil + Pan, grams	5926.80
Pan Weight, grams	0
Moisture Content, %	4.5
Dry Unit Weight, pcf	142.8
Saturation, %	93.1
Diameter, in.	6.013
Length, in.	5.568
Volume, in^3	158.11

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used Water

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
12600	1.70	24.60	24.40	0.20	23.2	20.4	20.2	1.34E-10	1.25E-10
23520	1.70	24.60	24.20	0.40	23.2	20.4	20.0	1.45E-10	1.34E-10
55800	1.70	23.50	22.80	0.70	23.2	19.4	18.7	1.13E-10	1.05E-10
83160	1.70	23.50	22.40	1.10	23.2	19.4	18.4	1.20E-10	1.11E-10
146100	1.70	23.50	21.95	1.55	23.2	19.4	17.9	9.76E-11	9.04E-11

Avg. k at 20 °C 1.1E-10 cm/sec

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

a_o = 0.76712 cm^2 a_w= 0.031416 cm^2 Remarks: Subcontract No. AC54317N
A = 183.21 cm^2 M_1= 0.03018 Specification No. K-SPC-G-0013
L = 14.14 cm M_2= 1.04095 Revision 10 08-13-2007
S=L/A= 0.07720 1/cm $C = M_1S/(G_{fig}-1)$= 0.0001854 for 15° to 25° Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8971
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 09/10/08

Boring No.: V1-080025-5
Depth: n/a
Sample ID: Core Age 28 Days (6x12)
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	5.52			Tare No.		
2	5.548	Top	6.017	Tare Weight	0.00	*grams*
3	5.637	Bottom	6.009	Wet Weight + Tare	6191.60	*grams*
Average	5.57	Average	6.013	Dry Weight + Tare	5926.80	*grams*
				Moisture Content	4.5	%

Total Weight of Soil + Tube Section	6191.60	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	13.65	*lbs*
Volume of Sample	0.092	ft^3

RESULT SUMMARY

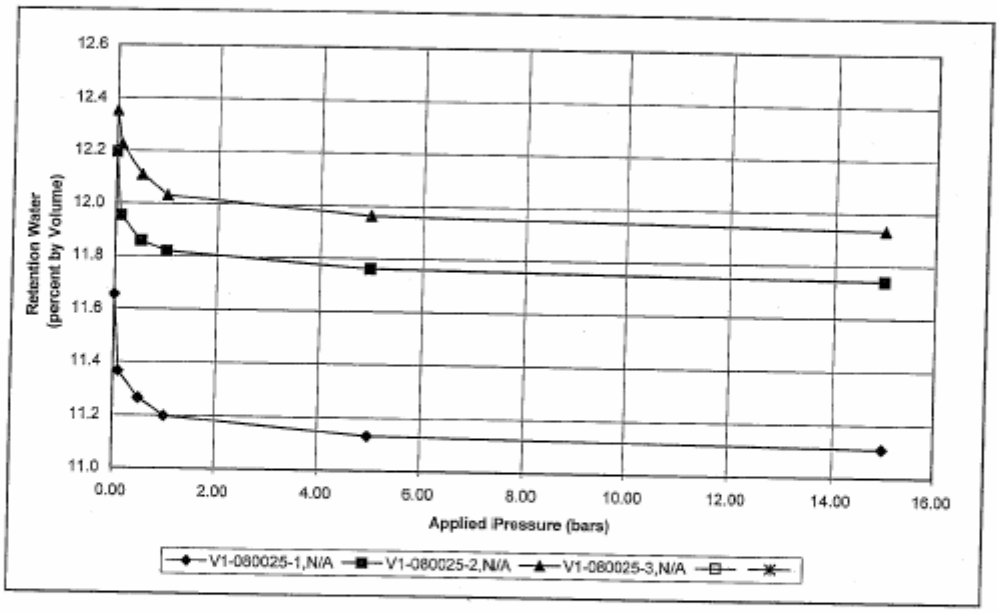
Moisture Content	**4.5**	**%**
Wet Density	**149.2**	***pcf***
Dry Density	**142.8**	***pcf***
Specific Gravity	**2.57043**	
Porosity	**0.11**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	9/9/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
V1-080025-1,N/A	11.7	140.3	11.7	11.4	11.3	11.2	11.1	11.1
V1-080025-2,N/A	12.2	133.9	12.2	12.0	11.9	11.8	11.8	11.7
V1-080025-3,N/A	12.4	136.5	12.4	12.2	12.1	12.0	12.0	11.9

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	9/9/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	V1-080826-1	V1-080825-2	V1-080825-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8966	8967	8968		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.610	7.792	7.718		
Container Height, (cm)	1.975	2.177	2.203		
Container Volume (cm^3)	89.83	103.81	103.07		
Wt. of Wet Soil + Container (g)	212.48	235.34	238.11		
Wt. of Dry Soil + Container (g)	202.01	222.68	225.38		
Moisture Content (%)	5.2	5.7	5.6		
Dry Unit Weight (pcf)	140.32	133.85	136.45		
Initial Wt.Wet Soil + Container (g)	212.48	235.34	238.11		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	11.7	12.2	12.4		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure	psi	0	1.45	7.25	14.5	72.5	217.5				
		bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By											
8966	Weight of Soil + Ring		212.48	212.22	212.13	212.07	212.01	211.99				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		11.7	11.4	11.3	11.2	11.1	11.1				
8967	Weight of Soil + Ring		235.34	235.09	234.99	234.95	234.89	234.87				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		12.2	12.0	11.9	11.8	11.8	11.7				
8968	Weight of Soil + Ring		238.11	237.98	237.88	237.78	237.71	237.68				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		12.4	12.2	12.1	12.0	12.0	11.9				

No. of Samples 3
No. of Tests per Sample 6

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*7/21/2008*
Boring No.	*V2M1 80010-4*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/15/2008*
Sample Depth	*n/a*	Lab No.	*8597*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*5.4*
Wet Unit Weight, pcf:	*143.4*
Dry Unit Weight, pcf:	*136.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***7.8E-11***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 07/21/08
Boring No. V2M1 80010-4 Reviewed By JW
Sample No. Core Review Date 10/15/08
Sample Depth n/a Lab No. 8597
Sample Description Concrete

Initial Sample Data			
Length, in		Diameter, in	
Location 1	4.659	Location 1	6.005
Location 2	4.712	Location 2	6.008
Location3	4.662	Location 3	6.005
Average	4.678	Average	6.006
Volume, in^3	132.52	Wet Soil + Tare, grams	4989.20
SG Measured	2.52	Tare Weight, grams	0.00
Soil Sample Wt., g	4989.20	Dry Soil +Tare, grams	4732.10
Dry UW, pcf	136.0	Moisture Content, %	5.4
Saturation, %	87.9		

Final Sample Data	
Pan No.	AB-19
Wet Soil+Pan, grams	5079.30
Dry Soil + Pan, grams	4821.20
Pan Weight, grams	89.1
Moisture Content, %	5.5
Dry Unit Weight, pcf	136.0
Saturation, %	88.2
Diameter, in.	6.006
Length, in.	4.678
Volume, in^3	132.52

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
12000	1.70	25.70	25.50	0.20	23.5	25.4	25.2	1.13E-10	1.04E-10
20700	1.70	25.70	25.35	0.35	23.5	25.4	25.0	1.15E-10	1.06E-10
77220	1.70	25.70	25.05	0.65	23.0	25.4	24.7	5.78E-11	5.38E-11
103320	1.70	25.70	24.95	0.75	23.0	25.4	24.6	5.00E-11	4.65E-11

Avg. k at 20 °C **7.8E-11 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
4	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 182.78 cm^2
L = 11.88 cm
S=L/A= 0.06500 1/cm

a_p= 0.031416 cm^2
M_1= 0.03018
M_2= 1.04095
$C = M_1 S/(G_{fg}-1)$= 0.00001561 for 15° to 25°

Remarks:

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8597
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 07/21/08

Boring No.: V2M1-800104-4
Depth: n/a
Sample ID: Core Age 28 Days (6x12)
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	4.659			Tare No.	AB-19	
2	4.712	Top	6.005	Tare Weight	0.00	*grams*
3	4.662	Bottom	6.007	Wet Weight + Tare	4989.20	*grams*
Average	4.68	Average	6.006	Dry Weight + Tare	4732.10	*grams*
				Moisture Content	5.4	%

Total Weight of Soil + Tube Section	4989.20	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	11.00	*lbs*
Volume of Sample	0.077	ft^3

RESULT SUMMARY

Moisture Content	**5.4**	%
Wet Density	**143.4**	*pcf*
Dry Density	**136.0**	*pcf*
Specific Gravity	**2.5195534**	
Porosity	**0.13**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*5/24/2008*
Boring No.	*V2M1 80010-5*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/15/2008*
Sample Depth	*n/a*	Lab No.	*8598*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*3.5*
Wet Unit Weight, pcf:	*142.5*
Dry Unit Weight, pcf:	*137.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.8E-10***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 05/24/08
Boring No. V2M1 80010-5 Reviewed By JW
Sample No. Core Review Date 10/15/08
Sample Depth n/a Lab No. 8598
Sample Description Concrete

Initial Sample Data			
Length, in		Diameter, in	
Location 1	10.049	Location 1	6.025
Location 2	10.002	Location 2	6.000
Location3	10.038	Location 3	6.030
Average	10.030	Average	6.018
Volume, in³	285.31	Wet Soil + Tare, grams	10670.40
SG Measured	2.41	Tare Weight, grams	0.00
Soil Sample Wt., g	10670.40	Dry Soil +Tare, grams	10312.82
Dry UW, pcf	137.7	Moisture Content, %	3.5
Saturation, %	90.7		

Final Sample Data		
Pan No.		L--20
Wet Soil+Pan, grams		10762.40
Dry Soil + Pan, grams		10403.80
Pan Weight, grams		90.98
Moisture Content, %		3.5
Dry Unit Weight, pcf		137.7
Saturation, %		90.9
Diameter, in.		6.018
Length, in.		10.03
Volume, in³		285.31

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Buret Reading	0
Final Buret Reading	0
Volume Change, cc	0

Permeant used water

Elapsed Time (sec)	z_a (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Inital Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
6120	1.70	26.00	25.65	0.35	25.6	12.0	11.8	8.23E-10	7.22E-10
62700	1.70	26.00	24.80	1.20	25.0	12.0	11.4	2.81E-10	2.49E-10
93600	1.70	26.00	24.60	1.40	25.6	12.0	11.3	2.20E-10	1.93E-10
149700	1.70	26.00	24.00	2.00	25.0	12.0	11.0	1.99E-10	1.77E-10
180720	1.70	26.00	23.50	2.50	26.7	12.0	10.7	2.09E-10	1.79E-10
236400	1.70	26.00	22.80	3.20	26.1	12.0	10.3	2.08E-10	1.80E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

Avg. k at 20 °C 2.8E-10 cm/sec

a_s = 0.76712 cm²
A = 183.53 cm²
L = 25.47 cm
S=L/A= 0.13880 1/cm

a_p= 0.031416 cm²
M_i= 0.03018
M_f= 1.04095
C = $M_i S/(G_{hg}-1)$= 0.0003333 for 15° to 25°

Remarks:

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.: 6155-08-0031 DO 2
Lab No: 8598
Project Name: Saltstone Grout & Vault Concrete
Tested By: HJ
Date: 05/24/08

Boring No.: V2M1-800104-5
Depth: n/a
Sample ID: Core Age 28 Days (6x12)
Reviewed By: JW
Date: 10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	10.049			Tare No.	L-20	
2	10.002	Top	6.006	Tare Weight	0.00	*grams*
3	10.038	Bottom	6.030	Wet Weight + Tare	10670.40	*grams*
Average	10.03	Average	6.018	Dry Weight + Tare	10312.82	*grams*
				Moisture Content	3.5	*%*

Total Weight of Soil + Tube Section	10670.40	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	23.52	*lbs*
Volume of Sample	0.165	ft^3

RESULT SUMMARY

Moisture Content	**3.5**	*%*
Wet Density	**142.5**	*pcf*
Dry Density	**137.7**	*pcf*
Specific Gravity	**2.4100761**	
Porosity	**0.08**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*5/24/2008*
Boring No.	*V2M1 80010-6*	Reviewed By	*JW*
Sample No.	*Core*	Review Date	*10/15/2008*
Sample Depth	*n/a*	Lab No.	*8599*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*6.2*
Wet Unit Weight, pcf:	*143.1*
Dry Unit Weight, pcf:	*134.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***6.0E-11***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

Project Number 6155-08-0031 DO 2 Tested By HJ
Project Name Saltstone Grout & Vault Concrete Test Date 05/24/08
Boring No. V2M1 80010-6 Reviewed By JW
Sample No. Core Review Date 10/15/08
Sample Depth n/a Lab No. 8599
Sample Description Concrete

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	10
Location 1	4.670	Location 1	6.015	Wet Soil+Pan, grams	5058.40
Location 2	4.614	Location 2	6.021	Dry Soil + Pan, grams	4765.60
Location3	4.636	Location 3	6.011	Pan Weight, grams	100.4
Average	4.640	Average	6.016	Moisture Content, %	6.3
Volume, in^3	131.88	Wet Soil + Tare, grams	4954.80	Dry Unit Weight, pcf	134.8
SG Measured	2.55	Tare Weight, grams	0.00	Saturation, %	88.4
Soil Sample Wt., g	4954.80	Dry Soil +Tare, grams	4665.20	Diameter, in.	6.016
Dry UW, pcf	134.8	Moisture Content, %	6.2	Length, in.	4.64
Saturation, %	87.4			Volume, in^3	131.88

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used water

Elapsed Time (sec)	z_0 (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
54480	1.70	23.70	23.20	0.50	26.7	23.5	22.9	6.78E-11	5.80E-11
84840	1.70	23.70	22.90	0.80	26.2	23.5	22.6	7.02E-11	6.07E-11
14940	1.70	25.20	25.00	0.20	26.7	25.1	24.8	9.19E-11	7.87E-11
70380	1.70	25.20	24.50	0.70	26.2	25.1	24.3	6.91E-11	5.98E-11
101880	1.70	25.20	24.30	0.90	26.0	25.1	24.1	6.16E-11	5.36E-11
157200	1.70	25.20	24.00	1.20	26.0	25.1	23.7	5.36E-11	4.66E-11

Avg. k at 20 °C **6.0E-11 cm/sec**

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
6	Core	N/A	N/A	Vertical

a_s = 0.76712 cm^2
A = 183.37 cm^2
L = 11.79 cm
S=L/A= 0.06427 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0001543 for 15° to 25°

Remarks:

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	V2M1-800104-6
Lab No:	8599	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 28 Days (6x12)
Tested By:	HJ	Reviewed By:	JW
Date:	05/24/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	4.67			Tare No.	10	
2	4.614	Top	6.021	Tare Weight	0.00	*grams*
3	4.636	Bottom	6.011	Wet Weight + Tare	4954.80	*grams*
Average	4.64	Average	6.016	Dry Weight + Tare	4665.20	*grams*
				Moisture Content	6.2	%

Total Weight of Soil + Tube Section	4954.80	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	10.92	*lbs*
Volume of Sample	0.076	ft^3

RESULT SUMMARY

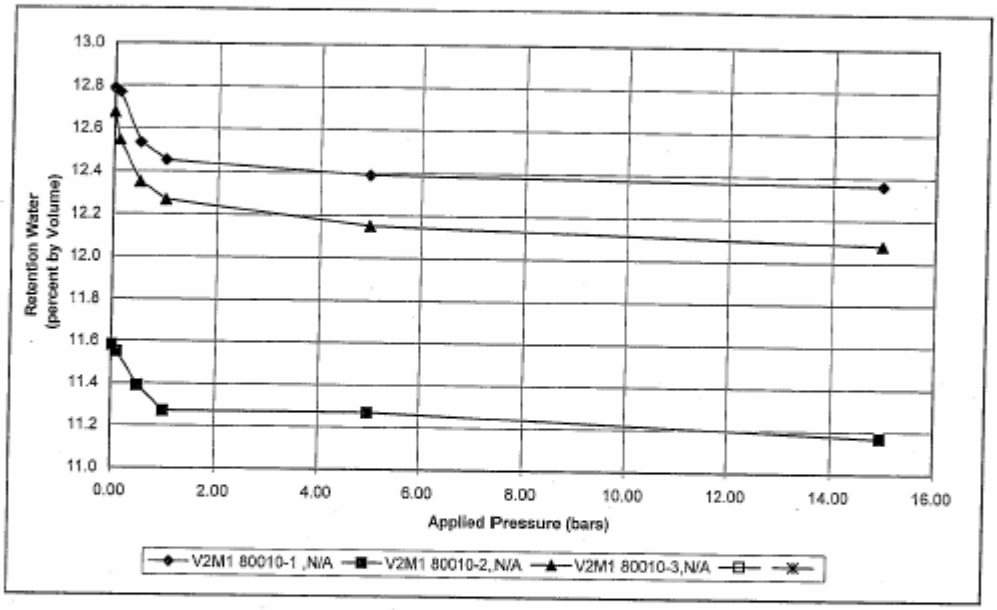
Moisture Content	**6.2**	**%**
Wet Density	**143.1**	***pcf***
Dry Density	**134.7**	***pcf***
Specific Gravity	**2.5507326**	
Porosity	**0.15**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	5/21/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0
			Retained Water (percent by volume)					
V2M1 80010-1 ,N/A	12.8	135.7	12.8	12.8	12.5	12.5	12.4	12.4
V2M1 80010-2,N/A	11.6	138.1	11.6	11.6	11.4	11.3	11.3	11.2
V2M1 80010-3,N/A	12.7	136.4	12.7	12.5	12.3	12.3	12.2	12.1

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	6/21/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	V2M1 80010-2	M1 80010-2	M1 80010-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8594	8595	8596		
Ring No.	N/A	N/A	N/A		
Container Weight, (g)	0	0	0		
Container Diameter (cm)	7.617	7.624	7.626		
Container Height, (cm)	2.423	2.179	1.888		
Container Volume (cm^3)	110.41	99.47	86.24		
Wt. of Wet Soil + Container (g)	254.28	231.61	199.46		
Wt. of Dry Soil + Container (g)	240.16	220.09	188.53		
Moisture Content (%)	5.9	5.2	5.8		
Dry Unit Weight (pcf)	135.73	138.06	136.42		
Initial Wt.Wet Soil + Container (g)	254.28	231.61	199.46		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	12.8	11.6	12.7		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure	psi	0	1.45	7.25	14.5	72.5	217.5				
		bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By											
8594	Weight of Soil + Ring		254.28	254.26	254	253.91	253.84	253.81				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		12.8	12.8	12.5	12.5	12.4	12.4				
8595	Weight of Soil + Ring		231.61	231.58	231.42	231.3	231.3	231.2				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		11.6	11.6	11.4	11.3	11.3	11.2				
8596	Weight of Soil + Ring		199.46	199.35	199.18	199.11	199.01	198.95				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		12.7	12.5	12.3	12.3	12.2	12.1				

No. of Samples 3
No. of Tests per Sample 6

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*8/5/2008*
Boring No.	*V2M2-080028-4*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8940*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*6.3*
Wet Unit Weight, pcf:	*143.4*
Dry Unit Weight, pcf:	*134.9*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***5.0E-11***

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031 DO 2	Tested By	HJ
Project Name	Saltstone Grout & Vault Concrete	Test Date	08/05/08
Boring No.	V2M2-080028-4	Reviewed By	JW
Sample No.	Core 28 days (6x12)	Review Date	10/14/08
Sample Depth	n/a	Lab No.	8940
Sample Description	Concrete		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	
Location 1	4.885	Location 1	5.995	Wet Soil+Pan, grams	5205.00
Location 2	4.896	Location 2	6.005	Dry Soil + Pan, grams	4895.90
Location3	4.894	Location 3	6.000	Pan Weight, grams	
Average	4.892	Average	6.000	Moisture Content, %	6.3
Volume, in^3	138.31	Wet Soil + Tare, grams	5204.50	Dry Unit Weight, pcf	134.9
SG Measured	2.50	Tare Weight, grams	0.00	Saturation, %	100.3
Soil Sample Wt., g	5204.50	Dry Soil +Tare, grams	4895.90	Diameter, in.	6.000
Dry UW, pcf	134.9	Moisture Content, %	6.3	Length, in.	4.892
Saturation, %	100.2			Volume, in^3	138.32

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used: Water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
9960	1.70	25.70	25.60	0.10	23.2	24.3	24.2	7.14E-11	6.61E-11
329460	1.70	25.70	24.00	1.70	22.5	24.3	22.5	3.80E-11	3.58E-11
10920	1.70	25.30	25.20	0.10	23.2	23.9	23.8	6.62E-11	6.14E-11
28860	1.70	25.30	25.10	0.20	23.2	23.9	23.7	5.02E-11	4.65E-11
83520	1.70	25.30	24.80	0.50	23.2	23.9	23.3	4.37E-11	4.05E-11

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	Core	N/A	N/A	Vertical

Avg. k at 20 °C **5.0E-11** **cm/sec**

a_s = 0.76712 cm^2
A = 182.41 cm^2
L = 12.42 cm
S=L/A= 0.06811 1/cm

a_p = 0.031416 cm^2
M_1 = 0.03018
M_2 = 1.04095
$C = M_1 S/(G_{Hg}-1)$ = 0.0001635 for 15° to 25°

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

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TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	V2M2-080028-4
Lab No:	8940	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 28 Days (6x12)
Tested By:	HJ	Reviewed By:	JW
Date:	08/05/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	4.885			Tare No.		
2	4.896	Top	5.995	Tare Weight	0.00	*grams*
3	4.894	Bottom	6.005	Wet Weight + Tare	5204.50	*grams*
Average	4.89	Average	6.000	Dry Weight + Tare	4895.90	*grams*
				Moisture Content	6.3	%

Total Weight of Soil + Tube Section	5204.50	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	11.47	*lbs*
Volume of Sample	0.080	ft^3

RESULT SUMMARY

Moisture Content	**6.3**	**%**
Wet Density	**143.4**	***pcf***
Dry Density	**134.9**	***pcf***
Specific Gravity	**2.501233**	
Porosity	**0.14**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/9/2008*
Boring No.	*V2M2-080028-5*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8941*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*3.9*
Wet Unit Weight, pcf:	*144.0*
Dry Unit Weight, pcf:	*138.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***5.0E-11***

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number	6155-08-0031 DO 2	Tested By	HJ
Project Name	Saltstone Grout & Vault Concrete	Test Date	09/09/08
Boring No.	V2M2-080028-5	Reviewed By	JW
Sample No.	Core 28 days (6x12)	Review Date	10/14/08
Sample Depth	n/a	Lab No.	8941
Sample Description	Concrete		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	
Location 1	5.009	Location 1	6.015	Wet Soil+Pan, grams	5326.60
Location 2	4.925	Location 2	6.007	Dry Soil + Pan, grams	5123.00
Location3	4.961	Location 3	6.011	Pan Weight, grams	0
Average	4.965	Average	6.011	Moisture Content, %	4.0
Volume, in^3	140.90	Wet Soil + Tare, grams	5324.60	Dry Unit Weight, pcf	138.5
SG Measured	2.43	Tare Weight, grams	0.00	Saturation, %	101.5
Soil Sample Wt., g	5324.60	Dry Soil +Tare, grams	5123.00	Diameter, in.	6.011
Dry UW, pcf	138.5	Moisture Content, %	3.9	Length, in.	4.965
Saturation, %	100.5			Volume, in^3	140.90

Consolidation	
Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used: Water

Elapsed Time (sec)	z_p (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
13440	1.70	24.50	24.40	0.10	23.2	22.7	22.6	5.63E-11	5.22E-11
6420	1.70	23.70	23.65	0.05	22.5	21.9	21.9	6.10E-11	5.75E-11
60420	1.70	23.70	23.30	0.40	23.2	21.9	21.5	5.23E-11	4.85E-11
147180	1.70	23.70	22.90	0.80	23.2	21.9	21.1	4.34E-11	4.02E-11

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
4	Core	N/A	N/A	Vertical

Avg. k at 20 °C **5.0E-11** **cm/sec**

a_s =	0.76712	cm^2	a_p =	0.031416	cm^2
A =	183.08	cm^2	M_1 =	0.03018	
L =	12.61	cm	M_2 =	1.04095	
S=L/A=	0.06888	1/cm	$C = M_1 S/(G_{H_2}-1)$ =	0.0001654	for 15° to 25°

Remarks:
- Subcontract No. AC54317N
- Specification No. K-SPC-G-0013
- Revision 10 08-13-2007
- Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	V2M2-080028-5
Lab No:	8941	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 28 Days (6x12)
Tested By:	HJ	Reviewed By:	JW
Date:	08/05/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	5.009			Tare No.		
2	4.925	Top	6.015	Tare Weight	0.00	*grams*
3	4.961	Bottom	6.007	Wet Weight + Tare	5324.60	*grams*
Average	4.97	Average	6.011	Dry Weight + Tare	5123.00	*grams*
				Moisture Content	3.9	%

Total Weight of Soil + Tube Section	5324.60	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	11.74	*lbs*
Volume of Sample	0.082	ft^3

RESULT SUMMARY

Moisture Content	**3.9**	*%*
Wet Density	**144.0**	*pcf*
Dry Density	**138.5**	*pcf*
Specific Gravity	**2.43103**	
Porosity	**0.09**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031 DO 2*	Tested By	*HJ*
Project Name	*Saltstone Grout & Vault Concrete*	Test Date	*9/18/2008*
Boring No.	*V2M2-080028-6*	Reviewed By	*JW*
Sample No.	*Core 28 days (6x12)*	Review Date	*10/14/2008*
Sample Depth	*n/a*	Lab No.	*8942*
Sample Description	*Concrete*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*4.7*
Wet Unit Weight, pcf:	*144.3*
Dry Unit Weight, pcf:	*137.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.2E-10***

Remarks:
Subcontract No. AC54317N
Specification No. K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No. 02

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

MACTEC

Project Number	6155-08-0031 DO 2	Tested By	HJ
Project Name	Saltstone Grout & Vault Concrete	Test Date	09/18/08
Boring No.	V2M2-080028-6	Reviewed By	JW
Sample No.	Core 28 days (6x12)	Review Date	10/14/08
Sample Depth	n/a	Lab No.	8942
Sample Description	Concrete		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	
Location 1	4.922	Location 1	6.027	Wet Soil+Pan, grams	5230.00
Location 2	4.801	Location 2	6.019	Dry Soil + Pan, grams	4995.00
Location3	4.803	Location 3	6.029	Pan Weight, grams	0
Average	4.842	Average	6.025	Moisture Content, %	4.7
Volume, in^3	138.05	Wet Soil + Tare, grams	5229.80	Dry Unit Weight, pcf	137.8
SG Measured	2.50	Tare Weight, grams	0.00	Saturation, %	89.0
Soil Sample Wt., g	5229.80	Dry Soil +Tare, grams	4995.00	Diameter, in.	6.025
Dry UW, pcf	137.8	Moisture Content, %	4.7	Length, in.	4.842
Saturation, %	88.9			Volume, in^3	138.05

Consolidation

Chamber Pressure, psi	78
Back Pressure, psi	68
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

Permeant used: Water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
353640	1.70	24.00	18.65	5.35	23.2	22.8	17.1	1.30E-10	1.21E-10
118800	1.70	24.00	20.15	3.85	23.2	22.8	18.7	2.68E-10	2.48E-10
29160	1.70	24.00	21.70	2.30	23.2	22.8	20.3	6.25E-10	5.80E-10
78360	1.70	24.00	20.45	3.55	23.2	22.8	19.0	3.71E-10	3.44E-10

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
4	Core	N/A	N/A	Vertical

Avg. k at 20 °C **3.2E-10** **cm/sec**

a_s = 0.76712 cm^2 — a_p = 0.031416 cm^2

A = 183.94 cm^2 — M_1 = 0.03018

L = 12.30 cm — M_2 = 1.04095

S=L/A= 0.06686 1/cm — $C = M_1 S/(G_{Hg}-1)$ = 0.0001605 for 15° to 25°

Remarks: Subcontract No. AC54317N; Specification No. K-SPC-G-0013; Revision 10 08-13-2007; Delivery Order No. 02

MACTEC

TP-4 UNIT WEIGHT OF SAMPLE

Project No.:	6155-08-0031 DO 2	Boring No.:	V2M2-080028-6
Lab No:	8942	Depth:	n/a
Project Name:	Saltstone Grout & Vault Concrete	Sample ID:	Core Age 28 Days (6x12)
Tested By:	HJ	Reviewed By:	JW
Date:	09/18/08	Date:	10/14/08

Total Sample Height, *inches*		Inside Diameter of Cut Tube, *inches*		Moisture Content		
1	4.922			Tare No.		
2	4.801	Top	6.020	Tare Weight	0.00	*grams*
3	4.803	Bottom	6.030	Wet Weight + Tare	5229.80	*grams*
Average	4.84	Average	6.025	Dry Weight + Tare	4995.00	*grams*
				Moisture Content	4.7	%

Total Weight of Soil + Tube Section	5229.80	*grams*
Weight of Clean, Dry Tube Section	0.00	*grams*
Wet Weight of Soil	11.53	*lbs*
Volume of Sample	0.080	ft^3

RESULT SUMMARY

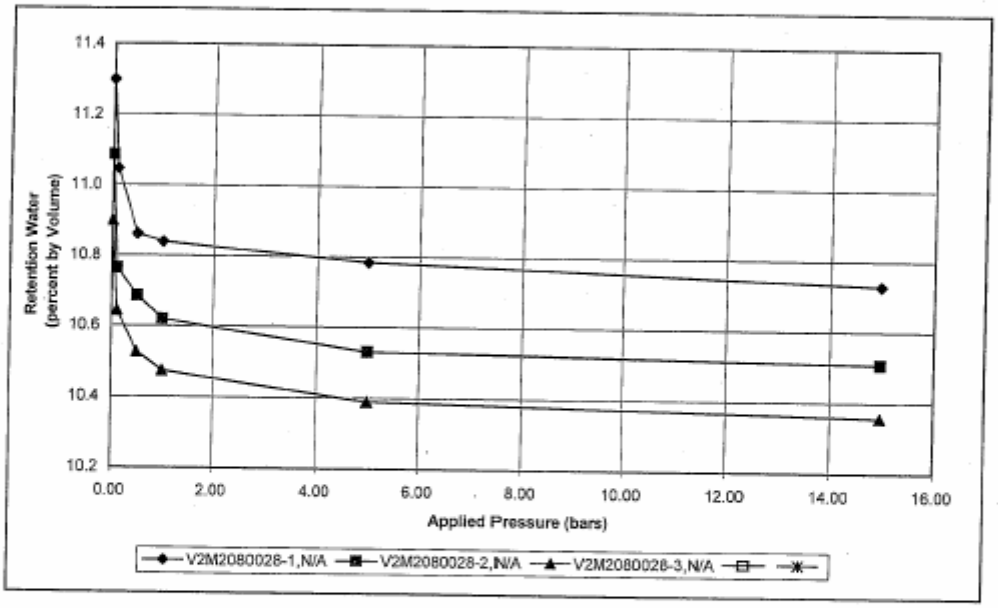
Moisture Content	**4.7**	*%*
Wet Density	**144.3**	*pcf*
Dry Density	**137.8**	*pcf*
Specific Gravity	**2.501233**	
Porosity	**0.12**	

Remarks: Subcontract No. AC54317N
Specification No. K-SPC-G-0013, Rev. 10 08-13--2007
Delivery Order No. 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	9/9/08
Reviewed By	JW	Review Date	10/14/08



Sample No. & Depth (ft)	Initial Moisture % by Vol.	Dry Unit Weight (pcf)	Applied Pressure (bars) 0.00	0.10	0.5	1.0	5.0	15.0				
			Retained Water (percent by volume)									
V2M2080028-1,N/A	11.3	140.9	11.3	11.0	10.9	10.8	10.8	10.7				
V2M2080028-2,N/A	11.1	140.7	11.1	10.8	10.7	10.6	10.5	10.5				
V2M2080028-3,N/A	10.9	140.8	10.9	10.6	10.5	10.5	10.4	10.4				

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

MACTEC

Water Retention Test
(ASTM D3152)

Project No	6155-08-0031 DO2	Project Name	Saltstone Grout & Vault Concrete
Tested By	HJ/JW	Test Date	9/9/2008
Reviewed By	JW	Review Date	10/14/2008

Sample No.	V2M0080028-1	V2M0080028-2	V2M0080028-3		
Depth (ft)	N/A	N/A	N/A		
Lab No.	8937	8938	8939		
Ring No.	N/A	N/A	N/A		
Container Weight (g)	0	0	0		
Container Diameter (cm)	7.631	7.620	7.620		
Container Height, (cm)	1.997	1.97	2.058		
Container Volume (cm^3)	91.33	89.84	93.85		
Wt. of Wet Soil + Container (g)	216.54	212.54	222.02		
Wt. of Dry Soil + Container (g)	206.22	202.58	211.79		
Moisture Content (%)	5.0	4.9	4.8		
Dry Unit Weight (pcf)	140.89	140.71	140.81		
Initial Wt.Wet Soil + Container (g)	216.54	212.54	222.02		
Initial Wt. Container (g)	0.00	0.00	0.00		
Initial Moisture, % by Volume	11.3	11.1	10.9		

Remarks: Subcontract No. AC54317N
Specification No K-SPC-G-0013
Revision 10 08-13-2007
Delivery Order No 02

Lab No.	Pressure	psi	0	1.45	7.25	14.5	72.5	217.5				
		bars	0.0	0.10	0.5	1.0	5.0	15.0				
	Date / Read By											
8937	Weight of Soil + Ring		216.54	216.31	216.14	216.12	216.07	216.02				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		11.3	11.0	10.9	10.8	10.8	10.7				
8938	Weight of Soil + Ring		212.54	212.25	212.18	212.12	212.04	212.02				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		11.1	10.8	10.7	10.6	10.5	10.5				
8939	Weight of Soil + Ring		222.02	221.78	221.67	221.62	221.54	221.51				
	Weight of Ring		0	0	0	0	0	0				
	Retained Water (%)		10.9	10.6	10.5	10.5	10.4	10.4				

No. of Samples 3
No. of Tests per Sample 6

APPENDIX E. CALCULATIONS TO CORRECT FOR SALT PRECIPITATION

The purpose of this appendix is to demonstrate the calculations that were used to correct the raw laboratory measurements of dry bulk density, porosity, and moisture retention for the saltstone grout samples. For each of these measurements, the sample is ultimately oven dried and it is necessary to correct for salt precipitation that occurs during this process. For each type of saltstone, the amount of salt added per 100 gram of wet grout was measured and this information was used to make the corrections. The corrections were made for each of the three types of saltstone (DDA, ARP/MCU, SWPF). The example calculations presented are for DDA saltstone. However, the calculations were the same for each saltstone type except for the simulant ratios and properties.

Dry bulk density was calculated based on the following equations.

$$M_{liquid} = M_{sat} - M_{dry} + S$$

$$\rho_{dry} = \frac{M_{sat} - M_{liquid}}{V_{total}}$$

M_{liquid} = mass of interstitial liquid in sample
M_{sat} = mass of saturated sample
M_{dry} = mass of oven dried sample
S = known salt content of grout (g salt/100g grout)
V_{total} = total volume of sample
ρ_{dry} = dry bulk density

For sample DDA-TR430-1:

M_{sat} = 542.84 g
M_{dry} = 381.3 g
S = 9.28 (grams of salt per 100 gram of grout)
V_{total} = 318.24 cm^3

$$M_{liquid} = 542.84\,g - 381.3\,g + \frac{9.28\,g\ salt}{100\,g\ grout} * 542.84\,g\ grout$$

$$M_{liquid} = 211.92\,g$$

$$\rho_{dry} = \frac{542.84\,g - 211.92\,g}{318.24\,cm^3}$$

$$\rho_{dry} = 1.04\,\frac{g}{cm^3}$$

Porosity was calculated as:

$$V_{liquid} = \frac{M_{liquid}}{\rho_{liquid}}$$

$$\phi = \frac{V_{voids}}{V_{total}} = \frac{V_{liquid}}{V_{total}}$$

M_{liquid} = mass of interstitial liquid in sample
V_{voids} = total volume of voids
V_{liquid} = volume of interstitial liquid in sample
V_{total} = total volume of sample
ρ_{liquid} =density of interstitial liquid
ϕ = corrected porosity

For sample DDA-TR430-1:

M_{liquid} = 211.92 g
ρ_{liquid} = 1.19 g/cm^3
V_{total} = 318.24 cm^3

$$V_{liquid} = \frac{M_{liquid}}{\rho_{liquid}}$$

$$V_{liquid} = \frac{211.92\,g}{1.19\,\frac{g}{cm^3}}$$

$$V_{liquid} = 178.08\,cm^3$$

$$\phi = \frac{178.08\,cm^3}{318.24\,cm^3}$$

$$\phi = 0.560$$

The following equations were used to determine the initial moisture content (i.e., porosity) of the moisture retention samples. It is important to note that only the mass of liquid removed by oven drying needs to be corrected for salt precipitation. The liquid removed by pressure extraction does not need to be corrected. Therefore, to determine the mass of liquid initially in the sample, the calculation is broken into two parts. The first part of the calculation determines the mass of liquid removed by pressure extraction and the second part determines the mass of liquid removed by the oven drying process at the end of the test (which is corrected for salt precipitation). The sum of these two values equals the total mass of liquid in the sample at saturation. Corrections to the moisture retention data were slightly different than for porosity and dry bulk density. For these measurements, the water to simulant ratio was used rather than the measured salt content. Although the difference is negligible, some salt is lost during pressure extraction so the salt content of the grout prior to oven-drying is actually unknown.

1) Determine the initial moisture content of the sample:

$$M_{liquid-pressure} = M_{sat} - M_{pressure-final}$$

$$M_{liquid-oven} = \frac{M_{pressure-final} - M_{dry}}{\chi_{wil}}$$

$$M_{liquid} = M_{liquid-pressure} + M_{liquid-oven}$$

$$V_{liquid} = \frac{M_{liquid}}{\rho_{liquid}}$$

$$\phi = \frac{V_{voids}}{V_{total}} = \frac{V_{liquid}}{V_{total}}$$

$M_{liquid\text{-}pressure}$ = mass of interstitial liquid removed by pressure extraction, g
$M_{liquid\text{-}oven}$ = mass of interstitial liquid removed by oven drying, g
$M_{pressure\text{-}final}$ = final mass of sample following pressure extraction, g
M_{sat} = total mass of saturated sample, g
M_{liquid} = mass of interstitial liquid in sample at saturation, g
M_{dry} = mass of oven dried sample, g
χ_{wil}= mass fraction of water in interstitial liquid, fraction
V_{liquid} = volume of interstitial liquid in sample, cm^3
V_{voids} = total volume of voids, cm^3
V_{total} = total volume of sample, cm^3
ϕ = porosity, fraction
ρ_{liquid} =density of interstitial liquid, g/cm^3

For DDA-TR430-1:

M_{sat} = 156.54 g
$M_{pressure\text{-}final}$ = 156.08 g
M_{dry} = 109.81 g
χ_{wil}= 0.7767
V_{total} = 90.09 cm^3
ϕ = porosity, fraction
ρ_{liquid} =1.19 g/cm^3

$$M_{liquid-pressure} = 156.54\,g - 156.08\,g$$

$$M_{liquid-pressure} = 0.46\,g$$

$$M_{liquid-oven} = \frac{156.08\,g - 109.81\,g}{0.7767}$$

$$M_{liquid-oven} = 59.57\,g$$

$$M_{liquid} = 0.46\,g + 59.57\,g$$

$$M_{liquid} = 60.03\,g$$

$$V_{liquid} = \frac{60.03\,g}{1.19\,\frac{g}{cm^3}}$$

$$V_{liquid} = 50.45\,cm^3$$

$$\phi = \frac{50.45\,cm^3}{90.09\,cm^3}$$

$$\phi = 0.560$$

2) Determine the volumetric moisture content of the samples at each pressure increment. In this example, the volumetric liquid content at 15 bars is determined.

$$M_{solid} = M_{sat} - M_{liquid}$$

$$V_{liquid} = \frac{M_{sample} - M_{solid}}{\rho_{liquid}}$$

$$\theta_{liquid} = \frac{V_{liquid}}{V_{total}}$$

M_{sat} = total mass of saturated sample, g
M_{sample} = mass of sample at each pressure increment, g
M_{liquid} = mass of interstitial liquid in sample at saturation, g
M_{solid}= corrected final dry weight of sample, g
ρ_{liquid} =density of interstitial liquid, g/cm^3
V_{liquid} = volume of liquid in sample at each pressure increment, cm^3
V_{total} = total volume of sample, cm^3
θ_{liquid} = volumetric moisture content of sample at each pressure increment, fraction

For DDA-TR430-1

M_{sat} = 156.54 g
M_{sample} = mass of sample at each pressure increment, g
M_{liquid} =60.03 g
ρ_{liquid} =1.19 g/cm^3
V_{total} = 90.09 cm^3

$$M_{solid} = 156.54\,g - 60.03\,g$$

$$M_{solid} = 96.51\,g$$

$$V_{liquid} = \frac{156.08\,g - 96.51\,g}{1.19\,\frac{g}{cm^3}}$$

$$V_{liquid} = 50.06\,cm^3$$

$$\theta_{liquid} = \frac{50.06\,cm^3}{90.09\,cm^3}$$

$$\theta_{liquid} = 0.556$$

APPENDIX F. RECOMMENDED CHARACTERISTIC CURVE DATA

Table F.1. Recommended Characteristic Curves for the DDA Saltstone (w/pm 0.6).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.6 x 10^{-11} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999010535498E-01	5.00E-02	9.9999010535498E-01	1.868055E-02
9.9997986436144E-01	1.00E-01	9.9997986436144E-01	1.409047E-02
9.9995916826836E-01	2.00E-01	9.9995916826836E-01	1.010657E-02
9.9989725297926E-01	5.00E-01	9.9989725297926E-01	5.857499E-03
9.9979724454104E-01	1.00E+00	9.9979724454104E-01	3.469996E-03
9.9961184597960E-01	2.00E+00	9.9961184597960E-01	1.807035E-03
9.9915465067191E-01	5.00E+00	9.9915465067191E-01	5.962337E-04
9.9860302333373E-01	1.00E+01	9.9860302333373E-01	2.111529E-04
9.9788067099630E-01	2.00E+01	9.9788067099630E-01	6.441829E-05
9.9674249020172E-01	5.00E+01	9.9674249020172E-01	1.144766E-05
9.9580897825690E-01	1.00E+02	9.9580897825690E-01	2.890764E-06
9.9485355143488E-01	2.00E+02	9.9485355143488E-01	7.080560E-07
9.9359026361135E-01	5.00E+02	9.9359026361135E-01	1.077786E-07
9.9264684578947E-01	1.00E+03	9.9264684578947E-01	2.573860E-08
9.9245840185135E-01	1.15E+03	9.9245840185135E-01	1.927454E-08
9.9227060867993E-01	1.32E+03	9.9227060867993E-01	1.443233E-08
9.9208348235218E-01	1.52E+03	9.9208348235218E-01	1.080560E-08
9.9189703632961E-01	1.75E+03	9.9189703632961E-01	8.089594E-09
9.9171128180992E-01	2.01E+03	9.9171128180992E-01	6.055838E-09
9.9152622803278E-01	2.31E+03	9.9152622803278E-01	4.533103E-09
9.9134188254552E-01	2.66E+03	9.9134188254552E-01	3.393081E-09
9.9115825143362E-01	3.06E+03	9.9115825143362E-01	2.539646E-09
9.9097533952056E-01	3.52E+03	9.9097533952056E-01	1.900795E-09
9.9079315054099E-01	4.05E+03	9.9079315054099E-01	1.422599E-09
9.9061168729063E-01	4.65E+03	9.9061168729063E-01	1.064675E-09
9.9043095175602E-01	5.35E+03	9.9043095175602E-01	7.967839E-10
9.9025094522666E-01	6.15E+03	9.9025094522666E-01	5.962858E-10
9.9007166839208E-01	7.08E+03	9.9007166839208E-01	4.462313E-10
9.8989312142561E-01	8.14E+03	9.8989312142561E-01	3.339323E-10
9.8971530405684E-01	9.36E+03	9.8971530405684E-01	2.498910E-10
9.8953821563413E-01	1.08E+04	9.8953821563413E-01	1.869982E-10
9.8936185517866E-01	1.24E+04	9.8936185517866E-01	1.399328E-10
9.8918622143100E-01	1.42E+04	9.8918622143100E-01	1.047123E-10
9.8901131289143E-01	1.64E+04	9.8901131289143E-01	7.835600E-11
9.8883712785458E-01	1.88E+04	9.8883712785458E-01	5.863323E-11
9.8866366443946E-01	2.16E+04	9.8866366443946E-01	4.387456E-11
9.8849092061527E-01	2.49E+04	9.8849092061527E-01	3.283065E-11
9.8831889422372E-01	2.86E+04	9.8831889422372E-01	2.456655E-11
9.8814758299825E-01	3.29E+04	9.8814758299825E-01	1.838261E-11
9.8797698458060E-01	3.79E+04	9.8797698458060E-01	1.375525E-11
9.8780709653512E-01	4.35E+04	9.8780709653512E-01	1.029269E-11
9.8763791636112E-01	5.01E+04	9.8763791636112E-01	7.701725E-12

Table F.1. Recommended Characteristic Curves for the DDA Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.6 x 10^{-11} cm/s)
9.8746944150343E-01	5.76E+04	9.8746944150343E-01	5.762967E-12
9.8730166936164E-01	6.62E+04	9.8730166936164E-01	4.312246E-12
9.8713459729793E-01	7.61E+04	9.8713459729793E-01	3.226711E-12
9.8696822264388E-01	8.76E+04	9.8696822264388E-01	2.414438E-12
9.8680254270634E-01	1.01E+05	9.8680254270634E-01	1.806640E-12
9.8663755477250E-01	1.16E+05	9.8663755477250E-01	1.351844E-12
9.8647325611416E-01	1.33E+05	9.8647325611416E-01	1.011536E-12
9.8630964399154E-01	1.53E+05	9.8630964399154E-01	7.568946E-13
9.8614671565646E-01	1.76E+05	9.8614671565646E-01	5.663558E-13
9.8598446835513E-01	2.03E+05	9.8598446835513E-01	4.237825E-13
9.8582289933051E-01	2.33E+05	9.8582289933051E-01	3.171002E-13
9.8566200582437E-01	2.68E+05	9.8566200582437E-01	2.372738E-13
9.8550178507903E-01	3.08E+05	9.8550178507903E-01	1.775427E-13
9.8534223433890E-01	3.54E+05	9.8534223433890E-01	1.328482E-13
9.8518335085174E-01	4.07E+05	9.8518335085174E-01	9.940508E-14
9.8502513186981E-01	4.68E+05	9.8502513186981E-01	7.438087E-14
9.8486757465076E-01	5.39E+05	9.8486757465076E-01	5.565624E-14
9.8471067645852E-01	6.20E+05	9.8471067645852E-01	4.164534E-14
9.8455443456393E-01	7.13E+05	9.8455443456393E-01	3.116153E-14
9.8439884624536E-01	8.19E+05	9.8439884624536E-01	2.331692E-14
9.8424390878922E-01	9.42E+05	9.8424390878922E-01	1.744711E-14
9.8408961949036E-01	1.08E+06	9.8408961949036E-01	1.305497E-14
9.8393597565248E-01	1.25E+06	9.8393597565248E-01	9.768504E-15
9.8378297458839E-01	1.43E+06	9.8378297458839E-01	7.309375E-15
9.8363061362029E-01	1.65E+06	9.8363061362029E-01	5.469309E-15
9.8347889007999E-01	1.90E+06	9.8347889007999E-01	4.092461E-15
9.8332780130910E-01	2.18E+06	9.8332780130910E-01	3.062222E-15
9.8317734465911E-01	2.51E+06	9.8317734465911E-01	2.291336E-15
9.8302751749163E-01	2.88E+06	9.8302751749163E-01	1.714514E-15
9.8287831717839E-01	3.31E+06	9.8287831717839E-01	1.282901E-15
9.8272974110135E-01	3.81E+06	9.8272974110135E-01	9.599421E-16
9.8258178665277E-01	4.38E+06	9.8258178665277E-01	7.182855E-16
9.8243445123528E-01	5.04E+06	9.8243445123528E-01	5.374637E-16
9.8228773226185E-01	5.80E+06	9.8228773226185E-01	4.021621E-16
9.8214162715588E-01	6.67E+06	9.8214162715588E-01	3.009215E-16
9.8199613335117E-01	7.67E+06	9.8199613335117E-01	2.251673E-16
9.8185124829195E-01	8.82E+06	9.8185124829195E-01	1.684835E-16
9.8170696943287E-01	1.01E+07	9.8170696943287E-01	1.260693E-16
9.8156329423902E-01	1.17E+07	9.8156329423902E-01	9.433249E-17
9.8142022018586E-01	1.34E+07	9.8142022018586E-01	7.058514E-17
9.8127774475925E-01	1.54E+07	9.8127774475925E-01	5.281597E-17
9.8113586545544E-01	1.77E+07	9.8113586545544E-01	3.952003E-17
9.8099457978099E-01	2.04E+07	9.8099457978099E-01	2.957122E-17

Table F.1. Recommended Characteristic Curves for the DDA Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.6 x 10^{-11} cm/s)
9.8085388525283E-01	2.35E+07	9.8085388525283E-01	2.212694E-17
9.8071377939814E-01	2.70E+07	9.8071377939814E-01	1.655668E-17
9.8057425975438E-01	3.10E+07	9.8057425975438E-01	1.238869E-17
9.8043532386925E-01	3.57E+07	9.8043532386925E-01	9.269947E-18
9.8029696930064E-01	4.10E+07	9.8029696930064E-01	6.936322E-18
9.8015919361661E-01	4.72E+07	9.8015919361661E-01	5.190166E-18
9.8002199439533E-01	5.43E+07	9.8002199439533E-01	3.883588E-18
9.7988536922510E-01	6.24E+07	9.7988536922510E-01	2.905930E-18
9.7974931570425E-01	7.18E+07	9.7974931570425E-01	2.174389E-18
9.7961383144113E-01	8.25E+07	9.7961383144113E-01	1.627006E-18
9.7947891405409E-01	9.49E+07	9.7947891405409E-01	1.217422E-18
9.7934456117141E-01	1.09E+08	9.7934456117141E-01	9.109470E-19
9.7921077043126E-01	1.25E+08	9.7921077043126E-01	6.816244E-19
9.7907753948171E-01	1.44E+08	9.7907753948171E-01	5.100316E-19
9.7894486598063E-01	1.66E+08	9.7894486598063E-01	3.816358E-19
9.7881274759569E-01	1.91E+08	9.7881274759569E-01	2.855625E-19
9.7868118200430E-01	2.19E+08	9.7868118200430E-01	2.136746E-19
9.7855016689358E-01	2.52E+08	9.7855016689358E-01	1.598840E-19
9.7841969996034E-01	2.90E+08	9.7841969996034E-01	1.196347E-19
9.7828977891098E-01	3.34E+08	9.7828977891098E-01	8.951770E-20
9.7816040146154E-01	3.84E+08	9.7816040146154E-01	6.698246E-20
9.7803156533756E-01	4.41E+08	9.7803156533756E-01	5.012022E-20
9.7790326827413E-01	5.08E+08	9.7790326827413E-01	3.750289E-20
9.7777550801580E-01	5.84E+08	9.7777550801580E-01	2.806188E-20
9.7764828231655E-01	6.71E+08	9.7764828231655E-01	2.099756E-20
9.7752158893977E-01	7.72E+08	9.7752158893977E-01	1.571162E-20
9.7739542565818E-01	8.88E+08	9.7739542565818E-01	1.175635E-20
9.7726979025383E-01	1.02E+09	9.7726979025383E-01	8.796800E-21

Table F.2. Recommended Characteristic Curves for the ARP/MCU Saltstone (w/pm 0.6).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999614841617E-01	5.00E-02	9.9999614841617E-01	4.563459E-01
9.9999098293979E-01	1.00E-01	9.9999098293979E-01	3.839188E-01
9.9997894439345E-01	2.00E-01	9.9997894439345E-01	3.073041E-01
9.9993605635663E-01	5.00E-01	9.9993605635663E-01	2.044476E-01
9.9985461139490E-01	1.00E+00	9.9985461139490E-01	1.318531E-01
9.9968139960062E-01	2.00E+00	9.9968139960062E-01	7.171879E-02
9.9919782556041E-01	5.00E+00	9.9919782556041E-01	2.216349E-02
9.9858987175287E-01	1.00E+01	9.9858987175287E-01	6.583447E-03
9.9783038201652E-01	2.00E+01	9.9783038201652E-01	1.531679E-03
9.9677727558239E-01	5.00E+01	9.9677727558239E-01	1.759306E-04
9.9604152427855E-01	1.00E+02	9.9604152427855E-01	3.130601E-05
9.9539044037874E-01	2.00E+02	9.9539044037874E-01	5.390587E-06
9.9466198490639E-01	5.00E+02	9.9466198490639E-01	5.159668E-07
9.9420117768092E-01	1.00E+03	9.9420117768092E-01	8.690415E-08
9.9411669350360E-01	1.15E+03	9.9411669350360E-01	6.066360E-08
9.9403485226565E-01	1.32E+03	9.9403485226565E-01	4.234350E-08
9.9395557581617E-01	1.52E+03	9.9395557581617E-01	2.955431E-08
9.9387878747403E-01	1.75E+03	9.9387878747403E-01	2.062691E-08
9.9380441216504E-01	2.01E+03	9.9380441216504E-01	1.439561E-08
9.9373237652116E-01	2.31E+03	9.9373237652116E-01	1.004642E-08
9.9366260894936E-01	2.66E+03	9.9366260894936E-01	7.011008E-09
9.9359503967569E-01	3.06E+03	9.9359503967569E-01	4.892592E-09
9.9352960076973E-01	3.52E+03	9.9352960076973E-01	3.414199E-09
9.9346622615315E-01	4.05E+03	9.9346622615315E-01	2.382491E-09
9.9340485159577E-01	4.65E+03	9.9340485159577E-01	1.662522E-09
9.9334541470167E-01	5.35E+03	9.9334541470167E-01	1.160108E-09
9.9328785488761E-01	6.15E+03	9.9328785488761E-01	8.095151E-10
9.9323211335534E-01	7.08E+03	9.9323211335534E-01	5.648691E-10
9.9317813305939E-01	8.14E+03	9.9317813305939E-01	3.941554E-10
9.9312585867140E-01	9.36E+03	9.9312585867140E-01	2.750329E-10
9.9307523654191E-01	1.08E+04	9.9307523654191E-01	1.919108E-10
9.9302621466044E-01	1.24E+04	9.9302621466044E-01	1.339098E-10
9.9297874261435E-01	1.42E+04	9.9297874261435E-01	9.343809E-11
9.9293277154706E-01	1.64E+04	9.9293277154706E-01	6.519797E-11
9.9288825411596E-01	1.88E+04	9.9288825411596E-01	4.549284E-11
9.9284514445034E-01	2.16E+04	9.9284514445034E-01	3.174323E-11
9.9280339810957E-01	2.49E+04	9.9280339810957E-01	2.214922E-11
9.9276297204176E-01	2.86E+04	9.9276297204176E-01	1.545486E-11
9.9272382454296E-01	3.29E+04	9.9272382454296E-01	1.078378E-11
9.9268591521710E-01	3.79E+04	9.9268591521710E-01	7.524482E-12
9.9264920493672E-01	4.35E+04	9.9264920493672E-01	5.250272E-12
9.9261365580457E-01	5.01E+04	9.9261365580457E-01	3.663420E-12

Table F.2. Recommended Characteristic Curves for the ARP/MCU Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
9.9257923111605E-01	5.76E+04	9.9257923111605E-01	2.556179E-12
9.9254589532266E-01	6.62E+04	9.9254589532266E-01	1.783592E-12
9.9251361399633E-01	7.61E+04	9.9251361399633E-01	1.244514E-12
9.9248235379475E-01	8.76E+04	9.9248235379475E-01	8.683676E-13
9.9245208242764E-01	1.01E+05	9.9245208242764E-01	6.059091E-13
9.9242276862395E-01	1.16E+05	9.9242276862395E-01	4.227768E-13
9.9239438210007E-01	1.33E+05	9.9239438210007E-01	2.949951E-13
9.9236689352888E-01	1.53E+05	9.9236689352888E-01	2.058345E-13
9.9234027450981E-01	1.76E+05	9.9234027450981E-01	1.436222E-13
9.9231449753973E-01	2.03E+05	9.9231449753973E-01	1.002132E-13
9.9228953598472E-01	2.33E+05	9.9228953598472E-01	6.992434E-14
9.9226536405278E-01	2.68E+05	9.9226536405278E-01	4.879010E-14
9.9224195676726E-01	3.08E+05	9.9224195676726E-01	3.404356E-14
9.9221928994121E-01	3.54E+05	9.9221928994121E-01	2.375408E-14
9.9219734015242E-01	4.07E+05	9.9219734015242E-01	1.657454E-14
9.9217608471936E-01	4.68E+05	9.9217608471936E-01	1.156497E-14
9.9215550167778E-01	5.39E+05	9.9215550167778E-01	8.069520E-15
9.9213556975803E-01	6.20E+05	9.9213556975803E-01	5.630550E-15
9.9211626836316E-01	7.13E+05	9.9211626836316E-01	3.928746E-15
9.9209757754767E-01	8.19E+05	9.9209757754767E-01	2.741303E-15
9.9207947799691E-01	9.42E+05	9.9207947799691E-01	1.912759E-15
9.9206195100712E-01	1.08E+06	9.9206195100712E-01	1.334637E-15
9.9204497846618E-01	1.25E+06	9.9204497846618E-01	9.312502E-16
9.9202854283486E-01	1.43E+06	9.9202854283486E-01	6.497847E-16
9.9201262712871E-01	1.65E+06	9.9201262712871E-01	4.533907E-16
9.9199721490056E-01	1.90E+06	9.9199721490056E-01	3.163557E-16
9.9198229022347E-01	2.18E+06	9.9198229022347E-01	2.207388E-16
9.9196783767432E-01	2.51E+06	9.9196783767432E-01	1.540217E-16
9.9195384231787E-01	2.88E+06	9.9195384231787E-01	1.074694E-16
9.9194028969133E-01	3.31E+06	9.9194028969133E-01	7.498734E-17
9.9192716578939E-01	3.81E+06	9.9192716578939E-01	5.232280E-17
9.9191445704981E-01	4.38E+06	9.9191445704981E-01	3.650851E-17
9.9190215033933E-01	5.04E+06	9.9190215033933E-01	2.547400E-17
9.9189023294018E-01	5.80E+06	9.9189023294018E-01	1.777462E-17
9.9187869253687E-01	6.67E+06	9.9187869253687E-01	1.240233E-17
9.9186751720351E-01	7.67E+06	9.9186751720351E-01	8.653790E-18
9.9185669539146E-01	8.82E+06	9.9185669539146E-01	6.038227E-18
9.9184621591742E-01	1.01E+07	9.9184621591742E-01	4.213204E-18
9.9183606795184E-01	1.17E+07	9.9183606795184E-01	2.939785E-18
9.9182624100778E-01	1.34E+07	9.9182624100778E-01	2.051250E-18
9.9181672493003E-01	1.54E+07	9.9181672493003E-01	1.431270E-18
9.9180750988461E-01	1.77E+07	9.9180750988461E-01	9.986763E-19
9.9179858634865E-01	2.04E+07	9.9179858634865E-01	6.968315E-19

Table F.2. Recommended Characteristic Curves for the ARP/MCU Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
9.9178994510053E-01	2.35E+07	9.9178994510053E-01	4.862178E-19
9.9178157721032E-01	2.70E+07	9.9178157721032E-01	3.392610E-19
9.9177347403062E-01	3.10E+07	9.9177347403062E-01	2.367211E-19
9.9176562718754E-01	3.57E+07	9.9176562718754E-01	1.651734E-19
9.9175802857211E-01	4.10E+07	9.9175802857211E-01	1.152506E-19
9.9175067033189E-01	4.72E+07	9.9175067033189E-01	8.041669E-20
9.9174354486282E-01	5.43E+07	9.9174354486282E-01	5.611115E-20
9.9173664480141E-01	6.24E+07	9.9173664480141E-01	3.915184E-20
9.9172996301709E-01	7.18E+07	9.9172996301709E-01	2.731840E-20
9.9172349260487E-01	8.25E+07	9.9172349260487E-01	1.906156E-20
9.9171722687818E-01	9.49E+07	9.9171722687818E-01	1.330030E-20
9.9171115936199E-01	1.09E+08	9.9171115936199E-01	9.280355E-21
9.9170528378609E-01	1.25E+08	9.9170528378609E-01	6.475418E-21
9.9169959407864E-01	1.44E+08	9.9169959407864E-01	4.518252E-21
9.9169408435984E-01	1.66E+08	9.9169408435984E-01	3.152637E-21
9.9168874893592E-01	1.91E+08	9.9168874893592E-01	2.199769E-21
9.9168358229324E-01	2.19E+08	9.9168358229324E-01	1.534899E-21
9.9167857909254E-01	2.52E+08	9.9167857909254E-01	1.070983E-21
9.9167373416349E-01	2.90E+08	9.9167373416349E-01	7.472848E-22
9.9166904249932E-01	3.34E+08	9.9166904249932E-01	5.214209E-22
9.9166449925162E-01	3.84E+08	9.9166449925162E-01	3.638252E-22
9.9166009972539E-01	4.41E+08	9.9166009972539E-01	2.538604E-22
9.9165583937412E-01	5.08E+08	9.9165583937412E-01	1.771325E-22
9.9165171379515E-01	5.84E+08	9.9165171379515E-01	1.235952E-22
9.9164771872507E-01	6.71E+08	9.9164771872507E-01	8.623882E-23
9.9164385003536E-01	7.72E+08	9.9164385003536E-01	6.017355E-23
9.9164010372809E-01	8.88E+08	9.9164010372809E-01	4.198672E-23
9.9163647593180E-01	1.02E+09	9.9163647593180E-01	2.929657E-23

Table F.3. Characteristic Curves for MCU Saltstone as Determined by INL (Dixon and Phifer, 2007).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999976540962E-01	5.00E-02	9.9999976540962E-01	5.013543E-01
9.9999949012830E-01	1.00E-01	9.9999949012830E-01	4.661379E-01
9.9999889182528E-01	2.00E-01	9.9999889182528E-01	4.293214E-01
9.9999690770961E-01	5.00E-01	9.9999690770961E-01	3.784173E-01
9.9999327958840E-01	1.00E+00	9.9999327958840E-01	3.384701E-01
9.9998539616530E-01	2.00E+00	9.9998539616530E-01	2.975922E-01
9.9995927265626E-01	5.00E+00	9.9995927265626E-01	2.427984E-01
9.9991158215229E-01	1.00E+01	9.9991158215229E-01	2.014672E-01
9.9980830517116E-01	2.00E+01	9.9980830517116E-01	1.610389E-01
9.9946943274209E-01	5.00E+01	9.9946943274209E-01	1.106641E-01
9.9886370262499E-01	1.00E+02	9.9886370262499E-01	7.655804E-02
9.9760553368456E-01	2.00E+02	9.9760553368456E-01	4.768905E-02
9.9391355248690E-01	5.00E+02	9.9391355248690E-01	2.027161E-02
9.8853487285773E-01	1.00E+03	9.8853487285773E-01	8.443452E-03
9.8710980336367E-01	1.15E+03	9.8710980336367E-01	6.889821E-03
9.8556558070136E-01	1.32E+03	9.8556558070136E-01	5.571507E-03
9.8390345422771E-01	1.52E+03	9.8390345422771E-01	4.465546E-03
9.8212648862780E-01	1.75E+03	9.8212648862780E-01	3.548212E-03
9.8023949270192E-01	2.01E+03	9.8023949270192E-01	2.795807E-03
9.7824886091039E-01	2.31E+03	9.7824886091039E-01	2.185379E-03
9.7616234144880E-01	2.66E+03	9.7616234144880E-01	1.695324E-03
9.7398875142640E-01	3.06E+03	9.7398875142640E-01	1.305835E-03
9.7173766335656E-01	3.52E+03	9.7173766335656E-01	9.991959E-04
9.6941908735370E-01	4.05E+03	9.6941908735370E-01	7.599136E-04
9.6704317059299E-01	4.65E+03	9.6704317059299E-01	5.747188E-04
9.6461993065739E-01	5.35E+03	9.6461993065739E-01	4.324618E-04
9.6215903350220E-01	6.15E+03	9.6215903350220E-01	3.239348E-04
9.5966962095117E-01	7.08E+03	9.5966962095117E-01	2.416526E-04
9.5716018766385E-01	8.14E+03	9.5716018766385E-01	1.796153E-04
9.5463850379725E-01	9.36E+03	9.5463850379725E-01	1.330738E-04
9.5211157722331E-01	1.08E+04	9.5211157722331E-01	9.831164E-05
9.4958564802628E-01	1.24E+04	9.4958564802628E-01	7.244861E-05
9.4706620783297E-01	1.42E+04	9.4706620783297E-01	5.327253E-05
9.4455803702691E-01	1.64E+04	9.4455803702691E-01	3.909721E-05
9.4206525379006E-01	1.88E+04	9.4206525379006E-01	2.864607E-05
9.3959136998183E-01	2.16E+04	9.3959136998183E-01	2.095831E-05
9.3713934994577E-01	2.49E+04	9.3713934994577E-01	1.531453E-05
9.3471166933090E-01	2.86E+04	9.3471166933090E-01	1.117842E-05
9.3231037187351E-01	3.29E+04	9.3231037187351E-01	8.151749E-06
9.2993712278898E-01	3.79E+04	9.2993712278898E-01	5.939786E-06
9.2759325797390E-01	4.35E+04	9.2759325797390E-01	4.325028E-06
9.2527982863288E-01	5.01E+04	9.2527982863288E-01	3.147367E-06

Table F.3. Characteristic Curves for MCU Saltstone as Determined by INL continued (Dixon and Phifer, 2007).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
9.2299764124261E-01	5.76E+04	9.2299764124261E-01	2.289194E-06
9.2074729297073E-01	6.62E+04	9.2074729297073E-01	1.664279E-06
9.1852920279901E-01	7.61E+04	9.1852920279901E-01	1.209497E-06
9.1634363867811E-01	8.76E+04	9.1634363867811E-01	8.787039E-07
9.1419074107923E-01	1.01E+05	9.1419074107923E-01	6.382032E-07
9.1207054331820E-01	1.16E+05	9.1207054331820E-01	4.634166E-07
9.0998298901970E-01	1.33E+05	9.0998298901970E-01	3.364304E-07
9.0792794706904E-01	1.53E+05	9.0792794706904E-01	2.441983E-07
9.0590522437266E-01	1.76E+05	9.0590522437266E-01	1.772249E-07
9.0391457671848E-01	2.03E+05	9.0391457671848E-01	1.286030E-07
9.0195571799659E-01	2.33E+05	9.0195571799659E-01	9.331025E-08
9.0002832801077E-01	2.68E+05	9.0002832801077E-01	6.769659E-08
8.9813205908321E-01	3.08E+05	8.9813205908321E-01	4.910991E-08
8.9626654162840E-01	3.54E+05	8.9626654162840E-01	3.562390E-08
8.9443138884901E-01	4.07E+05	8.9443138884901E-01	2.583975E-08
8.9262620068522E-01	4.68E+05	8.9262620068522E-01	1.874187E-08
8.9085056713049E-01	5.39E+05	8.9085056713049E-01	1.359311E-08
8.8910407101055E-01	6.20E+05	8.8910407101055E-01	9.858455E-09
8.8738629030804E-01	7.13E+05	8.8738629030804E-01	7.149654E-09
8.8569680010327E-01	8.19E+05	8.8569680010327E-01	5.185008E-09
8.8403517419068E-01	9.42E+05	8.8403517419068E-01	3.760138E-09
8.8240098642187E-01	1.08E+06	8.8240098642187E-01	2.726776E-09
8.8079381181805E-01	1.25E+06	8.8079381181805E-01	1.977370E-09
8.7921322748836E-01	1.43E+06	8.7921322748836E-01	1.433904E-09
8.7765881338479E-01	1.65E+06	8.7765881338479E-01	1.039793E-09
8.7613015291968E-01	1.90E+06	8.7613015291968E-01	7.539957E-10
8.7462683346769E-01	2.18E+06	8.7462683346769E-01	5.467478E-10
8.7314844677091E-01	2.51E+06	8.7314844677091E-01	3.964623E-10
8.7169458926244E-01	2.88E+06	8.7169458926244E-01	2.874841E-10
8.7026486232183E-01	3.31E+06	8.7026486232183E-01	2.084603E-10
8.6885887247339E-01	3.81E+06	8.6885887247339E-01	1.511579E-10
8.6747623153657E-01	4.38E+06	8.6747623153657E-01	1.096065E-10
8.6611655673647E-01	5.04E+06	8.6611655673647E-01	7.947680E-11
8.6477947078092E-01	5.80E+06	8.6477947078092E-01	5.762927E-11
8.6346460190973E-01	6.67E+06	8.6346460190973E-01	4.178734E-11
8.6217158392090E-01	7.67E+06	8.6217158392090E-01	3.030019E-11
8.6090005617747E-01	8.82E+06	8.6090005617747E-01	2.197076E-11
8.5964966359855E-01	1.01E+07	8.5964966359855E-01	1.593105E-11
8.5842005663725E-01	1.17E+07	8.5842005663725E-01	1.155162E-11
8.5721089124767E-01	1.34E+07	8.5721089124767E-01	8.376080E-12
8.5602182884320E-01	1.54E+07	8.5602182884320E-01	6.073491E-12
8.5485253624744E-01	1.77E+07	8.5485253624744E-01	4.403881E-12
8.5370268563944E-01	2.04E+07	8.5370268563944E-01	3.193246E-12

Table F.3. Characteristic Curves for the MCU Saltstone as Determined by INL continued (Dixon and Phifer, 2007).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 8.5 x 10^{-10} cm/s)
8.5257195449417E-01	2.35E+07	8.5257195449417E-01	2.315416E-12
8.5146002551930E-01	2.70E+07	8.5146002551930E-01	1.678902E-12
8.5036658658906E-01	3.10E+07	8.5036658658906E-01	1.217367E-12
8.4929133067594E-01	3.57E+07	8.4929133067594E-01	8.827089E-13
8.4823395578063E-01	4.10E+07	8.4823395578063E-01	6.400492E-13
8.4719416486084E-01	4.72E+07	8.4719416486084E-01	4.640973E-13
8.4617166575932E-01	5.43E+07	8.4617166575932E-01	3.365152E-13
8.4516617113141E-01	6.24E+07	8.4516617113141E-01	2.440058E-13
8.4417739837237E-01	7.18E+07	8.4417739837237E-01	1.769276E-13
8.4320506954476E-01	8.25E+07	8.4320506954476E-01	1.282895E-13
8.4224891130609E-01	9.49E+07	8.4224891130609E-01	9.302213E-14
8.4130865483672E-01	1.09E+08	8.4130865483672E-01	6.744993E-14
8.4038403576840E-01	1.25E+08	8.4038403576840E-01	4.890764E-14
8.3947479411331E-01	1.44E+08	8.3947479411331E-01	3.546271E-14
8.3858067419381E-01	1.66E+08	8.3858067419381E-01	2.571385E-14
8.3770142457299E-01	1.91E+08	8.3770142457299E-01	1.864499E-14
8.3683679798596E-01	2.19E+08	8.3683679798596E-01	1.351940E-14
8.3598655127203E-01	2.52E+08	8.3598655127203E-01	9.802850E-15
8.3515044530773E-01	2.90E+08	8.3515044530773E-01	7.108000E-15
8.3432824494081E-01	3.34E+08	8.3432824494081E-01	5.153977E-15
8.3351971892507E-01	3.84E+08	8.3351971892507E-01	3.737124E-15
8.3272463985620E-01	4.41E+08	8.3272463985620E-01	2.709771E-15
8.3194278410853E-01	5.08E+08	8.3194278410853E-01	1.964842E-15
8.3117393177274E-01	5.84E+08	8.3117393177274E-01	1.424697E-15
8.3041786659450E-01	6.71E+08	8.3041786659450E-01	1.033041E-15
8.2967437591408E-01	7.72E+08	8.2967437591408E-01	7.490531E-16
8.2894325060689E-01	8.88E+08	8.2894325060689E-01	5.431347E-16
8.2822428502496E-01	1.02E+09	8.2822428502496E-01	3.938244E-16

Table F.4. Recommended Characteristic Curves for the SWPF Saltstone (w/pm 0.6).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.0 x 10^{-09} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999450512237E-01	5.00E-02	9.9999450512237E-01	5.922781E-01
9.9998649099373E-01	1.00E-01	9.9998649099373E-01	5.132622E-01
9.9996686324043E-01	2.00E-01	9.9996686324043E-01	4.240580E-01
9.9989251698424E-01	5.00E-01	9.9989251698424E-01	2.946031E-01
9.9974303973976E-01	1.00E+00	9.9974303973976E-01	1.957579E-01
9.9940878616220E-01	2.00E+00	9.9940878616220E-01	1.085018E-01
9.9843030311622E-01	5.00E+00	9.9843030311622E-01	3.294675E-02
9.9718023345998E-01	1.00E+01	9.9718023345998E-01	9.194285E-03
9.9564723793658E-01	2.00E+01	9.9564723793658E-01	1.936657E-03
9.9362164284766E-01	5.00E+01	9.9362164284766E-01	1.899584E-04
9.9228702148395E-01	1.00E+02	9.9228702148395E-01	2.985589E-05
9.9116514834577E-01	2.00E+02	9.9116514834577E-01	4.542393E-06
9.8998069206494E-01	5.00E+02	9.8998069206494E-01	3.696632E-07
9.8927370123159E-01	1.00E+03	9.8927370123159E-01	5.511103E-08
9.8914793987243E-01	1.15E+03	9.8914793987243E-01	3.753732E-08
9.8902730907304E-01	1.32E+03	9.8902730907304E-01	2.556609E-08
9.8891160484811E-01	1.52E+03	9.8891160484811E-01	1.741186E-08
9.8880063025300E-01	1.75E+03	9.8880063025300E-01	1.185795E-08
9.8869419536088E-01	2.01E+03	9.8869419536088E-01	8.075328E-09
9.8859211718782E-01	2.31E+03	9.8859211718782E-01	5.499195E-09
9.8849421957863E-01	2.66E+03	9.8849421957863E-01	3.744799E-09
9.8840033306328E-01	3.06E+03	9.8840033306328E-01	2.550056E-09
9.8831029469194E-01	3.52E+03	9.8831029469194E-01	1.736458E-09
9.8822394785494E-01	4.05E+03	9.8822394785494E-01	1.182424E-09
9.8814114209264E-01	4.65E+03	9.8814114209264E-01	8.051517E-10
9.8806173289903E-01	5.35E+03	9.8806173289903E-01	5.482494E-10
9.8798558152219E-01	6.15E+03	9.8798558152219E-01	3.733149E-10
9.8791255476398E-01	7.08E+03	9.8791255476398E-01	2.541967E-10
9.8784252478074E-01	8.14E+03	9.8784252478074E-01	1.730861E-10
9.8777536888644E-01	9.36E+03	9.8777536888644E-01	1.178562E-10
9.8771096935928E-01	1.08E+04	9.8771096935928E-01	8.024931E-11
9.8764921325255E-01	1.24E+04	9.8764921325255E-01	5.464228E-11
9.8758999221036E-01	1.42E+04	9.8758999221036E-01	3.720619E-11
9.8753320228852E-01	1.64E+04	9.8753320228852E-01	2.533382E-11
9.8747874378094E-01	1.88E+04	9.8747874378094E-01	1.724986E-11
9.8742652105158E-01	2.16E+04	9.8742652105158E-01	1.174545E-11
9.8737644237219E-01	2.49E+04	9.8737644237219E-01	7.997480E-12
9.8732841976567E-01	2.86E+04	9.8732841976567E-01	5.445482E-12
9.8728236885513E-01	3.29E+04	9.8728236885513E-01	3.707824E-12
9.8723820871851E-01	3.79E+04	9.8723820871851E-01	2.524652E-12
9.8719586174870E-01	4.35E+04	9.8719586174870E-01	1.719031E-12
9.8715525351900E-01	5.01E+04	9.8715525351900E-01	1.170485E-12

Table F.4. Recommended Characteristic Curves for the SWPF Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.0 x 10^{-09} cm/s)
9.8711631265375E-01	5.76E+04	9.8711631265375E-01	7.969803E-13
9.8707897070411E-01	6.62E+04	9.8707897070411E-01	5.426619E-13
9.8704316202864E-01	7.61E+04	9.8704316202864E-01	3.694969E-13
9.8700882367868E-01	8.76E+04	9.8700882367868E-01	2.515894E-13
9.8697589528833E-01	1.01E+05	9.8697589528833E-01	1.713064E-13
9.8694431896873E-01	1.16E+05	9.8694431896873E-01	1.166420E-13
9.8691403920675E-01	1.33E+05	9.8691403920675E-01	7.942116E-14
9.8688500276768E-01	1.53E+05	9.8688500276768E-01	5.407760E-14
9.8685715860186E-01	1.76E+05	9.8685715860186E-01	3.682125E-14
9.8683045775517E-01	2.03E+05	9.8683045775517E-01	2.507146E-14
9.8680485328308E-01	2.33E+05	9.8680485328308E-01	1.707107E-14
9.8678030016826E-01	2.68E+05	9.8678030016826E-01	1.162363E-14
9.8675675524152E-01	3.08E+05	9.8675675524152E-01	7.914488E-15
9.8673417710599E-01	3.54E+05	9.8673417710599E-01	5.388946E-15
9.8671252606444E-01	4.07E+05	9.8671252606444E-01	3.669314E-15
9.8669176404947E-01	4.68E+05	9.8669176404947E-01	2.498422E-15
9.8667185455666E-01	5.39E+05	9.8667185455666E-01	1.701167E-15
9.8665276258043E-01	6.20E+05	9.8665276258043E-01	1.158318E-15
9.8663445455248E-01	7.13E+05	9.8663445455248E-01	7.886945E-16
9.8661689828282E-01	8.19E+05	9.8661689828282E-01	5.370192E-16
9.8660006290317E-01	9.42E+05	9.8660006290317E-01	3.656543E-16
9.8658391881272E-01	1.08E+06	9.8658391881272E-01	2.489727E-16
9.8656843762609E-01	1.25E+06	9.8656843762609E-01	1.695246E-16
9.8655359212341E-01	1.43E+06	9.8655359212341E-01	1.154286E-16
9.8653935620248E-01	1.65E+06	9.8653935620248E-01	7.859493E-17
9.8652570483289E-01	1.90E+06	9.8652570483289E-01	5.351500E-17
9.8651261401202E-01	2.18E+06	9.8651261401202E-01	3.643816E-17
9.8650006072280E-01	2.51E+06	9.8650006072280E-01	2.481061E-17
9.8648802289329E-01	2.88E+06	9.8648802289329E-01	1.689345E-17
9.8647647935784E-01	3.31E+06	9.8647647935784E-01	1.150269E-17
9.8646540981992E-01	3.81E+06	9.8646540981992E-01	7.832136E-18
9.8645479481637E-01	4.38E+06	9.8645479481637E-01	5.332872E-18
9.8644461568325E-01	5.04E+06	9.8644461568325E-01	3.631133E-18
9.8643485452297E-01	5.80E+06	9.8643485452297E-01	2.472425E-18
9.8642549417284E-01	6.67E+06	9.8642549417284E-01	1.683465E-18
9.8641651817492E-01	7.67E+06	9.8641651817492E-01	1.146265E-18
9.8640791074704E-01	8.82E+06	9.8640791074704E-01	7.804874E-19
9.8639965675508E-01	1.01E+07	9.8639965675508E-01	5.314309E-19
9.8639174168635E-01	1.17E+07	9.8639174168635E-01	3.618493E-19
9.8638415162408E-01	1.34E+07	9.8638415162408E-01	2.463818E-19
9.8637687322294E-01	1.54E+07	9.8637687322294E-01	1.677605E-19
9.8636989368558E-01	1.77E+07	9.8636989368558E-01	1.142275E-19
9.8636320074015E-01	2.04E+07	9.8636320074015E-01	7.777706E-20

Table F.4. Recommended Characteristic Curves for the SWPF Saltstone (w/pm 0.6) continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 6.0 x 10^{-09} cm/s)
9.8635678261868E-01	2.35E+07	9.8635678261868E-01	5.295811E-20
9.8635062803642E-01	2.70E+07	9.8635062803642E-01	3.605898E-20
9.8634472617200E-01	3.10E+07	9.8634472617200E-01	2.455242E-20
9.8633906664837E-01	3.57E+07	9.8633906664837E-01	1.671765E-20
9.8633363951462E-01	4.10E+07	9.8633363951462E-01	1.138299E-20
9.8632843522841E-01	4.72E+07	9.8632843522841E-01	7.750630E-21
9.8632344463922E-01	5.43E+07	9.8632344463922E-01	5.277378E-21
9.8631865897230E-01	6.24E+07	9.8631865897230E-01	3.593346E-21
9.8631406981317E-01	7.18E+07	9.8631406981317E-01	2.446696E-21
9.8630966909289E-01	8.25E+07	9.8630966909289E-01	1.665945E-21
9.8630544907382E-01	9.49E+07	9.8630544907382E-01	1.134336E-21
9.8630140233607E-01	1.09E+08	9.8630140233607E-01	7.723658E-22
9.8629752176440E-01	1.25E+08	9.8629752176440E-01	5.259000E-22
9.8629380053574E-01	1.44E+08	9.8629380053574E-01	3.580834E-22
9.8629023210720E-01	1.66E+08	9.8629023210720E-01	2.438176E-22
9.8628681020453E-01	1.91E+08	9.8628681020453E-01	1.660144E-22
9.8628352881113E-01	2.19E+08	9.8628352881113E-01	1.130389E-22
9.8628038215744E-01	2.52E+08	9.8628038215744E-01	7.696738E-23
9.8627736471082E-01	2.90E+08	9.8627736471082E-01	5.240686E-23
9.8627447116579E-01	3.34E+08	9.8627447116579E-01	3.568353E-23
9.8627169643476E-01	3.84E+08	9.8627169643476E-01	2.429693E-23
9.8626903563900E-01	4.41E+08	9.8626903563900E-01	1.654368E-23
9.8626648410013E-01	5.08E+08	9.8626648410013E-01	1.126452E-23
9.8626403733188E-01	5.84E+08	9.8626403733188E-01	7.669913E-24
9.8626169103219E-01	6.71E+08	9.8626169103219E-01	5.222514E-24
9.8625944107564E-01	7.72E+08	9.8625944107564E-01	3.555977E-24
9.8625728350621E-01	8.88E+08	9.8625728350621E-01	2.421226E-24
9.8625521453033E-01	1.02E+09	9.8625521453033E-01	1.648639E-24

Table F.5. Recommended Characteristic Curves for the Vault 1/4 Concrete.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.1 x 10^{-10} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999448279510E-01	5.00E-02	9.9999448279510E-01	6.282651E-01
9.9998674147690E-01	1.00E-01	9.9998674147690E-01	5.635998E-01
9.9996815915692E-01	2.00E-01	9.9996815915692E-01	4.905770E-01
9.9989889329805E-01	5.00E-01	9.9989889329805E-01	3.822289E-01
9.9975898521165E-01	1.00E+00	9.9975898521165E-01	2.939217E-01
9.9943210243002E-01	2.00E+00	9.9943210243002E-01	2.050949E-01
9.9831283231788E-01	5.00E+00	9.9831283231788E-01	1.008801E-01
9.9642387568934E-01	1.00E+01	9.9642387568934E-01	4.524240E-02
9.9320747134925E-01	2.00E+01	9.9320747134925E-01	1.509831E-02
9.8721029833949E-01	5.00E+01	9.8721029833949E-01	2.283523E-03
9.8224817413294E-01	1.00E+02	9.8224817413294E-01	4.348143E-04
9.7759873675434E-01	2.00E+02	9.7759873675434E-01	7.473829E-05
9.7233495472900E-01	5.00E+02	9.7233495472900E-01	6.798478E-06
9.6904745807054E-01	1.00E+03	9.6904745807054E-01	1.085506E-06
9.6845153924636E-01	1.15E+03	9.6845153924636E-01	7.490880E-07
9.6787666760808E-01	1.32E+03	9.6787666760808E-01	5.168170E-07
9.6732220374801E-01	1.52E+03	9.6732220374801E-01	3.565002E-07
9.6678750732854E-01	1.75E+03	9.6678750732854E-01	2.458752E-07
9.6627194167485E-01	2.01E+03	9.6627194167485E-01	1.695558E-07
9.6577487735687E-01	2.31E+03	9.6577487735687E-01	1.169130E-07
9.6529569494875E-01	2.66E+03	9.6529569494875E-01	8.060705E-08
9.6483378712146E-01	3.06E+03	9.6483378712146E-01	5.557117E-08
9.6438856019673E-01	3.52E+03	9.6438856019673E-01	3.830874E-08
9.6395943526753E-01	4.05E+03	9.6395943526753E-01	2.640721E-08
9.6354584897116E-01	4.65E+03	9.6354584897116E-01	1.820235E-08
9.6314725398485E-01	5.35E+03	9.6314725398485E-01	1.254630E-08
9.6276311930115E-01	6.15E+03	9.6276311930115E-01	8.647491E-09
9.6239293032909E-01	7.08E+03	9.6239293032909E-01	5.960091E-09
9.6203618885884E-01	8.14E+03	9.6203618885884E-01	4.107767E-09
9.6169241291978E-01	9.36E+03	9.6169241291978E-01	2.831070E-09
9.6136113655673E-01	1.08E+04	9.6136113655673E-01	1.951141E-09
9.6104190954367E-01	1.24E+04	9.6104190954367E-01	1.344686E-09
9.6073429705090E-01	1.42E+04	9.6073429705090E-01	9.267191E-10
9.6043787927817E-01	1.64E+04	9.6043787927817E-01	6.386626E-10
9.6015225106383E-01	1.88E+04	9.6015225106383E-01	4.401406E-10
9.5987702147819E-01	2.16E+04	9.5987702147819E-01	3.033252E-10
9.5961181340718E-01	2.49E+04	9.5961181340718E-01	2.090370E-10
9.5935626313165E-01	2.86E+04	9.5935626313165E-01	1.440575E-10
9.5911001990598E-01	3.29E+04	9.5911001990598E-01	9.927665E-11
9.5887274553928E-01	3.79E+04	9.5887274553928E-01	6.841586E-11
9.5864411398141E-01	4.35E+04	9.5864411398141E-01	4.714822E-11
9.5842381091575E-01	5.01E+04	9.5842381091575E-01	3.249173E-11

Table F.5. Recommended Characteristic Curves for the Vault 1/4 Concrete continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.1 x 10^{-10} cm/s)
9.5821153336004E-01	5.76E+04	9.5821153336004E-01	2.239131E-11
9.5800698927628E-01	6.62E+04	9.5800698927628E-01	1.543070E-11
9.5780989719043E-01	7.61E+04	9.5780989719043E-01	1.063386E-11
9.5761998582242E-01	8.76E+04	9.5761998582242E-01	7.328178E-12
9.5743699372676E-01	1.01E+05	9.5743699372676E-01	5.050107E-12
9.5726066894393E-01	1.16E+05	9.5726066894393E-01	3.480205E-12
9.5709076866254E-01	1.33E+05	9.5709076866254E-01	2.398329E-12
9.5692705889240E-01	1.53E+05	9.5692705889240E-01	1.652770E-12
9.5676931414816E-01	1.76E+05	9.5676931414816E-01	1.138980E-12
9.5661731714356E-01	2.03E+05	9.5661731714356E-01	7.849090E-13
9.5647085849601E-01	2.33E+05	9.5647085849601E-01	5.409069E-13
9.5632973644128E-01	2.68E+05	9.5632973644128E-01	3.727568E-13
9.5619375655809E-01	3.08E+05	9.5619375655809E-01	2.568790E-13
9.5606273150226E-01	3.54E+05	9.5606273150226E-01	1.770237E-13
9.5593648075030E-01	4.07E+05	9.5593648075030E-01	1.219928E-13
9.5581483035198E-01	4.68E+05	9.5581483035198E-01	8.406922E-14
9.5569761269174E-01	5.39E+05	9.5569761269174E-01	5.793483E-14
9.5558466625863E-01	6.20E+05	9.5558466625863E-01	3.992477E-14
9.5547583542444E-01	7.13E+05	9.5547583542444E-01	2.751345E-14
9.5537097022984E-01	8.19E+05	9.5537097022984E-01	1.896041E-14
9.5526992617821E-01	9.42E+05	9.5526992617821E-01	1.306623E-14
9.5517256403690E-01	1.08E+06	9.5517256403690E-01	9.004360E-15
9.5507874964566E-01	1.25E+06	9.5507874964566E-01	6.205195E-15
9.5498835373203E-01	1.43E+06	9.5498835373203E-01	4.276200E-15
9.5490125173339E-01	1.65E+06	9.5490125173339E-01	2.946867E-15
9.5481732362548E-01	1.90E+06	9.5481732362548E-01	2.030781E-15
9.5473645375716E-01	2.18E+06	9.5473645375716E-01	1.399476E-15
9.5465853069107E-01	2.51E+06	9.5465853069107E-01	9.644241E-16
9.5458344705026E-01	2.88E+06	9.5458344705026E-01	6.646156E-16
9.5451109937021E-01	3.31E+06	9.5451109937021E-01	4.580080E-16
9.5444138795633E-01	3.81E+06	9.5444138795633E-01	3.156280E-16
9.5437421674666E-01	4.38E+06	9.5437421674666E-01	2.175094E-16
9.5430949317948E-01	5.04E+06	9.5430949317948E-01	1.498927E-16
9.5424712806585E-01	5.80E+06	9.5424712806585E-01	1.032959E-16
9.5418703546665E-01	6.67E+06	9.5418703546665E-01	7.118451E-17
9.5412913257425E-01	7.67E+06	9.5412913257425E-01	4.905553E-17
9.5407333959838E-01	8.82E+06	9.5407333959838E-01	3.380574E-17
9.5401957965619E-01	1.01E+07	9.5401957965619E-01	2.329662E-17
9.5396777866632E-01	1.17E+07	9.5396777866632E-01	1.605445E-17
9.5391786524684E-01	1.34E+07	9.5391786524684E-01	1.106364E-17
9.5386977061685E-01	1.54E+07	9.5386977061685E-01	7.624306E-18
9.5382342850176E-01	1.77E+07	9.5382342850176E-01	5.254154E-18
9.5377877504191E-01	2.04E+07	9.5377877504191E-01	3.620806E-18

Table F.5. Recommended Characteristic Curves for the Vault 1/4 Concrete continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 3.1 x 10^{-10} cm/s)
9.5373574870463E-01	2.35E+07	9.5373574870463E-01	2.495214E-18
9.5369429019941E-01	2.70E+07	9.5369429019941E-01	1.719532E-18
9.5365434239620E-01	3.10E+07	9.5365434239620E-01	1.184985E-18
9.5361585024673E-01	3.57E+07	9.5361585024673E-01	8.166109E-19
9.5357876070859E-01	4.10E+07	9.5357876070859E-01	5.627528E-19
9.5354302267221E-01	4.72E+07	9.5354302267221E-01	3.878110E-19
9.5350858689035E-01	5.43E+07	9.5350858689035E-01	2.672530E-19
9.5347540591032E-01	6.24E+07	9.5347540591032E-01	1.841726E-19
9.5344343400853E-01	7.18E+07	9.5344343400853E-01	1.269193E-19
9.5341262712751E-01	8.25E+07	9.5341262712751E-01	8.746414E-20
9.5338294281519E-01	9.49E+07	9.5338294281519E-01	6.027433E-20
9.5335434016642E-01	1.09E+08	9.5335434016642E-01	4.153697E-20
9.5332677976658E-01	1.25E+08	9.5332677976658E-01	2.862447E-20
9.5330022363727E-01	1.44E+08	9.5330022363727E-01	1.972604E-20
9.5327463518398E-01	1.66E+08	9.5327463518398E-01	1.359385E-20
9.5324997914566E-01	1.91E+08	9.5324997914566E-01	9.367959E-21
9.5322622154616E-01	2.19E+08	9.5322622154616E-01	6.455761E-21
9.5320332964734E-01	2.52E+08	9.5320332964734E-01	4.448871E-21
9.5318127190404E-01	2.90E+08	9.5318127190404E-01	3.065859E-21
9.5316001792055E-01	3.34E+08	9.5316001792055E-01	2.112783E-21
9.5313953840874E-01	3.84E+08	9.5313953840874E-01	1.455987E-21
9.5311980514773E-01	4.41E+08	9.5311980514773E-01	1.003367E-21
9.5310079094497E-01	5.08E+08	9.5310079094497E-01	6.914512E-22
9.5308246959876E-01	5.84E+08	9.5308246959876E-01	4.765017E-22
9.5306481586217E-01	6.71E+08	9.5306481586217E-01	3.283723E-22
9.5304780540826E-01	7.72E+08	9.5304780540826E-01	2.262917E-22
9.5303141479650E-01	8.88E+08	9.5303141479650E-01	1.559456E-22
9.5301562144054E-01	1.02E+09	9.5301562144054E-01	1.074670E-22

Table F.6. Recommended Characteristic Curves for Vault 2 Mix 1 Concrete.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.1 x 10^{-10} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9999997794816E-01	5.00E-02	9.9999997794816E-01	9.902710E-01
9.9999993064469E-01	1.00E-01	9.9999993064469E-01	9.847216E-01
9.9999978187144E-01	2.00E-01	9.9999978187144E-01	9.760256E-01
9.9999900794401E-01	5.00E-01	9.9999900794401E-01	9.565945E-01
9.9999688017126E-01	1.00E+00	9.9999688017126E-01	9.321615E-01
9.9999019071969E-01	2.00E+00	9.9999019071969E-01	8.943561E-01
9.9995545449709E-01	5.00E+00	9.9995545449709E-01	8.120898E-01
9.9986049204570E-01	1.00E+01	9.9986049204570E-01	7.133400E-01
9.9956697754547E-01	2.00E+01	9.9956697754547E-01	5.723132E-01
9.9815482322008E-01	5.00E+01	9.9815482322008E-01	3.246634E-01
9.9503286740494E-01	1.00E+02	9.9503286740494E-01	1.416418E-01
9.8903731339770E-01	2.00E+02	9.8903731339770E-01	3.586834E-02
9.7896836554982E-01	5.00E+02	9.7896836554982E-01	2.572257E-03
9.7268858661215E-01	1.00E+03	9.7268858661215E-01	2.460128E-04
9.7165837511642E-01	1.15E+03	9.7165837511642E-01	1.506568E-04
9.7070516687436E-01	1.32E+03	9.7070516687436E-01	9.194319E-05
9.6982559165950E-01	1.52E+03	9.6982559165950E-01	5.595516E-05
9.6901573228587E-01	1.75E+03	9.6901573228587E-01	3.397722E-05
9.6827137113171E-01	2.01E+03	9.6827137113171E-01	2.059469E-05
9.6758817348953E-01	2.31E+03	9.6758817348953E-01	1.246518E-05
9.6696181961962E-01	2.66E+03	9.6696181961962E-01	7.536038E-06
9.6638809653065E-01	3.06E+03	9.6638809653065E-01	4.551868E-06
9.6586295898000E-01	3.52E+03	9.6586295898000E-01	2.747383E-06
9.6538256748168E-01	4.05E+03	9.6538256748168E-01	1.657281E-06
9.6494330949589E-01	4.65E+03	9.6494330949589E-01	9.992451E-07
9.6454180857294E-01	5.35E+03	9.6454180857294E-01	6.022658E-07
9.6417492506746E-01	6.15E+03	9.6417492506746E-01	3.628919E-07
9.6383975111787E-01	7.08E+03	9.6383975111787E-01	2.186076E-07
9.6353360187074E-01	8.14E+03	9.6353360187074E-01	1.316658E-07
9.6325400438441E-01	9.36E+03	9.6325400438441E-01	7.928977E-08
9.6299868523621E-01	1.08E+04	9.6299868523621E-01	4.774310E-08
9.6276555755424E-01	1.24E+04	9.6276555755424E-01	2.874510E-08
9.6255270797064E-01	1.42E+04	9.6255270797064E-01	1.730554E-08
9.6235838383124E-01	1.64E+04	9.6235838383124E-01	1.041792E-08
9.6218098087891E-01	1.88E+04	9.6218098087891E-01	6.271293E-09
9.6201903154447E-01	2.16E+04	9.6201903154447E-01	3.775000E-09
9.6187119391974E-01	2.49E+04	9.6187119391974E-01	2.272292E-09
9.6173624144611E-01	2.86E+04	9.6173624144611E-01	1.367733E-09
9.6161305332376E-01	3.29E+04	9.6161305332376E-01	8.232476E-10
9.6150060562771E-01	3.79E+04	9.6150060562771E-01	4.955110E-10
9.6139796310488E-01	4.35E+04	9.6139796310488E-01	2.982435E-10
9.6130427161830E-01	5.01E+04	9.6130427161830E-01	1.795084E-10

Table F.6. Recommended Characteristic Curves for Vault 2 Mix 1 Concrete (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.1 x 10^{-10} cm/s)
9.6121875120111E-01	5.76E+04	9.6121875120111E-01	1.080427E-10
9.6114068968056E-01	6.62E+04	9.6114068968056E-01	6.502847E-11
9.6106943683224E-01	7.61E+04	9.6106943683224E-01	3.913899E-11
9.6100439902545E-01	8.76E+04	9.6100439902545E-01	2.355668E-11
9.6094503432203E-01	1.01E+05	9.6094503432203E-01	1.417808E-11
9.6089084799285E-01	1.16E+05	9.6089084799285E-01	8.533351E-12
9.6084138841825E-01	1.33E+05	9.6084138841825E-01	5.135953E-12
9.6079624334096E-01	1.53E+05	9.6079624334096E-01	3.091163E-12
9.6075503644206E-01	1.76E+05	9.6075503644206E-01	1.860468E-12
9.6071742421306E-01	2.03E+05	9.6071742421306E-01	1.119753E-12
9.6068309309869E-01	2.33E+05	9.6068309309869E-01	6.739408E-13
9.6065175688768E-01	2.68E+05	9.6065175688768E-01	4.056216E-13
9.6062315433003E-01	3.08E+05	9.6062315433003E-01	2.441295E-13
9.6059704696144E-01	3.54E+05	9.6059704696144E-01	1.469330E-13
9.6057321711693E-01	4.07E+05	9.6057321711693E-01	8.843378E-14
9.6055146611741E-01	4.68E+05	9.6055146611741E-01	5.322516E-14
9.6053161261417E-01	5.39E+05	9.6053161261417E-01	3.203433E-14
9.6051349107752E-01	6.20E+05	9.6051349107752E-01	1.928032E-14
9.6049695041718E-01	7.13E+05	9.6049695041718E-01	1.160414E-14
9.6048185272292E-01	8.19E+05	9.6048185272292E-01	6.984116E-15
9.6046807211493E-01	9.42E+05	9.6046807211493E-01	4.203490E-15
9.6045549369452E-01	1.08E+06	9.6045549369452E-01	2.529930E-15
9.6044401258620E-01	1.25E+06	9.6044401258620E-01	1.522674E-15
9.6043353306339E-01	1.43E+06	9.6043353306339E-01	9.164429E-16
9.6042396775035E-01	1.65E+06	9.6042396775035E-01	5.515741E-16
9.6041523689368E-01	1.90E+06	9.6041523689368E-01	3.319727E-16
9.6040726769743E-01	2.18E+06	9.6040726769743E-01	1.998024E-16
9.6039999371616E-01	2.51E+06	9.6039999371616E-01	1.202539E-16
9.6039335430092E-01	2.88E+06	9.6039335430092E-01	7.237650E-17
9.6038729409363E-01	3.31E+06	9.6038729409363E-01	4.356082E-17
9.6038176256551E-01	3.81E+06	9.6038176256551E-01	2.621769E-17
9.6037671359578E-01	4.38E+06	9.6037671359578E-01	1.577949E-17
9.6037210508711E-01	5.04E+06	9.6037210508711E-01	9.497105E-18
9.6036789861468E-01	5.80E+06	9.6036789861468E-01	5.715966E-18
9.6036405910571E-01	6.67E+06	9.6036405910571E-01	3.440235E-18
9.6036055454714E-01	7.67E+06	9.6036055454714E-01	2.070554E-18
9.6035735571862E-01	8.82E+06	9.6035735571862E-01	1.246192E-18
9.6035443594893E-01	1.01E+07	9.6035443594893E-01	7.500380E-19
9.6035177089360E-01	1.17E+07	9.6035177089360E-01	4.514209E-19
9.6034933833190E-01	1.34E+07	9.6034933833190E-01	2.716940E-19
9.6034711798158E-01	1.54E+07	9.6034711798158E-01	1.635229E-19
9.6034509132980E-01	1.77E+07	9.6034509132980E-01	9.841854E-20
9.6034324147872E-01	2.04E+07	9.6034324147872E-01	5.923458E-20

Table F.6. Recommended Characteristic Curves for Vault 2 Mix 1 Concrete (continued).

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 1.1 x 10^{-10} cm/s)
9.6034155300462E-01	2.35E+07	9.6034155300462E-01	3.565116E-20
9.6034001182933E-01	2.70E+07	9.6034001182933E-01	2.145716E-20
9.6033860510282E-01	3.10E+07	9.6033860510282E-01	1.291429E-20
9.6033732109608E-01	3.57E+07	9.6033732109608E-01	7.772646E-21
9.6033614910329E-01	4.10E+07	9.6033614910329E-01	4.678076E-21
9.6033507935261E-01	4.72E+07	9.6033507935261E-01	2.815567E-21
9.6033410292466E-01	5.43E+07	9.6033410292466E-01	1.694588E-21
9.6033321167815E-01	6.24E+07	9.6033321167815E-01	1.019912E-21
9.6033239818206E-01	7.18E+07	9.6033239818206E-01	6.138484E-22
9.6033165565359E-01	8.25E+07	9.6033165565359E-01	3.694531E-22
9.6033097790170E-01	9.49E+07	9.6033097790170E-01	2.223606E-22
9.6033035927541E-01	1.09E+08	9.6033035927541E-01	1.338309E-22
9.6032979461673E-01	1.25E+08	9.6032979461673E-01	8.054789E-23
9.6032927921765E-01	1.44E+08	9.6032927921765E-01	4.847900E-23
9.6032880878086E-01	1.66E+08	9.6032880878086E-01	2.917775E-23
9.6032837938396E-01	1.91E+08	9.6032837938396E-01	1.756106E-23
9.6032798744671E-01	2.19E+08	9.6032798744671E-01	1.056931E-23
9.6032762970122E-01	2.52E+08	9.6032762970122E-01	6.361289E-24
9.6032730316466E-01	2.90E+08	9.6032730316466E-01	3.828655E-24
9.6032700511444E-01	3.34E+08	9.6032700511444E-01	2.304326E-24
9.6032673306548E-01	3.84E+08	9.6032673306548E-01	1.386885E-24
9.6032648474948E-01	4.41E+08	9.6032648474948E-01	8.347126E-25
9.6032625809602E-01	5.08E+08	9.6032625809602E-01	5.023939E-25
9.6032605121533E-01	5.84E+08	9.6032605121533E-01	3.023706E-25
9.6032586238245E-01	6.71E+08	9.6032586238245E-01	1.819837E-25
9.6032569002294E-01	7.72E+08	9.6032569002294E-01	1.095299E-25
9.6032553269970E-01	8.88E+08	9.6032553269970E-01	6.592439E-26
9.6032538910100E-01	1.02E+09	9.6032538910100E-01	3.967600E-26

Table F.7. Recommended Characteristic Curves for Vault 2 Mix 2 Concrete.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.3 x 10^{-11} cm/s)
1.0000000000000E+00	0.00E+00	1.0000000000000E+00	1.000000E+00
9.9998800333577E-01	5.00E-02	9.9998800333577E-01	5.487652E-01
9.9997163686602E-01	1.00E-01	9.9997163686602E-01	4.807670E-01
9.9993301618303E-01	2.00E-01	9.9993301618303E-01	4.062577E-01
9.9979231640985E-01	5.00E-01	9.9979231640985E-01	3.002156E-01
9.9951532386600E-01	1.00E+00	9.9951532386600E-01	2.182504E-01
9.9888886201051E-01	2.00E+00	9.9888886201051E-01	1.409355E-01
9.9687748591834E-01	5.00E+00	9.9687748591834E-01	5.983137E-02
9.9379000673926E-01	1.00E+01	9.9379000673926E-01	2.330090E-02
9.8908372090643E-01	2.00E+01	9.8908372090643E-01	6.789228E-03
9.8128822875291E-01	5.00E+01	9.8128822875291E-01	9.207321E-04
9.7528138507094E-01	1.00E+02	9.7528138507094E-01	1.715413E-04
9.6977996900517E-01	2.00E+02	9.6977996900517E-01	2.981385E-05
9.6355647642560E-01	5.00E+02	9.6355647642560E-01	2.817478E-06
9.5962619706564E-01	1.00E+03	9.5962619706564E-01	4.663813E-07
9.5890799984945E-01	1.15E+03	9.5890799984945E-01	3.242999E-07
9.5821318832782E-01	1.32E+03	9.5821318832782E-01	2.254696E-07
9.5754108600444E-01	1.52E+03	9.5754108600444E-01	1.567381E-07
9.5689101982150E-01	1.75E+03	9.5689101982150E-01	1.089470E-07
9.5626232356661E-01	2.01E+03	9.5626232356661E-01	7.572121E-08
9.5565434052514E-01	2.31E+03	9.5565434052514E-01	5.262443E-08
9.5506642551724E-01	2.66E+03	9.5506642551724E-01	3.657042E-08
9.5449794643470E-01	3.06E+03	9.5449794643470E-01	2.541263E-08
9.5394828537268E-01	3.52E+03	9.5394828537268E-01	1.765835E-08
9.5341683943403E-01	4.05E+03	9.5341683943403E-01	1.226971E-08
9.5290302127021E-01	4.65E+03	9.5290302127021E-01	8.525205E-09
9.5240625941102E-01	5.35E+03	9.5240625941102E-01	5.923303E-09
9.5192599842567E-01	6.15E+03	9.5192599842567E-01	4.115413E-09
9.5146169895008E-01	7.08E+03	9.5146169895008E-01	2.859268E-09
9.5101283760855E-01	8.14E+03	9.5101283760855E-01	1.986504E-09
9.5057890685277E-01	9.36E+03	9.5057890685277E-01	1.380124E-09
9.5015941473677E-01	1.08E+04	9.5015941473677E-01	9.588315E-10
9.4975388464293E-01	1.24E+04	9.4975388464293E-01	6.661351E-10
9.4936185497104E-01	1.42E+04	9.4936185497104E-01	4.627846E-10
9.4898287880042E-01	1.64E+04	9.4898287880042E-01	3.215086E-10
9.4861652353287E-01	1.88E+04	9.4861652353287E-01	2.233593E-10
9.4826237052273E-01	2.16E+04	9.4826237052273E-01	1.551720E-10
9.4792001469919E-01	2.49E+04	9.4792001469919E-01	1.078005E-10
9.4758906418484E-01	2.86E+04	9.4758906418484E-01	7.489056E-11
9.4726913991365E-01	3.29E+04	9.4726913991365E-01	5.202740E-11
9.4695987525081E-01	3.79E+04	9.4695987525081E-01	3.614399E-11
9.4666091561655E-01	4.35E+04	9.4666091561655E-01	2.510957E-11
9.4637191811530E-01	5.01E+04	9.4637191811530E-01	1.744382E-11

Table F.7. Recommended Characteristic Curves for Vault 2 Mix 2 Concrete continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.3 x 10^{-11} cm/s)
9.4609255117138E-01	5.76E+04	9.4609255117138E-01	1.211835E-11
9.4582249417221E-01	6.62E+04	9.4582249417221E-01	8.418695E-12
9.4556143711947E-01	7.61E+04	9.4556143711947E-01	5.848516E-12
9.4530908028889E-01	8.76E+04	9.4530908028889E-01	4.062994E-12
9.4506513389869E-01	1.01E+05	9.4506513389869E-01	2.822581E-12
9.4482931778722E-01	1.16E+05	9.4482931778722E-01	1.960859E-12
9.4460136109945E-01	1.33E+05	9.4460136109945E-01	1.362217E-12
9.4438100198274E-01	1.53E+05	9.4438100198274E-01	9.463370E-13
9.4416798729153E-01	1.76E+05	9.4416798729153E-01	6.574236E-13
9.4396207230101E-01	2.03E+05	9.4396207230101E-01	4.567143E-13
9.4376302042965E-01	2.33E+05	9.4376302042965E-01	3.172808E-13
9.4357060297027E-01	2.68E+05	9.4357060297027E-01	2.204159E-13
9.4338459882974E-01	3.08E+05	9.4338459882974E-01	1.531236E-13
9.4320479427685E-01	3.54E+05	9.4320479427685E-01	1.063754E-13
9.4303098269832E-01	4.07E+05	9.4303098269832E-01	7.389924E-14
9.4286296436265E-01	4.68E+05	9.4286296436265E-01	5.133799E-14
9.4270054619169E-01	5.39E+05	9.4270054619169E-01	3.566463E-14
9.4254354153959E-01	6.20E+05	9.4254354153959E-01	2.477631E-14
9.4239176997900E-01	7.13E+05	9.4239176997900E-01	1.721216E-14
9.4224505709432E-01	8.19E+05	9.4224505709432E-01	1.195733E-14
9.4210323428167E-01	9.42E+05	9.4210323428167E-01	8.306784E-15
9.4196613855556E-01	1.08E+06	9.4196613855556E-01	5.770742E-15
9.4183361236182E-01	1.25E+06	9.4183361236182E-01	4.008948E-15
9.4170550339684E-01	1.43E+06	9.4170550339684E-01	2.785025E-15
9.4158166443270E-01	1.65E+06	9.4158166443270E-01	1.934763E-15
9.4146195314814E-01	1.90E+06	9.4146195314814E-01	1.344084E-15
9.4134623196513E-01	2.18E+06	9.4134623196513E-01	9.337385E-16
9.4123436789087E-01	2.51E+06	9.4123436789087E-01	6.486702E-16
9.4112623236505E-01	2.88E+06	9.4112623236505E-01	4.506326E-16
9.4102170111211E-01	3.31E+06	9.4102170111211E-01	3.130555E-16
9.4092065399857E-01	3.81E+06	9.4092065399857E-01	2.174803E-16
9.4082297489491E-01	4.38E+06	9.4082297489491E-01	1.510841E-16
9.4072855154223E-01	5.04E+06	9.4072855154223E-01	1.049584E-16
9.4063727542321E-01	5.80E+06	9.4063727542321E-01	7.291486E-17
9.4054904163744E-01	6.67E+06	9.4054904163744E-01	5.065411E-17
9.4046374878088E-01	7.67E+06	9.4046374878088E-01	3.518952E-17
9.4038129882936E-01	8.82E+06	9.4038129882936E-01	2.444624E-17
9.4030159702589E-01	1.01E+07	9.4030159702589E-01	1.698286E-17
9.4022455177180E-01	1.17E+07	9.4022455177180E-01	1.179803E-17
9.4015007452147E-01	1.34E+07	9.4015007452147E-01	8.196116E-18
9.4007807968060E-01	1.54E+07	9.4007807968060E-01	5.693859E-18
9.4000848450779E-01	1.77E+07	9.4000848450779E-01	3.955537E-18
9.3994120901951E-01	2.04E+07	9.3994120901951E-01	2.747920E-18

Table F.7. Recommended Characteristic Curves for Vault 2 Mix 2 Concrete continued.

Saturation	Suction Head (cm)	Saturation	Relative Permeability kr (Ksat = 9.3 x 10^{-11} cm/s)
9.3987617589814E-01	2.35E+07	9.3987617589814E-01	1.908986E-18
9.3981331040313E-01	2.70E+07	9.3981331040313E-01	1.326177E-18
9.3975254028513E-01	3.10E+07	9.3975254028513E-01	9.212979E-19
9.3969379570291E-01	3.57E+07	9.3969379570291E-01	6.400277E-19
9.3963700914312E-01	4.10E+07	9.3963700914312E-01	4.446287E-19
9.3958211534271E-01	4.72E+07	9.3958211534271E-01	3.088845E-19
9.3952905121392E-01	5.43E+07	9.3952905121392E-01	2.145827E-19
9.3947775577177E-01	6.24E+07	9.3947775577177E-01	1.490711E-19
9.3942817006395E-01	7.18E+07	9.3942817006395E-01	1.035600E-19
9.3938023710313E-01	8.25E+07	9.3938023710313E-01	7.194338E-20
9.3933390180141E-01	9.49E+07	9.3933390180141E-01	4.997921E-20
9.3928911090704E-01	1.09E+08	9.3928911090704E-01	3.472066E-20
9.3924581294319E-01	1.25E+08	9.3924581294319E-01	2.412053E-20
9.3920395814883E-01	1.44E+08	9.3920395814883E-01	1.675658E-20
9.3916349842152E-01	1.66E+08	9.3916349842152E-01	1.164084E-20
9.3912438726210E-01	1.91E+08	9.3912438726210E-01	8.086915E-21
9.3908657972131E-01	2.19E+08	9.3908657972131E-01	5.617995E-21
9.3905003234809E-01	2.52E+08	9.3905003234809E-01	3.902834E-21
9.3901470313964E-01	2.90E+08	9.3901470313964E-01	2.711306E-21
9.3898055149317E-01	3.34E+08	9.3898055149317E-01	1.883552E-21
9.3894753815923E-01	3.84E+08	9.3894753815923E-01	1.308508E-21
9.3891562519659E-01	4.41E+08	9.3891562519659E-01	9.090225E-22
9.3888477592864E-01	5.08E+08	9.3888477592864E-01	6.315004E-22
9.3885495490126E-01	5.84E+08	9.3885495490126E-01	4.387043E-22
9.3882612784203E-01	6.71E+08	9.3882612784203E-01	3.047686E-22
9.3879826162089E-01	7.72E+08	9.3879826162089E-01	2.117235E-22
9.3877132421204E-01	8.88E+08	9.3877132421204E-01	1.470851E-22
9.3874528465711E-01	1.02E+09	9.3874528465711E-01	1.021800E-22

APPENDIX G. DESIGN CHECK DOCUMENTATION

W02 Jones/SRNL/Srs
11/10/2008 09:39 AM

To Kenneth Dixon/SRNL/Srs@srs
cc
bcc
Subject Re: Design Check - SRNS-STI-2008-00042

Ken,

Just to note that the review comments for the referenced report that I returned last Thursday, November 6, included the review outlined below, with verifications and checks including approximately 10 percent of the data. As I mentioned, this report's succinct writing style made for easy reading - well done.

Bill

Kenneth Dixon/SRNL/Srs

Kenneth Dixon/SRNL/Srs
10/24/2008 04:09 PM

To W02 Jones/SRNL/Srs@Srs
cc Mark Phifer/SRNL/Srs@Srs, John Mayer/SRNL/Srs@Srs
Subject Design Check - SRNS-STI-2008-00042

Bill,

Please perform a design check on the document SRNS-STI-2008-00042 which is titled "HYDRAULIC AND PHYSICAL PROPERTIES OF SALTSTONE GROUTS AND VAULT CONCRETES". Elements of this design check should include but are not limited to:

- verify that data from the laboratory reports have been accurately entered into the spreadsheets and report tables
- verify the correction for salt content on the saltstone samples in the spreadsheets
- check the calculations in the spreadsheets for accuracy
- verify that the logic in determining the van Genuchten transport parameters is sound for both the saltstone and concrete materials
- verify that the assumptions, interpretations, and conclusions of the report are reasonable

Files associated with the design check may be found at the following path:

\\wg02\KLD\Salt08_DesignCheck

We can meet to discuss the file structure for the spreadsheets to speed the design check process. I will also provide hard copies of the lab sheets and strength reports. The charge code for your time is WCZPAREV2.

Thanks,
Ken

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