RECLAMATION

Managing Water in the West

San Luis Drainage Feature Re-evaluation

Feasibility Report

Appendix F

Geology Report

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

November 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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San Luis Drain Project
2005 Geologic Investigations

Central Valley Project – San Luis Unit – California

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Geology Branch, MP-230

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San Luis Drain Project
2005 Geologic Investigations
Central Valley Project - American River Division - California

Division of Design and Construction
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I. INTRODUCTION

This report includes the geotechnical data collected as part of the 2005 field investigations for the San Luis Drain Project. The purpose of the investigation was to determine subsurface conditions at potential evaporation pond and reuse sites in the Grasslands, North Westlands, Central Westlands, and South Westlands Areas in the San Luis Unit, California. The field investigations consisted of a drilling and sampling program and a field hydraulic conductivity/ permeability testing program.

As part of the design data collection process, the U.S. Bureau of Reclamation (Reclamation) completed ten undisturbed drill holes, and ten companion drill holes, thirty-one pneumatic slug tests and five piezometer tests. Reclamation personnel from the Mid Pacific (MP) and Pacific Northwest Regions and the Technical Service Center (TSC) conducted the drilling and sampling program and hydraulic conductivity testing in June through August, 2005. The purpose of these investigations were to: (1) provide geotechnical data on foundation conditions at each potential evaporation pond and reuse site; (2) provide undisturbed soil core samples for laboratory testing by Reclamation for correlation with previously performed laboratory permeability, field pneumatic slug permeability tests, and piezometer tests; and (3) characterize the site geology and determine lateral continuity of soil units and possibly low density and high permeability intervals.

Investigations included:

- 10 Undisturbed drill holes
- 31 In-situ permeability tests - pneumatic slug test method
- 5 In-situ permeability tests - piezometer test method

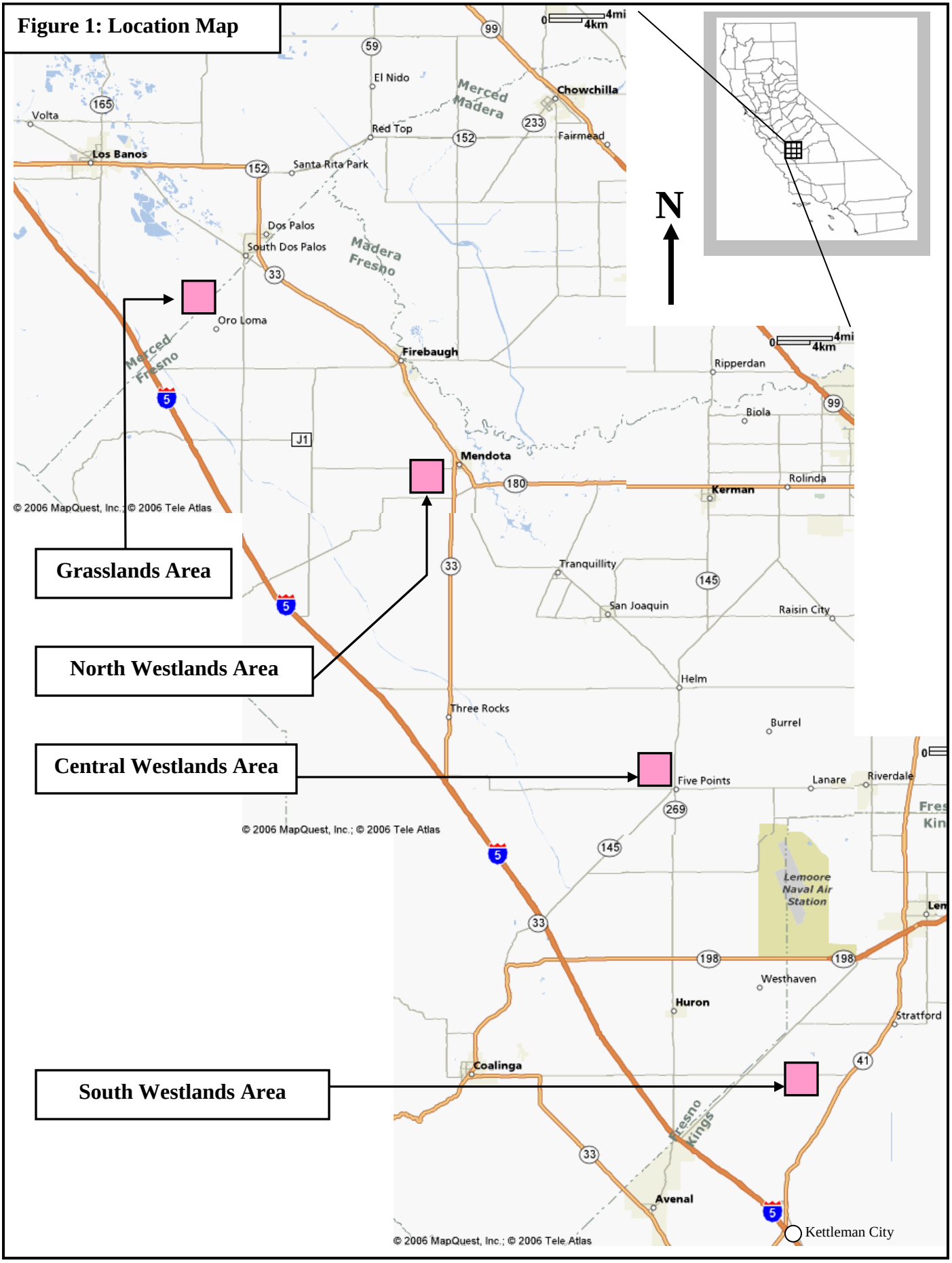
Terminology

The terms “hydraulic conductivity” and “permeability” are used interchangeably within this report. “K” and “K-values” is also used interchangeably with hydraulic conductivity and permeability within this report. Piezometer tests are also commonly referred to as pump out and recovery tests (Reclamation, Drainage Manual, 1993).

Location

The San Luis Drain Project is divided into the Grasslands, North Westlands, Central Westlands, and South Westlands Areas within the Central Valley, California, located in the Central Valley Project, San Luis Unit. The areas are located between Interstate Freeway 5 (I-5) on the west and Highway 99 to the east and between Los Banos to the north and Kettleman City to the south (Figure 1).

Figure 1: Location Map



Directions to the individual areas are given traveling south from Sacramento, California and are described below. Refer to the drawings located in Appendix J of this report for more specific roadways and the boundaries of proposed evaporation pond and reuse sites.

- The Grasslands Area is located about six miles southwest of the town of Dos Palos, California and can be accessed traveling south on I-5, turning east on West Nees Avenue, turning north on Russel Road, and turning west along the Outside Canal access road for ½ a mile to arrive at the southern edge of proposed Grasslands Evaporation Pond A.
- The North Westlands Area is located about two miles southeast from the town of Mendota, California and can be accessed traveling south down I-5 and turning south (southeast) on Highway 33, and turning west on Jensen Avenue at the eastern boundary of proposed Evaporation Pond C.
- The Central Westlands Area is located about four miles northeast from the town of Five Points, California and can be accessed traveling south on I-5, turning north on Highway 33 (for about 1 mile), turning east on Harlen Avenue which bends to the southeast and becomes West Mount Whitney Avenue, traveling east on West Mount Whitney Avenue and turning north on Yuba Avenue for 1 mile to arrive at the southwest corner of proposed Evaporation Pond B.
- The South Westlands Area is located about sixteen miles north of the city of Kettleman City, California and can be accessed traveling south down I-5, turning east on West Jayne Avenue which turns into Nevada Avenue, traveling east on Nevada Avenue and turning north on 25th Avenue for ½ mile to arrive at the southern edge of proposed Evaporation Pond A.

II. GEOLOGIC FIELD INVESTIGATIONS 2005

Geologic investigations in 2005 included ten undisturbed drill holes, thirty-one pneumatic slug tests, and five piezometer tests (pump out and recovery tests). A typical drill hole site consisted of an undisturbed sample hole, an adjacent companion hole, and multiple pneumatic slug tests. A companion drill hole was necessary in order to log and classify soil intervals that were logged visually through the lexan liner (acrylic undisturbed sample tube). Piezometer tests were also performed at selected drill hole locations to provide an in-situ permeability test comparison to the pneumatic slug test method. The GEOPROBE® sampling equipment was used to collect continuous samples and to generate a soil stratigraphy at drill hole locations where no previous drilling and sampling had been completed. Permeability tests intervals were chosen based on the soil stratigraphy at each drill hole site. Representative samples, mostly from the companion drill holes, were sent to the Mid Pacific Construction Office Materials Laboratory for physical properties analysis (Appendix G). Data from the sampling and permeability testing were used to assign permeability values to soil types. Laboratory testing (flexible wall permeability testing) was performed on selected undisturbed samples at the TSC Material Laboratory and lab permeability values were used to compare to in-situ permeability values. Flexible wall permeability test data is located in Appendix E of this report (References 5, 6, and 7).

Geologic logs of drill holes provide a detailed record of the subsurface materials encountered that include field descriptions of the materials using the Unified Soil Classification System (USCS), any significant in-situ characteristics, laboratory data, field densities, and field permeability data. Geologic logs are located in Appendix C of this report.

Previous Investigations

Reclamation completed twenty-four continuously sampled flight auger dry core holes, and sixty-seven cone penetrometer test holes in 2003 and 2004, in the proposed evaporation pond and reuse sites. A data package titled San Luis Drainage Study and dated October 2004 contains all geologic logs and drawings produced for the 2003 and 2004 investigations.

2005 Drilling and Sampling Investigations

Central Westlands Area (Proposed Evaporation Pond B)
Nine undisturbed drill holes and nine companion drill holes were completed in the Central Westlands Area, within the boundary of the proposed Evaporation Pond B site. The drill holes are listed in Table 1. Drilling and sampling was completed as described in the procedure section of this report. Undisturbed samples were sent to the TSC Materials Laboratory for permeability testing and laboratory data is found in Appendix E of this report. Drill hole locations are shown in plan view on drawing number 805-208-3946, in Appendix J.

Table 1 :	**List of Drill Holes**	**Central Westlands Area**
EDC-05-25	EDC-05-26	EDC-05-27
EDC-05-28	EDC-05-29	EDC-05-30
EDC-05-31	EDC-05-32	EDC-05-33

The nine drill holes were advanced to an average depth of 29.8 feet with seven drill holes reaching total depth at 29.7 feet. A companion drill hole was completed within five feet of each undisturbed drill hole and advanced to a depth of about 20.0 feet. Fat Clay and Lean Clay, CH and CL, were encountered at the surface to an average depth of 8.1 feet in all drill holes. Zones of alternating soil layers were encountered below the surface clay soil in eight of nine drill holes. The zones of alternating soil types ranged in thickness from 5.6 to 16.8 feet, with an average thickness of 12.8 feet. All zones of alternating soil types were fine grained and individual soil layers varied in the percentage of sand-size material (from Silty Sand to Fat Clay, SM to CH, soil types). Individual soil layer thickness ranged from 0.1 to 3.8 feet. Silty Sand, SM, was encountered near the bottom of six drill holes, ranged in thickness from 0.7 to 10.0 feet and averaged 6.1 feet-thick. Static groundwater, measured in all drill holes, ranged from 3.4 to 10.8 feet below the ground surface and averaged 6.8 feet below the ground surface.

Drill hole EDC-05-26 had a different soil layer profile than the other drill holes at this site. The drill hole encountered Fat and Lean Clay, CH and CL, from 0.0 to 22.6 feet of depth, a zone of alternating sandy and clayey soil layers from 22.6 to 24.7 feet of depth, and Silty Sand, SM, from 24.7 to 29.7 feet (the total depth of the drill hole).

Drill holes EDC-05-27 and EDC-05-29 encountered Lean and Fat Clay (CL/CH) at the surface, and then a zone of alternating soil types but neither encountered a layer of Silty Sand, SM material at the bottom of the drill holes. Drill hole EDC-05-27 encounter Lean to Fat Clay, CL-CH, from 25.5 feet of depth to the total depth (29.7 ft.) of the drill hole. Drill hole EDC-05-29 encountered Lean Clay with Sand, (CL)s, from 28.0 feet of depth to the total depth (29.7 ft.) of the drill hole.

South Westlands Area (Proposed Evaporation Pond A)
One drill hole and a companion hole were completed in the South Westlands Area, within the boundary of proposed Evaporation Pond A. The drill hole is listed in Table 2. Drilling and sampling was completed as described in the procedure section of this report. Undisturbed samples were sent to the TSC Materials Laboratory for permeability testing and laboratory data is found in Appendix E of this report. Drill hole locations are shown in plan view on drawing numbers 805-208-3978 and 805-208-3979, in Appendix J.

Table 2:	**List of Drill Holes**	**South Westlands Area**
	EDC-05-34	

Drill hole EDC-05-34 encountered Lean Clay to Silt, CL/ML, from the surface to a depth of 6.2 feet. A zone of alternating soil types was encountered from 6.2 to 14.2 feet of depth. Four of the five layers in the zone of alternating soil types were Silt with Sand or Sandy Silt, (ML)s or s(ML), and ranged in thickness from 0.8 to 2.7 feet. Lean Clay to Silt, CL/ML was encountered from 9.9 to 10.7 feet of depth. Below the zone of alternating soil types, Lean Clay to Silt, CL/ML, was encountered from 14.2 to 18.3 feet of depth. A thin layer of Silt with Sand, (ML)s, was encountered from 18.3 to 19.6 feet of depth. Lean Clay was encountered from 19.6 feet to the total depth (29.7 feet) of the drill hole, with a zone of Silty Sand, SM, encountered from 25.5 to 27.7 feet of depth.

Field Hydraulic Conductivity Investigations

Grasslands Area (Proposed Grasslands Evaporation Pond A)
One pneumatic slug test was preformed and documented by MP Geology in the Grasslands Area, within the boundary of the proposed Grasslands Evaporation Pond A. The hydraulic conductivity test was completed as described in the procedure section of this report. Additional hydraulic conductivity tests were performed and documented by Roger Burnett (TSC Agricultural Engineer) in this area (References 9 and 10). The GEOPROBE® sampling equipment was used to collect continuous samples at the drill hole location. The samples were logged and pneumatic slug test intervals were selected

based on the soil stratigraphy. Pneumatic slug test ESS-05-01 was performed at a depth of 7.1 to 8.1 feet of depth in Silty Sand, SM, and had an average K-value of 3.1 E-04 cm/s (Table 3). Drill hole locations are shown in plan view on drawing number 805-208-3943, in Appendix J.

Table 3:	Permeability Test Data			Grasslands Area
Drill Hole	**Soil Type**	**Ave. K (cm/s)**	**Permeability Testing Method**	**Depth interval (ft.)**
ESS-05-01	SM	3.1 E-04	Pneumatic Slug Test	7.1 – 8.1

North Westlands Area (Proposed Evaporation Pond C)

Five pneumatic slug tests and one piezometer test were performed in the North Westlands Area, within the boundary of proposed Evaporation Pond C. Hydraulic conductivity tests were completed as described in the procedure section of this report. The GEOPROBE® sampling equipment was used to collect continuous samples at each drill hole location. The samples were logged and pneumatic slug test intervals were selected based on the soil stratigraphy. Hydraulic conductivity data for proposed Evaporation Pond C is listed in Table 4. Drill hole locations are shown in plan view on drawing numbers 805-208-3944 and 805-208-3945 in Appendix J.

Table 4:	Permeability Test Data			North Westlands Area
Drill Hole	**Soil Type**	**Ave. K (cm/s)**	**Permeability Testing Method**	**Depth interval (ft.)**
ESS-05-04	s(ML)	**4.4 E-04**	Pneumatic Slug Test	10.0 - 11.0
ESS-05-04	s(ML)	**3.6 E-05**	Piezometer Test	10.0 – 10.5
ESS-05-04	CL	**1.6 E-04**	Pneumatic Slug Test	17.0 - 18.0
ESS-05-05	(CL)s	**1.3 E-04**	Pneumatic Slug Test	8.8 - 9.8
ESS-05-06	(CL)s	**4.7 E-04**	Pneumatic Slug Test	13.6 - 14.6
ESS-05-06	SM	**1.9 E-04**	Pneumatic Slug Test	17.5 - 18.5

Central Westlands Area (Proposed Evaporation Pond B)

Twenty-five pneumatic slug tests and six piezometer tests were performed in the Central Westlands Area, within the boundary of proposed Evaporation Pond B. All hydraulic conductivity tests were completed about five feet from previously drilled and sampled drill holes. Hydraulic conductivity tests were completed as described in the procedure section of this report. Many soil types were tested using the pneumatic slug test method and individual tests are shown in Table 5. Piezometer tests are listed below in Table 6. Drill hole locations are shown in plan view on drawing number 805-208-3946, in Appendix J.

Table 5:	**Pneumatic Slug Test Data**		Central Westlands Area
Drill Hole	**Soil Type**	**Ave. K (cm/s)**	**Depth interval (ft.)**
ESS-05-25	(CL)s	**6.299E-04**	9.0-10.0
ESS-05-25	s(CL)	**5.772E-03**	12.0-13.0
ESS-05-25	CL	**7.869E-03**	18.0-19.0
ESS-05-26	CL	**3.266E-04**	8.3-9.3
ESS-05-26	CH	**No recharge after 3 hours.**	12.0-13.0
ESS-05-27	CH	**6.334E-05**	11.0-12.0
ESS-05-27	s(CL)	**3.537E-03**	14.4-15.4
ESS-05-27	s(ML)	**6.506E-04**	17.0-18.0
ESS-05-28	CL	**5.149E-04**	10.0-11.0
ESS-05-28	s(CL)	**1.819E-04**	13.5-14.5
ESS-05-28	s(ML)	**1.156E-03**	15.6-16.6
ESS-05-29	(CL)s	**8.577E-04**	5.1-6.1
ESS-05-29	s(ML)	**3.298E-04**	8.5-9.5
ESS-05-29	CL	**2.380E-04**	13.5-14.5
ESS-05-30	CL	**2.385E-03**	11.0-12.0
ESS-05-30	(ML)s	**1.508E-02**	18.0-19.0
ESS-05-31	(CL)s	**7.571E-03**	12.0-13.0
ESS-05-31	(CL)s	**4.660E-03**	14.0-15.0
ESS-05-31	(CL)s	**2.059E-03**	17.0-18.0
ESS-05-32	(CL)s	**3.351E-05**	8.0-9.0
ESS-05-32	(ML)s	**6.116E-04**	11.0-12.0
ESS-05-33	s(ML)	**2.033E-04**	10.0-11.0
ESS-05-33	CL	**2.501E-04**	11.0-12.0
ESS-05-33	(ML)s	**5.665E-04**	13.2-14.2
ESS-05-33	CH	**4.502E-05**	15.0-16.0

Table 6:	**Piezometer Test Data**		Central Westlands Area
Drill Hole	**Soil Type**	**Ave. K (cm/s)**	**Depth interval (ft.)**
ESS-05-25	(CL)s	**4.3 E-04**	12.3 – 12.8
ESS-05-25	(CL)s	**2.1 E-03**	12.3 – 12.8
ESS-05-26	CH	**No recharge after 24 hours**	12.0 - 12.5
ESS-05-30	CL/CH	**3.4 E-03**	7.3 – 7.8
ESS-05-33	CL/ML	**6.4 E-05**	13.5 – 14.0
ESS-05-33	CL/ML	**1.1 E-04**	13.5 – 14.0

III. DISCUSSION

Drilling and sampling was done to characterize subsurface site conditions and obtain undisturbed samples for laboratory permeability testing at proposed evaporation ponds and reuse sites. Undisturbed samples from the Central and South Westlands Areas were sent to the TSC materials laboratory for Flexible Membrane Permeability testing (Appendix E). Discussion of the laboratory permeability testing has been done in the memorandum: Technical Review of Field and Laboratory Permeability Testing (Reclamation, 2006) and is included in Appendix H of this report. Drillers typically obtained high quality undisturbed samples in Fat and Lean Clay, CH and CL; Silt, ML; Fat and Lean Clay with Sand, (CH)s and (CL)s; and Silt with Sand, (ML)s. Drillers had more difficulty obtaining high quality undisturbed samples in materials with 30% or greater sand-sized material. Although many high quality undisturbed samples of sandy soils [Sandy Silt, s(ML); Sandy Lean Clay, s(CL); and Silty Sand, SM] were obtained, typically these samples did not transport well. Samples were often disturbed upon arrival to the TSC and consequently not tested by the TSC Materials Laboratory.

Test interval selection for field permeability testing was done with the involvement of Bob Davis the principal design engineers for the proposed evaporation pond sites and Roger Burnett the Lead Agricultural Engineer for the reuse areas. Proposed evaporation pond design called for soils with low permeability to minimize horizontal and vertical movement of evaporation pond water into the local groundwater system. Proposed reuse site design called for permeable to semi-permeable soil to allow reuse water to be able to move through soil layers and into the local groundwater system. Each designer was very interested in the horizontal movement of groundwater through the subsurface at the given sites, which led to the use of the pneumatic slug test method investigates in-situ horizontal permeability of soil layers. Test interval selection was restricted to soil layers below the water table and above 20.0 feet of depth (design depth of evaporation ponds and reuse sites was above 20.0 feet). Selected intervals were further limited to being homogenous soil units of at least, 1 foot-thick. The principle and geology staff specifically wanted to test upper sandy soil layers (potential groundwater conduits) and lower clayey layers (impermeable barriers). Typically three test intervals were chosen at each drill hole location and each test interval was tested two to three times. K-values presented in the tables included herein represent an average of tests recorded at that test interval.

Twenty-five test intervals were tested in the Central Westlands Area, within the boundary of proposed Evaporation Pond B (drawing number 805-208-3946, in Appendix J). At proposed Evaporation Pond B, average depths to soil types are as follows:

0.0 – 8.1 ft. = Fat and Lean Clay [CH and CL]

8.1 – 20.9 ft. = Alternating layers of different soil types from (soil types range from Silty Sand to Fat Clay, [SM and CH])

20.9 – 29.8 ft. (T.D.) = Sandy Silt and Silty Sand [s(ML) and SM]

The average static water level was 6.8 below the ground surface at this site. Most test intervals were selected within these zones of alternating soil layers (8.1 -20.9 ft.) The

average permeability of a given soil type as determined by the pneumatic slug tests in proposed Evaporation Pond B is summarized in Table 7.

Table 7: **Summary of Soil Types and K-values**
Central Westlands Area, Proposed Evaporation Pond B

Soil Type	Ave. K (cm/s)	Number of Tests
CH	**5.42E-05**	3
CL	**1.93E-03**	6
(CL)s	**2.64E-03**	6
(ML)s	**5.42E-03**	3
s(CL)	**3.16E-03**	3
s(ML)	**5.85E-04**	4

A small percentage of the pneumatic slug tests failed for various reasons. The most common reason for a pneumatc slug test to fail or to yield dramatic differences in the permeability values during the same test interval was insufficient time spent developing and surging the hole prior to testing. Time restrictions and logistics sometimes did not allow enough time to develop the hole properly. Proper well development typically yielded good repeatability during permeability testing. A brush was used to reduce clay smear along the drill hole wall of the test interval in a clayey soil layer prior to testing. A brush was not used to clean sandy soil test intervals to avoid caving of the drill hole walls. A few test intervals were abandoned due to sand flowing into the test interval and up into the outer casing. Sand in the outer casing often caused an improper seal of the slotted screen into the outer casing shoe and led to a failed pneumatic slug test. Leaving the pneumatic slug test assembly (slotted screen) in the ground overnight led to a failed attempt as the slotted screen filled with silt and sand. Equipment failure was the cause of a few failed pneumatic slug tests. Many of the components to the pneumatic slug test are made from PVC and exposure to heat and light with repeated use caused some of the components to break. Many of the seals between the components are rubber and also wear with usage. Many of the failed test intervals were re-tested with success by removing and cleaning the inner slotted screen, replacing rubber seals and proper development of the hole. In some instances the outer casing and inner rods were completely removed out of the hole and a new hole was started.

Permeability testing in the South Westlands Area, proposed Evaporation Pond A was not performed. The depth to the static water level was not encountered above 20 feet of depth (design depth of proposed evaporation and reuse sites) during the permeability investigations. The pneumatic slug test method and the piezometer test method (pump out and recovery test) must be performed below the static water level.

In-situ testing was performed with the piezometer (pump out and recovery) test method in the Grasslands, North Westland and Central Westlands areas. Piezometer test intervals were selected to correspond with pneumatic slug test intervals at the same depth in order to form a comparison. Comparison of the two field data collection methods and their results are summarized below.

Comparison of Hydraulic Conductivity Data

An in-depth comparison and analysis of hydraulic conductivity (permeability) testing data for the proposed evaporation ponds and reuse sites has been prepared by Jeff Farrar in the memorandum: Technical Review of Field and Laboratory Permeability Testing (Reclamation, 2006) and is included in Appendix I of this report. Conclusions of this memorandum that compare hydraulic conductivity data are paraphrased below:

- Field data best represent in-situ hydraulic conductivity (K) to be used for design and modeling permeability through subsurface layers at proposed Evaporation Pond and Reuse areas. Typical K-values of soil types are as follows:
  Silty Sand (SM) = 10^{-3} cm/sec
  Silt to Lean Clay (ML to CL) = 10^{-4} cm/sec
  Lean to Fat Clay (CL to CH) = 10^{-5} cm/sec

- Pneumatic slug test data appears to be reliable and compare well with piezometer test data.

- The laboratory data K values are lower than the field data by two to three orders of magnitude. It is commonly known that laboratory data are typically lower than field data. The postulated reason for higher field K is due to secondary structure, such as fissures in the clayey and silty soils. The macroscopic permeability in the finer soils cannot be measure effectively in the laboratory.

- Another reason the laboratory conductivities are so low is the fact that the sand and silty samples were disturbed in transport and not laboratory tested. The pneumatic slug testing method produced better results in silty and sandy soil types and more of these soil types were tested. Therefore the average lab data set appears even lower when compared to the field data.

IV. PROCEDURE

Procedure for Undisturbed Drilling and Sampling

Drill holes were drilled with a Central Mining Equipment 75 (CME 75) drill rig. Drilling and sampling was accomplished with a 6-5/8 inch I.D. by 10 inch O.D. by five-foot long hollow stem flight augers with a two-foot long, 6-inch O.D. by 5-3/4 inch I.D. split barrel dry coring system (Photo 4).

The undisturbed sampling system consisted of a rotating outer auger barrel (10 inch o.d.) with cutting bits at the bottom and a non-rotating split-tube inner barrel (sampler) with a smooth cutting shoe at the bottom that operated within the outer auger barrel (Photo 5). The sampler will accommodate a $5^1/_4$ or $5^1/_2$ inch i.d. cutting head (shoe) and a $5^5/_{16}$ or $5^1/_2$ inch i.d. liner. The sampler can be positioned within the auger so that the cutting

shoe is either ahead or behind the auger bit. The sampler is also fitted for two $2^1/_2$ foot-long sections of lexan liner. The liners are held in place in the sampler by the cutting shoe which threads onto the end of the inner barrel assembly. The sampler remains stationary and encases the sample while the outer rotating bit cuts an annular space around the sampler. The drill cuttings are lifted from the hole by the flight auger. Prior to being placed in the sampler, lexan liners are weighed, numbered, and wall thickness and diameter are recorded. The recovered sample is weighed, logged, and labeled (Photo 6). Field densities were calculated and are documented in Appendix F of this report. The geologic logs are located in Appendix B of this report. The liner samples were sealed with caps and duct tape to preserve moisture. Liner samples were packed in core boxes and shipped to the TSC Materials Laboratory, Denver, Colorado.

All drill holes were continuously cored from the ground surface to total depth. Soil samples from each drill hole were hand tested and visually classified in the field using the Unified Soil Classification System (USCS). Soil samples were sent to the Mid-Pacific Construction Office Materials Testing Laboratory in Willows, California for physical properties, gradation analysis, in-place moisture content, Plasticity Index, and Liquid Limit. The results of laboratory testing are included in Appendix G of this report. A companion hole was drilled about five feet away from each undisturbed sample drill hole to an average depth of 20.0 feet. Soil was logged using hand tests to identify physical properties and classify the soil type.

Procedure for Field Hydraulic Conductivity Tests

Pneumatic Slug Test Procedure

Field hydraulic conductivity tests were preformed at selected depth intervals adjacent to previously logged drill holes or utilizing the GEOPROBE® DT21 dual tube sampling system to recover and log soil samples. Selected test intervals were limited to homogenous soil type horizons greater than 1 foot-thick. Selected intervals were further limited to being below the static water table. An ASTM Standard for the pneumatic slug test has been created since the time of these investigations and is included in Appendix I of this report.

Installing the Sampler

The dual tube GEOPROBE® probe casing and rods were advanced by direct push with the Central Mining Equipment 45 (CME 45) drill rig, above the target test interval with no recovery. Inner rods and drive point was removed (Photos 7 – 10). A one-foot Precore Sample Tube (sampler) was connected to the inner rods and advanced 1-foot below the outer casing and shoe, and recovering a soil sample (Photo 11). Sampler and inner rods were removed from the casing. The recovered soil sample was measured and then removed from the sampler. Field hand test were preformed to classify the soil type and compare to previously logged drill holes (Photos 12 - 15). A brush was inserted down hole into the test interval to help clean clay smear from the hole walls, if caving was not likely (Photos 16 and 17). A DT21 Screen (PVC slotted screen) connected to flush threaded (square threaded) PVC casing was lowered into the target interval (Photos

18 and 19). The target interval was then surged one to three times in order to develop the well (Photo 20). Surging of the well was done with an inertial pump consisting of a check valve, check ball, and tubing. Water was removed from the well and groundwater was allowed to recharge into the well through the screened interval. After the ground water returned to the static water level, the slug test could continue.

Table 9 Specification for the Pneumatic Slug Test Equipment

Specifications for slug test equipment	**Outside Diameter (inches)**	**Inside Diameter (inches)**	**Length (feet)**	**Slot Size (inches)**
Outer Casing	2.25	1.5	4.0	NA
Inner Rods	1.0	0.5	4.0	NA
PVC Casing	0.75	0.5	5.0	NA
Slotted Screen	1.0	0.75	1.0 (slotted)	0.01

Pneumatic Manifold Assembly

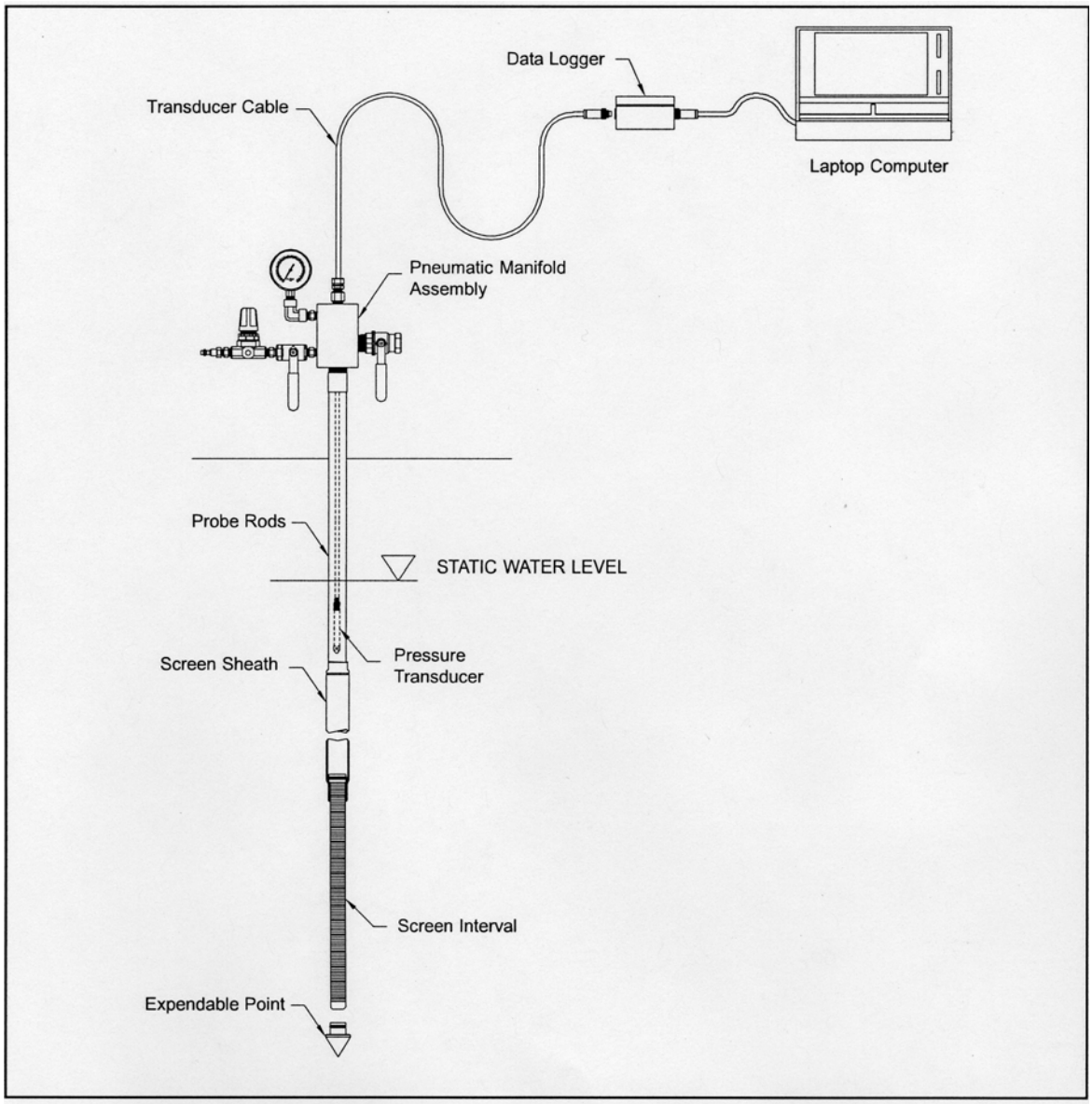
Once the slotted screen had been installed and the drill hole developed the Pneumatic Manifold Assembly could be installed. The Pneumatic Manifold Assembly is comprised of an inlet valve and pressure regulator, a pressure gauge, transducer port, a rod adapter, and a release valve. The manifold is depicted on Figure 2 and shown on photo number 21. A simple foot pump supplied air pressure through the pressure regulator down hole. The transducer was connected to a data logger. The data logger was connected to a field computer programmed with GEOPROBE® Pneumatic Slug Test Acquisition Software (Photo 22).

Running a Pneumatic Slug Test

The manifold was connected to the PVC casing. The transducer was lowered through the transducer port below static water level to equilibrate to ambient temperature. Slug test acquisition software would be initialized. For specific acquisition software steps, review GEOPROBE® Pneumatic Slug Test Kit, Standard Operating Procedure, Technical Bulletin No.19344. Once the transducer had attained the temperature of the groundwater, the transducer would be raised above static water level to zero it at atmospheric pressure. This was done by clicking on the ZERO TRANSDUCER button prompted on the field computer. The transducer was then lowered at least one foot below the water table. The transducer would stabilize at a given head pressure. This head pressure would become the baseline and was noted. The foot pump would then be pressurized 20 to 30 PSI. The inlet valve would be opened and the pressure regulator would be slowly turned open. The air pressure gauge on the manifold would rise with increased air pressure. The inlet valve would be closed and leak checks would be preformed to verify all connections were properly sealed. The air pressure gauge should stabilize at a baseline. The head pressure read out on the field computer should return to the original baseline. Once the head pressure stabilized, it would be noted and the release valve was quickly opened. Once air pressure is released, the head pressure reading will immediately drop and ground water will slowly recharge. With return of head pressure to the original baseline the test was

complete (Photo 23). Reclamation personnel typically ran two additional slug tests to verify repeatability, well performance and development.

Figure 2: GEOPROBE® Pneumatic Slug Test Diagram



Schematic depicts all the parts to the GEOPROBE® Pneumatic Slug Test. A field computer is connected to a data logger. A transducer connected to the data logger is lowered down the Pneumatic Manifold Assembly. The transducer is lowered below static water level inside square threaded PVC rods. A PVC slotted screen (with a one foot open interval) is located at the bottom of the PVC rods.

GEOPROBE® Standard Operating Procedure February 2002
Technical Bulletin No. 19344

Recommendations for Running a Successful Slug Test

1) Bring extra pneumatic slug test replacement parts, particularly the parts made from plastic to the field investigation. Extra parts needed for a successful pneumatic slug test field investigation include: slotted screen (DT21 Screen), quick connections (part that connects the slotted screen to the PVC inner rods), rubber O-rings and Soil Precore sample tubes.

2) Computer compatibility with the pneumatic slug test software and the field computer. Test the field computer with downloaded pneumatic slug test software connected to the pneumatic slug test equipment before going out to the field. Bring a power source (inverter plugged into a field vehicle) to charge the field computer's battery, because the computer will be turned on throughout each test.

3) Have a good understanding of the site geology, the soil profile and the approximate depth to the local static water level.

4) Proper development of the drill hole, with ample time spent surging the well and brushing the drill hole walls when necessary.

5) Lower the transducer below the static water level to cool the transducer to ambient groundwater temperature and then raise the transducer above the static water level before "zeroing" the transducer.

6) Watch the air pressure gauge during a test to detect slow leaks in the pneumatic slug test system. Bring a spray bottle filled with soapy water to perform a leak check on the pneumatic slug test manifold assembly before each test.

7) Run multiple tests at each test interval to verify repeatability of the permeability data.

Piezometer Test Procedure

Hydraulic conductivity piezometer tests (also referred to as pump out and recovery tests) were performed in accordance with procedures specified in the Ground Water Manual, Section 10-6 Auger-Hole Test for Hydraulic Conductivity (Reclamation, 1995). The tests were performed by advancing a hole with a drill rig using augers, inserting casing, and hand auguring one-foot above and through a six inch selected test interval (Photos 25 and 26). The casing was lowered to the top of the test interval and medium grained sand was lowered down the casing into the six inch test interval (vertical distance). The drill hole was developed by surging the water in the well with a pump and allowing the groundwater to recharge through the test interval, to a static water level. The depth to the static groundwater surface was measured. A transducer connected to a data logger was lowered to the bottom of the hole. The water was pumped out of the drill hole and the transducer was left for 18 to 24 hours to collect groundwater recovery data (Photo 28).

V. REFERENCES

1) GEOPROBE® Pneumatic Slug Test Kit, 2002: Standard Operating Procedure, Technical Bulletin No. 19344, GEOPROBE® Systems, Salina, Kansas.

2) Reclamation, 1993: Drainage Manual, Section 3.3 "Piezometer Test for Hydraulic Conductivity," Revised Re-Print 1993, U.S. Department of The Interior, Bureau of Reclamation, Denver.

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7) Reclamation, Strauss, T., 2006: Memorandum to Bob Davis, Geotechnical Engineering Group 2, D 8312, "Flexible Wall Permeability Test Results – San Luis Evaporation Pond Study, San Luis Drainage Project Study, Central Valley Project, California," Materials Engineering and Research Laboratory Referral Number MERL-06-04, Bureau of Reclamation, Technical Service Center, Denver, Colorado, March 3, 2006

8) Reclamation, Farrar, J.A., 2006: Technical Review of Field and Laboratory Permeability Testing – San Luis Drain Mitigation – Central Valley Project, California; Memorandum; TSC, Geotechnical Engineering Group.

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9) Reclamation, Burnett, R., 2006: *DRAFT REPORT*- San Luis Unit Drainage Reuse, In-Valley Water Needs Alternative; Bureau of Reclamation, Technical Service Center, Denver, Colorado, May 18th, 2006.

10) Reclamation, Burnett, R., 2006: *DRAFT REPORT*- Subsurface Drainage Field Investigations for Potential Reuse Areas, San Luis Unit Feasibility Study; Bureau of Reclamation, Technical Service Center, Denver, Colorado, May 30th, 2006.

Appendix A - Photographs

Photo 1 San Luis Drain
Grasslands Area

Grasslands Drilling Site

Typical drilling location, looking north, in the Grasslands Reuse Area. CME 45 drill rig is located on the left. The tent, located in the center, provides work area equipped with a laptop, pneumatic slug test kit and drilling casing and inside rods. Support vehicle is located to the right.

Photo by: Greg Mongano August, 2005

Photo 2

San Luis Drain
Central Westlands Area

Central Westlands Drill Site Area

Typical drilling location, looking northwest, in the Central Westlands Area. Proposed Evaporation Pond B is located to the north. Drilling, sampling and hydraulic conductivity tests were conducted along the side of dirt roads crossing the proposed evaporation pond site.

Photo by: Jared Vauk

August, 2005

Photo 3

San Luis Drain
Central Westlands Area

South Westlands Drill Site Area

Typical drilling location, looking northwest, in the South Westlands Area. Proposed Evaporation Pond A would be located covering the field shown above. Drilling, sampling and hydraulic conductivity tests were conducted along side the farm field near the vehicles on the right side of the photo. This parcel of land is “retired” marginal land bought by Westlands Water District and leased to farmers and ranchers.

Photo by: Jared Vauk

August, 2005

Photo 4

San Luis Drain
Drilling and Sampling

Undisturbed Sampling

View looking southwest at a Central Mining Equipment 75 drill rig. Hollow stem flight augers and bit hang vertically with a split-tube sampler and shoe are shown above. Photo inset shows the shoe and spit-tube sample placed ahead of the auger. Drillers can adjusted the shoe placement ahead or behind the augers in order to achieve the best possible undisturbed soil sample.

Photo by: Jared Vauk

August, 2005

Photo 5

San Luis Drain
Drilling and Sampling

Undisturbed Sampling

View looking north, drill helpers are removing the shoe, connected to a split-tube sampler.

Photo by: Jared Vauk

August, 2005

Photo 6 San Luis Drain
Drilling and Sampling

Undisturbed Sampling

View looking down at the geologist's work table and lexan encased undisturbed sample. Lexan liners are an acrylic plastic tube that can be cut-to-fit the given sample length. The ends are capped and duct taped to seal in the water content of the soil. Undisturbed samples were marked, weighed and packed into boxes with saturated wood chips in an effort to protect them from shaking, breaking, and losing moisture.

Photo by: Jared Vauk August, 2005

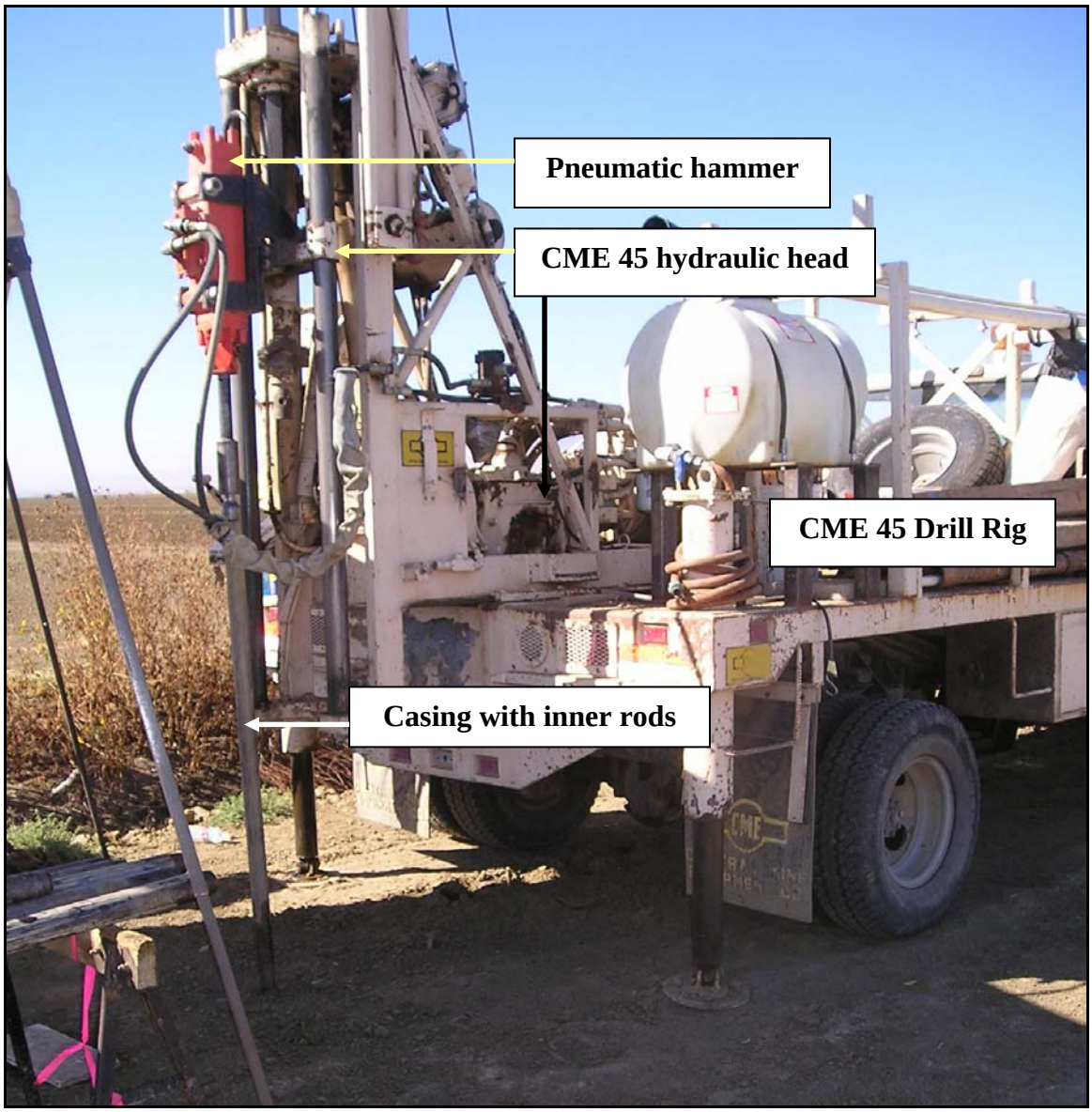


Photo 7

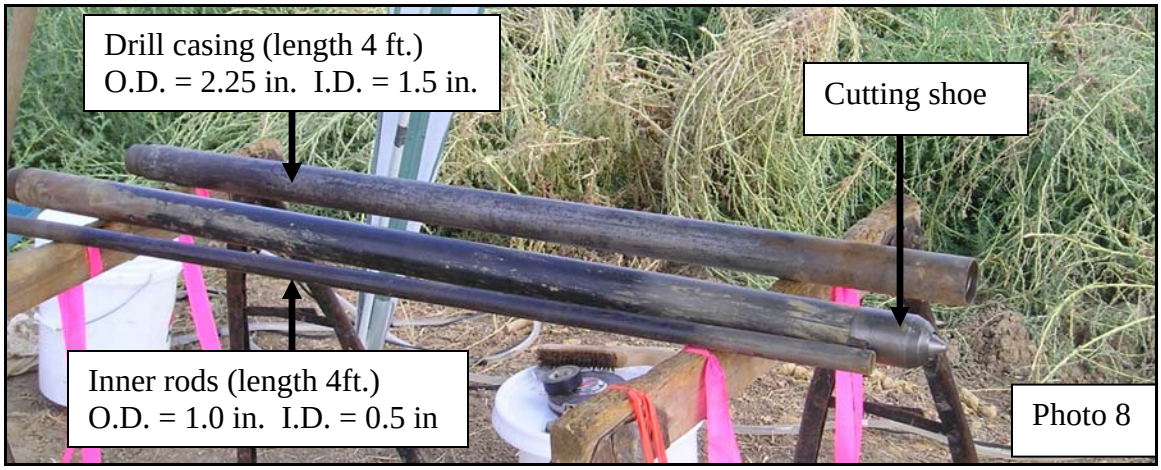
San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

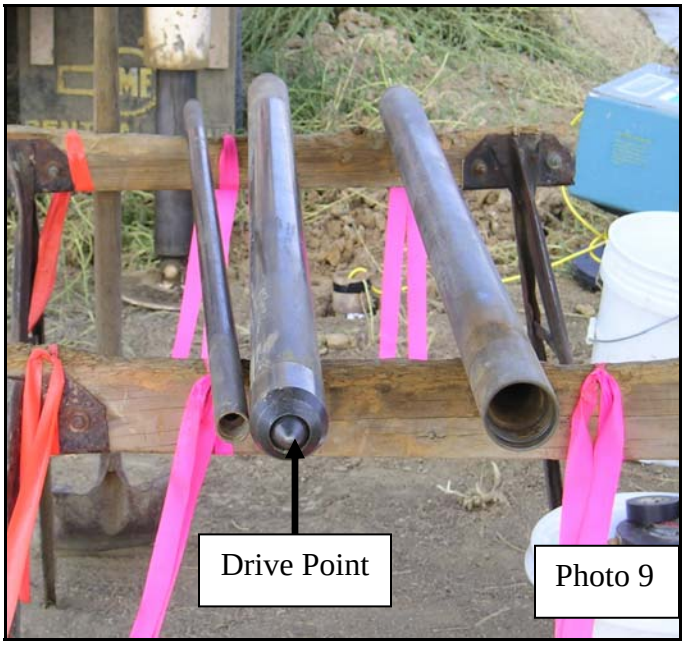
Drill Rig and Pneumatic Slug Test Drilling System

View looking southwest at Central Mining Equipment 45 (CME 45) drill rig, advancing casing and inner rods to targeted depth for pneumatic slug test. The GEOPROBE® pneumatic slug test equipment uses casing and inner rods to advance a hole to targeted depth intervals for testing. The CME 45 hydraulic press is the primary drilling apparatus used to advance casing by direct push method. The pneumatic hammer is attached to the hydraulic head and was typically not used. The pneumatic hammer is used to advance casing when the hydraulic head reaches its limits of penetration.

Photo by: Greg Mongano

August, 2005





Photos 8 and 9

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Drilling System

GEOPROBE® pneumatic slug test drill casing, cutting shoe, inner rods, and drive point are shown above.

Photo by: Greg Mongano

August, 2005

Photo 10 San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Drilling System

View looking northwest. Reclamation Agricultural Engineer, Roger Burnett, is holding a 4-foot, 2.25 inch (outside diameter) drill casing, with an inner rod and drive point. Casing was advanced with direct push from CME 45 hydraulic head and pneumatic hammer. Soil samples were not typically recovered above 4 feet of depth.

Photo by: Greg Mongano August, 2005

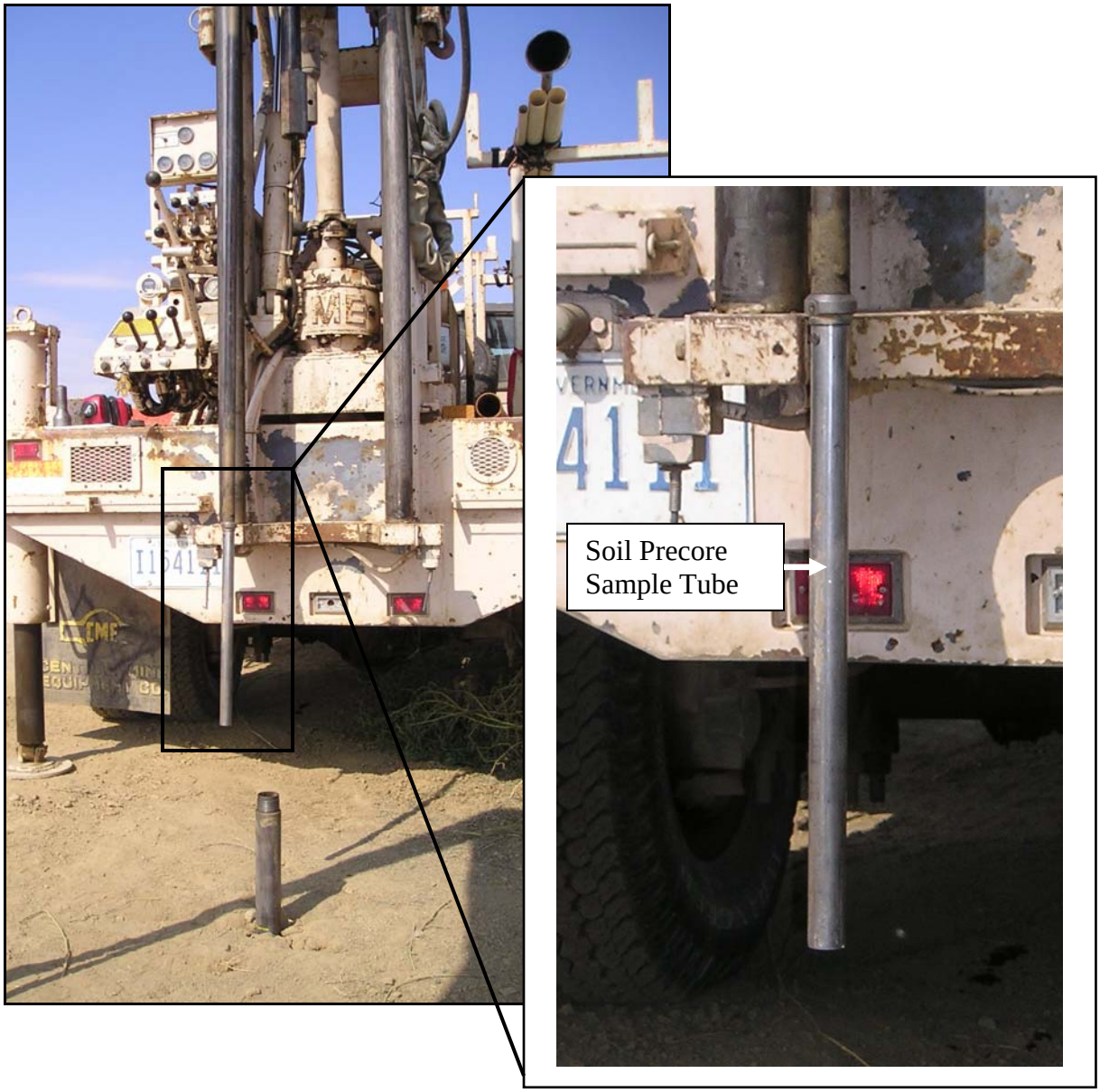


Photo 11

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Sampler

View looking northwest, photo and photo-inset is showing the one-foot Soil Precore Sample Tube. The sampling tube is inserted above the one-foot target test interval. The sampling tube removes the soil interval, in which a hydraulic conductivity test will be preformed.

Photo by: Jared Vauk

June, 2005

Photo 12

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Soil Sample

Photo and photo-inset show soil removed from the sampling tube that was classified using field hand tests. Soil sample were selected from targeted intervals based on previously logged companion drill holes.

Jared Vauk

June, 2005

Photo 13 San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Sample Tubes

View looking southwest, Reclamation driller (Marty Poos) is retrieving a 1-inch inside diameter LB Teflon Liner with a soil sample. The liner is being removed from a 2.25-inch (outside diameter) direct push rods (drill casing). Liners were used to obtain soil samples for field logging to generate a soil stratigraphy in locations with no previous explorations. The liners were also used to obtain a 1-foot soil sample, creating a 1-foot void for the insertion of the slotted screen "ground water profiler".

Photo by: Jared Vauk August, 2005

Photo 14

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Sample Tubes

View looking down, LB Teflon Liners contain 2-foot soil sample intervals. The liner labeled 1 contains soil from 5 to 7 feet of depth. The liner labeled 6 contains soil from 13 to 15 feet. Soil samples were pushed out with a wooden dowel for physical properties hand testing.

Photo by: Jared Vauk

August, 2005

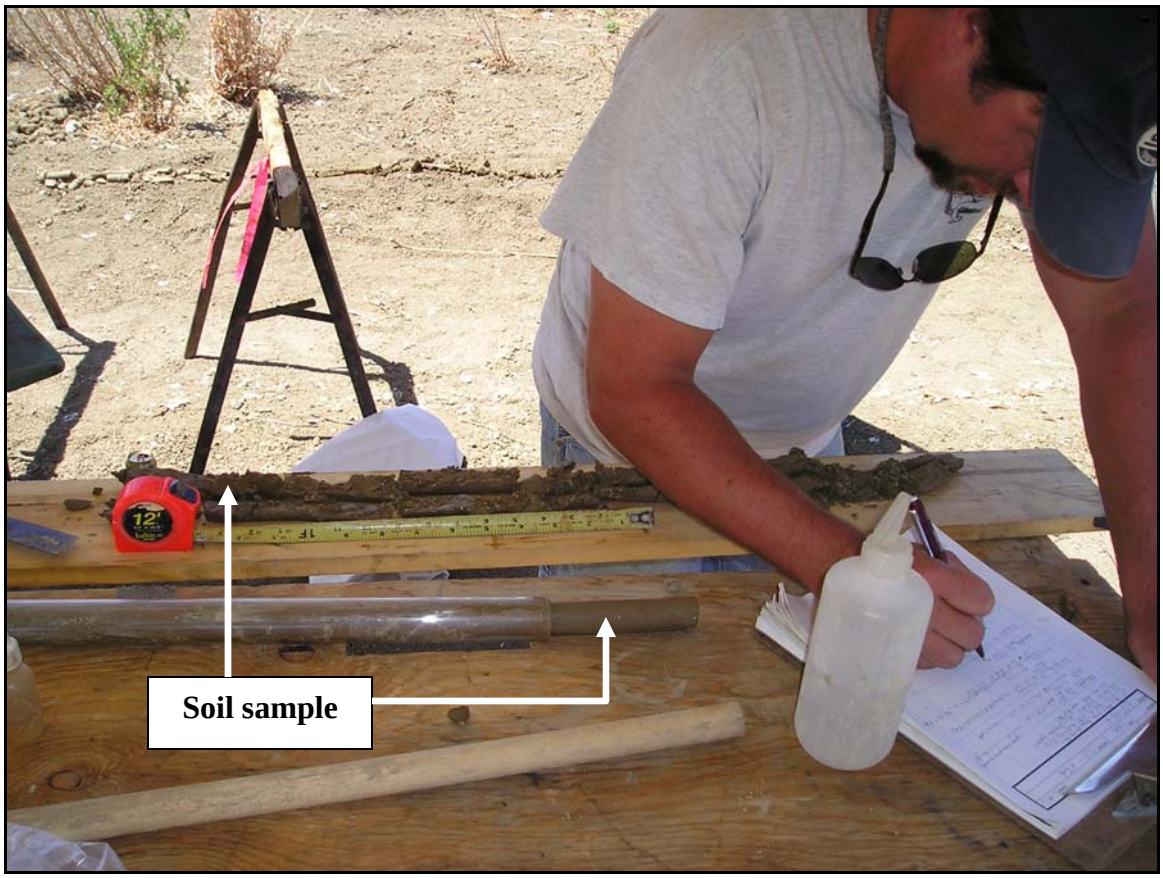


Photo 15

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Sample Tubes

View looking at the geologist's work table, soil samples were logged in the liner. The soil was pushed out of the liner with a wooden dowel. Geologist Greg Mongano is logging soil using field hand tests to identify physical properties.

Photo by: Tony Shanahan

August, 2005

Photos 16 and 17

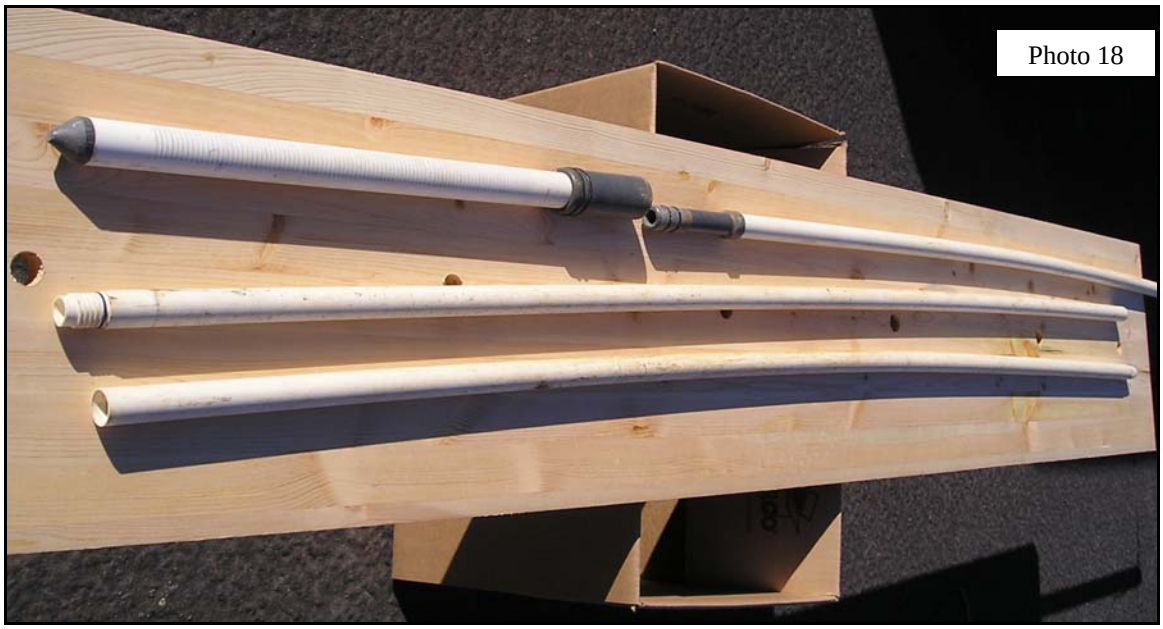
San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

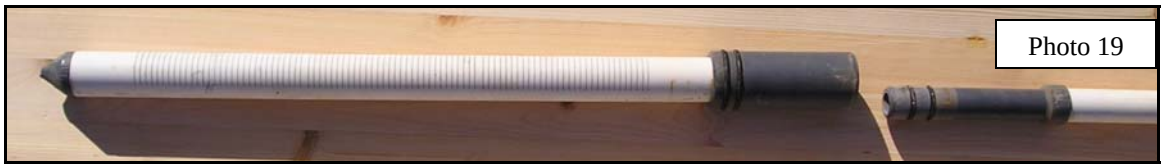
Pneumatic Slug Test Brush

View looking down, four foot extension rods, extension rod quick links, and were brush are shown above. Extension rods with brush were used to swab/ clean test interval before the ground water sampler is inserted.

Photo by: Greg Mongano

August, 2005





Photos 18 and 19

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

DT21 Screen and PVC inner rods

View looking down, the DT21 screen (slotted screen) and connecting PVC inner rods are shown above. The PVC rods have an O.D. of ¾-inch and an I.D. of ½-inch. The PVC rods are 5 feet in length and are flush threaded (square threaded) to provide less air leakage when connected to additional rods. The DT21 screen has an O.D. of 1-inch and length of 15 inches. The is DT21 screen has 12 inches of slotted screen, with two rows of 0.01 inch slots. The screen is connected to the PVC inner rods by a DT21 Adapter shown to the right of the slotted screen in Photo 19.

Photo by: Jared Vauk

January, 2006

Photo 20

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Surging the Drill Hole

View looking northwest. Reclamation driller, Tony Shanahan, is developing/ surging the drill hole to remove sand and fines. Reclamation field personnel would typically surge the well two or three times to produce more consistent test responses and results.

Photo by: Jared Vauk

June, 2005

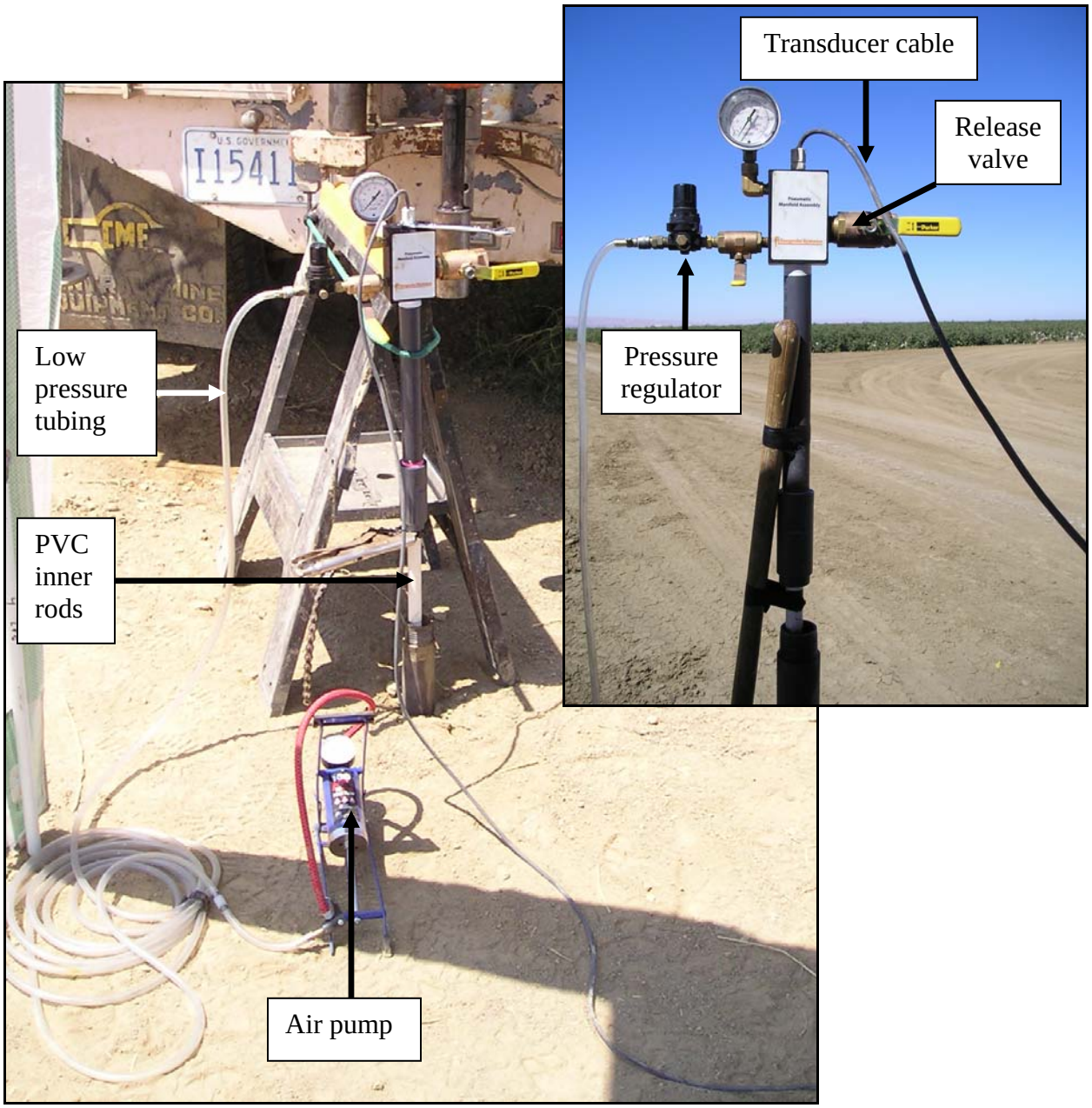


Photo 21

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Manifold Assembly

View looking west, the pneumatic manifold assembly allows the air pressures to be introduced and monitored. A simple foot air pump generates air pressure to push the water within the PVC assembly into the formation. A pressure regulator controls the pressure down hole. A release valve, when opened, initiates recharge of the formation water and is measured by a transducer.

Photo by: Jared Vauk

June, 2005

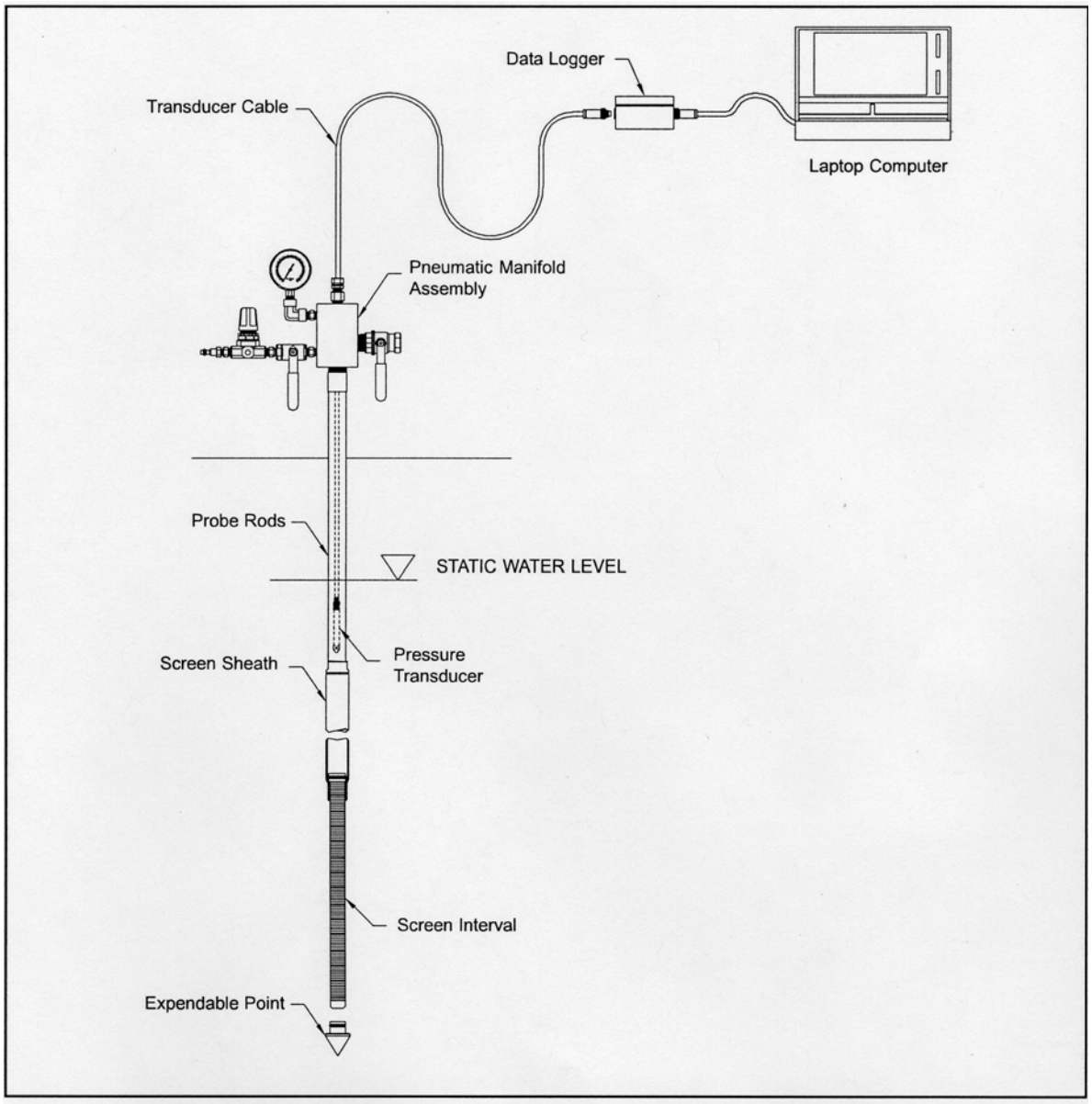


Figure 2

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Diagram

Schematic depicts all the parts to the GEOPROBE® Pneumatic Slug Test. A field computer is connected to a data logger. A transducer connected to the data logger is lowered through the pneumatic manifold assembly. The transducer is lowered below static water level inside the square threaded PVC rods. A PVC slotted screen with a one foot interval is located at the bottom of the PVC rods.

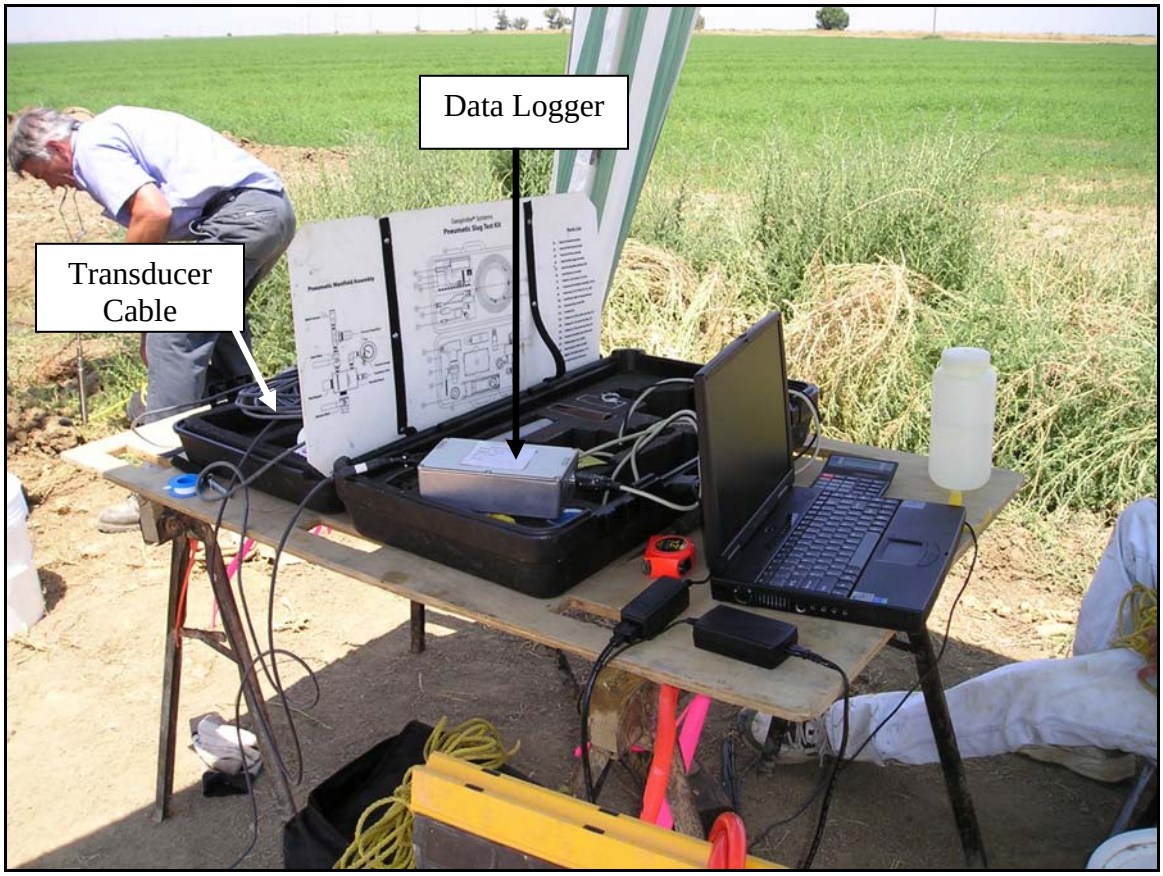


Photo 22

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Pneumatic Slug Test Kit and Field Computer

A field laptop computer with GEOPROBE® acquisition software is connected to a data logger and transducer. Keeping the field computer and transducer cable out of direct sun was critical to obtaining good test results.

Photo by: Jared Vauk

June, 2005

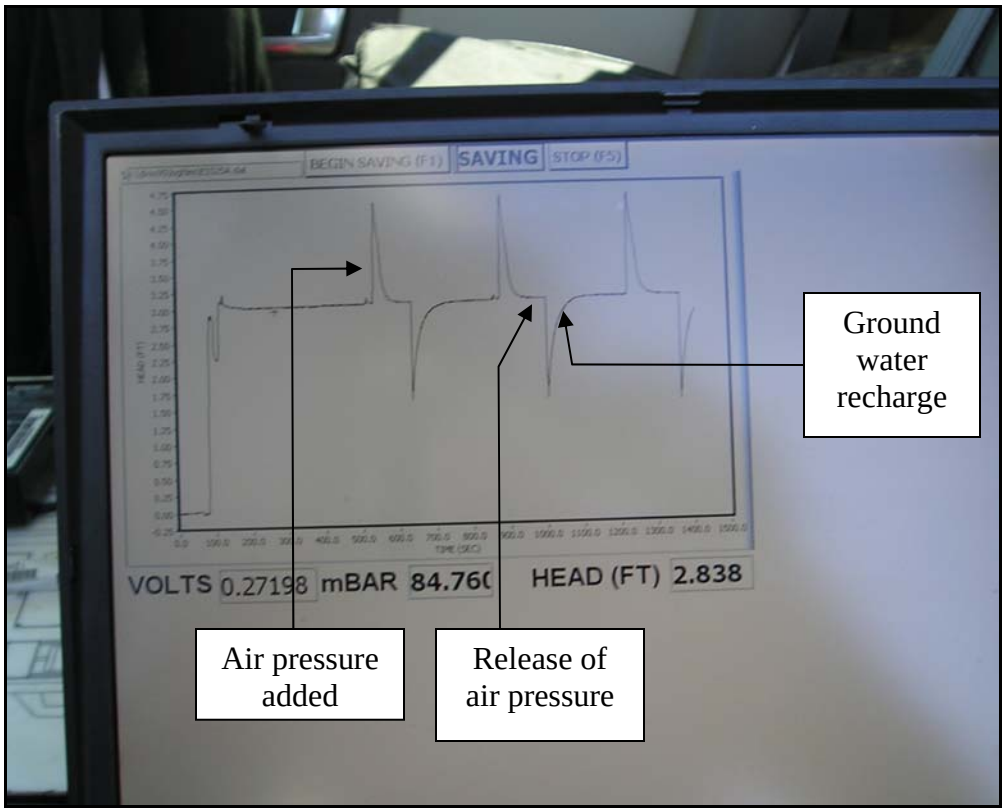


Photo 23

San Luis Drain
Hydraulic Conductivity Tests
Pneumatic Slug Test

Acquisition Software

The curves seen on the laptop screen represent individual test runs in a particular interval. Initial sharp rise in line are a result of adding pressure down hole. After the maximum pressure was added, ground water would reach equilibrium and the line would return to the initial head pressure. Opening the Release Valve would initiate water recharge represented by a sharp down spike and slow return of the line to the initial head pressure level.

Jared Vauk June, 2005

Photos 24 and 25

San Luis Drain
Hydraulic Conductivity Tests
Piezometer Test

Advancing the Piezometer Test Drill Holes

View looking north, and view looking west, geologist is holding a five-foot solid stem auger. Augers were used to drill to near the top of piezometer tests interval, stopping about 2 to 3 feet above the targeted depth interval.

Photo by: Tony Shanahan

June, 2005

Photos 26

San Luis Drain
Hydraulic Conductivity Tests
Piezometer Test

Hand Auger

View looking down at hand auger and soil sample. A hand auger was used to auger above the target test interval and through the six inch target test interval for piezometer (pump out and recovery) tests.

Photo by: Jared Vauk

August, 2005

Photos 27

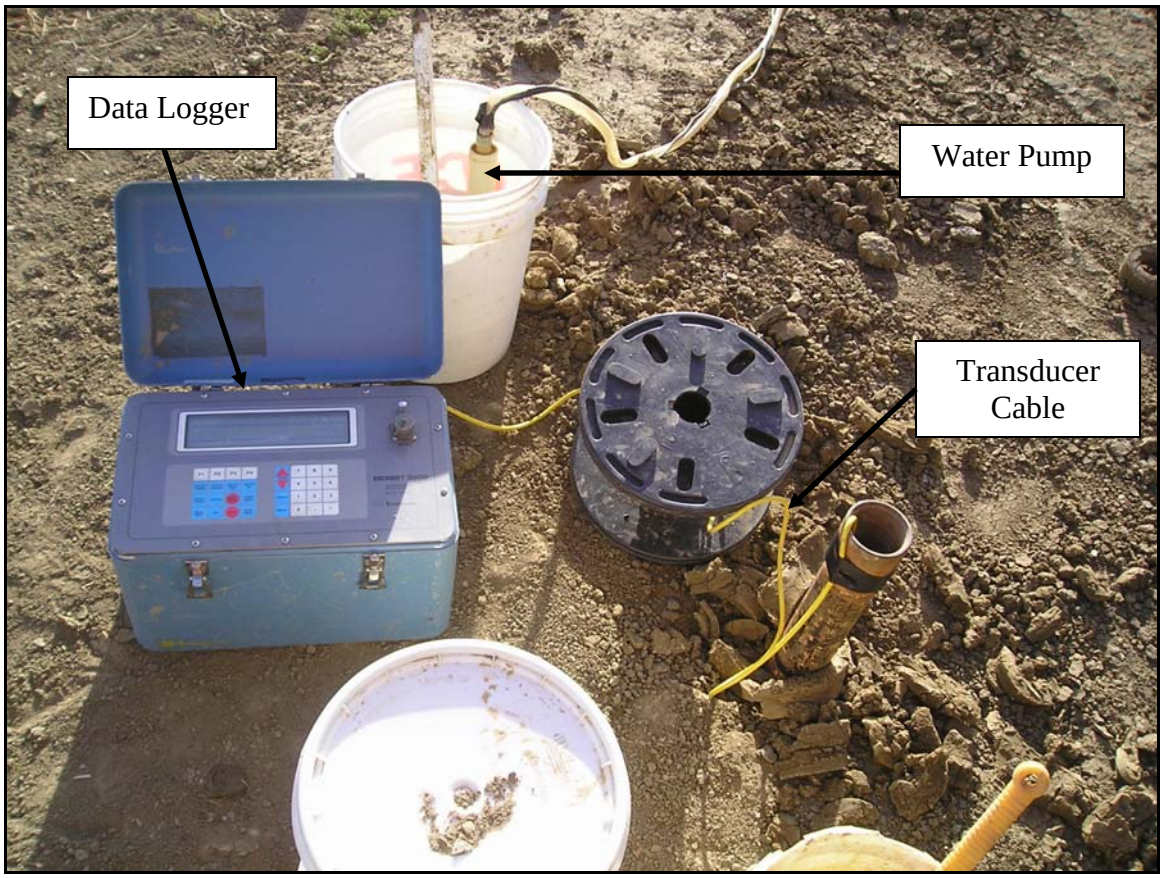
San Luis Drain
Hydraulic Conductivity Tests
Piezometer Test

Casing and Top of Piezometer Drill Hole.

View looking down, casing was installed from the surface to the top of the test interval. A hand auger was used to remove soil in the test interval, below the bottom of the casing. A transducer is connected to the yellow cord, which is taped to the casing.

Photo by: Jared Vauk

August, 2005



Photos 28

San Luis Drain
Hydraulic Conductivity Tests
Piezometer Test

Piezometer Drill Hole, Data Logger, and Water Pump

View looking down at the piezometer test equipment. A water pump powered by a car battery was used to pump out water from the drill hole. A transducer connected to the yellow transducer cable is taped to the casing and connected to a data logger. The data logger was used to record data overnight as the static groundwater recharge after pumping.

Photo by: Jared Vauk

August, 2005

Appendix B - Logs

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-25

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/13/05 FINISHED: 6/13/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,057,432.3 E 6,215,011.3
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 205.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 60 feet eastward from the southwest corner of Davis St. and Yuba St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.2 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 10.8 to 12.4 ft.
Sample #6: 13.5 to 16.2 ft.
Sample #7: 16.2 to 18.7 ft.
Sample #8: 18.9 to 21.4 ft.
Sample #9: 21.6 to 24.1 ft.
Sample #10: 24.3 to 26.8 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION / ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION / ELEVATION
	85								116.25			Qb	CH
	100	33.3	42.9	23.8	0	37.0	21.9	18.8	129.47		(CL)s 201.2		201.7
5													(CL)s
	100	35.4	46.3	18.3	0	40.6	24.0	27.3	127.89		(CL)s 198.2		198.2
													CL
		36.6	40.5	22.9	0	39.5	23.8	26.7			(CL)s 196.7		196.9
									125.44	6.299 E-04			(CL)s

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 3.5 ft. **Fat Clay, CH:** About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; hard; dry; brown; no reaction with HCl; contains some organic material and gypsum crystals.

3.5 to 7.0 ft. **Lean Clay with Sand, (CL)s:** About 80% fines with medium plasticity, high toughness and dry strength, no dilatancy; about 20% fine sand; maximum size, fine sand; hard; moist; brown; weak reaction with HCl.

Laboratory Data Interval
3.5 to 4.0 ft.

Laboratory Data Interval
6.6 to 7.0 ft.

7.0 to 8.3 ft. **Lean Clay, CL:** About 90% fines with high plasticity, toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

8.3 to 10.6 ft. **Lean Clay with Sand, (CL)s:** About 80% fines with medium plasticity, toughness and dry strength, rapid dilatancy; about 20% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
8.3 to 8.5 ft.

10.6 to 11.7 ft. **Lean Clay, CL:** About 90% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 10% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

11.7 to 11.9 ft. **Silty Sand, SM:** About 55% fine sand, about 45% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
11.7 to 11.9 ft.

11.9 to 13.1 ft. **Lean Clay with Sand, (CL)s:** About 75% fines with medium plasticity, low toughness and medium to high dry strength, rapid dilatancy; about 25% fine sand; maximum size, fine sand; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
12.0 to 13.1 ft.

13.1 to 13.5 ft. **Lean Clay, CL:** About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; firm; moist; brown; strong reaction with HCl; trace amount of maximum size 1/8-inch gypsum crystals.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-25 and EDC-05-25A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-25A was completed and logged first to a depth of 19.1 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners and with undisturbed sampling.

Undisturbed sample hole EDC-05-25 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic "liner" and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-25

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/13/05 FINISHED: 6/13/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,057,432.3 E 6,215,011.3
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 205.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay, Silt, and Silty Sand.
10.8 to 13.5 ft. and 13.5 to 16.2 ft.: Sample catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 10.8 ft. (Ground Water Level) before pulling out sample to enhance recovery.

CAVING CONDITIONS:
none

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets

DEPTH TO WATER

Date	Depth to Water
6/13/2005	10.8 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
															194.6
														CL	193.5
									114.88						
		28.0	23.7	48.3	0	NP	NP	22.1			s(ML)	193.3		SM	193.3
	67														
		47.9	29.8	22.3	0	34.1	15.9	28.0		5.772 E-03	(CL)s	192.1		(CL)s	192.1
		54.3	41.3	4.3	0	44.8	26.3	31.3			CL	191.7		CL	191.7
		48.5	24.9	26.6	0	31.8	9.7	25.7			(CL)s	191.3		(ML/CL)s	191.3
		63.4	32.6	4.0	0	40.4	21.5	32.3			CL	191.2		CL	
		58.4	35.7	5.9	0	46.6	24.9	33.2			CL	190.7			190.7
	0								NR						
15													Qb	(ML)s	189.7
		32.9	29.4	37.7	0	29.9	14.9	25.8			s(CL)	189.3		s(ML/CL)	189.3
		42.6	31.7	25.7	0	33.7	18.1	27.4			(CL)s	188.2		(CL)s	
									126.24						187.7
	100	57.2	30.3	12.5	0	32.2	15.5	28.7			CL	187.1			
		49.7	42.3	8.0	0	38.1	21.6	33.3		7.869 E-03	CL	185.7		CL	

CLASSIFICATION AND PHYSICAL CONDITION

Laboratory Data Interval
13.1 to 13.5 ft.

13.5 to 13.9 ft. Silt to Lean Clay with Sand, (ML/CL)s: About 75% fines with medium plasticity, low toughness and medium dry strength, rapid dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
13.5 to 13.9 ft.

13.9 to 14.5 ft. Lean Clay, CL: About 95% fines with medium to high plasticity, toughness and dry strength, no to slow dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist; brown; strong reaction with HCl.

Laboratory Data Interval
13.9 to 14.0 ft.

Laboratory Data Interval
14.3 to 14.5 ft.

14.5 to 15.5 ft. Silt with Sand, (ML)s: About 75% fines with medium plasticity, low toughness and medium dry strength, rapid dilatancy; about 25% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

15.5 to 15.9 ft. Sandy Lean Clay, s(CL): About 55% fines with low plasticity, toughness and no dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
15.5 to 15.9 ft.

15.9 to 17.5 ft. Lean Clay with Sand, (CL)s: About 75% fines with medium plasticity, low toughness and dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
15.9 to 17.0 ft.

17.5 to 20.1 ft. Lean Clay, CL: About 90% fines with high plasticity, medium toughness and dry strength, rapid dilatancy; about 10% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
17.5 to 18.1 ft.

Laboratory Data Interval
18.1 to 19.5 ft.

20.1 to 22.6 ft. Silty Sand, SM: About 55% fine sand, about 45% non-plastic fines, low toughness and dry strength, rapid dilatancy; maximum size, fine sand; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
21.4 to 21.6 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-25 and EDC-05-25A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-25A was completed and logged first to a depth of 19.1 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners and with undisturbed sampling.

Undisturbed sample hole EDC-05-25 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic "liner" and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-25

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/13/05 FINISHED: 6/13/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,057,432.3 E 6,215,011.3
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 205.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES	DEPTH	% CORE RECOVERY	LABORATORY DATA: % SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
		100								130.52						185.1
			10.3	12.0	77.7	0	NP	NP	21.7			SM	183.6		SM	
		100								128.37						182.6
			31.4	17.5	51.1	0	NP	NP	24.3			SM	181.1		s(ML)	180.9
	25	100								131.12				Qb	SM	178.8
			14.7	15.9	69.4	0	NP	NP	23.8			SM	178.2		SM	176.8
		100								130.53					s(ML/SM)	176.4
			16.9	20.0	63.1	0	NP	NP	25.8			SM	175.5		SM	175.5

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

22.6 to 24.3 ft. Sandy Silt, s(ML): About 55% non-plastic fines, low toughness and dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
23.9 to 24.1 ft.

24.3 to 26.4 ft. Silty Sand, SM: About 60% fine sand, about 40% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

26.4 to 26.7 ft. Sandy Silt s(ML): About 55% non-plastic fines, low toughness and dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

26.7 to 28.4 ft. Silty Sand, SM: About 75% fine sand, about 25% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
26.7 to 27.0 ft.

28.4 to 28.8 ft. Sandy Silt to Silty Sand, s(ML)/SM: About 50% fine sand, about 50% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

28.8 to 29.7 ft. Silty Sand, SM: About 70% fine sand, about 30% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
29.5 to 29.7 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-25 and EDC-05-25A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-25A was completed and logged first to a depth of 19.1 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners and with undisturbed sampling.

Undisturbed sample hole EDC-05-25 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic "liner" and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-26

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/14/05 FINISHED: 6/15/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,057,300.1 E 6,226,864.0
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 198.3
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 98 ft. eastward from the southwest corner Davis St. and Lake St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers,with a 5-1/4 inch i.d. cutting shoe and NWJ rods. Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC) using NWJ rods. Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.2 to 10.5 ft.
Sample #5: 10.9 to 13.3 ft.
Sample #6: 13.5 to 16.0 ft.
Sample #7: 16.2 to 18.7 ft.
Sample #8: 18.9 to 21.4 ft.
Sample #9: 21.6 to 24.0 ft.
Sample #10: 24.3 to 26.7 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	93								117.17				Qb		
		26.2	69.0	4.8	0	64.1	42.4	27.2			CH	195.8			
	100								117.83						
		33.0	64.4	2.6	0	52.2	33.3	34.1			CH	193.7		CH	
5		32.7	62.2	5.1	0	52.4	32.5	35.0			CH	192.8			
	100								119.74						190.0
		41.9	45.2	12.9	0	39.6	19.8	34.2		3.266 E-03	CL	189.1		CL	189.1
10	98								122.04						
	93								119.86	No Data					
		24.2	74.6	1.2	0	72.9	51.4	32.0			CH	184.9		CH	
	100								125.71						

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 8.3 ft. Fat Clay, CH: About 95% fines with high plasticity, toughness and dry strength, no to slow dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist to dry; brown; weak reaction with HCl; contains some organic material.

Laboratory Data Interval
1.8 to 2.5 ft.

Laboratory Data Interval
3.8 to 4.6 ft.

Laboratory Data Interval
5.1 to 5.5 ft.

8.3 to 9.2 ft. Lean Clay, CL: About 85% fines with medium plasticity, toughness and dry strength, slow to rapid dilatancy; about 15% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

Laboratory Data Interval
8.3 to 9.2 ft.

9.2 to 17.3 ft. Fat Clay, CH: About 90 to 95% fines with high plasticity, toughness and dry strength, no to low dilatancy; about 5 to 10% fine sand; maximum size, fine sand; hard to firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
13.1 to 13.4 ft.

17.3 to 22.6 ft. Silt to Lean Clay, ML/CL: About 90% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 10% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
18.6 to 18.9 ft.

Laboratory Data Interval
21.4 to 21.6 ft.

22.6 to 23.4 ft. Silty Sand, SM: About 55% fine sand; maximum size, fine sand; about 45% non-plastic fines, rapid dilatancy; soft; wet; brown; strong reaction with HCl.

23.4 to 24.5 ft. Silt with Sand, (ML)s: About 75% non-plastic fines, rapid dilatancy; about 25% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
24.0 to 24.1 ft.

24.5 to 24.7 ft. Silt to Lean Clay, ML/CL: About 90% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 10% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-26 and EDC-05-26A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-26A was completed and logged first to a depth of 19.1 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-26 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-26

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/14/05 FINISHED: 6/15/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,057,300.1 E 6,226,864.0
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 198.3
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay to Sand.
27.6 to 29.7 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 8.1 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
8.1 to 10.7 ft.: 0.6 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets

DEPTH TO WATER:

Date	Depth to Water
6/13/2005	8.1 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100								126.80						181.0
		61.4	27.9	10.7	0	24.7	7.2	23.1			CL	179.4			
20	100								120.37					ML/CL	
		49.5	38.7	11.8	0	43.4	23.4	33.9			CL	176.7			
	93								123.94				Qb		175.7
														SM	174.9
														(ML)s	173.8
		57.6	20.8	21.6	0	NP	NP	30.2			(ML)s	174.2		ML/CL	173.6
25	88								126.48						
	22								NR					SM	
		5.5	6.0	88.5	0	NP	NP	23.5			SP-SM	168.6			168.6

BOTTOM OF HOLE

24.7 to 29.7 ft. Silty Sand, SM: About 85% fine sand; maximum size, fine sand; about 15% non-plastic fines, low dry strength, rapid dilatancy; maximum size, fine sand; very soft to soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
29.5 to 29.7 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-26 and EDC-05-26A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-26A was completed and logged first to a depth of 19.1 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-26 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-27

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/10/05 FINISHED: 6/11/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,051,990.3 E 6,214,882.6
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 210.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk and Greg Mongano
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 155 ft. Southward from the Southwest corner of Cerini St. and Yuba St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 11.0 to 13.1 ft.
Sample #6: 13.5 to 15.0 ft.
Sample #7: 16.2 to 18.5 ft.
Sample #8: 18.9 to 21.3 ft.
Sample #9: 21.6 to 23.6 ft.
Sample #10: 24.3 to 26.8 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	93	35.2	58.7	6.1	0	52.4	33.1	22.9	111.12		CH	207.9	Qb	CL/CH	202.6
	100								124.45						
5	93	47.1	43.2	9.7	0	43.1	24.6	23.6	118.27		CL	203.5			
		44.1	30.4	25.5	0	31.0	13.7	32.6			(CL)s	202.3		s(ML)	202.3
10	100	57.7	38.1	3.6	0.6	48.0	24.8	37.4	125.12		CL	199.8		CL/CH	200.2
	93	48.3	50.5	1.2	0	50.0	30.3	35.2	115.83	6.334 E-05	CH	197.5		(CL)s	199.8
		56.4	31.4	12.2	0	35.5	1.9	34.9	109.19		CL	196.0		CL/CH	198.5
	56									3.537				CL/CH	197.0
														(ML)s	196.2
														s(ML)	195.7

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 8.0 ft. Lean to Fat Clay, CL/CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; soft to hard; dry; brown; no to weak reaction with HCl; 0.0 to 3.0 ft. contains some organic material and gypsum crystals.

Laboratory Data Interval
1.0 to 2.7 ft.

Laboratory Data Interval
4.6 to 7.1 ft.

8.0 to 8.3 ft. Sandy Silt, s(ML): About 60% fines with low plasticity, low toughness and low to medium dry strength, rapid dilatancy; about 40% fine sand; maximum size, fine sand; soft; wet; brown; weak reaction with HCl.

Laboratory Data Interval
8.0 to 8.3 ft.

8.3 to 10.4 ft. Lean to Fat Clay, CL/CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; soft to firm; dry; brown; no to weak reaction with HCl; gypsum crystal mottling.

10.4 to 10.8 ft. Lean Clay with Sand, (CL)s: About 75% fines with medium to high plasticity, toughness and high dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

Laboratory Data Interval
10.4 to 10.8 ft.

10.8 to 12.1 ft. Lean to Fat Clay, CL/CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; soft to firm; dry; brown; weak to no reaction with HCl.

12.1 to 13.6 ft. Lean to Fat Clay, CL/CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; hard to soft; dry; brown; weak to no reaction with HCl; gypsum crystal mottling.

Laboratory Data Interval
12.1 to 13.1 ft.

13.6 to 14.4 ft. Silt with Sand, (ML)s: About 75% fines with medium to high plasticity, toughness and dry strength, no dilatancy; about 25% fine sand; maximum size, fine sand; very soft to soft; wet; brown; weak reaction with HCl; gypsum crystal mottling.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-27 and EDC-05-27A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-27A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-27 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic liner and logged visually. A companion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:27:18 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-27

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/10/05 FINISHED: 6/11/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,051,990.3 E 6,214,882.6
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 210.6
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk and Greg Mongano
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay to Sand.
15.0 to 16.2 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 8.0 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
0.6 ft. after 2.7 - 4.6 ft.
2.5 ft. after 9.6 - 12.1 ft.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/13/2005	8.0 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
										E-03					
		23.5	11.5	65.0	0	NP	NP	28.4			SM	193.5		SM	192.9
	96								121.99	6.506 E-04				s(ML)	192.5
														SM	191.8
														s(ML)	191.3
		15.6	14.0	70.4	0	NP	NP	32.8			SM	191.0			
20	89								122.30						
									121.69				Qb	SM	
	85														
		7.9	4.7	87.4	0	NP	NP	24.5			SM	186.7			
25	100								127.12						185.1
		14.8	80.2	3.1	1.9	88.2	63.4	32.1			CH	183.6			
	100								126.40					CH	
		22.2	65.0	2.5	10.3	71.1	47.5	31.9			CH	180.9			180.9

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

14.4 to 14.9 ft. Sandy Silt s(ML): About 65% fines with low plasticity, toughness and dry strength, slow dilatancy; about 35% fine sand; maximum size, fine sand; soft; wet; brown; weak reaction with HCl.

Laboratory Data Interval
14.4 to 14.6 ft.

14.9 to 17.9 ft. Silty Sand, SM: About 70% fine sand; maximum size, fine sand; about 30% fines with no to low plasticity, toughness and dry strength, rapid dilatancy; very soft; wet; brown-gray; weak to strong reaction with HCl; minor lens of Sandy Silt are laminated with a maximum thickness of 0.3 in.; unit grades from 60% Sand to 80% Sand from the top of the interval to the bottom.

Laboratory Data Interval
15.9 to 17.1 ft.

17.9 to 18.1 ft. Sandy Silt, s(ML): About 60% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 40% fine sand; maximum size, fine sand; soft; moist to wet; brown-gray; strong reaction with HCl

18.1 to 18.8 ft. Silty Sand, SM: About 70% fine sand; maximum size, fine sand; about 30% non-plastic fines, rapid dilatancy; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

18.8 to 19.3 ft. Sandy Silt, s(ML): About 60% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 40% fine sand; maximum size, fine sand; soft; moist to wet; brown-gray; strong reaction with HCl.

19.3 to 25.5 ft. Silty Sand, SM: About 80% fine sand; maximum size, fine sand; about 20% non-plastic fines, low dry strength, rapid dilatancy; very soft; wet; brown-gray; strong reaction with HCl.

Laboratory Data Interval
19.3 to 19.6 ft.

Laboratory Data Interval
23.7 to 23.9 ft.

25.5 to 29.7 ft. Lean to Fat Clay, CL/CH: About 90% fines with high plasticity, toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm to hard; moist; brown; strong reaction with HCl.

Laboratory Data Interval
26.8 to 27.0 ft.

Laboratory Data Interval
29.5 to 29.7 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-27 and EDC-05-27A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-27A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-27 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within an acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:27:18 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-28

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/22/05 FINISHED: 6/23/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,052,288.4 E 6,221,425.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 204.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 194 ft. Northward from the Southwest Corner of Cerini St. and Butte St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.1 to 10.4 ft.
Sample #5: 11.0 to 13.3 ft.
Sample #6: 13.5 to 16.0 ft.
Sample #7: 16.5 to 18.7 ft.
Sample #8: 18.9 to 21.3 ft.
Sample #9: 21.6 to 24.1 ft.
Sample #10: 24.3 to 26.8 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100	38.6	56.0	5.4	0	49.2	32.6	18.4	117.23		CL	203.0			
		36.6	60.7	2.7	0	47.1	26.7	35.4			CL	201.8		CL	
	96	41.9	55.0	3.1	0	42.6	25.1	30.7	116.93		CL	200.6			
5		33.4	59.5	7.1	0	47.1	26.7	35.0			CL	199.1	Qb		199.0
	93	32.6	62.0	5.4	0	51.0	31.8	36.5	117.04		CH	198.6		(ML)s	197.8
		36.3	54.5	9.2	0	40.2	21.9	31.2			CL	197.3		(CL/ML)s	197.3
														(CL)s	
	93	42.0	52.7	5.3	0	42.8	23.5	32.9	124.87		CL	195.9			
		25.6	59.2	15.2	0	43.0	26.2	30.1			(CL)s	195.5			195.5
	93	31.0	59.3	9.7	0	49.4	32.8	23.0			CL	194.8		CL	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 5.5 ft. Lean Clay, CL: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; soft to firm; dry; brown; no to weak reaction with HCl; 0.0 to 1.3 ft. contains organic material.

Laboratory Data Interval
1.1 to 1.5 ft.

Laboratory Data Interval
2.5 to 2.7 ft.

Laboratory Data Interval
3.4 to 3.9 ft.

Laboratory Data Interval
5.2 to 5.4 ft.

5.5 to 6.7 ft. Silt with Sand, (ML)s: About 85% fines with high plasticity, medium toughness and dry strength, rapid dilatancy; about 15% fine sand; maximum size, fine sand; soft; wet; brown; weak reaction with HCl.

Laboratory Data Interval
5.5 to 5.9 ft.

6.7 to 7.2 ft. Lean Clay to Silt with Sand, (CL/ML)s: About 85% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 15% fine sand; maximum size, fine sand; soft; wet; brown; weak reaction with HCl.

Laboratory Data Interval
7.0 to 7.2 ft.

7.2 to 9.0 ft. Lean Clay with Sand, (CL)s: About 80% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 20% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
8.2 to 8.6 ft.

Laboratory Data Interval
8.8 to 9.0 ft.

9.0 to 11.2 ft. Lean Clay, CL: About 90% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; soft; dry; brown; strong reaction with HCl.

Laboratory Data Interval
9.4 to 9.7 ft.

Laboratory Data Interval
10.4 to 10.6 ft.

11.2 to 12.6 ft. Lean Clay to Silt with Sand, (CL/ML)s: About 85% fines with high plasticity, medium to high toughness and medium dry strength, slow dilatancy; about 15% fine sand; maximum size, fine sand; soft; moist to wet; brown; strong reaction with HCl.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-28 and EDC-05-28A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-28A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-28 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:30:03 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-28

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/22/05 FINISHED: 6/23/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,052,288.4 E 6,221,425.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 204.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Lean Clay to Sand.
16.2 to 18.9 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 4.2 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
16.2 to 18.9 ft.: 0.3 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:
Date Depth to Water
6/23/2005 4.2 ft.

LABORATORY DATA

% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT
27.4	70.6	2.0	0	65.6	43.7	35.0
40.9	47.2	11.9	0	39.2	22.2	30.1
36.2	49.6	14.2	0	38.1	21.1	24.5
19.3	43.1	37.6	0	32.9	18.0	27.7
4.6	15.0	84.4	0	NP	NP	22.8
51.7	22.5	25.8	0	25.2	5.2	29.9
39.5	33.8	26.7	0	31.6	16.8	25.6
46.7	22.8	30.5	0	24.4	7.3	26.4
57.8	37.0	5.2	0	37.9	19.2	31.9

DEPTH	% CORE RECOVERY	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
			5.149 E-04	CH	193.9	Qb	CL	193.3
	100	129.36		CL	192.7		(CL/ML)s	191.9
				CL	192.3			
				s(CL)	190.9		s(CL/ML)	189.8
			1.819 E-04					
15	100	132.29		SM	189.0		SM	188.0
			1.156 E-03					
	85	124.07		(CL-ML)s	187.3		s(ML)	186.2
				(CL)s	185.8		(CL)s	185.7
				s(CL)	185.2		s(CL)	185.1
				CL	184.8			

CLASSIFICATION AND PHYSICAL CONDITION

Laboratory Data Interval
11.2 to 11.8 ft.

Laboratory Data Interval
11.9 to 12.2 ft.

12.6 to 14.7 ft. Sandy Lean Clay to Silt, s(CL/ML): About 55% fines with medium plasticity, low toughness and dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
13.0 to 13.6 ft.

14.7 to 16.5 ft. Silty Sand, SM: About 85% fine sand; maximum size, fine sand; about 15% non-plsatic fines, rapid dilatancy; very soft; wet; brown with black speckling; strong reaction with HCl.

Laboratory Data Interval
14.8 to 15.5 ft.

16.5 to 18.3 ft. Sandy Silt, s(ML): About 70% fines with high plasticity, low toughness and dry strength, rapid dilatancy; about 30% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
16.7 to 17.2 ft.

18.3 to 18.8 ft. Lean Clay with sand, (CL)s: A bout 80% fines with high plasticity, medium to high toughness and dry strength, no dilatancy; about 20% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
18.4 to 18.7 ft.

18.8 to 19.4 ft. Sandy Lean Clay, s(CL): About 60% fines with low plasticity, low toughness and medium dry strength, rapid dilatancy; about 40% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
18.9 to 19.3 ft.

19.4 to 22.3 ft. Lean Clay, CL: About 90% fines with high plasticity, medium to high toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; soft to firm; moist; brown; no to weak reaction with HCl.

Laboratory Data Interval
19.4 to 19.7 ft.

Laboratory Data Interval
21.3 to 21.5 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-28 and EDC-05-28A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-28A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-28 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:30:03 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-28

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/22/05 FINISHED: 6/23/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,052,288.4 E 6,221,425.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 204.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES	DEPTH	% CORE RECOVERY	LABORATORY DATA: % SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
		100								130.03					CL		**22.3 to 24.3 ft. Silty Sand, SM:** About 65% fine sand; maximum size, fine sand; about 35% non-plastic fines with low dry strength, rapid dilatancy; soft; moist; brown; strong reaction with HCl.
			53.9	40.8	5.3	0	42.1	24.8	28.4			CL	183.0				**24.3 to 29.7 ft. Silty Sand, SM:** About 85% fine sand, about 15% fines with no plasticity, rapid dilatancy; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.
		100								129.68						182.2	Laboratory Data Interval 24.1 to 24.3 ft.
															SM		Laboratory Data Interval 26.8 to 26.9 ft.
			32.7	12.9	54.4	0	NP	NP	23.0			SM	180.2			180.2	
	25	96								130.91				Qb			
			6.8	5.6	87.6	0	NP	NP	22.7			SM	177.6		SM		
		100								130.48						174.8	

BOTTOM OF HOLE

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-28 and EDC-05-28A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-28A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-28 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:30:04 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-29

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/24/05 FINISHED: 6/25/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,051,972.8 E 6,231,929.2
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 202.1
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Pond B, Five Points Area, 60 ft. Westward of the Southwestern corner of Cerini St. and Trinity St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.8 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 11.0 to 13.3 ft.
Sample #6: 13.5 to 15.2 ft.
Sample #7: 16.3 to 18.7 ft.
Sample #8: 18.9 to 20.9 ft.
Sample #9: 21.6 to 24.3 ft.
Sample #10: 24.3 to 26.4 ft.
Sample #11: 27.0 to 29.1 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100	28.0	68.3	3.7	0	57.7	36.6	30.4	111.84		CH	200.6	Qb	CH	198.7
		33.3	61.5	5.2	0	49.1	30.0	29.9			CL	199.4			
	93	33.0	44.3	22.7	0	37.3	21.1	29.9	122.16		(CL)s	198.1		s(CL/ML)	197.4
5		29.7	65.7	4.6	0	53.8	32.0	38.5			CL	197.0		CL	197.6
	96	38.7	43.8	17.5	0	35.2	18.7	31.0	117.27	8.77 E-04	CL	196.0		(ML)s	196.6
		44.9	54.0	1.1	0	48.0	26.7	38.0			CH	195.1		CL/ML	194.8
		54.6	31.8	13.6	0	28.5	11.0	28.0			CL	193.2		s(ML)	193.1
	100	23.5	76.1	0.4	0	60.5	38.1	37.0	126.59	3.298 E-04	CH	192.6		CL	192.5
10															
	96	39.7	43.3	17.0	0	40.3	26.0	23.6	125.34		(CL)s	190.4		(ML)s	189.2
		59.6	37.4	3.0	0	39.4	22.3	33.3			CL	188.8			
		58.5	39.5	2.0	0	39.4	22.3	33.3			CH	188.6			
	100	18.3	79.8	1.9	0	61.0	38.5	37.6	116.17	2.380 E-04	CH	187.9			

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 3.4 ft. Fat Clay, CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; firm; dry; brown; no to weak reaction with HCl; contains some organic material; desiccation cracks found throughout interval.

Laboratory Data Interval
1.0 to 1.5 ft.

Laboratory Data Interval
2.5 to 2.7 ft.

3.4 to 4.7 ft. Sandy Silt to Sandy Lean Clay, s(CL/ML): About 65% fines with low plasticity, medium toughness and dry strength, rapid dilatancy; about 35% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
3.6 to 4.0 ft.

4.7 to 5.1 ft. Lean Clay, CL: About 90% fines with high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; moist; brown; weak reaction with HCl.

Laboratory Data Interval
4.7 to 5.1 ft.

5.1 to 6.1 ft. Silt with Sand, (ML)s: About 75% fines with medium plasticity, toughness and dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

Laboratory Data Interval
5.1 to 6.1 ft.

6.1 to 7.3 ft. Lean Clay to Silt, CL/ML: About 90% fines with high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
6.3 to 7.0 ft.

7.3 to 9.0 ft. Sandy Silt, s(ML): About 60% fines with low plasticity, medium toughness and low dry strength, rapid dilatancy; about 40% fine sand; maximum size, fine sand; very soft; wet; brown; no reaction with HCl

Laboratory Data Interval
7.4 to 8.3 ft.

9.0 to 9.6 ft. Lean Clay, CL: About 90% fines with high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; no reaction with HCl.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-29 and EDC-05-29A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-29A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-29 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:33:24 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-29

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/24/05 FINISHED: 6/25/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,051,972.8 E 6,231,929.2
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 202.1
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay to Sand.
20.9 to 21.6 and 21.6 to 24.3 ft.: Catcher was inserted to retrieve material lost during initial run. No recovery from 29.1 ft. to 29.7. Water was added to hole for each run below the depth of 3.4 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
7.1 to 9.6 ft.: 0.5 feet of material in augers.
8.1 to 10.8 ft.: 0.2 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/25/2005	3.4 ft

LABORATORY DATA

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
		55.2	44.0	0.8	0	42.1	21.1	38.6			CL	186.1		CL/ML	
	100								124.68						
		50.7	47.4	1.9	0	49.6	27.0	38.3			CH	183.5			183.3
		40.2	45.5	14.3	0	36.2	21.4	27.0			CL	182.7			
20	74								119.01					(CL)s	
		42.6	47.4	10.0	0	38.2	21.5	31.5			CH	180.0			180.0
	19								NR				Qb		
25	100								119.89					CH	
		20.7	78.9	0.4	0	69.7	49.1	36.9			CL	175.1			174.1
	78								129.68					(CL)s	173.6
														NR	

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

Laboratory Data Interval
9.1 to 9.5 ft.

9.6 to 12.9 ft. Silt with Sand, (ML)s: About 80% fines with medium plasticity, toughness and dry strength, no dilatancy; about 20% fine sand; maximum size, fine sand; soft; wet; brown; no reaction with HCl.

Laboratory Data Interval
10.7 to 11.7 ft.

12.9 to 18.8 ft. Lean Clay to Silt, CL/ML: About 90% fines with medium to high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; no reaction with HCl.

Laboratory Data Interval
10.7 to 11.7 ft.

Laboratory Data Interval
13.0 to 13.3 ft.

Laboratory Data Interval
13.3 to 13.5 ft.

Laboratory Data Interval
13.9 to 14.2 ft.

Laboratory Data Interval
15.3 to 16.0 ft.

Laboratory Data Interval
18.1 to 18.6 ft.

18.8 to 22.1 ft. Lean Clay with Sand, (CL)s: About 80% fines with high plasticity, medium toughness and dry strength, slow dilatancy; about 20% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

Laboratory Data Interval
18.9 to 19.4 ft.

Laboratory Data Interval
21.6 to 22.1 ft.

22.1 to 28.0 ft. Fat Clay, CH: About 90% fines with high plasticity, medium to high toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; no reaction with HCl.

Laboratory Data Interval
26.8 to 27.0 ft.

28.0 to 29.1 ft. Lean Clay with Sand, (CL)s: About 75% fines with medium plasticity, toughness and dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

29.1 to 29.7 ft.: No Recovery

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-29 and EDC-05-29A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-29A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-29 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:33:24 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-30

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/8/05 FINISHED: 6/10/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,845.1 E 6,214,826.1
TOTAL DEPTH: 30.8
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 218.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk and Greg Mongano
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 25 ft. Southward from the Southwest corner of Harlen St. and Yuba St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.5 to 4.3 ft.
Sample #3: 4.4 to 6.8 ft.
Sample #4A: 6.8 to 9.4 ft.
Sample #4B: 7.4 to 11.2 ft.
Sample #5: 11.9 to 13.7 ft.
Sample #6: 14.6 to 16.8 ft.
Sample #7: 17.3 to 19.8 ft.
Sample #8: 20.0 to 22.5 ft.
Sample #9: 22.7 to 25.2 ft.
Sample #10: 25.4 to 27.9 ft.
Sample #11: 28.1 to 31.8 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	96								NR					CH	
		38.1	53.2	8.7	0	49.5	30.1	25.6			CL	215.5			215.5
	95								110.29					CL/CH	
		46.8	46.5	8.7	0	38.4	18.9	28.6			CL				
5	96								117.80			212.4	Qb		212.4
														CH	211.2
														(CL/ML)s	210.9
		26.7	30.8	42.5	0	31.2	16.4	25.8			s(CL)	210.6		SM	210.6
	0	42.2	31.7	26.1	0	30.2	13.1	28.6	NR		(CL)s	209.2		s(ML)	209.2
									NR					SM	209.0
														CL/CH	208.1
10														s(ML)	207.9
	100	22.6	61.6	11.4	4.4	61.0	42.9	26.9			CH				

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS
(Qb)

0.0 to 2.5 ft. **Fat Clay, CH:** About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; trace of subangular gravel; maximum size, fine gravel; firm; dry; brown with brownish-orange and black mottling; weak to strong reaction with HCl; contains organic material.

Laboratory Data Interval
1.9 to 2.5 ft.

2.5 to 5.6 ft. **Lean to Fat Clay, CL/CH:** About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist; brown with gray-black mottling; strong reaction with HCl; trace of organic material.

Laboratory Data Interval
3.1 to 5.6 ft.

5.6 to 6.8 ft. **Fat Clay, CH:** About 90% fines with high plasticity, toughness and dry strength, no dilatancy; about 10% fine sand; trace of fine gravel; maximum size, fine gravel; soft; moist; brown; strong reaction with HCl;

6.8 to 7.1 ft. **Lean Clay to Silt with Sand, (CL/ML)s:** About 85% fines with medium plasticity, toughness and dry strength, slow dilatancy; about 15% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

7.1 to 7.4 ft. **Silty Sand, SM:** About 60% fine sand; maximum size, fine sand; about 40% non-plastic fines, rapid dilatancy; soft; wet; brown; no reaction with HCl.

Laboratory Data Interval
7.1 to 7.4 ft.

7.4 to 8.8 ft. **Sandy Silt, s(ML):** About 65% fines with medium plasticity, toughness and dry strength, rapid dilatancy; about 35% medium sand; maximum size, medium sand; soft; wet; brown; weak reaction with HCl.

Laboratory Data Interval
7.4 to 8.8 ft.

8.8 to 9.0 ft. **Silty Sand, SM:** About 60% medium sand; maximum size, medium sand; about 40% fines with no plasticity, rapid dilatancy; soft; wet; brown; no to weak reaction with HCl.

9.0 to 9.9 ft. **Lean to Fat Clay, CL/CH:** About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-30 and EDC-05-30A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-30A was completed and logged first to a depth of 16.8 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-30 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:36:37 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-30

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/8/05 FINISHED: 6/10/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,845.1 E 6,214,826.1
TOTAL DEPTH: 30.8
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 218.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk and Greg Mongano
REVIEWED BY: Greg Mongano

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 30.8 ft.: Slow and smooth through Clay to Sand. Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 5.0 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
5.6 to 6.8 ft.: 1.3 feet of material in augers.
6.8 to 9.3 ft.: 0.8 feet of material in augers.
9.3 to 11.8 ft.: 0.6 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/09/2005	5.0 ft

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100									2.385 E-03		206.2	Qb	CL	
	67								148.54						204.3
														SM	204.2
		39.4	44.6	16.0	0	38.3	21.9	29.9			(CL)s	203.7		s(CL/ML)	203.7
15	81								119.70					(CL/ML)s	203.0
														SM	202.5
														CL	201.9
		51.8	19.2	29.0	0	NP	NP	26.5			(ML)s	201.5		(ML)s	
	100								122.97	1.508 E-02					
20		60.6	17.3	22.1	0	NP	NP	29.3			(ML)s	198.0			
	100								126.88						

9.9 to 10.1 ft. Sandy Silt, s(ML): About 65% fines with low plasticity, toughness and dry strength, slow dilatancy; about 35% fine sand; maximum size, fine sand; soft; moist to wet; brown; weak reaction with HCl.

10.1 to 13.7 ft. Lean Clay, CL: About 90% fines with medium to high plasticity, high toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
10.1 to 11.8 ft.

13.7 to 13.8 ft. Silty Sand, SM: About 60% fine sand; maximum size, fine sand; about 40% fines with low plasticity, toughness and dry strength, rapid dilatancy; soft; moist; brown; no reaction with HCl.

13.8 to 14.3 ft. Sandy Lean Clay to Silt, s(CL/ML): About 65% fines with low to medium plasticity, toughness and dry strength, slow dilatancy; about 35% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

Laboratory Data Interval
13.8 to 14.3 ft.

14.3 to 15.0 ft. Lean Clay to Silt with Sand, (CL/ML)s: About 75% fines with medium plasticity, toughness and dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

15.0 to 15.5 ft. Silty Sand, SM: About 55% fine sand, about 45% fines with no to low plasticity, toughness and dry strength, rapid dilatancy; maximum size, fine sand; soft; wet; brown; no reaction with HCl.

15.5 to 16.1 ft. Lean Clay, CL: About 90% fines with medium plasticity, toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; no reaction with HCl.

16.1 to 22.5 ft. Silt with Sand, (ML)s: About 75% fines with low plasticity, toughness and dry strength, slow dilatancy; about 25% fine sand; maximum size, fine sand; firm; moist; brown; no to strong reaction with HCl.

Laboratory Data Interval
16.1 to 16.5 ft.

Laboratory Data Interval
19.8 to 20.0 ft.

22.5 to 28.1 ft. Silty Sand, SM: About 75% medium sand; maximum size, medium sand; about 25% fines with no to low plasticity, toughness and dry strength, rapid dilatancy; soft; wet; brown; strong reaction with HCl. Sand percentage increases with depth.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-30 and EDC-05-30A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-30A was completed and logged first to a depth of 16.8 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-30 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:36:37 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-30

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/8/05 FINISHED: 6/10/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,845.1 E 6,214,826.1
TOTAL DEPTH: 30.8
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 218.0
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk and Greg Mongano
REVIEWED BY: Greg Mongano

NOTES	DEPTH	% CORE RECOVERY	LABORATORY DATA % SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION / ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
														(ML)s 195.5	Laboratory Data Interval 22.5 to 22.7 ft.
			31.4	20.1	48.5	0	NP	NP	26.2			s(ML) 195.3			Laboratory Data Interval 25.2 to 25.4 ft.
		100								129.97					Laboratory Data Interval 27.9 to 28.1 ft.
	25														28.1 to 30.8 ft.: No Recovery
			22.4	14.8	62.8	0	NP	NP	24.3			SM 192.6		SM	
		100								129.84			Qb		
			6.0	8.2	85.8	0	NP	NP	24.2			SM 189.9		189.9	
		0								NR				NR	
	30													187.2	

BOTTOM OF HOLE

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-30 and EDC-05-30A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-30A was completed and logged first to a depth of 16.8 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-30 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-31

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/28/05 FINISHED: 6/22/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,725.0 E 6,221,358.5
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 213.9
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 70 ft. Southward of the Southwest corner of Harlen St. and Butte St.

DRILL RIG:
Central Mining (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 4.9 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 10.8 to 13.0 ft.
Sample #6: 13.5 to 15.9 ft.
Sample #7: 16.2 to 18.6 ft.
Sample #8: 18.9 to 21.4 ft.
Sample #9: 21.6 to 24.3 ft.
Sample #10: 24.3 to 26.5 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100								115.51					CH	
		39.1	56.5	4.4	0	49.5	33.3	23.6			CL	211.2			
	89								120.10						209.2
5		37.4	59.6	3.0	0	46.5	29.2	26.8			CL	208.8		CL	
	93								120.45						206.7
	100								126.99				Qb	CH	
10		22.2	65.0	12.8	0	56.0	37.3	22.7			CH	203.1			202.4
	89								127.70	7.571 E-03				(CL/ML)s	201.7
														SM	200.9
		48.1	23.7	28.2	0	30.4	12.0	23.2			(CL)s	200.8			
	93								131.17	4.660 E-03				(CL/ML)s	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 4.7 ft. **Fat Clay, CH:** About 90% fines with high plasticity, medium to high toughness and no dilatancy; about 10% fine sand; maximum size, fine sand; hard; dry; brown; no to strong reaction with HCl; some organic material; desiccation cracks throughout.

Laboratory Data Interval
2.5 to 2.7 ft.

4.7 to 7.2 ft. **Lean Clay, CL:** About 90% fines with medium to high plasticity, medium toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
4.9 to 5.1 ft.

7.2 to 11.5 ft. **Fat Clay, CH:** About 90% fines with high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; hard; dry; brown; weak to strong reaction with HCl, rotation of the sample in core barrel attributed to the change in soil types.

Laboratory Data Interval
10.6 to 10.8 ft.

11.5 to 12.2 ft. **Lean Clay to Silt with Sand, (CL/ML)s:** About 80% fines with high plasticity, dry strength, medium toughness and no dilatancy; about 25% fine sand; maximum size, fine sand; firm; moist; brown; strong reaction with HCl.

12.2 to 13.0 ft. **Silty Sand, SM:** About 80% fine sand; about 20% non-plastic fines, no toughness, low dry strength and rapid dilatancy; soft; moist; brown-gray; weak reaction with HCl, mottled with gypsum crystals.

13.0 to 15.6 ft. **Lean Clay to Silt with Sand, (CL/ML)s:** About 80% fines with high plasticity, medium toughness and dry strength, no to slow dilatancy; about 20% fine sand; maximum size, fine sand; soft to firm; moist; brown; no reaction with HCl, mottled with gypsum crystals

Laboratory Data Interval
13.0 to 13.1 ft.

15.6 to 18.0 ft. **Silty Sand, SM:** About 85% fine sand; about 15% non-plastic fines, low dry strength and rapid dilatancy; soft; wet; brown-gray; weak reaction with HCl.

Laboratory Data Interval
15.9 to 16.1 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-31 and EDC-05-31A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-31A was completed and logged first to a depth of 19.7 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-31 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:39:10 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-31

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/28/05 FINISHED: 6/22/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,725.0 E 6,221,358.5
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 213.9
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay to Sand.
21.6 to 24.3 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 6.6 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
4.7 to 7.2 ft.: 0.7 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/22/2005	6.6 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
															198.3
		43.5	18.5	38.0	0	NP	NP	24.8			s(ML)	197.8			
	89								118.58	2.059 E-03				SM	195.9
														CL/CH	193.6
20	100								126.19						
		33.5	40.5	26.0	0	33.0	17.9	21.9			(CL)s	192.3			
	0								NR				Qb	(ML)s	189.9
														CL	189.1
25														SM	188.9
	93								124.10					s(CL)	186.5
		46.0	38.0	16.0	0	28.8	13.4	26.6			(CL)s	187.2			
	100								131.79					SM	184.2
		31.0	9.4	59.6	0	NP	NP	23.1			SM	184.2			

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

18.0 to 20.3 ft. Lean to Fat Clay, CL/CH: About 90% fines with medium to high plasticity, high toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

20.3 to 24.0 ft. Silt with Sand, (ML)s: About 85% fines with medium plasticity, toughness and dry strength, no dilatancy; about 15% fine sand; maximum size, fine sand; soft; wet; brown; weak reaction with HCl.

21.4 to 21.6 ft.: Laboratory Data Interval

24.0 to 24.8 ft. Lean Clay, CL: About 90% fines with medium to high plasticity, medium toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

24.8 to 25.0 ft. Silty Sand, SM: About 60% fine sand; about 40% non-plastic fines and rapid dilatancy; maximum size, fine sand; soft; wet; brown-gray; weak reaction with HCl.

25.0 to 27.4 ft. Sandy Lean Clay, s(CL): About 65% fines with high plasticity, toughness and dry strength, rapid dilatancy; about 35% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

Laboratory Data Interval
26.5 to 26.7 ft.

27.4 to 29.7 ft. Silty Sand, SM: About 85% fine sand; maximum size, fine sand; about 15% non-plastic fines and rapid dilatancy; soft; wet; brown-gray; no reaction with HCl;

Laboratory Data Interval
29.5 to 29.7 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-31 and EDC-05-31A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-31A was completed and logged first to a depth of 19.7 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-31 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:39:10 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-32

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/28/05 FINISHED: 2/28/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,745.8 E 6,226,766.0
TOTAL DEPTH: 29.6
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 210.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 97 ft. East of the Southwest corner of Harlen St. and Lake St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 1.8 ft.
Sample #2: 2.6 to 5.1 ft.
Sample #3: 5.3 to 7.7 ft.
Sample #4: 8.0 to 10.3 ft.
Sample #5: 10.7 to 12.9 ft.
Sample #6: 13.4 to 15.9 ft.
Sample #7: 16.1 to 18.9 ft.
Sample #8: 18.8 to 21.3 ft.
Sample #9: 21.5 to 23.6 ft.
Sample #10: 24.2 to 26.7 ft.
Sample #11: 26.9 to 29.4 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	70								109.14				Qb	CH	
		38.2	56.9	4.9	0	46.2	30.6	23.2			CL	208.3			
	100	36.5	46.7	16.8	0	40.4	25.1	29.2	121.17		(CL)s	206.3			206.9
5														(CL/ML)s	
	96	20.5	78.2	1.3	0	64.5	40.4	37.6	122.50		CH	203.6			204.4
														(CL/ML)	203.4
		52.8	39.6	7.6	0	38.6	23.6	27.9			CL	202.4			
	93	38.7	53.0	8.3	0	43.7	27.2	28.7	125.63	3.351 E-05	CL	201.1		(ML)s	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 3.6 ft. **Fat Clay, CH:** About 90% fines with high plasticity and dry strength and medium to high toughness, no dilatancy; about 10% fine sand; maximum size, fine sand; soft; dry; brown; weak reaction with HCl; 0.0 to 3.0 ft. contains some organic material, desiccation cracks.

Laboratory Data Interval
1.8 to 2.2 ft.

3.6 to 6.1 ft. **Lean Clay to Silt with Sand, (CL/ML)s:** About 75% fines with high plasticity, low toughness and medium to high dry strength, rapid dilatancy; about 25% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
3.8 to 4.2 ft.

6.1 to 7.1 ft. **Lean Clay to Silt, CL/ML:** About 90% fines with high plasticity and dry strength, medium toughness and no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; strong reaction with HCl.

Laboratory Data Interval
6.5 to 6.9 ft.

7.1 to 10.9 ft. **Silt with Sand, (ML)s:** About 85% fines with medium to high plasticity, medium toughness and low to medium dry strength, slow to rapid dilatancy; about 15% fine sand; maximum size, fine sand; soft to firm; moist to wet; brown; weak to strong reaction with HCl; soils are saturated at 7.1 feet of depth.

Laboratory Data Interval
7.7 to 8.1 ft.

Laboratory Data Interval
9.0 to 9.4 ft.

Laboratory Data Interval
10.3 to 10.5 ft.

10.9 to 12.9 ft. **Silty Sand, SM:** About 55% fine sand; maximum size, fine sand; about 45% fines with low plasticity, toughness and dry strength, rapid dilatancy; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
11.4 to 11.9 ft.

12.9 to 13.7 ft. **Lean Clay to Silt, CL/ML:** About 90% fines with high plasticity and dry strength, low to medium toughness, no dilatancy; about 10% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
13.0 to 13.6 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-32 and EDC-05-32A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-32A was completed and logged first to a depth of 19.7 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-32 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:43:35 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-32

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/28/05 FINISHED: 2/28/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,745.8 E 6,226,766.0
TOTAL DEPTH: 29.6
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 210.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.6 ft.: Slow and smooth through Clay to Sand.
1.8 to 2.6 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 7.1 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
0.0 to 2.6 ft.: 0.6 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
7/13/2005	7.1 ft.

LABORATORY DATA

% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT
42.8	48.1	9.1	0	41.7	23.4	35.2
53.5	36.0	10.5	0	34.6	17.4	28.6
30.8	62.5	6.7	0	46.9	28.4	30.1
50.6	47.1	2.3	0	44.1	24.4	33.6
71.6	24.4	4.0	0	34.1	12.0	36.6
60.2	34.7	5.1	0	35.9	16.9	31.7
53.8	43.8	2.4	0	38.7	18.7	38.8
35.3	27.7	37.0	0	27.7	10.1	29.0
65.5	32.2	2.3	0	35.2	15.9	33.2
66.6	17.3	16.1	0	NP	NP	29.9

DEPTH: 15

% CORE RECOVERY: 96; 100; 100

FIELD TUBE DENSITY* lb/ft.³: 120.40; 121.42; 124.24

UNCONFINED PERMEABILITY (k)** cm/sec: 6.116 E-04

LABORATORY CLASSIFICATION	ELEVATION
CL	200.0
CL	198.6
CL	196.9
CL	195.4
CL	194.4
CL	193.7
CL	193.4
s(CL)	192.7
CL	192.3
(ML)s	190.9

GEOLOGIC UNIT SYMBOL: Qb

VISUAL CLASSIFICATION	ELEVATION
	199.6
SM	197.6
(CL/ML)	196.8
(ML)s	193.7
CL	192.9
SM	192.7
s(ML)	192.3
SM	190.9

CLASSIFICATION AND PHYSICAL CONDITION

13.7 to 16.8 ft. Silt with Sand, (ML)s: About 85% fines with medium to high plasticity, low to medium toughness and dry strength, no to rapid dilatancy; about 15% fine sand; maximum size, 3mm; very soft to soft; wet; brown; weak to strong reaction with HCl; mottled with gypsum crystals with a max size of 3mm.

Laboratory Data Interval
14.6 to 15.1 ft.

Laboratory Data Interval
15.9 to 16.1 ft.

Laboratory Data Interval
16.4 to 16.8 ft.

16.8 to 17.6 ft. Lean Clay, CL: About 90% fines with high plasticity, medium toughness and low dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; soft; moist; brown; no reaction with HCl.

Laboratory Data Interval
16.8 to 17.1 ft.

17.6 to 17.8 ft. Silty Sand, SM: About 65% fine sand; maximum size, fine sand; about 35% fines with, low plasticity, toughness and dry strength, rapid dilatancy; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
17.6 to 17.8 ft.

17.8 to 18.2 ft. Sandy Silt, s(ML): About 65% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 35% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl, mottled with gypsum crystals.

Laboratory Data Interval
17.8 to 18.2 ft.

18.2 to 19.6 ft. Silty Sand, SM: About 55% fine sand; maximum size, fine sand; about 45% fines with, no plasticity, and low dry strength, rapid dilatancy; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
18.2 to 19.6 ft.

19.6 to 21.5 ft. Sandy Silt, s(ML): About 65% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 35% fine sand; maximum size, fine sand; soft; moist; brown; strong reaction with HCl, mottled with gypsum crystals.

Laboratory Data Interval
21.3 to 21.5 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-32 and EDC-05-32A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-32A was completed and logged first to a depth of 19.7 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-32 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:43:35 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-32

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/28/05 FINISHED: 2/28/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,745.8 E 6,226,766.0
TOTAL DEPTH: 29.6
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 210.5
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES	DEPTH	% CORE RECOVERY	LABORATORY DATA: % SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION / ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
		100								127.74				s(ML)	**21.5 to 29.6 ft. Sandy Silt to Silty Sand, s(ML)/SM:** About 50 to 65% fines with no to low plasticity, toughness and dry strength, rapid dilatancy; about 35 to 50% fine sand; maximum size, fine sand; very soft to soft; moist; brown; strong reaction with HCl; interbedded Sandy Silt and Silty Sand layers, minor Silty Sand layers had up to 85% sand sized material.
			52.6	24.2	23.2	0	NP	NP	28.4			(ML)s 189.0		189.0	Laboratory Data Interval 26.7 to 26.9 ft.
		78								119.53					Laboratory Data Interval 29.4 to 29.6 ft.
														s(ML) - SM	
	25	100								131.47			Qb		
														183.9	
			30.9	14.9	54.2	0	NP	NP	23.2			SM 183.6			
		100								132.88					
			46.7	29.7	23.6	0	28.1	9.6	19.5			(CL)s 180.9			

BOTTOM OF HOLE

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-32 and EDC-05-32A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-32A was completed and logged first to a depth of 19.7 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-32 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:43:35 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-33

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/25/05 FINISHED: 6/27/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,821.6 E 6,232,002.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 209.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Five Points Area, 115 ft. North of the Southwest corner of Harlen St. and Trinity St.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.5 ft.
Sample #2: 2.7 to 5.2 ft.
Sample #3: 5.4 to 7.8 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 10. to 13.2 ft.
Sample #6: 13.5 to 16.0 ft.
Sample #7: 16.2 to 17.5 ft.
Sample #8: 18.9 to 21.4 ft.
Sample #9: 21.6 to 23.8 ft.
Sample #10: 24.3 to 26.8 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; D. Steinke, Helper; S. Thomas, Helper.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
	100	28.5	65.7	5.8	0	55.6	35.5	22.2	122.85		CH	207.7	Qb	CH	
		23.3	46.6	30.1	0	25.9	12.4	16.4			s(CL)	206.8			206.8
														SM	206.7
		31.1	63.3	5.6	0	50.4	33.4	25.6			CH	206.5			
	100	39.9	42.3	17.8	0	38.3	21.9	32.8			(CL)s	205.5			
5									114.98					CH	
	96	26.4	69.9	3.7	0	58.5	36.5	34.0			CH	202.6			
									116.94					CL/ML	
		67.3	20.8	11.9	0	27.8	4.9	29.8			ML	201.1			201.1
	100	50.4	32.9	16.7	0	28.5	5.2	33.7			(ML)s	200.8			
		68.4	23.1	8.5	0	32.4	11.9	33.1			CL	200.2		SM	200.2
		48.5	43.8	7.7	0	43.0	22.5	40.2	120.05		CL	199.7		(CL)s	199.7
		43.9	45.5	10.6	0	41.9	23.5	37.9			CL			s(ML)	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 2.4 ft. Fat Clay, CH: About 95% fines with high plasticity, toughness and dry strength, no dilatancy; about 5% fine sand; maximum size, fine sand; hard; dry; brown; strong reaction with HCl; contains organic material; mottled with gypsum crystals.

Laboratory Data Interval
1.0 to 1.5 ft.

Laboratory Data Interval
2.3 to 2.4 ft.

2.4 to 2.5 ft. Silty Sand, SM: About 75% fine sand; maximum size, fine sand; about 25% non-plastic fines with rapid dilatancy; soft; dry; brown-gray; strong reaction with HCl.

Laboratory Data Interval
2.5 to 2.7 ft.

2.5 to 6.1 ft. Fat Clay, CH: About 95% fines with high plasticity and dry strength, medium to high toughness and no dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist; brown; strong reaction with HCl; mottled with gypsum crystals.

Laboratory Data Interval
2.7 to 3.7 ft.

6.1 to 8.1 ft. Lean Clay to Silt, CL/ML: About 95% fines with high plasticity and dry strength, medium toughness and no dilatancy; about 5% fine sand; maximum size, fine sand; firm; moist; brown; strong reaction with HCl.

Laboratory Data Interval
6.1 to 6.6 ft.

Laboratory Data Interval
7.9 to 8.1 ft.

8.1 to 9.0 ft. Silty Sand, SM: About 55% fine sand; maximum size, fine sand; about 45% fines with no to low plasticity, toughness and low dry strength, rapid dilatancy; very soft; wet; brown; weak to strong reaction with HCl.

Laboratory Data Interval
8.1 to 8.4 ft.

Laboratory Data Interval
8.4 to 9.0 ft.

9.0 to 9.5 ft. Lean Clay with Sand, (CL)s: About 85% fines with high plasticity, medium to high toughness and medium dry strength, no dilatancy; about 15% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

Laboratory Data Interval
9.0 to 9.5 ft.

9.5 to 10.2 ft. Sandy Silt, s(ML): About 65% fines with low plasticity, toughness and medium dry strength,

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-33 and EDC-05-33A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-33A was completed and logged first to a depth of 19.5 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-33 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:45:31 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-33

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/25/05 FINISHED: 6/27/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,821.6 E 6,232,002.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 209.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.6 ft.: Slow and smooth through Clay to Sand.
17.5 to 18.9 ft.: Catcher was inserted to retrieve material lost during initial run. Water was added to hole for each run below the depth of 8.1 ft. before pulling out sample to enhance recovery.

CAVING CONDITIONS:
16.2 to 18.9 ft.: 0.5 feet of material in augers.

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/27/2005	8.1 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
												199.1			199.0
		42.4	15.0	42.6	0	NP	NP	25.0		2.033 E04	s(ML)	198.4		SM	198.1
	96	28.3	67.7	4.0	0	59.6	38.1	31.2	125.69	2.501 E-04	CH	197.5		CL/ML	196.2
		64.4	29.3	6.3	0	40.5	21.1	35.9			CL	196.0		(ML)s	195.7
		66.1	28.4	5.5	0	69.7	52.0	32.0		5.665 E-04	CH	195.7		NR	
15	93	35.7	61.9	2.4	0	48.7	27.8	37.0	121.76	4.502 E-05	CL	193.4	Qb	CH	191.2
	52	41.5	33.1	25.4	0	36.6	23.5	27.0	141.45		(CL)s	191.6			
		27.8	29.7	42.5	0	30.0	16.8	21.3			s(CL)	190.8		s(ML)	190.8
		38.4	17.5	44.1	0	NP	NP	23.1			s(ML)	190.1			

CLASSIFICATION AND PHYSICAL CONDITION

rapid dilatancy; about 35% fine sand; maximum size, fine sand; very soft; wet; brown; no reaction with HCl.

Laboratory Data Interval
9.7 to 10.1 ft.

10.2 to 11.1 ft. Silty Sand, SM: About 70% fine sand; maximum size, fine sand; about 30% non-plastic fines with low dry strength and rapid dilatancy; soft; wet; dark brown; strong reaction with HCl.

Laboratory Data Interval
10.3 to 10.8 ft.

11.1 to 13.0 ft. Lean Clay to Silt, CL/ML: About 90% fines with high plasticity and dry strength, medium to high toughness and no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
11.3 to 11.7 ft.

13.0 to 13.5 ft. Silt with Sand, (ML)s: About 80% fines with medium to high plasticity, medium toughness and dry strength, rapid dilatancy; about 20% fine sand; maximum size, fine sand; very soft to soft; wet; brown; weak to strong reaction with HCl.

Laboratory Data Interval
13.1 to 13.2 ft.

Laboratory Data Interval
13.3 to 13.5 ft.

13.5 to 14.5 ft.: **No Recovery**

14.5 to 18.0 ft. Fat Clay, CH: About 90% fines with high plasticity, toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl; mottled with gypsum crystals.

Laboratory Data Interval
15.0 to 15.8 ft.

Laboratory Data Interval
17.5 to 17.6 ft.

18.0 to 18.4 ft. Sandy Silt, s(ML): About 55% fines with low plasticity, toughness and medium dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; very soft; moist; brown; strong reaction with HCl.

Laboratory Data Interval
18.0 to 18.4 ft.

18.4 to 21.6 ft. Lean Clay to Silt with Sand, (CL/ML)s: About 80% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 20% fine sand; maximum size, fine sand; very soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
18.7 to 19.1 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-33 and EDC-05-33A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-33A was completed and logged first to a depth of 19.5 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-33 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:45:32 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-33

FEATURE: Proposed Evaporation Pond B
LOCATION: Westlands Water District - Five Points Area (See Notes)
BEGUN: 6/25/05 FINISHED: 6/27/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 2,046,821.6 E 6,232,002.7
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 209.2
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES	DEPTH	% CORE RECOVERY	LABORATORY DATA: % SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION / ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION / ELEVATION	CLASSIFICATION AND PHYSICAL CONDITION
		100								126.34				*CL/ML)s	Laboratory Data Interval 21.4 to 21.6 ft. **21.6 to 27.0 ft. Lean Clay to Silt, CL/ML:** About 90% fines with high plasticity, medium to high toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm to hard; moist; brown; strong reaction with HCl.
			35.5	55.2	9.3	0	43.7	28.4	26.2			CL 187.6		187.6	Laboratory Data Interval 23.8 to 24.0 ft.
		89								127.86					Laboratory Data Interval 26.8 to 27.0 ft. **27.0 to 29.7 ft. Silty Sand, SM:** About 85% fine sand; maximum size, fine sand; about 15% non-plastic fines with low dry strength, rapid dilatancy; very soft; moist; brown-gray; strong reaction with HCl. Laboratory Data Interval 29.5 to 29.7 ft.
			33.0	65.0	2.0	0	60.0	41.9	34.5			CH 185.2			
	25	100								126.53			Qb	CL/ML	
			19.7	79.0	1.3	0	60.6	41.8	32.8			CH 182.2		182.2	
		100								128.16				SM	
			12.1	7.2	80.7	0	NP	NP	22.0			SM 179.5		179.5	

BOTTOM OF HOLE

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NP = Non-plastic
NR = No Recovery

* = Determined from undisturbed samples
** = Unconfined Permeability (k) data was collected *in situ* using Geoprobe Pneumatic Slug Test System.

Geologic log is a compilation of two drill holes, EDC-05-33 and EDC-05-33A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-33A was completed and logged first to a depth of 19.5 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-33 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

SANLUISDRAIN_DH SANLUISDRAINAGE.GPJ SANLUISDRAINAGE.GDT 1/31/06 10:45:32 AM

GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-34

FEATURE: Proposed Evaporation Pond A
LOCATION: Westlands Water District - Huron Area (See Notes)
BEGUN: 7/12/05 FINISHED: 7/12/05
DEPTH AND ELEVATION OF WATER LEVEL
AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 1,937,235.9 E 6,299,745.5
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 200.3
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

ALL MEASUREMENTS ARE IN FEET FROM GROUND SURFACE.

PURPOSE OF HOLE:
Collect geologic data to determine soil properties, permeabilities, stratigraphy, and undisturbed samples for feasibility of several proposed evaporation and reuse area sites.

LOCATION:
Proposed Evaporation Pond B, Westlands water district, Southeast of Huron, Between 24th Street and 25th Street 0.5 miles north of Nevada Street.

DRILL RIG:
Central Mining Equipment (CME) 75

DRILLING & SAMPLING METHODS:
Drilled two holes with approximately 5 feet of separation (undisturbed sample hole and companion hole).
Drilling was completed using 10-inch o.d. by 6-5/8 inch i.d. hollow stem flight augers with a 5-1/4 inch i.d. cutting shoe and NWJ rods.
Undisturbed samples were collected with 5-3/4 inch o.d. by 5-1/2 inch i.d. by 2-1/2 foot long split barrel dry core system (FADC). Undisturbed samples were recovered in a Lexan (acrylic plastic) tube 5-1/2 inch o.d. by 5.325 inch i.d. by 2.5 feet length, that fits inside the split barrel dry core system. Recovery percentages are representative of the undisturbed sample hole only.

UNDISTURBED SAMPLE INTERVALS:
Sample #1: 0.0 to 2.7 ft.
Sample #2: 2.7 to 4.9 ft.
Sample #3: 5.4 to 7.9 ft.
Sample #4: 8.1 to 10.6 ft.
Sample #5: 10.8 to 13.1 ft.
Sample #6: 13.5 to 16.0 ft.
Sample #7: 16.2 to 18.5 ft.
Sample #8: 18.9 to 21.3 ft.
Sample #9: 21.6 to 23.2 ft.
Sample #10: 24.3 to 26.7 ft.
Sample #11: 27.0 to 29.5 ft.

DRILLED BY:
PN-Regional Drill Crew; J. Hansen Driller; T.C. Cole, Helper; S. Thomas, Helper.

DRILLING CONDITIONS AND DRILLER'S COMMENTS:
0.0 to 29.7 ft.: Slow and smooth through Clay to Sand.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
		27.6	67.0	5.4	0	50.7	33.5	14.7			CH	199.3			
	33								NR						
		28.2	68.7	3.1	0	68.1	52.7	22.5			CH	198.1			
		29.8	67.6	2.6	0	57.5	42.0	24.7			CH	196.8		CL/ML	
	100								122.96						
5		50.1	46.5	3.4	0	45.2	28.6	28.5			CH	194.9			
		43.0	51.1	5.9	0	48.5	31.3	33.1			CH	194.3			194.1
	100	41.8	21.4	36.8	0	23.1	6.4	18.9	119.97		s(CL/CH)	193.2		s(ML)	192.8
										NA*			Qb		
		356	40.5	23.9	0	45.2	31.5	23.4			(CL)s	191.9		(ML)s	
	100								136.19						190.4
10		43.0	30.0	27.0	0	33.0	19.6	19.6			(CL)s	189.8		CL/ML	189.6
		33.6	13.3	53.1	0	NP	NP	20.5			SM	189.5			
		39.3	16.4	44.3	0	NP	NP	21.9			s(ML)	188.8			
	93	58.6	28.1	13.3	0	25.8	8.4	20.9	125.81		CL	188.2		(ML)s	
		64.3	22.3	13.4	0	32.9	11.7	28.4			CL	187.2			
		67.8	25.4	6.8	0	34.1	14.1	29.7			CL	187.0			186.9
		68.0	20.8	11.2	0	36.3	12.9	30.4			CL	186.1		s(ML)	186.1
		46.0	42.8	11.2	0	40.5	21.4	32.5			CL	185.7			
	100								129.18						

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 29.7 ft.
QUATERNARY BASIN DEPOSITS (Qb)

0.0 to 6.2 ft. Lean Clay to Silt, CL/ML: About 90% fines with medium to high plasticity, toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, 3mm; firm; dry; brown; weak reaction with HCl; contains organic material; desiccation cracks; mottled with gypsum crystals.

Laboratory Data Interval
0.5 to 1.0 ft.

Laboratory Data Interval
1.9 to 2.2 ft.

Laboratory Data Interval
3.0 to 3.5 ft.

Laboratory Data Interval
5.0 to 5.4 ft.

Laboratory Data Interval
5.7 to 6.0 ft.

6.2 to 7.5 ft. Sandy Silt, s(ML): About 55% non-plastic fines with medium dry strength and rapid dilatancy; about 45% fine sand; maximum size, fine sand; soft; dry; gray with reddish and light brown mottling; weak reaction with HCl.

Laboratory Data Interval
6.8 to 7.1 ft.

7.5 to 9.9 ft. Silt with Sand, (ML)s: About 75% fines with high plasticity and dry strength, medium toughness and no dilatancy; about 25% fine sand; maximum size, fine sand; soft; dry; brown; weak reaction with HCl.

Laboratory Data Interval
8.0 to 8.4 ft.

9.9 to 10.7 ft. Lean Clay to Silt, CL/ML: About 90% fines with medium to high plasticity, medium toughness and high dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; dry; brown with brown-orange molting; weak reaction with HCl.

Laboratory Data Interval
10.0 to 10.5 ft.

10.7 to 13.4 ft. Silt with Sand, (ML)s: About 75% fines with medium plasticity, toughness and low to medium dry strength, no to slow dilatancy; about 25% fine sand; maximum size, fine sand; soft to firm; dry; brown; weak reaction with HCl; mottled with gypsum crystals.

Laboratory Data Interval
10.6 to 10.8 ft.

Laboratory Data Interval
11.0 to 11.5 ft.

Laboratory Data Interval
11.9 to 12.1 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NA = Not Applicable
NP = Non-plastic
NR = No Recovery

* Pneumatic slug tests were not performed. The water table was not enountered above the depth of 20.0 ft.

Geologic log is a compilation of two drill holes, EDC-05-34 and EDC-05-34A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-34A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-34 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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GEOLOGIC LOG OF DRILL HOLE NO. EDC-05-34

FEATURE: Proposed Evaporation Pond A
LOCATION: Westlands Water District - Huron Area (See Notes)
BEGUN: 7/12/05 FINISHED: 7/12/05
DEPTH AND ELEVATION OF WATER LEVEL AND DATE MEASURED: See Notes

PROJECT: San Luis Drain Project
COORDINATES: N 1,937,235.9 E 6,299,745.5
TOTAL DEPTH: 29.7
DEPTH TO BEDROCK: Not Encountered

STATE: California
GROUND ELEVATION: 200.3
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: Jared Vauk
REVIEWED BY: Greg Mongano

NOTES

0.0 to 2.7 ft. and 23.2 to 24.3 ft.: Catcher was inserted to retrieve material lost during initial run. No water was added to hole.

CAVING CONDITIONS:
none

ESTIMATED DRILLING FLUID RETURN:
None used; advanced hole with flight augers, water was added to the inside of flight augers (when drilling below static ground water level) prior to sample retrieval.

HOLE COMPLETION:
Hole backfilled with bentonite pellets.

DEPTH TO WATER:

Date	Depth to Water
6/30/2005	14.2 ft.

DEPTH	% CORE RECOVERY	% SILT	% CLAY	% SAND	% GRAVEL	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT	FIELD TUBE DENSITY* lb/ft.³	UNCONFINED PERMEABILITY (k)** cm/sec	LABORATORY CLASSIFICATION	ELEVATION	GEOLOGIC UNIT SYMBOL	VISUAL CLASSIFICATION	ELEVATION
		32.4	54.0	13.6	0	53.1	34.1	34.5			CH	184.1		CL/ML	
		56.6	35.8	7.6	0	55.8	33.4	27.9			CH	183.4			
	93								132.49						
		26.4	72.6	0.9	0	61.9	42.3	37.5			CH	182.3			
															182.0
		66.5	20.8	12.7	0	NP	NP	29.6			ML	181.1		(ML)s	
															180.7
20	96								125.08						
		63.3	31.7	5.0	0	36.7	14.2	32.2			s(CL)	178.8			
									116.64	NA*			Qb	CL	
	67														
		22.5	77.3	0.2	0	69.7	46.9	40.2			CH	176.9			
		33.8	65.7	0.5	0	56.2	32.7	36.8			CH	176.3			
25	89								129.50						174.8
														SM	
															172.6
	100								128.53					CL	
		26.8	58.9	14.3	0	47.1	30.0	28.2			CL	170.6			170.6

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

Laboratory Data Interval
12.7 to 13.1 ft.

Laboratory Data Interval
13.1 to 13.3 ft.

13.4 to 14.2 ft. Sandy Silt, s(ML): About 55% fines with low plasticity, toughness and dry strength, rapid dilatancy; about 45% fine sand; maximum size, fine sand; soft; moist; brown; weak reaction with HCl.

Laboratory Data Interval
13.6 to 14.2 ft.

14.2 to 18.3 ft. Lean Clay to Silt, CL/ML: About 90% fines with high plasticity, medium toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; weak reaction with HCl; 15.6 to 16.3 ft. contained up to 40 % gypsum.

Laboratory Data Interval
14.2 to 14.6 ft.

Laboratory Data Interval
15.7 to 16.2 ft.

Laboratory Data Interval
16.5 to 16.9 ft.

Laboratory Data Interval
17.4 to 18.0 ft.

18.3 to 19.6 ft. Silt with Sand, (ML)s: About 80% non-plastic fines with low dry strength, rapid dilatancy; about 20% fine sand; maximum size, fine sand; soft; wet; brown; strong reaction with HCl.

Laboratory Data Interval
18.4 to 19.2 ft.

19.6 to 25.5 ft. Lean Clay, CL: About 90% fines with medium to high plasticity, low to medium toughness and medium dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; soft to firm; moist; brown; weak reaction with HCl.

Laboratory Data Interval
21.3 to 21.5 ft.

Laboratory Data Interval
23.2 to 23.4 ft.

Laboratory Data Interval
23.4 to 24.0 ft.:

25.5 to 27.7 ft. Silty Sand, SM: About 70% fine sand; maximum size, fine sand; about 30% non-plastic fines with rapid dilatancy; very soft; wet; brown-gray; weak reaction with HCl.

27.7 to 29.7 ft. Lean Clay, CL: About 90% fines with medium plasticity, toughness and dry strength, no dilatancy; about 10% fine sand; maximum size, fine sand; firm; moist; brown; no reaction with HCl.

Laboratory Data Interval
29.5 to 29.7 ft.

FADC = Flight Auger Dry Core
FAPB = Flight Auger Pilot Bit
NA = Not Applicable
NP = Non-plastic
NR = No Recovery

* Pneumatic slug tests were not performed. The water table was not enountered above the depth of 20.0 ft.

Geologic log is a compilation of two drill holes, EDC-05-34 and EDC-05-34A (undisturbed sample hole and companion hole respectively) located approximately 5.0 feet apart. Companion drill hole EDC-05-34A was completed and logged first to a depth of 19.6 ft. in order to perform hand tests and collect lab samples without being restricted by the lexan liners used with undisturbed sampling.

Undisturbed sample hole EDC-05-34 was completed and logged to a depth of 29.7 ft. Hand tests were performed to determine soil properties on soil material captured in the cutting shoe, the remainder of the recovered sample was encased within a acrylic liner and logged visually. A campanion hole was drilled next to the primary hole in order to perform hand test and describe soil properties to an approximate depth of twenty feet.

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Appendix C – Pneumatic Slug Tests

Pneumatic Slug Test

San Luis Drain Project
2005 Geologic Investigations

GRASSLANDS AREA
Proposed Evaporation Pond A

Table 1

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s)			Confined Ave. K (cm/s)	Confined K (cm/s)			Comments
					Test 1	Test 2	Test 3		Test 1	Test 2	Test 3	
ESS-05-01	SM	7.1-8.1	3.2	**3.094E-04**	1.303E-04	4.035E-04	3.945E-04	**3.432E-04**	1.446E-04	4.475E-04	4.376E-04	

Pneumatic Slug Test

San Luis Drain Project
2005 Geologic Investigations

NORTHERN WESTLANDS AREA
Proposed Evaporation Pond C

Table 2

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s)			Confined Ave. K (cm/s)	Confined K (cm/s)			Comments
					Test 1	Test 2	Test 3		Test 1	Test 2	Test 3	
ESS-05-04	s(ML)	10.0-11.0	8.5	**4.351E-04**	4.880E-04	3.479E-04	4.693E-04	**5.539E-04**	6.213E-04	4.430E-04	5.975E-04	
ESS-05-04	CL	17.0-18.0	8.5	**1.617E-04**	1.588E-04	1.646E-04	NA	**1.844E-04**	1.810E-04	1.877E-04	NA	
ESS-05-05	(CL)s	8.8-9.8	5.8	**1.314E-04**	1.513E-04	1.336E-04	1.093E-04	**1.656E-04**	1.906E-04	1.684E-04	1.377E-04	
ESS-05-06	(CL)s	13.6-14.6	10.1	**4.679E-04**	6.391E-04	2.967E-04	NA	**1.652E-04**	2.256E-04	1.048E-04	NA	
ESS-05-06	SM	17.5-18.5	10.1	**1.876E-04**	1.729E-04	2.022E-04	NA	**2.127E-04**	1.960E-04	2.293E-04	NA	

Pneumatic Slug Test

San Luis Drain Project
2005 Geologic Investigations

CENTRAL WESTLANDS AREA
Proposed Evaporation Pond B

Table 3

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-25	(CL)s	9.0-10.0	7.1	**6.299E-04**	6.550E-04	6.124E-04	6.223E-04	**7.887E-04**	8.202E-04	7.668E-04	7.792E-04	
ESS-05-25	s(CL)	12.0-13.0	7.1	**5.772E-03**	5.219E-03	5.710E-03	6.387E-03	**6.496E-03**	5.873E-03	6.426E-03	7.188E-03	
ESS-05-25	CL	18.0-19.0	7.1	**7.869E-03**	7.809E-03	7.929E-03	NA	**8.494E-03**	8.429E-03	8.558E-03	NA	0.1 sCL layer
ESS-05-26	CL	8.3-9.3	4.5	**3.266E-04**	3.266E-04	3.266E-04	NA	**1.005E-04**	9.388E-05	1.071E-04	NA	fully penetrating
ESS-05-26	CH	12.0-13.0	4.5	**NO DATA**	no water recovery in 3 hours			**NO DATA**				no water in 3 hrs
ESS-05-27	CH	11.0-12.0	7.3	**6.334E-05**	6.470E-05	6.198E-05	NA	**8.321E-05**	8.515E-05	8.127E-05	NA	
ESS-05-27	s(CL)	14.4-15.4	7.6	**3.537E-03**	3.695E-03	3.370E-03	3.545E-03	**4.352E-03**	4.547E-03	4.147E-03	4.362E-03	
ESS-05-27	s(ML)	17.0-18.0	7.6	**6.506E-04**	6.082E-04	6.718E-04	6.718E-04	**7.462E-04**	7.187E-04	7.939E-04	7.259E-04	
ESS-05-28	CL	10.0-11.0	4.2	**5.149E-04**	3.106E-04	7.192E-04	NA	**6.385E-04**	3.851E-04	8.918E-04	NA	
ESS-05-28	s(CL)	13.5-14.5	4.2	**1.819E-04**	1.710E-04	1.927E-04	NA	**1.664E-04**	1.088E-04	2.240E-04	NA	
ESS-05-28	s(ML)	15.6-16.6	4.2	**1.156E-03**	1.186E-03	1.203E-03	1.079E-03	**1.289E-03**	1.323E-03	1.342E-03	1.203E-03	
ESS-05-29	(CL)s	5.1-6.1	3.6	**8.577E-04**	7.477E-04	9.222E-04	9.031E-04	**5.947E-04**	5.184E-04	6.394E-04	6.262E-04	fully penetrating
ESS-05-29	s(ML)	8.5-9.5	3.6	**3.298E-04**	3.182E-04	3.414E-04	NA	**3.459E-04**	3.337E-04	3.581E-04	NA	
ESS-05-29	CL	13.5-14.5	3.6	**2.380E-04**	3.235E-04	1.277E-04	2.627E-04	**2.801E-04**	3.808E-04	1.503E-04	3.091E-04	
ESS-05-30	CL	11.0-12.0	5.5	**2.385E-03**	2.367E-03	2.403E-03	NA	**2.877E-03**	2.855E-03	2.898E-03	NA	
ESS-05-30	(ML)s	18.0-19.0	5.6	**1.508E-02**	1.499E-02	1.539E-02	1.485E-02	**1.430E-02**	1.460E-02	1.422E-02	1.409E-02	
ESS-05-31	(CL)s	12.0-13.0	5.0	**7.571E-03**	7.452E-03	7.706E-03	7.556E-03	**9.092E-03**	8.897E-03	9.279E-03	9.099E-03	
ESS-05-31	(CL)s	14.0-15.0	5.0	**4.660E-03**	4.390E-03	5.136E-03	4.453E-03	**5.399E-03**	5.086E-03	5.951E-03	5.159E-03	
ESS-05-31	(CL)s	17.0-18.0	5.0	**2.059E-03**	2.341E-03	2.368E-03	1.468E-03	**2.203E-03**	2.504E-03	2.534E-03	1.571E-03	
ESS-05-32	(CL)s	8.0-9.0	4.7	**3.351E-05**	4.907E-05	2.685E-05	2.461E-05	**4.378E-05**	6.412E-05	3.508E-05	3.215E-05	
ESS-05-32	(ML)s	11.0-12.0	4.7	**6.116E-04**	1.662E-04	1.795E-04	1.489E-03	**1.991E-04**	2.007E-04	2.168E-04	1.798E-04	
ESS-05-33	s(ML)	10.0-11.0	8.9	**2.033E-04**	2.087E-04	1.978E-04	NA	**2.854E-04**	2.777E-04	2.930E-04	NA	0.7 s(ML) layer, near the top of water table
ESS-05-33	CL	11.0-12.0	9.1	**2.501E-04**	2.150E-04	3.295E-04	2.058E-04	**3.302E-04**	2.838E-04	4.350E-04	2.717E-04	
ESS-05-33	(ML)s	13.2-14.2	9.1	**5.665E-04**	5.417E-04	5.547E-04	6.030E-04	**6.249E-04**	5.976E-04	6.119E-04	6.652E-04	
ESS-05-33	CH	15.0-16.0	8.9	**4.502E-05**	4.802E-05	4.202E-05	NA	**5.538E-05**	5.907E-05	5.168E-05	NA	

Appendix D – Piezometer Tests

Piezometer Tests (Pump Out and Recovery Tests)

San Luis Drain Project
2005 Geologic Investigations
Northern and Central Westlands Areas
Evaporation Ponds C and B

Summary Sheet

HOLE	STEP	Soil Type	Depth (ft.)	Water level (ft.)	K (cm/s)	Comments
ESS-05-04A	0	s(ML)	10.0-10.5	7.8	3.58E-05	
ESS-05-25A	0	(CL)s/s(CL)	12.3-12.8	7.1	4.32E-04	
ESS-05-25B	1	(CL)s/s(CL)	12.3-12.8	7.1	2.11E-03	
ESS-05-26	0	CH	12.0-12.5	4.5	NA	no return of water after 24 hours
ESS-05-30-AA	1	CL/CH	7.3-7.8	5.7	3.41E-03	
ESS-05-33A	0	CL/ML	13.5-14.0	9.1	6.44E-05	
ESS-05-33B	1	CL/ML	13.5-14.0	9.1	1.10E-04	

Piezometer Tests (Pump Out and Recovery Tests) **San Luis Drain Project**
2005 Geologic Investigations

ESS-05-04A

Depth = 10.0 to 10.5 ft. **K = 0.05 in/hr**
Soil type= (CL)s **K = 3.58E-05 cm/sec**

Time, minutes	wt, ft from NGS	Y, ft	Y, inches	Delta t,sec	K, in/hr
0	10.02	-0.08	-0.96		
0.0083	10.02	-0.08	-0.96	0.498	
0.0166	10.02	-0.08	-0.96	0.498	
0.025	10.02	-0.08	-0.96	0.504	
0.0333	10.02	-0.08	-0.96	0.498	
0.0416	10.02	-0.08	-0.96	0.498	
0.05	10.02	-0.08	-0.96	0.504	
0.0583	10.02	-0.08	-0.96	0.498	
0.0666	10.02	-0.08	-0.96	0.996	
0.075	10.02	-0.08	-0.96	0.504	
0.0833	10.02	-0.08	-0.96	0.498	
0.0916	10.05	-0.05	-0.6	0.498	
0.1	10.129	0.029	0.348	0.504	
0.1083	10.179	0.079	0.948	0.498	
0.1166	10.224	0.124	1.488	0.498	
0.125	10.269	0.169	2.028	0.504	
0.1333	10.304	0.204	2.448	0.498	
0.1416	10.314	0.214	2.568	0.498	
0.15	10.323	0.223	2.676	0.504	
0.1583	10.607	0.507	6.084	0.498	
0.1666	10.612	0.512	6.144	0.498	
0.175	10.901	0.801	9.612	0.504	
0.1833	10.896	0.796	9.552	0.498	
0.1916	10.896	0.796	9.552	0.498	
0.2	10.896	0.796	9.552	0.504	
0.2083	10.891	0.791	9.492	0.498	
0.2166	10.896	0.796	9.552	0.498	
0.225	10.891	0.791	9.492	0.504	
0.2333	10.896	0.796	9.552	0.498	

Piezometer Test - Step 0
Uncased test zone - backfilled with coarse sand

Top of Test	10	ft from NGS
Bottom of Test	10.5	ft from NGS (6-inch test)
Test Diameter	2.375	inches test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	7.8	ft from NGS
Pipe Stickup to TOC =	2.2	ft from NGS
Reference	10.1	ft. (setting on Hermit)

Water Table starting at 7.8 ft from TOC (2.2 stickup)

Set reference as 8.0 ft as depth of transducer below NGS
Started Data Logger to track drawdown:

K =	0.05	in/hr	Field Texture	%Sd
K =	3.58E-05	cm/sec	(CL)s	10
				%Clay
				32

0.2416	10.891	0.791	9.492	0.498	
0.25	10.896	0.796	9.552	0.504	
0.2583	10.896	0.796	9.552	0.498	
0.2666	10.896	0.796	9.552	0.498	
0.275	10.891	0.791	9.492	0.504	
0.2833	10.891	0.791	9.492	0.498	
0.2916	10.891	0.791	9.492	0.498	
0.3	10.891	0.791	9.492	0.504	
0.3083	10.891	0.791	9.492	0.498	
0.3166	10.896	0.796	9.552	0.498	Max Drawdown
0.325	10.891	0.791	9.492	0.504	8.152
0.3333	10.891	0.791	9.492	0.498	0.000
0.35	10.891	0.791	9.492	1.002	0.000
0.3666	10.891	0.791	9.492	0.996	0.000
0.3833	10.891	0.791	9.492	1.002	0.000
0.4	10.891	0.791	9.492	1.002	0.000
0.4166	10.891	0.791	9.492	0.996	0.000
0.4333	10.891	0.791	9.492	1.002	0.000
0.45	10.891	0.791	9.492	1.002	0.000
0.4666	10.891	0.791	9.492	0.996	0.000
0.4833	10.891	0.791	9.492	1.002	0.000
0.5	10.886	0.786	9.432	1.002	4.126
0.5166	10.886	0.786	9.432	0.996	0.000
0.5333	10.886	0.786	9.432	1.002	0.000
0.55	10.886	0.786	9.432	1.002	0.000
0.5666	10.886	0.786	9.432	0.996	0.000
0.5833	10.886	0.786	9.432	1.002	0.000
0.6	10.881	0.781	9.372	1.002	4.153
0.6166	10.886	0.786	9.432	0.996	-4.178
0.6333	10.886	0.786	9.432	1.002	0.000
0.65	10.881	0.781	9.372	1.002	4.153
0.6666	10.881	0.781	9.372	0.996	0.000
0.6833	10.881	0.781	9.372	1.002	0.000
0.7	10.881	0.781	9.372	1.002	0.000
0.7166	10.881	0.781	9.372	0.996	0.000
0.7333	10.881	0.781	9.372	1.002	0.000
0.75	10.881	0.781	9.372	1.002	0.000

0.7666	10.881	0.781	9.372	0.996	0.000
0.7833	10.881	0.781	9.372	1.002	0.000
0.8	10.881	0.781	9.372	1.002	0.000
0.8166	10.881	0.781	9.372	0.996	0.000
0.8333	10.881	0.781	9.372	1.002	0.000
0.85	10.881	0.781	9.372	1.002	0.000
0.8666	10.881	0.781	9.372	0.996	0.000
0.8833	10.881	0.781	9.372	1.002	0.000
0.9	10.881	0.781	9.372	1.002	0.000
0.9166	10.881	0.781	9.372	0.996	0.000
0.9333	10.881	0.781	9.372	1.002	0.000
0.95	10.881	0.781	9.372	1.002	0.000
0.9666	10.881	0.781	9.372	0.996	0.000
0.9833	10.881	0.781	9.372	1.002	0.000
1	10.881	0.781	9.372	1.002	0.000
1.2	10.876	0.776	9.312	12	0.349
1.4	10.881	0.781	9.372	12	-0.349
1.6	10.881	0.781	9.372	12	0.000
1.8	10.881	0.781	9.372	12	0.000
2	10.881	0.781	9.372	12	0.000
2.2	10.881	0.781	9.372	12	0.000
2.4	10.881	0.781	9.372	12	0.000
2.6	10.881	0.781	9.372	12	0.000
2.8	10.881	0.781	9.372	12	0.000
3	10.886	0.786	9.432	12	-0.347
3.2	10.886	0.786	9.432	12	0.000
3.4	10.886	0.786	9.432	12	0.000
3.6	10.886	0.786	9.432	12	0.000
3.8	10.886	0.786	9.432	12	0.000
4	10.886	0.786	9.432	12	0.000
4.2	10.886	0.786	9.432	12	0.000
4.4	10.886	0.786	9.432	12	0.000
4.6	10.886	0.786	9.432	12	0.000
4.8	10.886	0.786	9.432	12	0.000
5	10.886	0.786	9.432	12	0.000
5.2	10.886	0.786	9.432	12	0.000
5.4	10.886	0.786	9.432	12	0.000

5.6	10.886	0.786	9.432	12	0.000
5.8	10.886	0.786	9.432	12	0.000
6	10.886	0.786	9.432	12	0.000
6.2	10.886	0.786	9.432	12	0.000
6.4	10.886	0.786	9.432	12	0.000
6.6	10.886	0.786	9.432	12	0.000
6.8	10.886	0.786	9.432	12	0.000
7	10.886	0.786	9.432	12	0.000
7.2	10.886	0.786	9.432	12	0.000
7.4	10.886	0.786	9.432	12	0.000
7.6	10.886	0.786	9.432	12	0.000
7.8	10.886	0.786	9.432	12	0.000
8	10.886	0.786	9.432	12	0.000
8.2	10.886	0.786	9.432	12	0.000
8.4	10.886	0.786	9.432	12	0.000
8.6	10.886	0.786	9.432	12	0.000
8.8	10.886	0.786	9.432	12	0.000
9	10.886	0.786	9.432	12	0.000
9.2	10.886	0.786	9.432	12	0.000
9.4	10.886	0.786	9.432	12	0.000
9.6	10.886	0.786	9.432	12	0.000
9.8	10.886	0.786	9.432	12	0.000
10	10.886	0.786	9.432	12	0.000
12	10.891	0.791	9.492	120	-0.034
14	10.891	0.791	9.492	120	0.000
16	10.891	0.791	9.492	120	0.000
18	10.891	0.791	9.492	120	0.000
20	10.891	0.791	9.492	120	0.000
22	10.891	0.791	9.492	120	0.000
24	10.896	0.796	9.552	120	-0.034
26	10.896	0.796	9.552	120	0.000
28	10.896	0.796	9.552	120	0.000
30	10.891	0.791	9.492	120	0.034
32	10.891	0.791	9.492	120	0.000
34	10.896	0.796	9.552	120	-0.034
36	10.896	0.796	9.552	120	0.000
38	10.896	0.796	9.552	120	0.000

40	10.896	0.796	9.552	120	0.000
42	10.896	0.796	9.552	120	0.000
44	10.891	0.791	9.492	120	0.034
46	10.891	0.791	9.492	120	0.000
48	10.891	0.791	9.492	120	0.000
50	10.896	0.796	9.552	120	-0.034
52	10.896	0.796	9.552	120	0.000
54	10.891	0.791	9.492	120	0.034
56	10.891	0.791	9.492	120	0.000
58	10.891	0.791	9.492	120	0.000
60	10.896	0.796	9.552	120	-0.034
62	10.896	0.796	9.552	120	0.000
64	10.891	0.791	9.492	120	0.034
66	10.891	0.791	9.492	120	0.000
68	10.896	0.796	9.552	120	-0.034
70	10.891	0.791	9.492	120	0.034
72	10.891	0.791	9.492	120	0.000
74	10.891	0.791	9.492	120	0.000
76	10.891	0.791	9.492	120	0.000
78	10.891	0.791	9.492	120	0.000
80	10.891	0.791	9.492	120	0.000
82	10.891	0.791	9.492	120	0.000
84	10.896	0.796	9.552	120	-0.034
86	10.891	0.791	9.492	120	0.034
88	10.891	0.791	9.492	120	0.000
90	10.891	0.791	9.492	120	0.000
92	10.891	0.791	9.492	120	0.000
94	10.891	0.791	9.492	120	0.000
96	10.886	0.786	9.432	120	0.034
98	10.886	0.786	9.432	120	0.000
100	10.891	0.791	9.492	120	-0.034
110	10.886	0.786	9.432	600	0.007
120	10.881	0.781	9.372	600	0.007
130	10.881	0.781	9.372	600	0.000
140	10.876	0.776	9.312	600	0.007
150	10.866	0.766	9.192	600	0.014
160	10.866	0.766	9.192	600	0.000

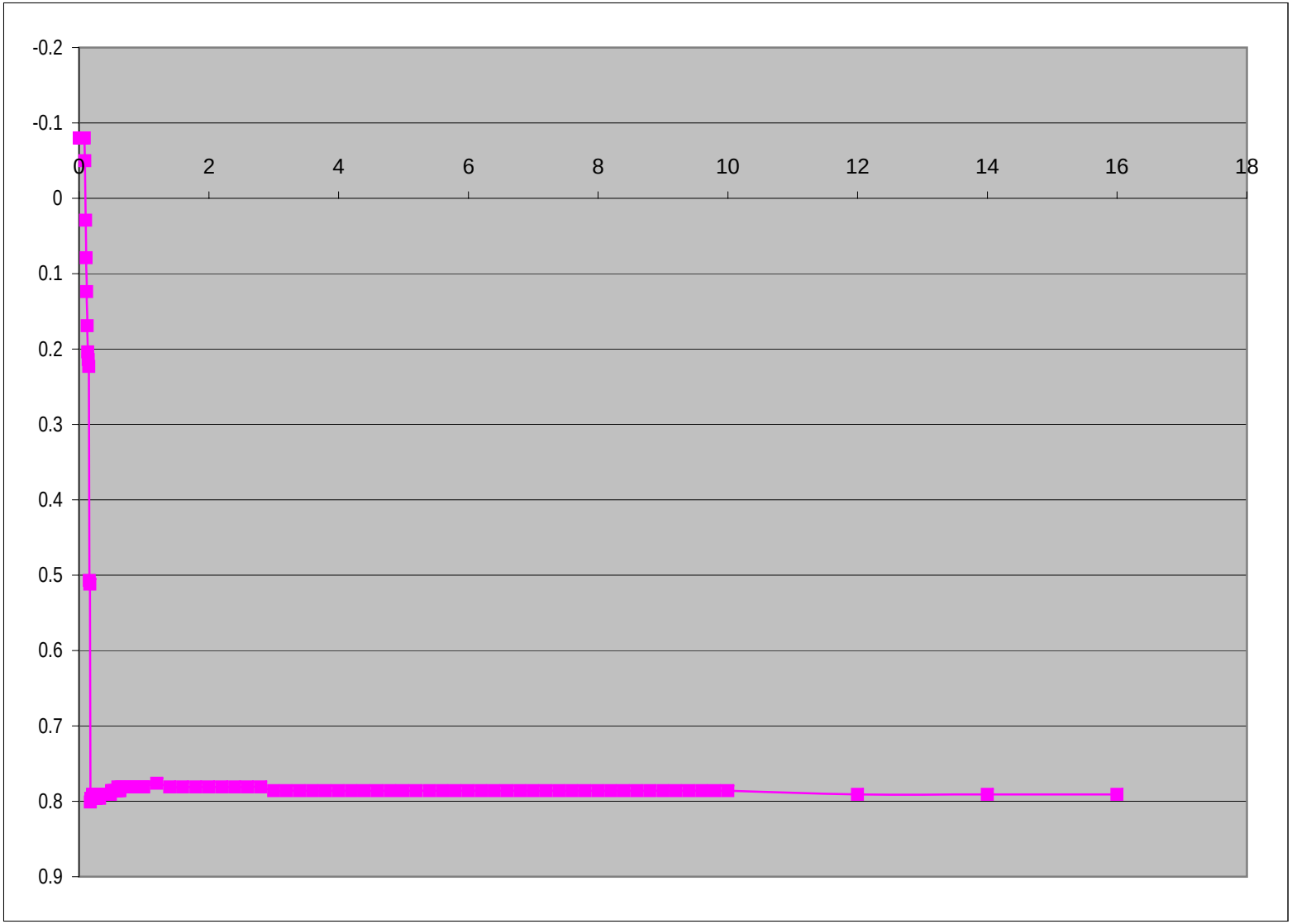
170	10.861	0.761	9.132	600	0.007
180	10.856	0.756	9.072	600	0.007
190	10.846	0.746	8.952	600	0.014
200	10.846	0.746	8.952	600	0.000
210	10.841	0.741	8.892	600	0.007
220	10.836	0.736	8.832	600	0.007
230	10.836	0.736	8.832	600	0.000
240	10.831	0.731	8.772	600	0.007
250	10.831	0.731	8.772	600	0.000
260	10.826	0.726	8.712	600	0.007
270	10.821	0.721	8.652	600	0.008
280	10.816	0.716	8.592	600	0.008
290	10.811	0.711	8.532	600	0.008
300	10.811	0.711	8.532	600	0.000
310	10.806	0.706	8.472	600	0.008
320	10.801	0.701	8.412	600	0.008
330	10.801	0.701	8.412	600	0.000
340	10.791	0.691	8.292	600	0.016
350	10.786	0.686	8.232	600	0.008
360	10.786	0.686	8.232	600	0.000
370	10.781	0.681	8.172	600	0.008
380	10.781	0.681	8.172	600	0.000
390	10.771	0.671	8.052	600	0.016
400	10.771	0.671	8.052	600	0.000
410	10.766	0.666	7.992	600	0.008
420	10.762	0.662	7.944	600	0.007
430	10.762	0.662	7.944	600	0.000
440	14.09	3.99	47.88	600	-1.952
450	14.09	3.99	47.88	600	0.000
460	14.09	3.99	47.88	600	0.000
470	14.09	3.99	47.88	600	0.000
480	14.09	3.99	47.88	600	0.000
490	14.09	3.99	47.88	600	0.000
500	14.09	3.99	47.88	600	0.000
510	14.09	3.99	47.88	600	0.000
520	14.09	3.99	47.88	600	0.000
530	14.09	3.99	47.88	600	0.000

540	14.09	3.99	47.88	600	0.000
550	14.09	3.99	47.88	600	0.000
560	14.09	3.99	47.88	600	0.000
570	14.09	3.99	47.88	600	0.000
580	14.09	3.99	47.88	600	0.000
590	14.09	3.99	47.88	600	0.000
600	14.09	3.99	47.88	600	0.000
610	14.09	3.99	47.88	600	0.000
620	14.09	3.99	47.88	600	0.000
630	14.09	3.99	47.88	600	0.000
640	14.09	3.99	47.88	600	0.000
650	14.09	3.99	47.88	600	0.000
660	14.09	3.99	47.88	600	0.000
670	14.09	3.99	47.88	600	0.000
680	14.09	3.99	47.88	600	0.000
690	14.09	3.99	47.88	600	0.000
700	14.09	3.99	47.88	600	0.000
710	14.09	3.99	47.88	600	0.000
720	14.09	3.99	47.88	600	0.000
730	14.09	3.99	47.88	600	0.000
740	14.09	3.99	47.88	600	0.000
750	14.09	3.99	47.88	600	0.000
760	14.09	3.99	47.88	600	0.000
770	14.09	3.99	47.88	600	0.000
780	14.09	3.99	47.88	600	0.000
790	14.09	3.99	47.88	600	0.000
800	14.09	3.99	47.88	600	0.000
810	14.09	3.99	47.88	600	0.000
820	14.09	3.99	47.88	600	0.000
830	14.09	3.99	47.88	600	0.000
840	14.09	3.99	47.88	600	0.000
850	14.09	3.99	47.88	600	0.000
860	14.09	3.99	47.88	600	0.000
870	14.09	3.99	47.88	600	0.000
880	14.09	3.99	47.88	600	0.000
890	14.09	3.99	47.88	600	0.000
900	14.09	3.99	47.88	600	0.000

910	14.09	3.99	47.88	600	0.000
920	14.09	3.99	47.88	600	0.000
930	14.09	3.99	47.88	600	0.000
940	14.09	3.99	47.88	600	0.000
950	14.09	3.99	47.88	600	0.000
960	14.09	3.99	47.88	600	0.000
970	14.09	3.99	47.88	600	0.000
980	14.09	3.99	47.88	600	0.000
990	14.09	3.99	47.88	600	0.000
1000	14.09	3.99	47.88	600	0.000
1010	14.09	3.99	47.88	600	0.000
1020	14.09	3.99	47.88	600	0.000
1030	14.09	3.99	47.88	600	0.000
1040	14.09	3.99	47.88	600	0.000
1050	14.09	3.99	47.88	600	0.000
1060	14.09	3.99	47.88	600	0.000
1070	14.09	3.99	47.88	600	0.000
1080	14.09	3.99	47.88	600	0.000
1090	14.09	3.99	47.88	600	0.000
1100	14.09	3.99	47.88	600	0.000
1110	14.09	3.99	47.88	600	0.000
1120	14.09	3.99	47.88	600	0.000
1130	14.09	3.99	47.88	600	0.000
1140	14.09	3.99	47.88	600	0.000
1150	14.09	3.99	47.88	600	0.000
1160	14.09	3.99	47.88	600	0.000
1170	14.09	3.99	47.88	600	0.000
1180	14.09	3.99	47.88	600	0.000
1190	14.09	3.99	47.88	600	0.000
1200	14.09	3.99	47.88	600	0.000
1210	14.09	3.99	47.88	600	0.000
1220	14.09	3.99	47.88	600	0.000
1230	14.09	3.99	47.88	600	0.000
1240	14.09	3.99	47.88	600	0.000
1250	14.09	3.99	47.88	600	0.000
1260	14.09	3.99	47.88	600	0.000
1270	14.09	3.99	47.88	600	0.000

1280	14.09	3.99	47.88	600	0.000
1290	14.09	3.99	47.88	600	0.000
1300	14.09	3.99	47.88	600	0.000
1310	14.09	3.99	47.88	600	0.000
1320	14.09	3.99	47.88	600	0.000
1330	14.09	3.99	47.88	600	0.000
1340	14.09	3.99	47.88	600	0.000
1350	14.09	3.99	47.88	600	0.000
1360	14.09	3.99	47.88	600	0.000
1370	14.09	3.99	47.88	600	0.000
1380	14.09	3.99	47.88	600	0.000
1390	14.09	3.99	47.88	600	0.000
1400	14.09	3.99	47.88	600	0.000
1410	14.09	3.99	47.88	600	0.000
1420	14.09	3.99	47.88	600	0.000
1430	14.09	3.99	47.88	600	0.000
1440	14.09	3.99	47.88	600	0.000
1450	14.09	3.99	47.88	600	0.000
1460	14.09	3.99	47.88	600	0.000
1470	14.09	3.99	47.88	600	0.000
1480	14.09	3.99	47.88	600	0.000
1490	14.09	3.99	47.88	600	0.000
1500	14.09	3.99	47.88	600	0.000
1510	14.09	3.99	47.88	600	0.000
1520	14.09	3.99	47.88	600	0.000
1530	14.09	3.99	47.88	600	0.000
1540	11.817	1.717	20.604	600	0.916
1550	11.836	1.736	20.832	600	-0.012
1560	11.846	1.746	20.952	600	-0.006
1570	11.856	1.756	21.072	600	-0.006
1580	11.856	1.756	21.072	600	0.000
1590	11.861	1.761	21.132	600	-0.003
1600	11.866	1.766	21.192	600	-0.003
1610	11.871	1.771	21.252	600	-0.003
1620	11.871	1.771	21.252	600	0.000
1630	11.871	1.771	21.252	600	0.000
1640	11.881	1.781	21.372	600	-0.006

1650	11.891	1.791	21.492	600	-0.006
1660	11.906	1.806	21.672	600	-0.009
1670	11.906	1.806	21.672	600	0.000
1680	11.926	1.826	21.912	600	-0.012
1690	11.926	1.826	21.912	600	0.000
1700	11.931	1.831	21.972	600	-0.003
1710	11.931	1.831	21.972	600	0.000
1720	11.941	1.841	22.092	600	-0.006
1730	11.936	1.836	22.032	600	0.003
1740	11.921	1.821	21.852	600	0.009
1750	11.881	1.781	21.372	600	0.024
1760	11.886	1.786	21.432	600	-0.003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0
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12
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16
18

Piezometer Tests (Pump Out and Recovery Tests) **San Luis Drain Project**
2005 Geologic Investigations

Depth = 12.3 to 12.8 ft. **K = 0.61 in/hr**
ESS-05-25A **Soil type= (CL)s/ s(CL)** **K = 4.32E-04 cm/sec**

Time, minutes	wt, ft from NGS	Y, ft	Y, inches	Delta t,sec	K, in/hr
0.0000	8.094	0.094	1.128		
0.0083	8.094	0.094	1.128	0.498	
0.0166	8.1	0.1	1.2	0.498	
0.0250	8.094	0.094	1.128	0.504	
0.0333	8.094	0.094	1.128	0.498	
0.0416	8.094	0.094	1.128	0.498	
0.0500	8.094	0.094	1.128	0.504	
0.0583	8.1	0.1	1.2	0.498	
0.0666	8.094	0.094	1.128	0.996	
0.0750	8.094	0.094	1.128	0.504	
0.0833	8.094	0.094	1.128	0.498	
0.0916	8.094	0.094	1.128	0.498	
0.1000	8.094	0.094	1.128	0.504	
0.1083	8.094	0.094	1.128	0.498	
0.1166	8.1	0.1	1.2	0.498	max draw
0.1250	8.1	0.1	1.2	0.504	0.000
0.1333	8.1	0.1	1.2	0.498	0.000
0.1416	8.1	0.1	1.2	0.498	0.000
0.1500	8.1	0.1	1.2	0.504	0.000
0.1583	8.1	0.1	1.2	0.498	0.000
0.1666	8.1	0.1	1.2	0.498	0.000
0.1750	8.1	0.1	1.2	0.504	0.000
0.1833	8.1	0.1	1.2	0.498	0.000
0.1916	8.1	0.1	1.2	0.498	0.000
0.2000	8.1	0.1	1.2	0.504	0.000
0.2083	8.094	0.094	1.128	0.498	81.013
0.2166	8.1	0.1	1.2	0.498	-81.013
0.2250	8.094	0.094	1.128	0.504	80.048
0.2333	8.094	0.094	1.128	0.498	0.000

Piezometer Test - Step 0
Uncased test zone - backfilled with coarse sand

Top of Test	12.3	ft from NGS
Bottom of Test	12.8	ft from NGS (6-inch test)
Test Diameter	2.375	inches test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	7.1	ft from NGS
Pipe Stickup to TOC =	0.8	ft from NGS
Reference =	8	ft. (setting on Hermit)

Water Table starting at 5.0 ft from TOC (Piez Length 8.3 ft, 0.8 stickup)
Set reference as 8.0 ft as depth of transducer below NGS
Started Data Logger to track drawdown: Field Texture

K =	0.61	in/hr	(CL)s/ s(CL)
K =	4.32E-04	cm/sec	

0.2416	8.094	0.094	1.128	0.498	0.000
0.2500	8.094	0.094	1.128	0.504	0.000
0.2583	8.094	0.094	1.128	0.498	0.000
0.2666	8.094	0.094	1.128	0.498	0.000
0.2750	8.1	0.1	1.2	0.504	-80.048
0.2833	8.094	0.094	1.128	0.498	81.013
0.2916	8.1	0.1	1.2	0.498	-81.013
0.3000	8.1	0.1	1.2	0.504	0.000
0.3083	8.094	0.094	1.128	0.498	81.013
0.3166	8.094	0.094	1.128	0.498	0.000
0.3250	8.094	0.094	1.128	0.504	0.000
0.3333	8.094	0.094	1.128	0.498	0.000
0.3500	8.094	0.094	1.128	1.002	0.000
0.3666	8.094	0.094	1.128	0.996	0.000
0.3833	8.094	0.094	1.128	1.002	0.000
0.4000	8.094	0.094	1.128	1.002	0.000
0.4166	8.094	0.094	1.128	0.996	0.000
0.4333	8.094	0.094	1.128	1.002	0.000
0.4500	8.094	0.094	1.128	1.002	0.000
0.4666	8.094	0.094	1.128	0.996	0.000
0.4833	8.094	0.094	1.128	1.002	0.000
0.5000	8.094	0.094	1.128	1.002	0.000
0.5166	8.094	0.094	1.128	0.996	0.000
0.5333	8.094	0.094	1.128	1.002	0.000
0.5500	8.094	0.094	1.128	1.002	0.000
0.5666	8.094	0.094	1.128	0.996	0.000
0.5833	8.094	0.094	1.128	1.002	0.000
0.6000	8.094	0.094	1.128	1.002	0.000
0.6166	8.094	0.094	1.128	0.996	0.000
0.6333	8.094	0.094	1.128	1.002	0.000
0.6500	8.094	0.094	1.128	1.002	0.000
0.6666	8.094	0.094	1.128	0.996	0.000
0.6833	8.089	0.089	1.068	1.002	35.568
0.7000	8.094	0.094	1.128	1.002	-35.568
0.7166	8.094	0.094	1.128	0.996	0.000
0.7333	8.089	0.089	1.068	1.002	35.568
0.7500	8.089	0.089	1.068	1.002	0.000

0.7666	8.094	0.094	1.128	0.996	-35.782
0.7833	8.094	0.094	1.128	1.002	0.000
0.8000	8.094	0.094	1.128	1.002	0.000
0.8166	8.094	0.094	1.128	0.996	0.000
0.8333	8.089	0.089	1.068	1.002	35.568
0.8500	8.089	0.089	1.068	1.002	0.000
0.8666	8.089	0.089	1.068	0.996	0.000
0.8833	8.089	0.089	1.068	1.002	0.000
0.9000	8.089	0.089	1.068	1.002	0.000
0.9166	8.089	0.089	1.068	0.996	0.000
0.9333	8.089	0.089	1.068	1.002	0.000
0.9500	8.089	0.089	1.068	1.002	0.000
0.9666	8.089	0.089	1.068	0.996	0.000
0.9833	8.089	0.089	1.068	1.002	0.000
1.0000	8.089	0.089	1.068	1.002	0.000
1.2000	8.089	0.089	1.068	12	0.000
1.4000	8.084	0.084	1.008	12	3.142
1.6000	8.084	0.084	1.008	12	0.000
1.8000	8.084	0.084	1.008	12	0.000
2.0000	8.079	0.079	0.948	12	3.335
2.2000	8.079	0.079	0.948	12	0.000
2.4000	8.079	0.079	0.948	12	0.000
2.6000	8.079	0.079	0.948	12	0.000
2.8000	8.074	0.074	0.888	12	3.553
3.0000	8.074	0.074	0.888	12	0.000
3.2000	8.074	0.074	0.888	12	0.000
3.4000	8.074	0.074	0.888	12	0.000
3.6000	8.069	0.069	0.828	12	3.801
3.8000	8.069	0.069	0.828	12	0.000
4.0000	8.069	0.069	0.828	12	0.000
4.2000	8.064	0.064	0.768	12	4.087
4.4000	8.064	0.064	0.768	12	0.000
4.6000	8.064	0.064	0.768	12	0.000
4.8000	8.064	0.064	0.768	12	0.000
5.0000	8.064	0.064	0.768	12	0.000
5.2000	8.064	0.064	0.768	12	0.000
5.4000	8.059	0.059	0.708	12	4.420

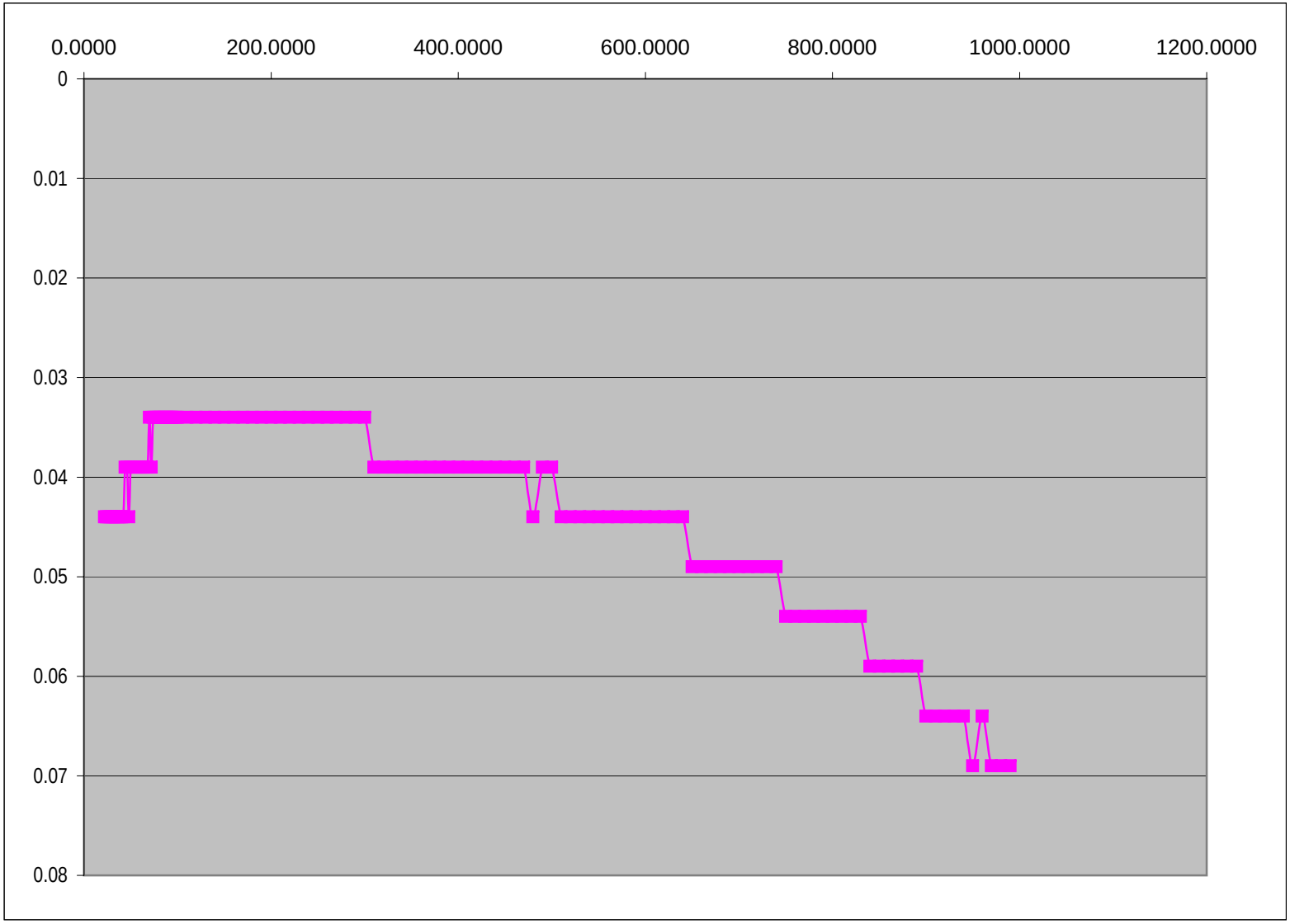
5.6000	8.059	0.059	0.708	12	0.000
5.8000	8.059	0.059	0.708	12	0.000
6.0000	8.059	0.059	0.708	12	0.000
6.2000	8.059	0.059	0.708	12	0.000
6.4000	8.054	0.054	0.648	12	4.812
6.6000	8.054	0.054	0.648	12	0.000
6.8000	8.054	0.054	0.648	12	0.000
7.0000	8.054	0.054	0.648	12	0.000
7.2000	8.054	0.054	0.648	12	0.000
7.4000	8.054	0.054	0.648	12	0.000
7.6000	8.054	0.054	0.648	12	0.000
7.8000	8.054	0.054	0.648	12	0.000
8.0000	8.054	0.054	0.648	12	0.000
8.2000	8.049	0.049	0.588	12	5.279
8.4000	8.049	0.049	0.588	12	0.000
8.6000	8.049	0.049	0.588	12	0.000
8.8000	8.049	0.049	0.588	12	0.000
9.0000	8.049	0.049	0.588	12	0.000
9.2000	8.049	0.049	0.588	12	0.000
9.4000	8.049	0.049	0.588	12	0.000
9.6000	8.044	0.044	0.528	12	5.848
9.8000	8.044	0.044	0.528	12	0.000
10.0000	8.049	0.049	0.588	12	-5.848
12.0000	8.049	0.049	0.588	120	0.000
14.0000	8.044	0.044	0.528	120	0.585
16.0000	8.044	0.044	0.528	120	0.000
18.0000	8.044	0.044	0.528	120	0.000
20.0000	8.044	0.044	0.528	120	0.000
22.0000	8.044	0.044	0.528	120	0.000
24.0000	8.044	0.044	0.528	120	0.000
26.0000	8.044	0.044	0.528	120	0.000
28.0000	8.044	0.044	0.528	120	0.000
30.0000	8.044	0.044	0.528	120	0.000
32.0000	8.044	0.044	0.528	120	0.000
34.0000	8.044	0.044	0.528	120	0.000
36.0000	8.044	0.044	0.528	120	0.000
38.0000	8.044	0.044	0.528	120	0.000

40.0000	8.044	0.044	0.528	120	0.000
42.0000	8.044	0.044	0.528	120	0.000
44.0000	8.039	0.039	0.468	120	0.655
46.0000	8.039	0.039	0.468	120	0.000
48.0000	8.044	0.044	0.528	120	-0.655
50.0000	8.039	0.039	0.468	120	0.655
52.0000	8.039	0.039	0.468	120	0.000
54.0000	8.039	0.039	0.468	120	0.000
56.0000	8.039	0.039	0.468	120	0.000
58.0000	8.039	0.039	0.468	120	0.000
60.0000	8.039	0.039	0.468	120	0.000
62.0000	8.039	0.039	0.468	120	0.000
64.0000	8.039	0.039	0.468	120	0.000
66.0000	8.039	0.039	0.468	120	0.000
68.0000	8.039	0.039	0.468	120	0.000
70.0000	8.034	0.034	0.408	120	0.745
72.0000	8.039	0.039	0.468	120	-0.745
74.0000	8.034	0.034	0.408	120	0.745
76.0000	8.034	0.034	0.408	120	0.000
78.0000	8.034	0.034	0.408	120	0.000
80.0000	8.034	0.034	0.408	120	0.000
82.0000	8.034	0.034	0.408	120	0.000
84.0000	8.034	0.034	0.408	120	0.000
86.0000	8.034	0.034	0.408	120	0.000
88.0000	8.034	0.034	0.408	120	0.000
90.0000	8.034	0.034	0.408	120	0.000
92.0000	8.034	0.034	0.408	120	0.000
94.0000	8.034	0.034	0.408	120	0.000
96.0000	8.034	0.034	0.408	120	0.000
98.0000	8.034	0.034	0.408	120	0.000
100.0000	8.034	0.034	0.408	120	0.000
110.0000	8.034	0.034	0.408	600	0.000
120.0000	8.034	0.034	0.408	600	0.000
130.0000	8.034	0.034	0.408	600	0.000
140.0000	8.034	0.034	0.408	600	0.000
150.0000	8.034	0.034	0.408	600	0.000
160.0000	8.034	0.034	0.408	600	0.000

170.0000	8.034	0.034	0.408	600	0.000
180.0000	8.034	0.034	0.408	600	0.000
190.0000	8.034	0.034	0.408	600	0.000
200.0000	8.034	0.034	0.408	600	0.000
210.0000	8.034	0.034	0.408	600	0.000
220.0000	8.034	0.034	0.408	600	0.000
230.0000	8.034	0.034	0.408	600	0.000
240.0000	8.034	0.034	0.408	600	0.000
250.0000	8.034	0.034	0.408	600	0.000
260.0000	8.034	0.034	0.408	600	0.000
270.0000	8.034	0.034	0.408	600	0.000
280.0000	8.034	0.034	0.408	600	0.000
290.0000	8.034	0.034	0.408	600	0.000
300.0000	8.034	0.034	0.408	600	0.000
310.0000	8.039	0.039	0.468	600	-0.149
320.0000	8.039	0.039	0.468	600	0.000
330.0000	8.039	0.039	0.468	600	0.000
340.0000	8.039	0.039	0.468	600	0.000
350.0000	8.039	0.039	0.468	600	0.000
360.0000	8.039	0.039	0.468	600	0.000
370.0000	8.039	0.039	0.468	600	0.000
380.0000	8.039	0.039	0.468	600	0.000
390.0000	8.039	0.039	0.468	600	0.000
400.0000	8.039	0.039	0.468	600	0.000
410.0000	8.039	0.039	0.468	600	0.000
420.0000	8.039	0.039	0.468	600	0.000
430.0000	8.039	0.039	0.468	600	0.000
440.0000	8.039	0.039	0.468	600	0.000
450.0000	8.039	0.039	0.468	600	0.000
460.0000	8.039	0.039	0.468	600	0.000
470.0000	8.039	0.039	0.468	600	0.000
480.0000	8.044	0.044	0.528	600	-0.131
490.0000	8.039	0.039	0.468	600	0.131
500.0000	8.039	0.039	0.468	600	0.000
510.0000	8.044	0.044	0.528	600	-0.131
520.0000	8.044	0.044	0.528	600	0.000
530.0000	8.044	0.044	0.528	600	0.000

540.0000	8.044	0.044	0.528	600	0.000
550.0000	8.044	0.044	0.528	600	0.000
560.0000	8.044	0.044	0.528	600	0.000
570.0000	8.044	0.044	0.528	600	0.000
580.0000	8.044	0.044	0.528	600	0.000
590.0000	8.044	0.044	0.528	600	0.000
600.0000	8.044	0.044	0.528	600	0.000
610.0000	8.044	0.044	0.528	600	0.000
620.0000	8.044	0.044	0.528	600	0.000
630.0000	8.044	0.044	0.528	600	0.000
640.0000	8.044	0.044	0.528	600	0.000
650.0000	8.049	0.049	0.588	600	-0.117
660.0000	8.049	0.049	0.588	600	0.000
670.0000	8.049	0.049	0.588	600	0.000
680.0000	8.049	0.049	0.588	600	0.000
690.0000	8.049	0.049	0.588	600	0.000
700.0000	8.049	0.049	0.588	600	0.000
710.0000	8.049	0.049	0.588	600	0.000
720.0000	8.049	0.049	0.588	600	0.000
730.0000	8.049	0.049	0.588	600	0.000
740.0000	8.049	0.049	0.588	600	0.000
750.0000	8.054	0.054	0.648	600	-0.106
760.0000	8.054	0.054	0.648	600	0.000
770.0000	8.054	0.054	0.648	600	0.000
780.0000	8.054	0.054	0.648	600	0.000
790.0000	8.054	0.054	0.648	600	0.000
800.0000	8.054	0.054	0.648	600	0.000
810.0000	8.054	0.054	0.648	600	0.000
820.0000	8.054	0.054	0.648	600	0.000
830.0000	8.054	0.054	0.648	600	0.000
840.0000	8.059	0.059	0.708	600	-0.096
850.0000	8.059	0.059	0.708	600	0.000
860.0000	8.059	0.059	0.708	600	0.000
870.0000	8.059	0.059	0.708	600	0.000
880.0000	8.059	0.059	0.708	600	0.000
890.0000	8.059	0.059	0.708	600	0.000
900.0000	8.064	0.064	0.768	600	-0.088

910.0000	8.064	0.064	0.768	600	0.000
920.0000	8.064	0.064	0.768	600	0.000
930.0000	8.064	0.064	0.768	600	0.000
940.0000	8.064	0.064	0.768	600	0.000
950.0000	8.069	0.069	0.828	600	-0.082
960.0000	8.064	0.064	0.768	600	0.082
970.0000	8.069	0.069	0.828	600	-0.082
980.0000	8.069	0.069	0.828	600	0.000
990.0000	8.069	0.069	0.828	600	0.000



Piezometer Tests
Pump Out and Recovery Tests

ESS-05-25A

San Luis Drain Project
2005 Geologic Investigations

Piezometer Tests (Pump Out and Recovery Tests) **San Luis Drain Project**
2005 Geologic Investigations

ESS-05-25B

Depth = 12.3 to 12.8 ft. **K = 2.99 in/hr**
Soil type= (CL)s/ s(CL) **K = 2.11E-03 cm/sec**

Time, minutes	wt, ft from NGS	Y, ft	Y, inches	Delta t,sec	K, in/hr
0	7.845	-0.255	-3.06		
0.0083	7.85	-0.25	-3	0.498	
0.0166	7.85	-0.25	-3	0.498	
0.025	7.855	-0.245	-2.94	0.504	
0.0333	7.855	-0.245	-2.94	0.498	
0.0416	7.835	-0.265	-3.18	0.498	
0.05	7.83	-0.27	-3.24	0.504	
0.0583	7.95	-0.15	-1.8	0.498	
0.0666	8.019	-0.081	-0.972	0.996	
0.075	7.995	-0.105	-1.26	0.504	
0.0833	8.124	0.024	0.288	0.498	
0.0916	8.119	0.019	0.228	0.498	
0.1	8.194	0.094	1.128	0.504	
0.1083	8.313	0.213	2.556	0.498	
0.1166	8.388	0.288	3.456	0.498	
0.125	8.493	0.393	4.716	0.504	
0.1333	8.617	0.517	6.204	0.498	
0.1416	8.717	0.617	7.404	0.498	
0.15	8.856	0.756	9.072	0.504	
0.1583	8.861	0.761	9.132	0.498	
0.1666	8.946	0.846	10.152	0.498	
0.175	9.05	0.95	11.4	0.504	
0.1833	9.13	1.03	12.36	0.498	
0.1916	9.195	1.095	13.14	0.498	
0.2	9.304	1.204	14.448	0.504	
0.2083	9.364	1.264	15.168	0.498	
0.2166	9.429	1.329	15.948	0.498	
0.225	9.489	1.389	16.668	0.504	
0.2333	9.608	1.508	18.096	0.498	

Piezometer Test -Step 1
Uncased test zone - backfilled with coarse sand

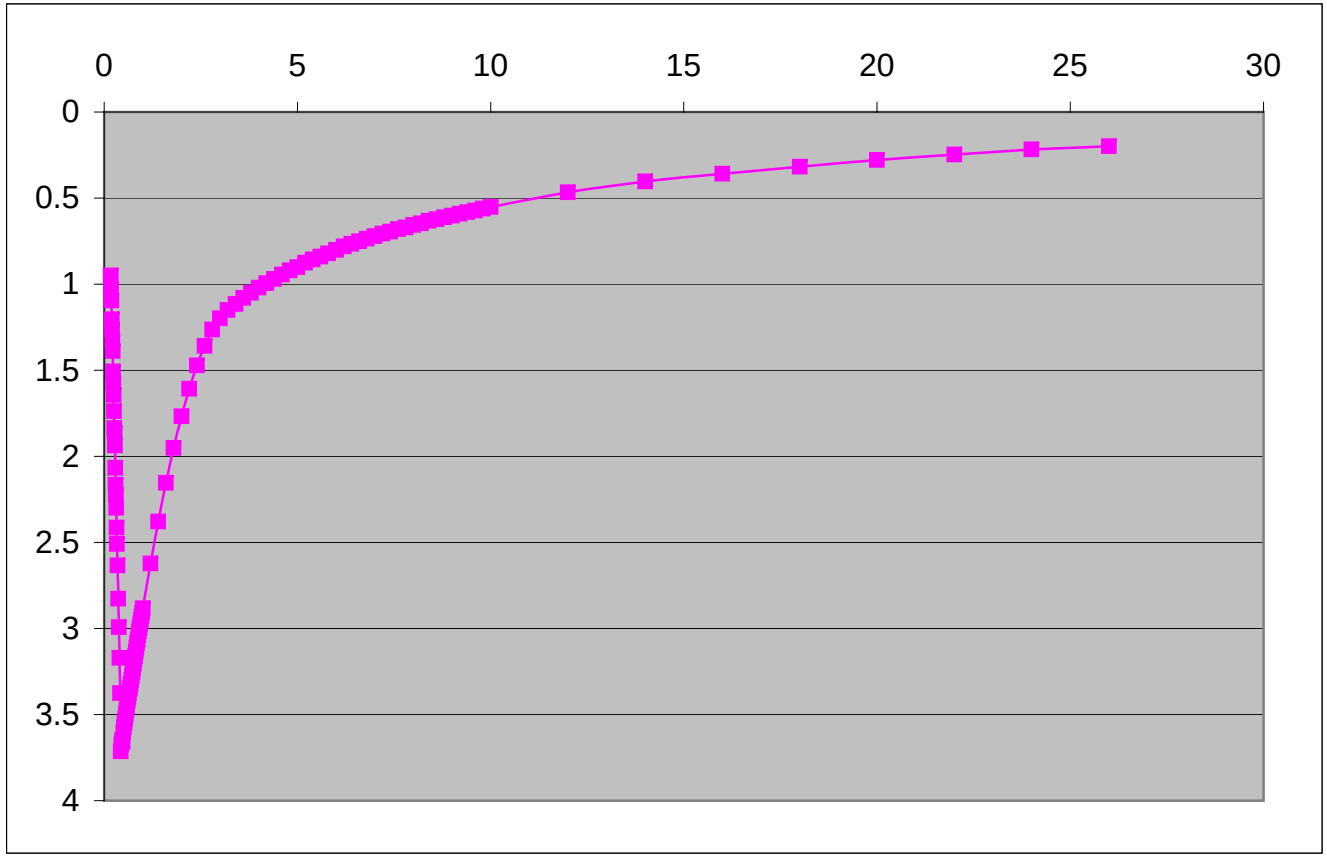
Top of Test	12.3	ft from NGS
Bottom of Test	12.8	ft from NGS (6-inch test)
Test Diameter	2.375	inches test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	7.1	ft from NGS
Pipe Stickup to TOC =	1.1	ft from NGS
Reference =	8.1	ft. (setting on Hermit)

Water Table starting at 8.1 ft from TOC (Piez Length 8.3 ft, 1.1 stickup)
Set reference as 8.0 ft as depth of transducer below TOC= 8.1
Started Data Logger to track drawdown: Field Texture
K = 2.99 in/hr **(Cl)s/ s(CL)**
K = 2.11E-03 cm/sec

0.2416	9.673	1.573	18.876	0.498	
0.25	9.743	1.643	19.716	0.504	
0.2583	9.837	1.737	20.844	0.498	
0.2666	9.937	1.837	22.044	0.498	
0.275	9.962	1.862	22.344	0.504	
0.2833	10.036	1.936	23.232	0.498	
0.2916	10.166	2.066	24.792	0.498	
0.3	10.265	2.165	25.98	0.504	
0.3083	10.325	2.225	26.7	0.498	
0.3166	10.4	2.3	27.6	0.498	
0.325	10.514	2.414	28.968	0.504	
0.3333	10.609	2.509	30.108	0.498	
0.35	10.733	2.633	31.596	1.002	
0.3666	10.927	2.827	33.924	0.996	
0.3833	11.092	2.992	35.904	1.002	
0.4	11.271	3.171	38.052	1.002	
0.4166	11.475	3.375	40.5	0.996	
0.4333	11.813	3.713	44.556	1.002	Max Drawdown
0.45	11.774	3.674	44.088	1.002	6.871
0.4666	11.749	3.649	43.788	0.996	4.470
0.4833	11.759	3.659	43.908	1.002	-1.781
0.5	11.704	3.604	43.248	1.002	9.856
0.5166	11.674	3.574	42.888	0.996	5.472
0.5333	11.649	3.549	42.588	1.002	4.568
0.55	11.624	3.524	42.288	1.002	4.600
0.5666	11.599	3.499	41.988	0.996	4.661
0.5833	11.574	3.474	41.688	1.002	4.666
0.6	11.55	3.45	41.4	1.002	4.511
0.6166	11.52	3.42	41.04	0.996	5.717
0.6333	11.5	3.4	40.8	1.002	3.817
0.65	11.475	3.375	40.5	1.002	4.802
0.6666	11.45	3.35	40.2	0.996	4.867
0.6833	11.425	3.325	39.9	1.002	4.874
0.7	11.4	3.3	39.6	1.002	4.911
0.7166	11.375	3.275	39.3	0.996	4.978
0.7333	11.355	3.255	39.06	1.002	3.986
0.75	11.331	3.231	38.772	1.002	4.816

0.7666	11.306	3.206	38.472	0.996	5.085
0.7833	11.281	3.181	38.172	1.002	5.094
0.8	11.261	3.161	37.932	1.002	4.104
0.8166	11.236	3.136	37.632	0.996	5.198
0.8333	11.211	3.111	37.332	1.002	5.208
0.85	11.186	3.086	37.032	1.002	5.250
0.8666	11.166	3.066	36.792	0.996	4.256
0.8833	11.141	3.041	36.492	1.002	5.328
0.9	11.117	3.017	36.204	1.002	5.156
0.9166	11.097	2.997	35.964	0.996	4.354
0.9333	11.072	2.972	35.664	1.002	5.451
0.95	11.052	2.952	35.424	1.002	4.394
0.9666	11.032	2.932	35.184	0.996	4.450
0.9833	11.007	2.907	34.884	1.002	5.572
1	10.982	2.882	34.584	1.002	5.620
1.2	10.723	2.623	31.476	12	5.117
1.4	10.479	2.379	28.548	12	5.305
1.6	10.255	2.155	25.86	12	5.373
1.8	10.051	1.951	23.412	12	5.404
2	9.867	1.767	21.204	12	5.382
2.2	9.708	1.608	19.296	12	5.123
2.4	9.573	1.473	17.676	12	4.765
2.6	9.459	1.359	16.308	12	4.377
2.8	9.364	1.264	15.168	12	3.938
3	9.299	1.199	14.388	12	2.869
3.2	9.25	1.15	13.8	12	2.267
3.4	9.215	1.115	13.38	12	1.679
3.6	9.18	1.08	12.96	12	1.733
3.8	9.15	1.05	12.6	12	1.531
4	9.12	1.02	12.24	12	1.575
4.2	9.095	0.995	11.94	12	1.348
4.4	9.07	0.97	11.64	12	1.383
4.6	9.045	0.945	11.34	12	1.419
4.8	9.021	0.921	11.052	12	1.398
5	9.001	0.901	10.812	12	1.193
5.2	8.976	0.876	10.512	12	1.529
5.4	8.956	0.856	10.272	12	1.255

5.6	8.941	0.841	10.092	12	0.961
5.8	8.921	0.821	9.852	12	1.308
6	8.901	0.801	9.612	12	1.340
6.2	8.881	0.781	9.372	12	1.374
6.4	8.866	0.766	9.192	12	1.054
6.6	8.851	0.751	9.012	12	1.075
6.8	8.836	0.736	8.832	12	1.096
7	8.821	0.721	8.652	12	1.119
7.2	8.806	0.706	8.472	12	1.142
7.4	8.796	0.696	8.352	12	0.775
7.6	8.781	0.681	8.172	12	1.184
7.8	8.771	0.671	8.052	12	0.804
8	8.757	0.657	7.884	12	1.146
8.2	8.747	0.647	7.764	12	0.833
8.4	8.732	0.632	7.584	12	1.275
8.6	8.722	0.622	7.464	12	0.867
8.8	8.712	0.612	7.344	12	0.881
9	8.702	0.602	7.224	12	0.895
9.2	8.692	0.592	7.104	12	0.910
9.4	8.682	0.582	6.984	12	0.926
9.6	8.672	0.572	6.864	12	0.942
9.8	8.662	0.562	6.744	12	0.958
10	8.652	0.552	6.624	12	0.976
12	8.567	0.467	5.604	120	0.909
14	8.503	0.403	4.836	120	0.801
16	8.458	0.358	4.296	120	0.643
18	8.418	0.318	3.816	120	0.644
20	8.378	0.278	3.336	120	0.730
22	8.348	0.248	2.976	120	0.620
24	8.318	0.218	2.616	120	0.701
26	8.298	0.198	2.376	120	0.523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Piezometer Tests (Pump Out and Recovery Tests)

San Luis Drain Project
2005 Geologic Investigations

ESS-05-26A **Depth = 12.0 to 12.5 ft.**
Soil type = CH

K = 0.0 in/hr
K = 0.0 cm/sec
K = NO RETURN OF WATER AFTER 24 HOURS

Time, minutes	wt, ft from	Y, ft	Y, inches	Delta t,sec	K, in/hr
0.0000	5.3430	-0.357	-4.284		
0.0083	5.3280	-0.372	-4.464	0.498	-53.888
0.0166	5.3090	-0.391	-4.692	0.498	-65.220
0.0250	5.2990	-0.401	-4.812	0.504	-32.671
0.0333	5.2890	-0.411	-4.932	0.498	-32.250
0.0416	5.2890	-0.411	-4.932	0.498	0.000
0.0500	5.2640	-0.436	-5.232	0.504	-76.392
0.0583	5.2940	-0.406	-4.872	0.498	93.338
0.0666	5.2840	-0.416	-4.992	0.996	-15.929
0.0750	5.2740	-0.426	-5.112	0.504	-30.731
0.0833	5.2740	-0.426	-5.112	0.498	0.000
0.0916	5.2690	-0.431	-5.172	0.498	-15.278
0.1000	5.2640	-0.436	-5.232	0.504	-14.922
0.1083	5.2640	-0.436	-5.232	0.498	0.000
0.1166	5.2590	-0.441	-5.292	0.498	-14.929
0.1250	5.2540	-0.446	-5.352	0.504	-14.585
0.1333	5.2540	-0.446	-5.352	0.498	0.000
0.1416	5.2490	-0.451	-5.412	0.498	-14.596
0.1500	5.2490	-0.451	-5.412	0.504	0.000
0.1583	5.2440	-0.456	-5.472	0.498	-14.436
0.1666	5.2440	-0.456	-5.472	0.498	0.000
0.1750	5.2390	-0.461	-5.532	0.504	-14.108
0.1833	5.2390	-0.461	-5.532	0.498	0.000
0.1916	5.2340	-0.466	-5.592	0.498	-14.124
0.2000	5.2340	-0.466	-5.592	0.504	0.000
0.2083	5.2340	-0.466	-5.592	0.498	0.000
0.2166	5.2300	-0.47	-5.64	0.498	-11.191
0.2250	5.2300	-0.47	-5.64	0.504	0.000
0.2333	5.2300	-0.47	-5.64	0.498	0.000

Piezometer Test - Step 0
Uncased test zone - backfilled with coarse sand

Top of Test	12	ft from NGS
Bottom of Test	12.5	ft from NGS (6-inch test)
Test Diameter	2.375	in. test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	4.5	ft from NGS
Pipe Stickup to TOC =	1.3	ft from NGS
Reference =	5.7	ft. (setting on Hermit)

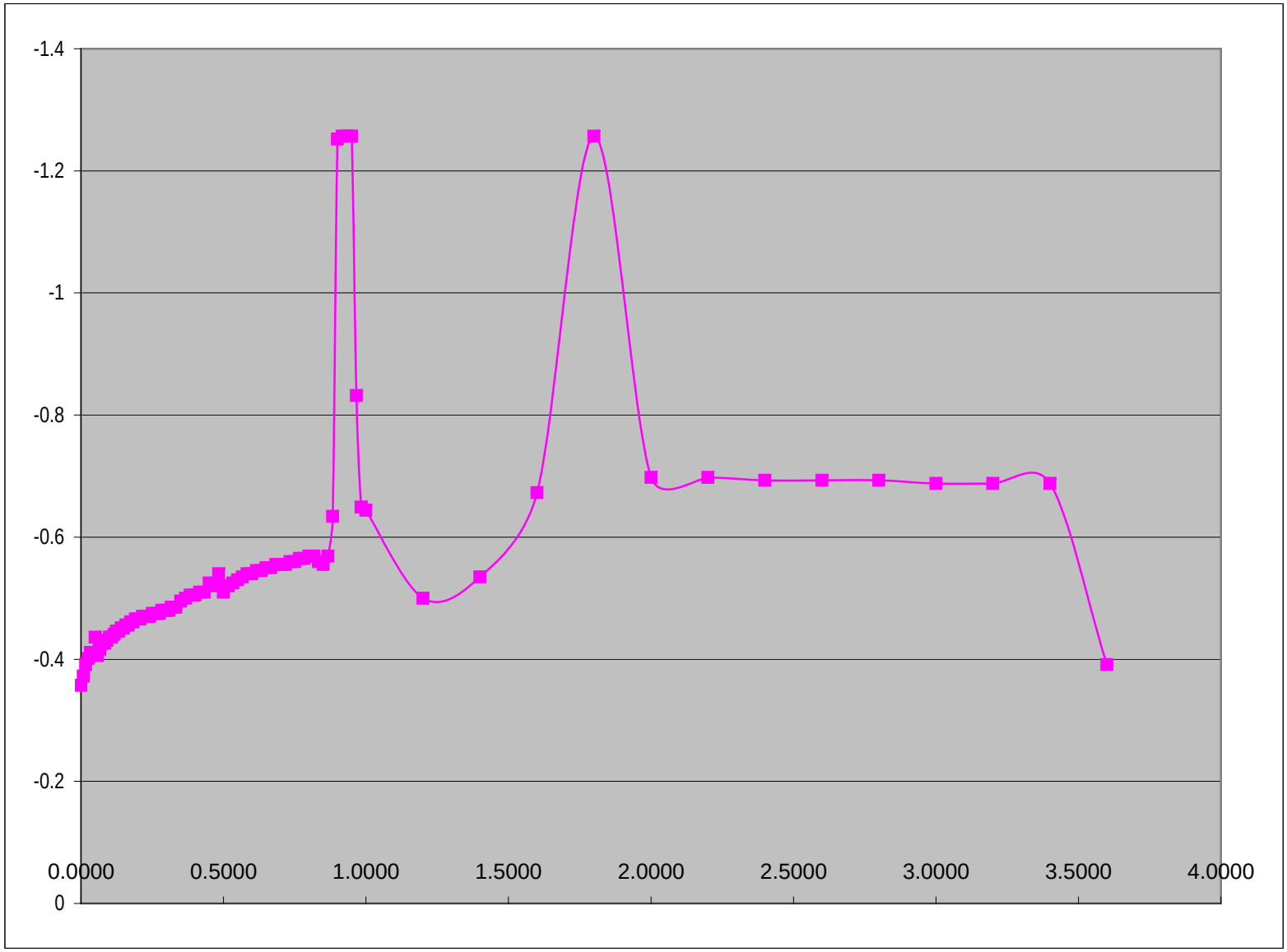
Water Table starting at 2.1 ft from TOC
(Piez Length 8.3 ft, 1 stickup)
Set reference as 8.0 ft as depth of transducer below NGS
Started Data Logger to track drawdown:

K =	0.00	in/hr
K =	0.00E+00	cm/sec

Field Texture	%Sd	%Clay
SiCL	10	32

	0.2416	5.2300	-0.47	-5.64	0.498	0.000	
	0.2500	5.2250	-0.475	-5.7	0.504	-13.690	
	0.2583	5.2250	-0.475	-5.7	0.498	0.000	
	0.2666	5.2250	-0.475	-5.7	0.498	0.000	
	0.2750	5.2250	-0.475	-5.7	0.504	0.000	
	0.2833	5.2200	-0.48	-5.76	0.498	-13.710	
	0.2916	5.2200	-0.48	-5.76	0.498	0.000	
	0.3000	5.2200	-0.48	-5.76	0.504	0.000	
	0.3083	5.2200	-0.48	-5.76	0.498	0.000	
	0.3166	5.2150	-0.485	-5.82	0.498	-13.568	
	0.3250	5.2150	-0.485	-5.82	0.504	0.000	
	0.3333	5.2150	-0.485	-5.82	0.498	0.000	
	0.3500	5.2050	-0.495	-5.94	1.002	-13.281	
	0.3666	5.2000	-0.5	-6	0.996	-6.579	
	0.3833	5.1950	-0.505	-6.06	1.002	-6.475	
	0.4000	5.1950	-0.505	-6.06	1.002	0.000	
	0.4166	5.1900	-0.51	-6.12	0.996	-6.450	
	0.4333	5.1900	-0.51	-6.12	1.002	0.000	
	0.4500	5.1750	-0.525	-6.3	1.002	-18.863	
	0.4666	5.1800	-0.52	-6.24	0.996	6.265	Max Drawdown
	0.4833	5.1600	-0.54	-6.48	1.002	-24.559	
	0.5000	5.1900	-0.51	-6.12	1.002	37.194	
	0.5166	5.1800	-0.52	-6.24	0.996	-12.712	
	0.5333	5.1750	-0.525	-6.3	1.002	-6.227	
	0.5500	5.1700	-0.53	-6.36	1.002	-6.168	
	0.5666	5.1650	-0.535	-6.42	0.996	-6.147	
	0.5833	5.1600	-0.54	-6.48	1.002	-6.053	
	0.6000	5.1600	-0.54	-6.48	1.002	0.000	
	0.6166	5.1550	-0.545	-6.54	0.996	-6.034	
	0.6333	5.1550	-0.545	-6.54	1.002	0.000	
	0.6500	5.1500	-0.55	-6.6	1.002	-5.943	
	0.6666	5.1500	-0.55	-6.6	0.996	0.000	
	0.6833	5.1450	-0.555	-6.66	1.002	-5.889	
	0.7000	5.1450	-0.555	-6.66	1.002	0.000	
	0.7166	5.1450	-0.555	-6.66	0.996	0.000	
	0.7333	5.1400	-0.56	-6.72	1.002	-5.836	
	0.7500	5.1400	-0.56	-6.72	1.002	0.000	

	0.7666	5.1350	-0.565	-6.78	0.996	-5.819
	0.7833	5.1350	-0.565	-6.78	1.002	0.000
	0.8000	5.1310	-0.569	-6.828	1.002	-4.591
	0.8166	5.1310	-0.569	-6.828	0.996	0.000
	0.8333	5.1400	-0.56	-6.72	1.002	10.375
	0.8500	5.1450	-0.555	-6.66	1.002	5.836
	0.8666	5.1310	-0.569	-6.828	0.996	-16.309
	0.8833	5.0660	-0.634	-7.608	1.002	-70.388
	0.9000	4.4480	-1.252	-15.024	1.002	-442.784
	0.9166	4.4430	-1.257	-15.084	0.996	-2.609
	0.9333	4.4430	-1.257	-15.084	1.002	0.000
	0.9500	4.4430	-1.257	-15.084	1.002	0.000
	0.9666	4.8680	-0.832	-9.984	0.996	270.139
	0.9833	5.0510	-0.649	-7.788	1.002	161.640
	1.0000	5.0560	-0.644	-7.728	1.002	5.033
	1.2000	5.2000	-0.5	-6	12	13.752
	1.4000	5.1650	-0.535	-6.42	12	-3.676
	1.6000	5.0270	-0.673	-8.076	12	-12.469
	1.8000	4.4430	-1.257	-15.084	12	-33.945
	2.0000	5.0020	-0.698	-8.376	12	31.964
	2.2000	5.0020	-0.698	-8.376	12	0.000
	2.4000	5.0070	-0.693	-8.316	12	0.391
	2.6000	5.0070	-0.693	-8.316	12	0.000
	2.8000	5.0070	-0.693	-8.316	12	0.000
	3.0000	5.0120	-0.688	-8.256	12	0.393
	3.2000	5.0120	-0.688	-8.256	12	0.000
	3.4000	5.0120	-0.688	-8.256	12	0.000
	3.6000	5.3090	-0.391	-4.692	12	30.704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Piezometer Tests (Pump Out and Recovery Tests) **San Luis Drain Project**
2005 Geologic Investigations

ESS-05-30-AA

Depth = 7.3 to 7.8 ft. **K = 4.84 in/hr**
Soil type= (CL)s **K = 3.41E-03 cm/sec**

Time, minutes	wt, ft from NGS	Y, ft	Y, inches	Delta t,sec	K, in/hr
0	7.845	-0.155	-1.86		
0.0083	7.85	-0.15	-1.8	0.498	
0.0166	7.85	-0.15	-1.8	0.498	
0.025	7.855	-0.145	-1.74	0.504	
0.0333	7.855	-0.145	-1.74	0.498	
0.0416	7.835	-0.165	-1.98	0.498	
0.05	7.83	-0.17	-2.04	0.504	
0.0583	7.95	-0.05	-0.6	0.498	
0.0666	8.019	0.019	0.228	0.996	
0.075	7.995	-0.005	-0.06	0.504	
0.0833	8.124	0.124	1.488	0.498	
0.0916	8.119	0.119	1.428	0.498	
0.1	8.194	0.194	2.328	0.504	
0.1083	8.313	0.313	3.756	0.498	
0.1166	8.388	0.388	4.656	0.498	
0.125	8.493	0.493	5.916	0.504	
0.1333	8.617	0.617	7.404	0.498	
0.1416	8.717	0.717	8.604	0.498	
0.15	8.856	0.856	10.272	0.504	
0.1583	8.861	0.861	10.332	0.498	
0.1666	8.946	0.946	11.352	0.498	
0.175	9.05	1.05	12.6	0.504	
0.1833	9.13	1.13	13.56	0.498	
0.1916	9.195	1.195	14.34	0.498	
0.2	9.304	1.304	15.648	0.504	
0.2083	9.364	1.364	16.368	0.498	
0.2166	9.429	1.429	17.148	0.498	
0.225	9.489	1.489	17.868	0.504	
0.2333	9.608	1.608	19.296	0.498	

Piezometer Test -Step 1
Uncased test zone - backfilled with coarse sand

Top of Test	7.3	ft from NGS
Bottom of Test	7.8	ft from NGS (6-inch test)
Test Diameter	2.375	inches test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	1.1	ft from NGS
Pipe Stickup to TOC =	1	ft from NGS
Reference =	8	ft. (setting on Hermit)

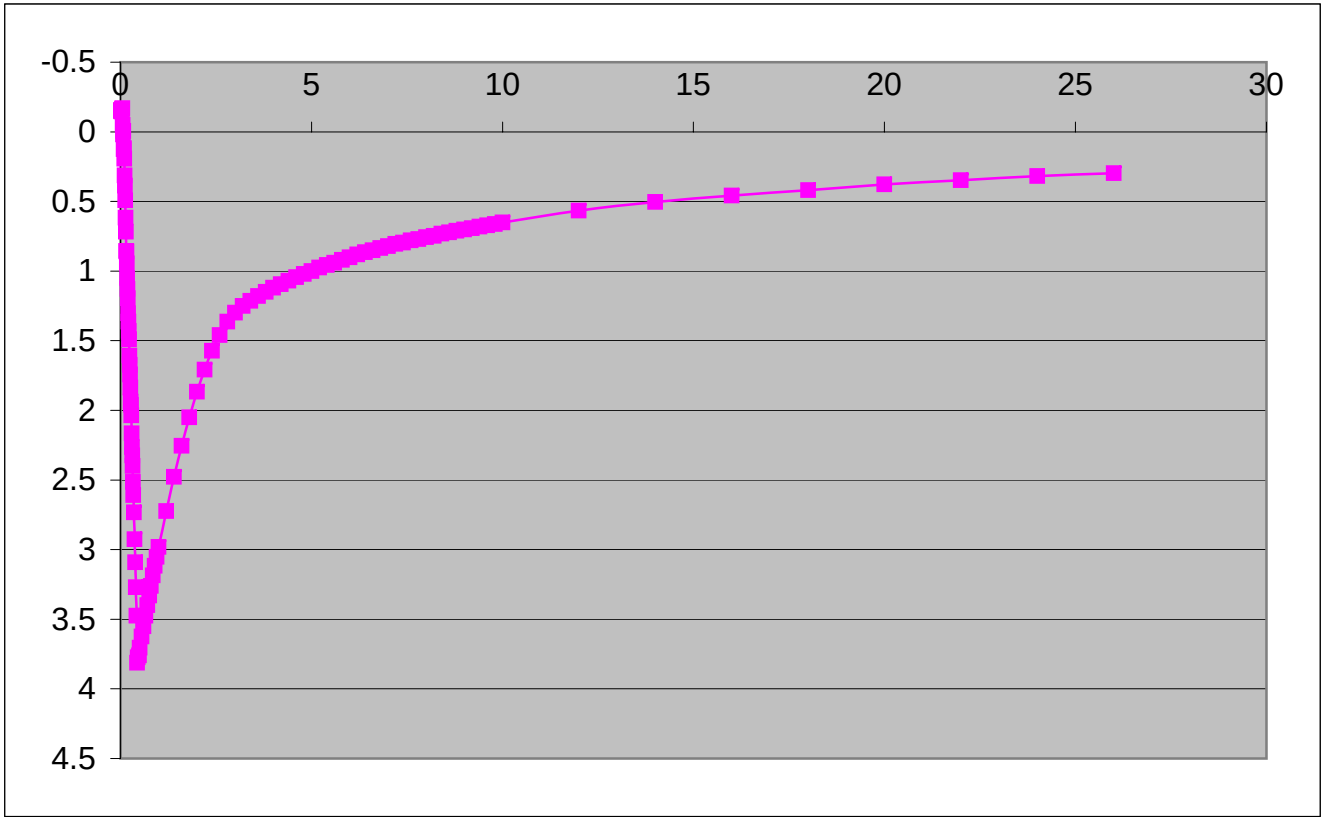
Water Table starting at 2.1 ft from TOC (Piez Length 8.3 ft, 1 stickup)
Set reference as 8.0 ft as depth of transducer below TOC
Started Data Logger to track drawdown:

			Field Texture	%Sd
K =	**4.84**	**in/hr**	(CL)s	20
K =	**3.41E-03**	**cm/sec**		%Clay
				30

0.2416	9.673	1.673	20.076	0.498	
0.25	9.743	1.743	20.916	0.504	
0.2583	9.837	1.837	22.044	0.498	
0.2666	9.937	1.937	23.244	0.498	
0.275	9.962	1.962	23.544	0.504	
0.2833	10.036	2.036	24.432	0.498	
0.2916	10.166	2.166	25.992	0.498	
0.3	10.265	2.265	27.18	0.504	
0.3083	10.325	2.325	27.9	0.498	
0.3166	10.4	2.4	28.8	0.498	
0.325	10.514	2.514	30.168	0.504	
0.3333	10.609	2.609	31.308	0.498	
0.35	10.733	2.733	32.796	1.002	
0.3666	10.927	2.927	35.124	0.996	
0.3833	11.092	3.092	37.104	1.002	
0.4	11.271	3.271	39.252	1.002	
0.4166	11.475	3.475	41.7	0.996	
0.4333	11.813	3.813	45.756	1.002	Max Drawdown
0.45	**11.774**	3.774	45.288	1.002	6.690
0.4833	11.759	3.759	45.108	1.998	1.300
0.5	11.704	3.704	44.448	1.002	9.591
0.55	11.624	3.624	43.488	3	4.746
0.6	11.55	3.55	42.6	3	4.484
0.65	11.475	3.475	41.7	3	4.641
0.7	11.4	3.4	40.8	3	4.742
0.75	11.331	3.331	39.972	3	4.456
0.8	11.261	3.261	39.132	3	4.616
0.85	11.186	3.186	38.232	3	5.057
0.9	11.117	3.117	37.404	3	4.759
0.95	11.052	3.052	36.624	3	4.580
1	10.982	2.982	35.784	3	5.043
1.2	10.723	2.723	32.676	12	4.937
1.4	10.479	2.479	29.748	12	5.101
1.6	10.255	2.255	27.06	12	5.146
1.8	10.051	2.051	24.612	12	5.152
2	9.867	1.867	22.404	12	5.107
2.2	9.708	1.708	20.496	12	4.836

2.4	9.573	1.573	18.876	12	4.474
2.6	9.459	1.459	17.508	12	4.088
2.8	9.364	1.364	16.368	12	3.658
3	9.299	1.299	15.588	12	2.653
3.2	9.25	1.25	15	12	2.089
3.4	9.215	1.215	14.58	12	1.543
3.6	9.18	1.18	14.16	12	1.588
3.8	9.15	1.15	13.8	12	1.399
4	9.12	1.12	13.44	12	1.436
4.2	9.095	1.095	13.14	12	1.227
4.4	9.07	1.07	12.84	12	1.255
4.6	9.045	1.045	12.54	12	1.285
4.8	9.021	1.021	12.252	12	1.262
5	9.001	1.001	12.012	12	1.075
5.2	8.976	0.976	11.712	12	1.374
5.4	8.956	0.956	11.472	12	1.125
5.6	8.941	0.941	11.292	12	0.859
5.8	8.921	0.921	11.052	12	1.167
6	8.901	0.901	10.812	12	1.193
6.2	8.881	0.881	10.572	12	1.220
6.4	8.866	0.866	10.392	12	0.933
6.6	8.851	0.851	10.212	12	0.949
6.8	8.836	0.836	10.032	12	0.966
7	8.821	0.821	9.852	12	0.984
7.2	8.806	0.806	9.672	12	1.002
7.4	8.796	0.796	9.552	12	0.678
7.6	8.781	0.781	9.372	12	1.034
7.8	8.771	0.771	9.252	12	0.700
8	8.757	0.757	9.084	12	0.996
8.2	8.747	0.747	8.964	12	0.723
8.4	8.732	0.732	8.784	12	1.102
8.6	8.722	0.722	8.664	12	0.747
8.8	8.712	0.712	8.544	12	0.758
9	8.702	0.702	8.424	12	0.769
9.2	8.692	0.692	8.304	12	0.780
9.4	8.682	0.682	8.184	12	0.791
9.6	8.672	0.672	8.064	12	0.803

9.8	8.662	0.662	7.944	12	0.815
10	8.652	0.652	7.824	12	0.827
12	8.567	0.567	6.804	120	0.759
14	8.503	0.503	6.036	120	0.651
16	8.458	0.458	5.496	120	0.509
18	8.418	0.418	5.016	120	0.497
20	8.378	0.378	4.536	120	0.547
22	8.348	0.348	4.176	120	0.449
24	8.318	0.318	3.816	120	0.490
26	8.298	0.298	3.576	120	0.353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Piezometer Tests (Pump Out and Recovery Tests) **San Luis Drain Project**
2005 Geologic Investigations

ESS-05-33B **Depth 13.5 to 14.0 ft.** **K = 0.16 in/hr**
Soil type= CL/ML **K = 1.10E-04 cm/sec**

Time, minutes	wt, ft from NGS	Y, ft	Y, inches	Delta t,sec	K, in/hr
0	10.097	0.497	5.964		
0.0083	10.102	0.502	6.024	0.498	
0.0166	10.167	0.567	6.804	0.498	
0.025	10.237	0.637	7.644	0.504	
0.0333	10.302	0.702	8.424	0.498	
0.0416	10.386	0.786	9.432	0.498	
0.05	10.461	0.861	10.332	0.504	
0.0583	10.506	0.906	10.872	0.498	
0.0666	10.575	0.975	11.7	0.996	
0.075	10.645	1.045	12.54	0.504	
0.0833	10.695	1.095	13.14	0.498	
0.0916	10.77	1.17	14.04	0.498	
0.1	10.824	1.224	14.688	0.504	
0.1083	10.889	1.289	15.468	0.498	
0.1166	10.939	1.339	16.068	0.498	
0.125	11.004	1.404	16.848	0.504	
0.1333	11.068	1.468	17.616	0.498	
0.1416	11.133	1.533	18.396	0.498	
0.15	11.188	1.588	19.056	0.504	
0.1583	11.253	1.653	19.836	0.498	
0.1666	11.317	1.717	20.604	0.498	
0.175	11.377	1.777	21.324	0.504	
0.1833	11.442	1.842	22.104	0.498	
0.1916	11.501	1.901	22.812	0.498	
0.2	11.561	1.961	23.532	0.504	
0.2083	11.626	2.026	24.312	0.498	
0.2166	11.681	2.081	24.972	0.498	
0.225	11.735	2.135	25.62	0.504	
0.2333	11.795	2.195	26.34	0.498	

Piezometer Test - Step 0
Uncased test zone - backfilled with coarse sand

Top of Test	13.5	ft from NGS
Bottom of Test	14	ft from NGS (6-inch test)
Test Diameter	2.375	inches test cavity (2.5 inches pipe OD)
w/D =	2.526316	
A Factor =	24.46	inches
Static WT =	9.1	ft from NGS
Pipe Stickup to TOC =	0.4	ft from NGS
Reference =	9.6	ft. (setting on Hermit)

Water Table starting at 9.1 ft from TOC (, 0.4 stickup)

Set reference as 9.1 ft as depth of transducer below NGS
Started Data Logger to track drawdown: Field Texture
K = 0.16 in/hr CL/ML
K = 1.10E-04 cm/sec

0.2416	11.855	2.255	27.06	0.498	
0.25	11.92	2.32	27.84	0.504	
0.2583	11.984	2.384	28.608	0.498	
0.2666	12.049	2.449	29.388	0.498	
0.275	12.163	2.563	30.756	0.504	
0.2833	12.273	2.673	32.076	0.498	
0.2916	12.387	2.787	33.444	0.498	
0.3	12.502	2.902	34.824	0.504	
0.3083	12.527	2.927	35.124	0.498	
0.3166	12.497	2.897	34.764	0.498	
0.325	12.442	2.842	34.104	0.504	
0.3333	12.402	2.802	33.624	0.498	
0.35	12.303	2.703	32.436	1.002	
0.3666	12.223	2.623	31.476	0.996	
0.3833	12.134	2.534	30.408	1.002	
0.4	12.318	2.718	32.616	1.002	Max Drawdown
0.4166	12.303	2.703	32.436	0.996	3.623
0.4333	12.298	2.698	32.376	1.002	1.205
0.45	12.283	2.683	32.196	1.002	3.628
0.4666	12.283	2.683	32.196	0.996	0.000
0.4833	12.268	2.668	32.016	1.002	3.648
0.5	12.263	2.663	31.956	1.002	1.221
0.5166	12.263	2.663	31.956	0.996	0.000
0.5333	12.258	2.658	31.896	1.002	1.223
0.55	12.253	2.653	31.836	1.002	1.225
0.5666	12.248	2.648	31.776	0.996	1.235
0.5833	12.248	2.648	31.776	1.002	0.000
0.6	12.248	2.648	31.776	1.002	0.000
0.6166	12.243	2.643	31.716	0.996	1.237
0.6333	12.243	2.643	31.716	1.002	0.000
0.65	12.238	2.638	31.656	1.002	1.232
0.6666	12.238	2.638	31.656	0.996	0.000
0.6833	12.238	2.638	31.656	1.002	0.000
0.7	12.238	2.638	31.656	1.002	0.000
0.7166	12.233	2.633	31.596	0.996	1.242
0.7333	12.233	2.633	31.596	1.002	0.000
0.75	12.233	2.633	31.596	1.002	0.000

0.7666	12.228	2.628	31.536	0.996	1.244
0.7833	12.228	2.628	31.536	1.002	0.000
0.8	12.228	2.628	31.536	1.002	0.000
0.8166	12.223	2.623	31.476	0.996	1.247
0.8333	12.223	2.623	31.476	1.002	0.000
0.85	12.223	2.623	31.476	1.002	0.000
0.8666	12.218	2.618	31.416	0.996	1.249
0.8833	12.218	2.618	31.416	1.002	0.000
0.9	12.218	2.618	31.416	1.002	0.000
0.9166	12.218	2.618	31.416	0.996	0.000
0.9333	12.213	2.613	31.356	1.002	1.244
0.95	12.213	2.613	31.356	1.002	0.000
0.9666	12.213	2.613	31.356	0.996	0.000
0.9833	12.213	2.613	31.356	1.002	0.000
1	12.208	2.608	31.296	1.002	1.246
1.2	12.193	2.593	31.116	12	0.313
1.4	12.183	2.583	30.996	12	0.210
1.6	12.173	2.573	30.876	12	0.211
1.8	12.158	2.558	30.696	12	0.318
2	12.149	2.549	30.588	12	0.192
2.2	12.139	2.539	30.468	12	0.214
2.4	12.129	2.529	30.348	12	0.214
2.6	12.119	2.519	30.228	12	0.215
2.8	12.109	2.509	30.108	12	0.216
3	12.099	2.499	29.988	12	0.217
3.2	12.089	2.489	29.868	12	0.218
3.4	12.079	2.479	29.748	12	0.219
3.6	12.069	2.469	29.628	12	0.220
3.8	12.059	2.459	29.508	12	0.221
4	12.049	2.449	29.388	12	0.221
4.2	12.039	2.439	29.268	12	0.222
4.4	12.034	2.434	29.208	12	0.112
4.6	12.024	2.424	29.088	12	0.224
4.8	12.014	2.414	28.968	12	0.225
5	12.009	2.409	28.908	12	0.113
5.2	11.999	2.399	28.788	12	0.226
5.4	11.989	2.389	28.668	12	0.227

5.6	11.979	2.379	28.548	12	0.228
5.8	11.969	2.369	28.428	12	0.229
6	11.964	2.364	28.368	12	0.115
6.2	11.954	2.354	28.248	12	0.230
6.4	11.949	2.349	28.188	12	0.116
6.6	11.939	2.339	28.068	12	0.232
6.8	11.93	2.33	27.96	12	0.209
7	11.92	2.32	27.84	12	0.234
7.2	11.915	2.315	27.78	12	0.117
7.4	11.905	2.305	27.66	12	0.235
7.6	11.895	2.295	27.54	12	0.236
7.8	11.89	2.29	27.48	12	0.119
8	11.88	2.28	27.36	12	0.238
8.2	11.87	2.27	27.24	12	0.239
8.4	11.865	2.265	27.18	12	0.120
8.6	11.855	2.255	27.06	12	0.240
8.8	11.85	2.25	27	12	0.121
9	11.84	2.24	26.88	12	0.242
9.2	11.835	2.235	26.82	12	0.121
9.4	11.825	2.225	26.7	12	0.244
9.6	11.82	2.22	26.64	12	0.122
9.8	11.81	2.21	26.52	12	0.245
10	11.805	2.205	26.46	12	0.123
12	11.74	2.14	25.68	120	0.163
14	11.671	2.071	24.852	120	0.178
16	11.611	2.011	24.132	120	0.160
18	11.551	1.951	23.412	120	0.165
20	11.496	1.896	22.752	120	0.155
22	11.442	1.842	22.104	120	0.157
24	11.392	1.792	21.504	120	0.150
26	11.347	1.747	20.964	120	0.138
28	11.302	1.702	20.424	120	0.142
30	11.258	1.658	19.896	120	0.142
32	11.218	1.618	19.416	120	0.133
34	11.183	1.583	18.996	120	0.119
36	11.148	1.548	18.576	120	0.121
38	11.113	1.513	18.156	120	0.124

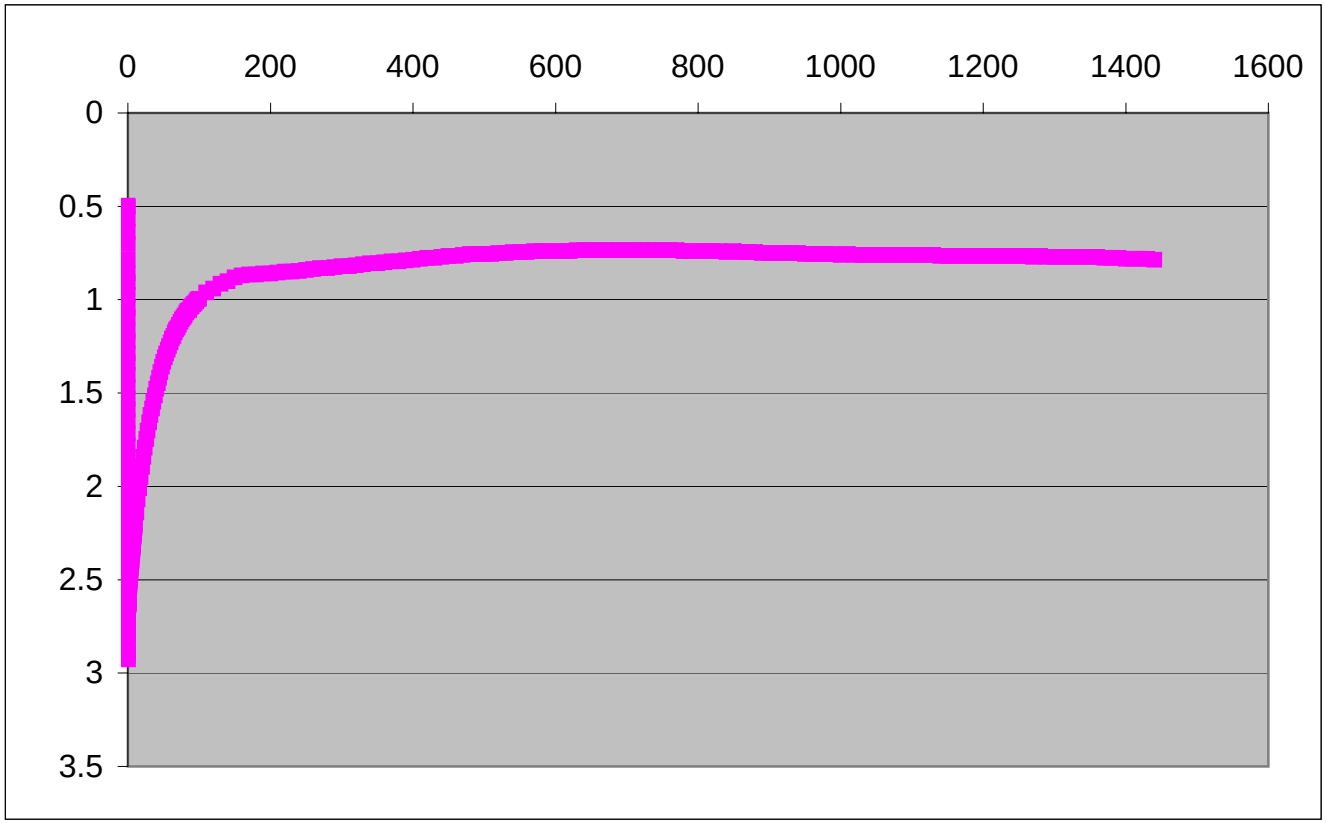
40	11.078	1.478	17.736	120	0.127
42	11.048	1.448	17.376	120	0.111
44	11.019	1.419	17.028	120	0.110
46	10.989	1.389	16.668	120	0.116
48	10.959	1.359	16.308	120	0.119
50	10.934	1.334	16.008	120	0.101
52	10.909	1.309	15.708	120	0.103
54	10.889	1.289	15.468	120	0.084
56	10.869	1.269	15.228	120	0.085
58	10.849	1.249	14.988	120	0.086
60	10.829	1.229	14.748	120	0.088
62	10.809	1.209	14.508	120	0.089
64	10.795	1.195	14.34	120	0.063
66	10.775	1.175	14.1	120	0.092
68	10.76	1.16	13.92	120	0.070
70	10.75	1.15	13.8	120	0.047
72	10.735	1.135	13.62	120	0.071
74	10.72	1.12	13.44	120	0.072
76	10.705	1.105	13.26	120	0.073
78	10.695	1.095	13.14	120	0.049
80	10.685	1.085	13.02	120	0.050
82	10.67	1.07	12.84	120	0.076
84	10.66	1.06	12.72	120	0.051
86	10.655	1.055	12.66	120	0.026
88	10.64	1.04	12.48	120	0.078
90	10.635	1.035	12.42	120	0.026
92	10.625	1.025	12.3	120	0.053
94	10.62	1.02	12.24	120	0.027
96	10.61	1.01	12.12	120	0.054
98	10.6	1	12	120	0.054
100	10.595	0.995	11.94	120	0.027
110	10.561	0.961	11.532	600	0.038
120	10.541	0.941	11.292	600	0.023
130	10.516	0.916	10.992	600	0.029
140	10.501	0.901	10.812	600	0.018
150	10.481	0.881	10.572	600	0.024
160	10.471	0.871	10.452	600	0.012

170	10.466	0.866	10.392	600	0.006
180	10.466	0.866	10.392	600	0.000
190	10.461	0.861	10.332	600	0.006
200	10.461	0.861	10.332	600	0.000
210	10.456	0.856	10.272	600	0.006
220	10.451	0.851	10.212	600	0.006
230	10.451	0.851	10.212	600	0.000
240	10.446	0.846	10.152	600	0.006
250	10.441	0.841	10.092	600	0.006
260	10.436	0.836	10.032	600	0.006
270	10.431	0.831	9.972	600	0.007
280	10.431	0.831	9.972	600	0.000
290	10.426	0.826	9.912	600	0.007
300	10.421	0.821	9.852	600	0.007
310	10.421	0.821	9.852	600	0.000
320	10.416	0.816	9.792	600	0.007
330	10.411	0.811	9.732	600	0.007
340	10.406	0.806	9.672	600	0.007
350	10.406	0.806	9.672	600	0.000
360	10.401	0.801	9.612	600	0.007
370	10.396	0.796	9.552	600	0.007
380	10.396	0.796	9.552	600	0.000
390	10.391	0.791	9.492	600	0.007
400	10.386	0.786	9.432	600	0.007
410	10.381	0.781	9.372	600	0.007
420	10.376	0.776	9.312	600	0.007
430	10.376	0.776	9.312	600	0.000
440	10.371	0.771	9.252	600	0.007
450	10.366	0.766	9.192	600	0.007
460	10.366	0.766	9.192	600	0.000
470	10.361	0.761	9.132	600	0.007
480	10.356	0.756	9.072	600	0.007
490	10.356	0.756	9.072	600	0.000
500	10.356	0.756	9.072	600	0.000
510	10.356	0.756	9.072	600	0.000
520	10.351	0.751	9.012	600	0.007
530	10.351	0.751	9.012	600	0.000

540	10.346	0.746	8.952	600	0.007
550	10.346	0.746	8.952	600	0.000
560	10.346	0.746	8.952	600	0.000
570	10.341	0.741	8.892	600	0.007
580	10.341	0.741	8.892	600	0.000
590	10.341	0.741	8.892	600	0.000
600	10.341	0.741	8.892	600	0.000
610	10.341	0.741	8.892	600	0.000
620	10.341	0.741	8.892	600	0.000
630	10.336	0.736	8.832	600	0.007
640	10.336	0.736	8.832	600	0.000
650	10.336	0.736	8.832	600	0.000
660	10.336	0.736	8.832	600	0.000
670	10.336	0.736	8.832	600	0.000
680	10.336	0.736	8.832	600	0.000
690	10.336	0.736	8.832	600	0.000
700	10.336	0.736	8.832	600	0.000
710	10.336	0.736	8.832	600	0.000
720	10.336	0.736	8.832	600	0.000
730	10.336	0.736	8.832	600	0.000
740	10.336	0.736	8.832	600	0.000
750	10.336	0.736	8.832	600	0.000
760	10.336	0.736	8.832	600	0.000
770	10.336	0.736	8.832	600	0.000
780	10.341	0.741	8.892	600	-0.007
790	10.341	0.741	8.892	600	0.000
800	10.341	0.741	8.892	600	0.000
810	10.341	0.741	8.892	600	0.000
820	10.341	0.741	8.892	600	0.000
830	10.341	0.741	8.892	600	0.000
840	10.346	0.746	8.952	600	-0.007
850	10.341	0.741	8.892	600	0.007
860	10.346	0.746	8.952	600	-0.007
870	10.346	0.746	8.952	600	0.000
880	10.346	0.746	8.952	600	0.000
890	10.351	0.751	9.012	600	-0.007
900	10.351	0.751	9.012	600	0.000

910	10.351	0.751	9.012	600	0.000
920	10.351	0.751	9.012	600	0.000
930	10.351	0.751	9.012	600	0.000
940	10.351	0.751	9.012	600	0.000
950	10.356	0.756	9.072	600	-0.007
960	10.356	0.756	9.072	600	0.000
970	10.356	0.756	9.072	600	0.000
980	10.356	0.756	9.072	600	0.000
990	10.356	0.756	9.072	600	0.000
1000	10.361	0.761	9.132	600	-0.007
1010	10.356	0.756	9.072	600	0.007
1020	10.361	0.761	9.132	600	-0.007
1030	10.361	0.761	9.132	600	0.000
1040	10.361	0.761	9.132	600	0.000
1050	10.361	0.761	9.132	600	0.000
1060	10.361	0.761	9.132	600	0.000
1070	10.361	0.761	9.132	600	0.000
1080	10.361	0.761	9.132	600	0.000
1090	10.361	0.761	9.132	600	0.000
1100	10.361	0.761	9.132	600	0.000
1110	10.361	0.761	9.132	600	0.000
1120	10.361	0.761	9.132	600	0.000
1130	10.361	0.761	9.132	600	0.000
1140	10.366	0.766	9.192	600	-0.007
1150	10.366	0.766	9.192	600	0.000
1160	10.366	0.766	9.192	600	0.000
1170	10.366	0.766	9.192	600	0.000
1180	10.366	0.766	9.192	600	0.000
1190	10.366	0.766	9.192	600	0.000
1200	10.366	0.766	9.192	600	0.000
1210	10.366	0.766	9.192	600	0.000
1220	10.366	0.766	9.192	600	0.000
1230	10.366	0.766	9.192	600	0.000
1240	10.366	0.766	9.192	600	0.000
1250	10.366	0.766	9.192	600	0.000
1260	10.366	0.766	9.192	600	0.000
1270	10.371	0.771	9.252	600	-0.007

1280	10.366	0.766	9.192	600	0.007
1290	10.371	0.771	9.252	600	-0.007
1300	10.371	0.771	9.252	600	0.000
1310	10.371	0.771	9.252	600	0.000
1320	10.371	0.771	9.252	600	0.000
1330	10.371	0.771	9.252	600	0.000
1340	10.371	0.771	9.252	600	0.000
1350	10.371	0.771	9.252	600	0.000
1360	10.371	0.771	9.252	600	0.000
1370	10.376	0.776	9.312	600	-0.007
1380	10.376	0.776	9.312	600	0.000
1390	10.376	0.776	9.312	600	0.000
1400	10.381	0.781	9.372	600	-0.007
1410	10.381	0.781	9.372	600	0.000
1420	10.381	0.781	9.372	600	0.000
1430	10.381	0.781	9.372	600	0.000
1440	10.386	0.786	9.432	600	-0.007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Appendix E – TSC Perm Lab Data

Summary of Index Properties Test Results

San Luis Drain - Evaporation Pond Study - California

Sample Number	Drill Hole	Sample Depth	Gravel	Sand	Fines	Liquid Limit	Plasticity Index	Specific Gravity	Moisture Content	Classification Symbol	Description
		ft	percent passing			%	%		%		
5H-149	EDC-05-25	5.4-7.9	0	11	89	47	22	2.68	27.4	CL	Lean Clay
5H-150	EDC-05-25	8.1-10.6	0	9	91	37	15	2.70	32.6	CL	Lean Clay
5H-153	EDC-05-25	18.9-21.4	0	3	97	38	13	2.69	34.6	ML	Silt
5H-160	EDC-05-26	8.2-10.5	0	2	98	57	30	2.75	32.2	CH	Fat Clay
5H-163	EDC-05-26	16.2-18.7	0	6	94	42	20	2.74	29.8	CL	Lean Clay
5H-169	EDC-05-27	5.4-7.9	0	5	95	46	21	2.70	32.9	CL	Lean Clay
5H-171	EDC-05-27	11.0-13.1	0	2	98	52	23	2.74	34.9	MH	Elastic Silt
5H-179	EDC-05-28	2.7-5.2	0	2	98	59	27	2.72	39.9	MH	Elastic Silt
5H-180	EDC-05-28	5.4-7.9	0	8	92	47	24	2.65	35.8	CL	Lean Clay
5H-182	EDC-05-28	10.8-13.3	0	16	84	35	15	2.70	31.9	$(CL)_s$	Lean Clay with Sand
5H-190	EDC-05-29	2.7-5.2	0	10	90	42	20	2.72	32.9	CL	Lean Clay
5H-191	EDC-05-29	5.4-7.8	0	8	92	55	28	2.72	39.2	CH	Fat Clay
5H-201	EDC-05-30	11.9-13.7	0	8	92	48	25	2.67	30.3	CL	Lean Clay
5H-203	EDC-05-30	17.3-18.8	0	3	97	49	20	2.69	41.0	ML	Silt
5H-210	EDC-05-31	8.1-10.6	0	4	96	49	23	2.77	34.5	CL	Lean Clay
5H-211	EDC-05-31	10.8-13.1	0	36	64	30	10	2.71	24.6	$_s(CL)$	Sandy Lean Clay
5H-219	EDC-05-33	5.4-7.8	0	1	99	67	36	2.76	38.6	CH	Fat Clay
5H-221	EDC-05-33	10.8-13.2	0	6	94	50	29	2.73	26.3	CH	Fat Clay
5H-222	EDC-05-33	13.5-16.0	0	1	100	54	24	2.78	39.6	MH	Elastic Silt

Table 1

Summary of Preliminary Flexible Wall Permeablity Test Results

San Luis Drain - Evaporation Pond Study - California

Sample Number	Specimen Number	Drill Hole	Sample Depth	Specimen Depth	Specimen Height	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow	Date Started	Date Completed
			ft	ft	in	cm/sec	cm/sec	cm/sec				
5H-149	40	EDC-05-25	5.4-7.9	5.6-6.1	4.0	1.3E-06	8.5E-06	6.9E-06	5	Vertical	7/18/2005	7/26/2005
5H-149	41	EDC-05-25	5.4-7.9	6.1-6.4	3.5	5.6E-05	7.9E-05	6.8E-05	6	Horizontal	7/18/2005	7/22/2005
5H-150	42	EDC-05-25	8.1-10.6	8.7-9.2	4.0	6.8E-07	8.4E-07	7.7E-07	3	Vertical	7/18/2005	7/26/2005
5H-150	43	EDC-05-25	8.1-10.6	8.3-8.7	3.5	1.2E-06	1.2E-06	1.2E-06	3	**Horizontal**	7/22/2005	8/2/2005
5H-153	44	EDC-05-25	18.9-21.4	19.1-19.6	3.5	1.7E-07	2.5E-07	2.2E-07	3	Horizontal	8/2/2005	8/10/2005
5H-160	45	EDC-05-26	8.2-10.5	9.2-9.7	4.0	9.3E-07	1.9E-06	1.3E-06	8	**Vertical**	7/26/2005	8/2/2005
5H-160	46	EDC-05-26	8.2-10.5	9.7-10.1	3.5	5.0E-07	6.0E-07	5.5E-07	4	Horizontal	7/26/2005	8/2/2005
5H-163	47	EDC-05-26	16.2-18.7	17.1-17.6	4.0	1.4E-06	1.7E-06	1.6E-06	5	Vertical	8/2/2005	8/10/2005
5H-163	48	EDC-05-26	16.2-18.7	17.6-18.0	3.5	9.7E-06	1.7E-05	1.4E-05	7	**Horizontal**	8/2/2005	8/9/2005
5H-169	49	EDC-05-27	5.4-7.9	6.1-6.5	3.5	1.6E-06	1.7E-06	1.7E-06	5	Horizontal	8/9/2005	8/17/2005
5H-169	50	EDC-05-27	5.4-7.9	6.5-7.0	4.0	5.1E-05	5.7E-05	5.5E-05	7	**Vertical**	8/10/2005	8/16/2005
5H-171	51	EDC-05-27	11.0-13.1	11.1-11.5	3.5	9.1E-07	1.0E-06	9.8E-07	6	Horizontal	8/10/2005	8/17/2005
5H-171	52	EDC-05-27	11.0-13.1	11.5-12.0	4.0	5.8E-07	6.8E-07	6.2E-07	6	Vertical	8/16/2005	8/23/2005
5H-179	53	EDC-05-28	2.7-5.2	4.1-4.6	4.0	1.5E-07	2.8E-07	2.0E-07	6	Vertical	8/17/2005	8/24/2005
5H-179	54	EDC-05-28	2.7-5.2	4.6-5.0	3.5	2.2E-07	4.1E-07	3.4E-07	6	Horizontal	8/17/2005	8/24/2005
5H-180	55	EDC-05-28	5.4-7.9	6.1-6.6	4.0	2.0E-07	3.1E-07	2.4E-07	5	Vertical	8/23/2005	8/30/2005
5H-180	56	EDC-05-28	5.4-7.9	6.6-7.0	3.5	1.3E-06	1.4E-06	1.4E-06	5	**Horizontal**	8/24/2005	8/30/2005
5H-182	57	EDC-05-28	10.8-13.3	12.1-12.6	4.0	1.5E-06	1.7E-06	1.6E-06	5	Vertical	8/24/2005	8/30/2005
5H-182	58	EDC-05-28	10.8-13.3	12.6-13.3	3.5	1.9E-05	2.8E-05	2.5E-05	8	Horizontal	8/30/2005	9/2/2005
5H-190	59	EDC-05-29	2.7-5.2	3.0-3.5	4.0	3.5E-07	4.0E-07	3.7E-07	7	Vertical	8/30/2005	9/6/2005
5H-191	60	EDC-05-29	5.4-7.8	6.0-6.4	3.5	3.6E-06	3.8E-06	3.7E-06	7	**Horizontal**	8/30/2005	9/6/2005
5H-201	61	EDC-05-30	11.9-13.7	13.3-13.7	3.5	1.9E-06	2.1E-06	2.0E-06	6	Horizontal	9/6/2005	9/14/2005
5H-201	62	EDC-05-30	11.9-13.7	12.8-13.3	4.0	1.3E-06	1.5E-06	1.4E-06	5	Vertical	9/2/2005	9/9/2005
5H-203	63	EDC-05-30	17.3-19.8	17.8-18.2	4.0	3.8E-06	3.5E-05	2.7E-05	7	Vertical	9/7/2005	9/13/2005
5H-203	64	EDC-05-30	17.3-19.8	18.2-18.6	3.5	4.8E-06	9.2E-05	7.4E-05	7	Horizontal	9/9/2005	9/13/2005

Table 2

Summary of Preliminary Flexible Wall Permeablity Test Results

San Luis Drain - Evaporation Pond Study - California

Sample Number	Specimen Number	Drill Hole	Sample Depth	Specimen Depth	Specimen Height	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow	Date Started	Date Completed
			ft	ft	in	cm/sec	cm/sec	cm/sec				
5H-210	65	EDC-05-31	8.1-10.6	8.2-8.7	4.0	1.2E-07	1.8E-07	1.5E-07	5	Vertical	9/13/2005	9/19/2005
5H-210	66	EDC-05-31	8.1-10.6	8.7-9.1	3.5	5.1E-07	9.0E-07	6.3E-07	5	Horizontal	9/13/2005	9/19/2005
5H-211	67	EDC-05-31	10.8-13.1	12.0-12.4	3.5	3.5E-06	5.3E-06	3.9E-06	5	Horizontal	9/19/2005	9/23/2005
5H-211	68	EDC-05-31	10.8-13.1	12.4-12.9	4.0	3.1E-06	3.8E-06	3.3E-06	4	Vertical	9/14/2005	9/19/2005
5H-219	69	EDC-05-33	5.4-7.8	5.6-6.0	3.5	3.4E-06	3.6E-06	3.6E-06	5	Horizontal	9/19/2005	9/23/2005
5H-219	70	EDC-05-33	5.4-7.8	6.0-6.5	4.0	1.4E-05	2.5E-05	1.8E-05	6	Vertical	9/19/2005	9/23/2005
5H-221	71	EDC-05-33	10.8-13.2	12.5-13.0	4.0	5.4E-07	5.7E-07	5.5E-07	5	Vertical	9/23/2005	9/30/2005
5H-221	72	EDC-05-33	10.8-13.2	12.5-13.0	3.5	4.0E-06	5.0E-06	4.6E-06	6	**Horizontal**	9/23/2005	9/30/2005
5H-222	73	EDC-05-33	13.5-16.0	15.4-15.8	3.5	5.0E-06	1.5E-05	1.3E-05	7	Horizontal	9/23/2005	9/29/2005

Shaded cells indicate samples which had both horizonatal and vertical permeability testing performed.
Specimens which exhibited higher permeabilities are shown in**BOLD,** if results are not bolded, then there was no significant difference between vertical and horizontal flow.

Table 2

Appendix F – Field Densities

FIELD DENSITIES San Luis Drain 2005

Undisturbed sample list Proposed Evaporation Pond Site B

EDC-05-25		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.00 - 2.2	116.25
2	2.7 - 5.2	129.47
3	5.4 - 7.9	127.89
4	8.1 - 10.6	125.44
5	10.8 - 12.4	114.88
6	13.5 - 16.2	NR
7	16.2 - 18.7	126.24
8	18.9 - 21.4	130.52
9	21.6 - 24.1	128.37
10	24.3 - 26.8	131.12
11	27.0 - 29.5	130.53

EDC-05-26		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 - 2.5	117.17
2	2.7 - 5.2	117.83
3	5.4 - 7.9	119.74
4	8.2 - 10.5	122.04
5	10.9 -13.3	119.86
6	13.5 - 16.0	125.71
7	16.2 -18.7	126.80
8	18.9 - 21.4	120.37
9	21.6 - 24.0	123.94
10	24.3 - 26.7	126.48
11	27.0 - 29.5	NR

EDC-05-27		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 - 2.5	111.12
2	2.7 - 5.2	124.45
3	5.4 - 7.9	118.27
4	8.1 - 10.6	125.12
5	11.0 -13.1	115.83
6	13.5 -15.0	109.19
7	16.2 - 18.5	121.99
8	18.9 - 21.3	122.30
9	21.6 - 23.6	121.69
10	24.3 - 26.8	127.12
11	27.0 - 29.5	126.40

EDC-05-28		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 -2.5	117.23
2	2.7 - 5.2	116.93
3	5.4 - 7.9	117.04
4	8.1 - 10.4	124.87
5	10.8 - 13.3	129.36
6	13.5 - 16.0	132.29
7	16.5 - 18.7	124.07
8	18.9 - 21.3	130.03
9	21.6 - 24.1	129.68
10	24.3 - 26.8	130.91
11	27.0 - 29.5	130.48

EDC-05-29		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 -2.5	111.84
2	2.7 - 5.2	122.16
3	5.4 - 7.8	117.27
4	8.1 -10.6	126.59
5	11.0 - 13.3	125.34
6	13.5 - 15.2	116.17
7	16.25 - 18.7	124.68
8	18.9 - 20.9	119.01
9	21.6 - 24.3	NR
10	24.3 - 26.4	119.98
11	27.0 - 29.1	129.68

EDC-05-30		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 -2.5	NR
2	2.5 - 4.3	110.29
3	4.4 - 6.8	117.80
4-A	6.8 - 9.4	NR
4-B	7.4 - 11.2	NR
5	11.9 -13.7	148.54
6	14.6 - 16.8	119.70
7	17.3 - 19.8	122.97
8	20.0 - 22.5	126.88
9	22.7 - 25.2	129.97
10	25.4 - 27.9	129.84
11	28.1 - 31.8	NR

FIELD DENSITIES San Luis Drain 2005

Undisturbed sample list Proposed Evaporation Pond Site

EDC-05-31		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 - 2.5	115.51
2	2.7 - 4.9	120.10
3	5.4 - 7.9	120.45
4	8.1 - 10.6	126.99
5	10.8 - 13.0	127.70
6	13.5 - 15.9	131.17
7	16.2 - 18.6	118.58
8	18.9 - 21.4	126.19
9	21.6 - 24.3	NR
10	24.3 - 26.5	124.10
11	27.0 - 29.5	131.79

EDC-05-32		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.00 - 1.8	109.14
2	2.6 - 5.1	121.17
3	5.3 - 7.7	122.50
4	8.0 - 10.3	125.63
5	10.7 - 12.9	120.40
6	13.4 - 15.9	121.42
7	16.1 - 18.96	124.24
8	18.8 - 21.3	127.74
9	21.5 - 23.6	119.53
10	24.2 - 26.7	131.47
11	26.9 - 29.4	132.88

EDC-05-33		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 -2.5	122.85
2	2.7 - 5.2	114.98
3	5.4 - 7.8	116.94
4	8.1 - 10.6	120.05
5	10.8 - 13.2	125.69
6	13.5 -16.0	121.76
7	16.2 - 17.5	141.45
8	18.9 - 21.35	126.34
9	21.6 - 23.8	127.86
10	24.3 - 26.8	126.53
11	27.0 - 29.5	128.16

EDC-05-34		
Sample #	**Depth Interval (ft.)**	**Density (lb/ft.^{3})**
1	0.0 - 2.7	NR
2	2.7 - 4.9	122.96
3	5.4 - 7.9	119.97
4	8.1 - 10.6	136.19
5	10.8 - 13.1	125.81
6	13.5 - 16.0	129.18
7	16.2 - 18.5	132.49
8	18.9 - 21.3	125.08
9	21.6 - 23.2	116.64
10	24.3 - 26.7	129.50
11	27.0 - 29.5	128.53

Appendix G – Physical Properties Laboratory Data

TABLE #1

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number ESS-05-1 to 6 PROJECT Central Valley FEATURE San Luis Drain

DATE September 19, 2005
SHEET 1 OF 1

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
ESS-05-1-1	7.1	8.1	SM	16.3	14.0	69.7	0.0	0.0	0.0	NP	NP	17.6								
ESS-05-1-2	11	11.5	(CL)S	47.7	35.5	16.8	0.0	0.0	0.0	32.6	18.0	22.5								
ESS-05-04B-2	10	11	(CL)s	35.1	42.6	22.3	0.0	0.0	0.0	38.5	21.7	27.8								
ESS-05-04C-3	14	15	CH	58.6	38.3	3.1	0.0	0.0	0.0	59.5	41.1	29.6								
ESS-05-04D-4*	17	18	CH	71.4	23.4	5.2	0.0	0.0	0.0	61.2	40.3	29.0								
ESS-05-05A-1	8.8	9.8	CL	43.0	49.9	7.1	0.0	0.0	0.0	48.0	30.8	30.2								
ESS-05-05C-3	19	20	CH	65.4	31.4	3.2	0.0	0.0	0.0	58.1	38.3	45.5								
ESS-05-6-1	13.6	14.6	CL	42.8	48.2	9.0	0.0	0.0	0.0	42.7	26.1	5.4								
ESS-05-6B-2	17	18	SM	19.6	15.5	64.9	0.0	0.0	0.0	NP	NP	18.0								

*Flocculation observed at the 25 hour 45 minute hydrometer readings

NP = Non-Plastic

TABLE #2

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-25 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 1 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-25-1	2.4	2.6	SM	12.0	10.3	77.7	0.0	0.0	0.0	NP	NP	21.7								
EDC-05-25-2	7.2	7.6	CH	53.0	38.0	9.0	0.0	0.0	0.0	50.5	32.1	30.5								
EDC-05-25-3	23.9	24.1	SM	17.5	31.4	51.1	0.0	0.0	0.0	NP	NP	24.3								
EDC-05-25-4	26.7	27	SM	15.9	14.7	69.4	0.0	0.0	0.0	NP	NP	23.8								
EDC-05-25-5	29.5	29.7	SM	20.0	16.9	63.1	0.0	0.0	0.0	NP	NP	25.8								
NP = Non-Plastic																				

TABLE #3

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-25A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 2 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-25A-1	3.5	4	(CL)s	42.9	33.3	23.8	0.0	0.0	0.0	37.0	21.9	18.8								
EDC-05-25A-2	6.6	7	(CL)s	46.3	35.4	18.3	0.0	0.0	0.0	40.6	24.0	27.3								
EDC-05-25A-3	8.3	8.5	(CL)s	40.5	36.6	22.9	0.0	0.0	0.0	39.5	23.8	26.7								
EDC-05-25A-4	11.7	11.9	s(ML)	23.7	28.0	48.3	0.0	0.0	0.0	NP	NP	22.1								
EDC-05-25A-5	12	13.1	(CL)s	29.8	47.9	22.3	0.0	0.0	0.0	34.1	15.9	28.0								
EDC-05-25A-6	13.1	13.5	CL	41.3	54.4	4.3	0.0	0.0	0.0	44.8	26.3	31.3								
EDC-05-25A-7	13.5	13.9	(CL)s	24.9	48.5	26.6	0.0	0.0	0.0	31.8	9.7	25.7								
EDC-05-25A-8	13.9	14	CL	32.6	63.4	4.0	0.0	0.0	0.0	40.4	21.5	32.3								
EDC-05-25A-9	14.3	14.5	CL	35.7	58.5	5.9	0.0	0.0	0.0	46.6	24.9	33.2								
EDC-05-25A-10	15.5	15.9	s(CL)	29.4	32.9	37.7	0.0	0.0	0.0	29.9	14.9	25.8								
EDC-05-25A-11	15.9	17	(CL)s	31.7	42.6	25.7	0.0	0.0	0.0	33.7	18.1	27.4								
EDC-05-25A-12	17.5	18.1	CL	30.3	57.2	12.5	0.0	0.0	0.0	32.2	15.5	28.7								
EDC-05-25A-13	18.1	19.5	CL	42.3	49.7	8.0	0.0	0.0	0.0	38.1	21.6	33.3								
NP = Non-Plastic																				

TABLE #4

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-26 PROJECT Central Valley FEATURE San Luis Drains

DATE August 30, 2005
SHEET 3 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-26-1	21.4	21.6	CL	38.7	49.5	11.8	0.0	0.0	0.0	43.4	23.4	33.9								
EDC-05-26-2	24	24.1	(ML)s	20.8	57.6	21.6	0.0	0.0	0.0	NP	NP	30.2								
EDC-05-26-3	29.5	29.7	SP-SM	6.0	11.5	88.5	0.0	0.0	0.0	NP	NP	23.5								

NP = Non-Plastic

TABLE # 5

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-26A PROJECT Central Valley FEATURE San Luis Drains DATE August 30, 2005 SHEET 4 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-26A-1	1.8	2.5	CH	69.0	26.2	4.8	0.0	0.0	0.0	64.1	42.4	27.2								
EDC-05-26A-2	3.8	4.6	CH	64.4	33.0	2.6	0.0	0.0	0.0	52.4	33.3	34.1								
EDC-05-26A-3	5.1	5.5	CH	62.2	32.7	5.1	0.0	0.0	0.0	52.4	32.5	35.0								
EDC-05-26A-4*	8.3	9.2	CL	45.2	41.9	12.9	0.0	0.0	0.0	39.6	19.8	34.2								
EDC-05-26A-5	9.2	9.6	CH	70.9	26.2	2.9	0.0	0.0	0.0	62.5	44.7	36.3								
EDC-05-26A-6	10.1	10.4	CH	67.2	30.1	2.7	0.0	0.0	0.0	62.6	46.3	26.4								
EDC-05-26A-7	13.1	13.4	CH	74.6	24.2	1.2	0.0	0.0	0.0	72.9	51.4	32.0								
EDC-05-26A-8	18.5	18.9	CH	65.0	32.4	2.6	0.0	0.0	0.0	58.8	37.1	33.1								
EDC-05-26A-9	18.6	18.9	CL	27.9	61.3	10.8	0.0	0.0	0.0	24.7	7.2	23.1								

*Flocculation observed at 7 hour 15 minute and 25 hour 45 minute readings

TABLE #6

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-27 PROJECT Central Valley FEATURE San Luis Drains

DATE August 30, 2005
SHEET 5 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-27-1	23.7	23.9	SM	4.7	7.9	87.4	0.0	0.0	0.0	NP	NP	24.5								
EDC-05-27-2	26.8	27	CH	80.2	14.8	3.1	1.9	0.0	0.0	88.2	63.4	32.1								
EDC-05-27-3*	29.5	29.7	CH	65.0	22.2	2.5	10.3	0.0	0.0	71.1	47.5	31.9								

NP = Non-Plastic

*Flocculation observed at the 25h 45min reading

TABLE #7

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-27A PROJECT Central Valley FEATURE San Luis Drains DATE August 30, 2005 SHEET 6 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-27A-1	1	2.7	CH	58.7	35.2	6.1	0.0	0.0	0.0	52.4	33.1	22.9								
EDC-05-27A-2	4.6	7.1	CL	43.2	47.1	9.7	0.0	0.0	0.0	43.1	24.6	23.6								
EDC-05-27A-3	8	8.3	(CL)s	30.4	44.1	25.5	0.0	0.0	0.0	31.0	13.7	32.6								
EDC-05-27A-4	10.4	10.8	CL	38.1	57.7	3.6	0.6	0.0	0.0	48.0	24.8	37.4								
EDC-05-27A-5	12.1	13.1	CH	50.5	48.3	1.2	0.0	0.0	0.0	50.0	30.3	35.2								
EDC-05-27A-6	14.4	14.6	CL	31.4	56.4	12.2	0.0	0.0	0.0	35.5	1.9	34.9								
EDC-05-27A-7	15.9	17.1	SM	11.5	23.5	65.0	0.0	0.0	0.0	NP	NP	28.4								
EDC-05-27A-8	19.3	19.6	SM	14.0	15.6	70.4	0.0	0.0	0.0	NP	NP	32.8								
NP = Non-Plastic																				

TABLE #8

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-28 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 7 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-28-1	2.5	2.7	CL	60.7	36.6	2.7	0.0	0.0	0.0	44.6	26.2	24.5								
EDC-05-28-2	5.2	5.4	CL	59.5	33.4	7.1	0.0	0.0	0.0	47.1	26.7	35.4								
EDC-05-28-3	10.4	10.6	CH	70.6	27.4	2.0	0.0	0.0	0.0	65.6	43.7	35.0								
EDC-05-28-4	13.3	13.6	(CL)s	48.3	34.5	17.2	0.0	0.0	0.0	36.4	20.1	25.0								
EDC-05-28-5	16	16.2	SM	6.0	13.0	81.0	0.0	0.0	0.0	NP	NP	23.3								
EDC-05-28-6	18.5	18.7	CL	27.6	60.0	12.4	0.0	0.0	0.0	27.4	11.0	25.7								
EDC-05-28-7	21.3	21.5	CL	40.8	53.9	5.3	0.0	0.0	0.0	42.1	24.8	28.4								
EDC-05-28-8	24.1	24.3	SM	12.9	32.7	54.4	0.0	0.0	0.0	NP	NP	23.0								
EDC-05-28-9	26.8	26.9	SM	5.6	6.8	87.6	0.0	0.0	0.0	NP	NP	22.7								

NP= Non-Plastic

TABLE #9

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-28A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 8 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-28A-1	1.1	1.5	CL	56.0	38.6	5.4	0.0	0.0	0.0	49.2	32.6	18.4								
EDC-05-28A-2	3.4	3.9	CL	55.0	41.9	3.1	0.0	0.0	0.0	42.6	25.1	30.7								
EDC-05-28A-3	5.5	5.9	CH	62.0	32.6	5.4	0.0	0.0	0.0	51.0	31.8	36.5								
EDC-05-28A-4	7	7.2	CL	54.5	36.3	9.2	0.0	0.0	0.0	40.2	21.9	31.2								
EDC-05-28A-5	8.2	8.6	CL	52.7	42.0	5.3	0.0	0.0	0.0	42.8	23.5	32.9								
EDC-05-28A-6	8.8	9	(CL)s	59.2	25.6	15.2	0.0	0.0	0.0	43.0	26.2	30.1								
EDC-05-28A-7	9.4	9.7	CL	59.3	31.0	9.7	0.0	0.0	0.0	49.4	32.8	23.0								
EDC-05-28A-8	11.2	11.8	CL	47.2	40.9	11.9	0.0	0.0	0.0	39.2	22.2	30.1								
EDC-05-28A-9	11.9	12.2	CL	49.6	36.2	14.2	0.0	0.0	0.0	38.1	21.1	24.5								
EDC-05-28A-10	13	13.6	s(CL)	43.1	19.3	37.6	0.0	0.0	0.0	32.9	18.0	27.7								
EDC-05-28A-11	14.8	15.5	SM	4.6	15.0	80.4	0.0	0.0	0.0	NP	NP	22.8								
EDC-05-28A-12	16.7	17.2	(CL-ML)s	22.5	51.7	25.8	0.0	0.0	0.0	25.2	5.2	29.9								
EDC-05-28A-13	18.4	18.7	(CL)s	33.8	39.5	26.7	0.0	0.0	0.0	31.6	16.8	25.6								
EDC-05-28A-14	18.9	19.3	s(CL)	22.8	46.7	30.5	0.0	0.0	0.0	24.4	7.3	26.4								
EDC-05-28A-15	19.4	19.7	CL	37.0	57.8	5.2	0.0	0.0	0.0	37.9	19.2	31.9								
NP = Non-Plastic																				

TABLE #10

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-29 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 9 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-29-1	2.5	2.7	CL	61.5	33.4	5.1	0.0	0.0	0.0	49.1	30.0	29.9								
EDC-05-29-2	7.8	8	(ML)s	25.0	50.2	24.8	0.0	0.0	0.0	NP	NP	26.2								
EDC-05-29-3	10.6	10.8	CL	43.3	43.7	13.0	0.0	0.0	0.0	40.6	26.9	26.2								
EDC-05-29-4	13.3	13.5	CL	39.5	58.5	2.0	0.0	0.0	0.0	35.4	17.6	35.3								
EDC-05-29-5	15.3	16	CL	44.0	55.2	0.8	0.0	0.0	0.0	42.1	21.1	38.6								
EDC-05-29-6	18.5	18.7	CL	49.6	41.0	9.4	0.0	0.0	0.0	49.0	33.4	31.6								
EDC-05-29-7*	21.6	22.1	CL	47.4	42.6	10.0	0.0	0.0	0.0	38.2	21.5	31.5								
EDC-05-29-8	26.8	27	CH	78.9	20.7	0.4	0.0	0.0	0.0	69.7	49.1	36.9								

*Flocculation observed at the 25h 45m hydrometer reading

NP = Non-Plastic

TABLE #11

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-29A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 10 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-29A-1	1	1.5	CH	68.3	28.0	3.7	0.0	0.0	0.0	57.7	36.6	30.4								
EDC-05-29A-2	3.6	4	(CL)s	44.3	33.0	22.7	0.0	0.0	0.0	37.7	21.1	29.9								
EDC-05-29A-3	4.7	5.1	CH	65.7	29.7	4.6	0.0	0.0	0.0	53.8	32.0	38.5								
EDC-05-29A-4	5.1	6.1	(CL)s	43.8	38.7	17.5	0.0	0.0	0.0	35.2	18.7	31.0								
EDC-05-29A-5	6.3	7	CL	54.0	44.9	1.1	0.0	0.0	0.0	48.0	26.7	38.0								
EDC-05-29A-6	7.4	8.9	CL	31.8	54.6	13.6	0.0	0.0	0.0	28.5	11.0	28.0								
EDC-05-29A-7	9.1	9.5	CH	76.1	23.5	0.4	0.0	0.0	0.0	60.5	38.1	37.0								
EDC05-29A-8	10.7	11.7	(CL)s	43.3	39.7	17.0	0.0	0.0	0.0	40.3	26.0	23.6								
EDC05-29A-9	13	13.3	CL	37.4	59.6	3.0	0.0	0.0	0.0	39.4	22.3	33.3								
EDC-05-29A-10	13.9	14.2	CH	79.8	18.3	1.9	0.0	0.0	0.0	61.0	38.5	37.6								
EDC-05-29A-11	15.1	15.2	CL	37.1	61.0	1.9	0.0	0.0	0.0	44.5	23.0	35.9								
EDC-05-29A-12*	18.1	18.6	CL	47.4	50.7	1.9	0.0	0.0	0.0	49.6	27.0	38.3								
EDC-05-29A-13	18.9	19.4	CL	45.5	40.2	14.3	0.0	0.0	0.0	36.2	21.4	27.0								

*Flocculation observed at the 25 hour 45 minute hydrometer reading

TABLE #12

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-30 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 11 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-30-1	19.8	20	(ML)s	17.3	60.6	22.1	0.0	0.0	0.0	NP	NP	29.3								
EDC-05-30-2	22.5	22.7	s(ML)	20.1	31.4	48.5	0.0	0.0	0.0	NP	NP	26.2								
EDC-05-30-3	25.2	25.4	SM	14.8	22.4	62.8	0.0	0.0	0.0	NP	NP	24.3								
EDC-05-30-4	27.9	28.1	SM	8.2	6.0	85.8	0.0	0.0	0.0	NP	NP	24.2								

NP = Non-Plastic

TABLE #13

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-30A PROJECT Central Valley FEATURE San Luis Drains DATE August 30, 2005 SHEET 12 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-30A-1	1.9	2.5	CL	53.2	38.1	8.7	0.0	0.0	0.0	49.5	30.1	25.6								
EDC-05-30A-2	3.1	5.6	CL	45.5	45.8	8.7	0.0	0.0	0.0	38.4	18.9	28.6								
EDC-05-30A-3	7.1	7.4	s(CL)	30.8	26.7	42.5	0.0	0.0	0.0	31.2	16.4	25.8								
EDC-05-30A-4	7.4	8.8	(CL)s	31.7	42.2	26.1	0.0	0.0	0.0	30.2	13.1	28.6								
EDC-05-30A-5	10.1	11.8	CH	61.6	22.6	11.4	4.4	0.0	0.0	61.0	42.9	26.9								
EDC-05-30A-6	13.8	14.3	(CL)s	44.6	39.3	16.1	0.0	0.0	0.0	38.3	21.9	29.9								
EDC-05-30A-7	16.1	16.5	(ML)s	19.2	51.8	29.0	0.0	0.0	0.0	NP	NP	26.5								

NP = Non-Plastic

TABLE #14

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-31 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 13 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-31-1	2.5	2.7	CL	56.5	39.1	4.4	0.0	0.0	0.0	49.5	33.3	23.6								
EDC-05-31-2	4.9	5.1	CL	59.6	37.4	3.0	0.0	0.0	0.0	46.5	29.2	26.8								
EDC-05-31-3	10.4	10.8	CH	65.0	22.2	12.8	0.0	0.0	0.0	56.0	37.3	22.7								
EDC-05-31-4	13	13.1	(CL)s	23.7	48.1	28.2	0.0	0.0	0.0	30.4	12.0	23.2								
EDC-05-31-5	15.9	16.1	s(ML)	18.5	43.5	38.0	0.0	0.0	0.0	NP	NP	24.8								
EDC-05-31-6	18.7	18.9	(CL)s	40.5	33.5	26.0	0.0	0.0	0.0	33.0	17.9	21.9								
EDC-05-31-7	26.5	26.8	(CL)s	38.0	46.0	16.0	0.0	0.0	0.0	28.8	13.4	26.6								
EDC-05-31-8	29.5	29.7	SM	9.4	31.0	59.6	0.0	0.0	0.0	NP	NP	23.1								
NP = Non-Plastic																				

TABLE #15

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-32 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 14 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-32-1	1.8	1.9	(CL)s	40.6	32.3	27.1	0.0	0.0	0.0	34.5	19.0	19.5								
EDC-05-32-2	5.1	5.3	CH	72.0	24.2	3.8	0.0	0.0	0.0	58.4	36.2	38.3								
EDC-05-32-3	7.7	7.9	CH	63.6	30.5	5.9	0.0	0.0	0.0	54.5	35.2	31.6								
EDC-05-32-4	10.3	10.5	CL	48.1	42.8	9.1	0.0	0.0	0.0	41.7	23.4	35.2								
EDC-05-32-5	12.9	13.3	CH	58.2	35.9	5.7	0.2	0.0	0.0	55.4	33.5	35.1								
EDC-05-32-6	15.9	16.1	CL	24.4	71.6	4.0	0.0	0.0	0.0	34.1	12.0	36.6								
EDC-05-32-7	18.6	18.8	s(ML)	14.0	50.3	35.7	0.0	0.0	0.0	NP	NP	26.9								
EDC-05-32-8	21.3	21.5	(ML)s	24.2	52.6	23.2	0.0	0.0	0.0	NP	NP	28.4								
EDC-05-32-9	26.7	26.9	SM	14.9	30.9	54.2	0.0	0.0	0.0	NP	NP	23.2								
EDC-05-32-10	29.4	29.6	(CL)s	29.7	46.7	23.6	0.0	0.0	0.0	28.1	9.6	19.5								
NP = Non-Plastic																				

TABLE #16

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-32A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 15 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-32A-1	1.8	2.2	CL	56.9	38.2	4.9	0.0	0.0	0.0	46.2	30.6	23.2								
EDC-05-32A-2	3.8	4.2	(CL)s	46.7	36.5	16.8	0.0	0.0	0.0	40.4	25.1	29.2								
EDC-05-32A-3	4.9	5.2	CH	71.2	27.3	1.5	0.0	0.0	0.0	63.0	37.3	34.3								
EDC-05-32A-4	5.6	6	CL	42.8	45.4	11.8	0.0	0.0	0.0	39.6	22.3	35.8								
EDC-05-32A-5	6.5	6.7	CH	78.2	20.5	1.3	0.0	0.0	0.0	64.5	40.4	37.6								
EDC-05-32A-6	7.7	8.1	CL	39.6	52.8	7.6	0.0	0.0	0.0	38.6	23.6	27.9								
EDC-05-32A-7	9	9.4	CL	53.0	38.7	8.3	0.0	0.0	0.0	43.7	27.2	28.7								
EDC-05-32A-8	11.4	11.7	CL	36.0	53.5	10.5	0.0	0.0	0.0	34.6	17.4	28.6								
EDC-05-32A-9	13	13.6	CL	62.5	30.8	6.7	0.0	0.0	0.0	46.9	28.4	30.1								
EDC-05-32A-10	14.6	15.1	CL	47.1	50.6	2.3	0.0	0.0	0.0	44.1	24.4	33.6								
EDC-05-32A-11	16.4	16.8	CL	34.7	60.2	5.1	0.0	0.0	0.0	35.9	16.9	31.7								
EDC-05-32A-12	16.8	17.1	CL	43.8	53.8	2.4	0.0	0.0	0.0	38.7	18.7	38.8								
EDC-05-32A-13	17.6	17.8	s(CL)	27.7	35.3	37.0	0.0	0.0	0.0	27.7	10.1	29.0								
EDC-05-32A-14	17.8	18.2	CL	32.2	65.5	2.3	0.0	0.0	0.0	35.2	15.9	33.2								
EDC-05-32A-15	18.2	19.6	(ML)s	17.3	66.6	16.1	0.0	0.0	0.0	NP	NP	29.9								
NP = Non-Plastic																				

TABLE #17

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-33 PROJECT Central Valley FEATURE San Luis Drain

DATE August 30, 2005
SHEET 16 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-33-1	2.5	2.7	CH	63.3	31.1	5.6	0.0	0.0	0.0	50.4	33.4	25.6								
EDC-05-33-2	5.2	5.4	CH	65.7	28.6	5.7	0.0	0.0	0.0	57.7	39.7	30.0								
EDC-05-33-3	7.9	8.1	ML	20.8	67.3	11.9	0.0	0.0	0.0	27.8	4.9	29.8								
EDC-05-33-4	10.6	10.8	CH	68.4	30.9	0.7	0.0	0.0	0.0	55.1	36.5	33.8								
EDC-05-33-5	13.2	13.4	CL	34.3	61.7	4.0	0.0	0.0	0.0	39.2	22.4	35.1								
EDC-05-33-6	17.5	17.6	(CL)s	33.1	41.5	25.4	0.0	0.0	0.0	36.6	23.5	27.0								
EDC-05-33-7	22.4	22.6	CL	55.2	35.5	9.3	0.0	0.0	0.0	43.7	28.4	26.2								
EDC-05-33-8*	22.8	23	CH	65.0	33.0	2.0	0.0	0.0	0.0	60.0	41.9	34.5								
EDC-05-33-9*	26.8	27	CH	79.0	19.7	1.3	0.0	0.0	0.0	60.6	41.8	32.8								
EDC-05-33-10	29.5	29.7	SM	7.2	12.1	80.7	0.0	0.0	0.0	NP	NP	22.0								

*Flocculation observed at the 25 hour 45 minute hydrometer reading

NP = Non-Plastic

TABLE #18

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-33A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 17 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-33A-1	1	1.5	CH	65.7	28.5	5.8	0.0	0.0	0.0	55.6	35.5	22.2								
EDC-05-33A-2	2.35	2.4	s(CL)	46.6	23.3	30.1	0.0	0.0	0.0	25.9	12.4	16.4								
EDC-05-33A-3	2.7	3.7	(CL)s	42.3	39.9	17.8	0.0	0.0	0.0	38.3	21.9	32.8								
EDC-05-33A-4	6.1	6.6	CH	69.9	26.4	3.7	0.0	0.0	0.0	58.5	36.5	34.0								
EDC-05-33A-5	8.1	8.4	(ML)s	32.9	50.4	16.7	0.0	0.0	0.0	28.5	5.2	33.7								
EDC-05-33A-6	8.4	9	CL	23.1	68.4	8.5	0.0	0.0	0.0	32.4	11.9	33.1								
EDC-05-33A-7*	9	9.5	CL	43.8	48.5	7.7	0.0	0.0	0.0	43.0	22.5	40.2								
EDC-05-33A-8	9.7	1.1	CL	45.5	43.9	10.6	0.0	0.0	0.0	41.9	23.5	37.9								
EDC-05-33A-9	10.3	10.8	s(ML)	15.0	42.4	42.6	0.0	0.0	0.0	NP	NP	25.0								
EDC-05-33A-10	11.3	11.7	CH	67.7	28.3	4.0	0.0	0.0	0.0	59.6	38.1	31.2								
EDC-05-33A-11	13.1	13.2	CL	29.3	64.4	6.3	0.0	0.0	0.0	40.5	21.1	35.9								
EDC-05-33A-12	13.3	13.5	CH	28.4	66.1	5.5	0.0	0.0	0.0	69.7	52.0	32.0								
EDC-05-33A-13*	15	15.8	CL	61.9	35.7	2.4	0.0	0.0	0.0	48.7	27.8	37.0								
EDC-05-33A-14	18	18.4	s(CL)	29.7	27.8	42.5	0.0	0.0	0.0	30.0	16.8	21.3								
EDC-05-33A-15	18.7	19.1	s(ML)	17.5	38.4	44.1	0.0	0.0	0.0	NP	NP	23.1								

NP = Non-plastic

*Flocculation observed at the 25 hour 45 minute hydrometer reading

TABLE #19

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-34 PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 18 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
	DEPTH (Feet)			FINES										PLUS NO. 4						
SAMPLE NUMBER	From	To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-34-1	0.5	1	CH	67.0	27.6	5.4	0.0	0.0	0.0	50.7	33.5	14.7								
EDC-05-34-2*	2	2.5	CH	68.4	27.8	3.8	0.0	0.0	0.0	55.2	36.6	21.4								
EDC-05-34-3*	5	5.4	CL	46.5	50.1	3.4	0.0	0.0	0.0	45.2	28.6	28.5								
EDC-05-34-4*	7.9	8.1	(CH)s	51.5	30.1	18.4	0.0	0.0	0.0	50.7	37.7	25.6								
EDC-05-34-5	10.6	10.8	SM	13.3	33.6	53.1	0.0	0.0	0.0	NP	NP	20.5								
EDC-05-34-6*	13.1	13.3	CL	25.4	67.8	6.8	0.0	0.0	0.0	34.1	14.1	29.7								
EDC-05-34-7*	16	16.2	s(CL)	12.9	54.0	33.1	0.0	0.0	0.0	37.5	23.3	21.7								
EDC-05-34-8	18.5	18.7	(ML)s	19.2	57.1	23.7	0.0	0.0	0.0	NP	NP	31.2								
EDC-05-34-9	21.3	21.5	s(CL)	31.7	63.3	5.0	0.0	0.0	0.0	36.7	14.2	32.2								
EDC-05-34-10	23.2	23.4	CH	77.3	22.5	0.2	0.0	0.0	0.0	69.7	46.9	40.2								
EDC-05-34-11	23.4	24	CH	65.7	33.8	0.5	0.0	0.0	0.0	56.2	32.7	36.8								
EDC-05-34-12	29.5	29.7	CL	58.9	26.8	14.3	0.0	0.0	0.0	47.1	30.0	28.2								
NP = Non-Plastic																				
*Flocculation observed during the hydrometer readings																				

TABLE #20

SUMMARY OF PHYSICAL PROPERTIES TEST RESULTS

Hole Number EDC-05-34A PROJECT Central Valley FEATURE San Luis Drain DATE August 30, 2005 SHEET 19 OF 19

				PARTICLE - SIZE FRACTION IN PERCENT						CONSISTANCY LIMITS			SPECIFIC GRAVITY				IN-PLACE UNIT WT.		COMPACTION TEST	
				FINES										PLUS NO. 4						
SAMPLE NUMBER	DEPTH (Feet) From	DEPTH (Feet) To	LAB CLASSIFI-CATION	< .005	< .075	Sand #200 to #4	Gravel #4 to 3 inch	Cob-bles 3 inch to 5 inch	Over-size > 5 inch	Liquid Limit %	Plasti-city Index %	Field Mois-ture %	Minus No. 4	Bulk	Appar-ent	Absorp-tion %	Dry Unit Weight lbs/ft³	Water Con-tent %	Max. Dry Unit Wt lbs/ft³	Opti-mum Moist-ure %
EDC-05-34A-1*	1.9	2.2	CH	68.7	28.2	3.1	0.0	0.0	0.0	68.1	52.7	22.5								
EDC-05-34A-2*	3	3.5	CH	67.6	29.8	2.6	0.0	0.0	0.0	57.5	42.0	24.7								
EDC-05-34A-3*	5.7	6	CL	51.1	43.0	5.9	0.0	0.0	0.0	48.5	31.3	33.1								
EDC-05-34A-4	6.8	7.1	s(CL-ML)	21.4	41.8	36.8	0.0	0.0	0.0	23.1	6.4	18.9								
EDC-05-34A-5	8	8.4	(CL)s	40.5	35.6	23.9	0.0	0.0	0.0	45.2	31.5	23.4								
EDC-05-34A-6	10	10.5	(CL)s	30.0	43.0	27.0	0.0	0.0	0.0	33.3	19.6	19.6								
EDC-05-34A-7	11	11.5	s(ML)	16.4	39.3	44.3	0.0	0.0	0.0	NP	NP	21.9								
EDC-05-34A-8	11.9	12.1	CL	28.1	58.6	13.3	0.0	0.0	0.0	25.8	8.4	20.9								
EDC-05-34A-9	12.7	13.1	CL	22.3	64.3	13.4	0.0	0.0	0.0	32.9	11.7	28.3								
EDC-05-34A-10	13.6	14.2	CL	20.8	68.0	11.2	0.0	0.0	0.0	36.3	12.9	30.4								
EDC-05-34A-11	14.2	14.6	CL	42.8	46.0	11.2	0.0	0.0	0.0	40.5	21.4	32.5								
EDC-05-34A-12*	15.7	16.2	CH	54.0	32.4	13.6	0.0	0.0	0.0	53.1	34.1	34.5								
EDC-05-34A-13*	16.5	16.9	CH	35.8	56.6	7.6	0.0	0.0	0.0	55.8	33.4	27.9								
EDC-05-34A-14*	17.4	18	CH	72.6	26.5	0.9	0.0	0.0	0.0	61.9	42.3	37.5								
EDC-05-34A-15	18.4	19.2	ML	20.8	66.5	12.7	0.0	0.0	0.0	NP	NP	29.6								

*Flocculation observed during hydrometer readings

NP = Non-Plastic

Appendix H – Technical Review of Hydraulic Conductivity Data

D-8320
PRJ-13.00

MEMORANDUM

To: Geotechnical Engineering Group, D-8312
Attention: Robert Davis

From: Jeffrey A Farrar
Civil Engineer, Engineering Geology Group, D-8320

Subject: Technical Review of Field and Laboratory Permeability Testing – San Luis Evaporation Ponds – San Luis Drain Mitigations – Central Valley Project, California.

Testing Performed by: Jared Vauk & Greg Mongano MP-200, Tony Shanahan D-8340, Roger Burnett D 8560

INTRODUCTION

The purpose of this memorandum is to provide a review of field permeability (Hydraulic Conductivty, K) testing performed for investigation and design of evaporation ponds in the vicinity of the San Luis Drain. This review should identify any problems or errors with the field testing along with evaluation of the test procedures and validity of the measured permeability values. Any extensive laboratory permeability was also undertaken*[1,2,3]. This review will also comment on the comparison between field and laboratory values and the appropriate use of these values for design.

TESTING PROCEDURES

USBR Auger and Piezometer Testing

USBR auger hole and piezometer tests were performed in accordance with procedures in the USBR Drainage Manual[4]. The tests were performed by Ground Water and Drainage personnel. A significant amount of piezometer and auger tests were performed for the investigations for re-use areas. The tests were in general accordance with ASTM slug testing procedures [5,6]. In slug testing, either a slug or weight is dropped into the water column to elevate the water level in the well bore, or a slug of water is removed (bailed) to reduce the water level. The water level or equilibrium pressure is monitored with time as the aquifer recovers. For the re-use areas and for evaporation pond areas, the slug was removed and wells allowed to

* Numbers in brackets refer to entries in the bibliography

recover. The auger test uses and open hole but the Piezometer test, seals a 2-inch riser pipe above the test interval. Water level was monitored with a pressure transducer data logger.

The Auger Tests use derivations of K according to Maasland and Haskew considering a possible barrier at the base of the test interval. Since these are shallow tests intended for drainage studies, an un-confined aquifer is used. In the USBR piezometer test, K is derived using equations developed by Kirkham also assuming an un-confined aquifer. For the ASTM standards K derivations are made by methods proposed by Bouwer and Rice for un-confined aquifers, and the Hvorslev method for confined aquifers. I assume that the USBR methods are fairly equivalent and are modifications of Bouwer and Rice method. All of our tests were over-damped and we did not see oscillatory response of the aquifer as sometimes is found in very high permeability deposits.

Most of the tests performed by the drainage staff were piezometer tests and great care was taken in the conduct of the test. After the riser pipe was set into the soil, a 1 ft test zone was hand augered below the riser. The test zone was then brushed to re-expose soil structure, and then the test zone was filled with sand prior to the bail out. Soil logs were carefully kept.

Pneumatic Slug Testing

In an effort to reduce testing time and effort it was decided to try a new pneumatic slug test developed by Geoprobe for double tube direct push equipment. The double tube direct push equipment is capable of taking continuous soil samples in the inner tube. The double tube system is driven with a hydraulic breaker hammer mounted to the mast of our CME 45 drill. A schematic of the test system is shown on Figure 1. After the depth to the top of the test zone has been reached a thin walled sampler was used ahead of the double tube to clear the test zone. The test zone was then brushed and/or surged in an effort to develop the well. Brushing the interval was done only when the soil interval was a CH, CL, or CLs layer, ie and would not cave. If the soil sample interval was an sML or SM caving conditions did not allow the interval to be brushed. We typically surged every interval. Typically we surged the sandy zones 2 to 3 times before running any slug tests. Clayey intervals were surged 1 or twice depending on the rate of recovery. An 1 inch diameter riser pipe and slotted screen (0.01 in slot) was set into the outer casing (shoe) of the outer tube and sealed with double O-rings.

The pneumatic slug is from a pressure source and manifold on the top of the riser. A spike of pneumatic pressure is injected and the water level in the riser is depressed. A 10 psi (Full Scale Output) transducer is in the riser to monitor the pressure and time.

A Geoprobe has a detailed SOP [7] and the procedure was recently passed as an ASTM standard [8]. We found the test to be a only a little easier to do than the USBR piezometer test. We did have some difficulties with plastic fittings and leakage. The leakage problems were easily detected. The PVC fittings sometimes leaked and the seal around the transducer cable also gave us leakage problems.

The slug test analysis software STA Version 1.0 originally did not have the Bower and Rice equations for an un-confined aquifer, and Reclamation worked with Geoprobe Systems to modify that software. The analysis software does have a correction for small diameter well friction losses in high K formations. The software works well except if negative numbers get recorded. For each field test we ran three slug trials. This allowed us to check repeatability.

Laboratory Flexible Membrane Permeability

Seventy three laboratory flexible membrane permeability tests were performed in accordance with the procedure outlined in ASTM D 5084 "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. In this test the specimen is hand trimmed into a flexible rubber membrane. The ends of the specimens were roughened to expose soil structure. Porous stone endplates are then placed on the specimen ends. The specimen is placed in a chamber and an effective confining pressure of approximately 10 lb/in2 was applied with simultaneous increase in backpressure of the specimen. The backpressure is maintained in the specimen to drive any air bubbles into solution. Saturation is checked by B value test, and testing is performed when a B value of greater than 95 percent is reached. K testing is performed by falling head – rising tail water test. Numerous trials are made to assure K is stable. Both horizontal and vertical K was measured from the large 5.25 in diameter hollw-stem auger soil cores. The soil cores were taken in accordance with ASTM D 6151 [12]. The vertical permeability specimens were 4-inch diameter by 4-inches tall. The horizontal permeability specimens were 4 inches in diameter by 3 inches tall.

LOCATIONS OF TESTING

The Mid-Pacific Regional Office Geology group (MP-200) has detailed boring logs and performed a bulk of the field testing for the evaporation ponds. They selected samples for laboratory index properties. The locations of the explorations, drilling logs, and slug test data, and location maps will be reported at a later date. The locations of the testing will not be included in this memo. The MP region staff performed most of the pneumatic slug testing and reduced the data in the STA 1.0 software. TSC Groundwater & drainage staff performed the bulk of the piezometer testing. Spreadsheets of piezometer test data were provided by Roger Burnett.

DISCUSSION

Pnuematic Slug Test Data

Pneumatic slug test data are summarized on Tables 1, 2 and 3 for evaporation pond sites A,B, and C respectively. Along with the test data the soil type from either visual or laboratory test are given. The Unified Soil Classification System was used to classify the soil [10,11]. A wide variety of soils types were tested. Testing was often performed near the top of the ground water table. This caused problems in some areas near the ground water interface as some intervals

were dry or didn't recover.

The results are given for several trials and for the case of confined or un-confined aquifer. Generally, the trials were within an order of magnitude and showed good repeatability. Examples of the output from the data reduction software STA version 1.0 are shown in the Appendix. Examples are given for a range of permeabilites, from 10^{-3} to 10^{-5} cm/sec are shown. The output is from my runs with example MP region data files. The curve fitting and input data all appear to be in order. The assumption of "confined" or "unconfined aquifer" didn't not change the data usually only results in a 5 to 15% change in K. Use of an "Unconfined Aquifer" is more appropriate for these shallow tests. You will note that the examples in the Appendix do not agree with those on the summary table. The reason is, on my output runs, I used "Fully Penetrating" screen in my analysis. Analyses performed by MP region used the assumption of "Partial Penetration." Changing from partial to fully penetration results in an increase in K of 20 percent. Full penetration is where the aquifer layer is completely screened. Use of "Partial Penetration" is appropriate for our analyses.

For the soil types tested, the trend of the K data can be summarized by soil type as follows;

SM 10^{-3} cm/sec
ML to CL 10^{-4} cm/sec
CL to CH 10^{-5} cm/sec.

The complete set of data for all soil types appears to be about and order of magnitude higher than anticipated. There were only few trials were the permeability of clays could be as low as 10^{-6} cm/sec. For Fat Clay (CH) we would normally expect K of 10^{-6} to 10^{-7} cm/sec. The higher K was encountered in piezometer tests investigations for the re-use area. Burnett reported that the high K values in clay are likely caused by soil structure. Some of the clays out in the valley have a "Blocky" or "Fissured" structure as show on Figure 2. This fissuring is likely remnant desiccation cracking.

<u>USBR Piezometer Data</u>

Over 100 auger and piezometer tests were performed in investigations for the re-use areas. This data have not been documented in a technical memorandum. Burnett from D-8570 performed a comparison study in the Grasslands area between the pneumatic slug test and the USBR piezometer test. Side by sides tests were performed. The comparison data are shown on Table 4. The data also show extra information in the test zone in case layer continuity is somewhat off. The soil classifications are based on the USDA textural system.

Of the 8 comparisons, 6 tests fall within the same exponential order of magnitude. Many of the tests are very close to one another. The degree of agreement is surprising considering the difficulty running these tests. The only short coming of this comparison is the lack of data on light to heavy clays. Most of the comparison tests were in Silty Clays and Silty Clay Loams.

DRAFT

Laboratory Flexible Membrane Permeability Testing

Laboratory test results are summarized on Tables 5 and 6. The soil type was from trimmings "nearby" the test specimens, but not trimmings were not tested for each specimen. The shaded tests show horizontal and vertical test orientations for evaluation of anisotropy. Figure 3 shows a distribution of anisotropy ratio by area, and Figure 4 shows distribution of K_H and K_V by sample. There appears to be no consistent trend in anisotropy. In some areas there higher horizontal conductivities. Considering the blocky structure of the clay and it's possibly from desiccation cracking, we would not expect and strong anisotropy because desiccation cracks run both horizontally and vertically on level ground. For soils subject to desiccation cracking, the permeability will vary vertically.

Laboratory tests were performed with saline water taken from ground water taken in the vicinity of the San Luis Drain. Field tests were performed with tap water. It has been postulated that the salinity of the pore fluid has major effect on K, but it was estimated that K with tap water would be lower due to leaching of salts (especially stabilizing divalent cations) and resulting swelling of clays. However, the effect of tap water versus saline ground water was not systematically determined. A final series of three tests were performed using the treatment plant "source" water[3]. This water was high in salt content. The use of the source water lowered the permeability sometimes as much as one order of magnitude probably due to precipitation of salts.

Review of the lab data indicate that K values are two and sometimes three orders of magnitude lower that the field test data. Comparisons of the lab versus field data are shown on Table 7 and on Figure 5. On Figure 5 the range of results from the field tests are displayed by drill hole location. It is not unusual to see lab data one or two orders of magnitude lower than field tests, because of macroscopic structure effects such as secondary permeability through fissures. Even though the ends of the specimens were roughened, the application of confining pressure closes the fissures.

The laboratory data can reflect primary permeability and the possible properties of the soils when they are remolded. The lab data show that the clay and silty clay soils can be easily re-compacted to reach permeabilities of less than 10^{-7} cm/sec.

There is further bias in the laboratory data. The tube samples of cleaner sands were disturbed during transport. The sand had settled, with and separated by free water. It was not possible to test the sand zones, therefore the laboratory data are further biased to fine grained soils.

Possible Other Tests

Large scale aquifer tests provide even a better measure of aquifer properties. The large scale tests consist of pumping from a central well and monitoring draw down is surrounding wells.

The hydraulic properties of the vadose zone have not been characterized. Infiltrometer tests may

shed light on the vadose zone K. It is anticipated that the vadose zone soils should have similar or higher conductivities of the saturated soils due to desiccation cracking.

CONCLUSIONS

A review was made of the field and laboratory hydraulic conductivity testing performed for investigations of potential evaporation basins near the San Luis Drain in the Central Valley of California. Two field tests were used, the USBR piezometer test in conventional borings and new the pneumatic slug using direct push double tube system. Laboratory testing was performed on large diameter soil samples using the flexible membrane test method with falling head, rising tail water. Field data are up to 2 to 3 orders of magnitude higher than the laboratory data. The purpose of this memorandum is to evaluate the reliability of these results. The following conclusions can be made;

1.) The field data best represent the in-situ hydraulic conductivity (K). Typical K versus soil type are as follows;

SM 10^{-3} cm/sec
ML to CL 10^{-4} cm/sec
CL to CH 10^{-5} cm/sec.

2.) The pneumatic slug test data appears to be reliable and compared well with USBR piezometer tests. Both tests were conducted using accepted consensus standards practice. For both tests, appropriate measures were taken to assure collection of high quality conductivity data.

3.) The laboratory data are lower than the field data by two to three orders of magnitude. That finding is not new, normally the lab data run one to two orders of magnitude lower that field data. The postulated reason for the higher field K is due to secondary structure in the clayey and silty soils. This macroscopic permeability in the finer soils cannot be measured effectively in the laboratory.

4.) Another reason the laboratory conductivities are so low is the fact that the silty sand samples were disturbed and not tested. Therefore the lab data set appears even lower when compared to the field data.

5.) Laboratory data were collected to evaluate the anisotropy in hydraulic conductivity (K_V/K_h). In some areas there appear to be higher horizontal conductivity, while in others a difference is not apparent. If desiccation cracking is the chief structure governing K, we would expect much anisotropy, because the cracks proprogate both vertically and horizontally.

6.) Laboratory data indicate the clayey and silty soils can be easily re-compacted to achieve low conductivity.

Cc: Turlington D-8320, Vauk & Mongano MP-200, Burnett D-8570, Torres D-8312

Bibliography

[1] Strauss, T, memorandum to Bob Davis, Geotechnical Engineering Group 2, D 8312, "Flexible Wall Permeability Test Results – San Luis Evaporation Pond Study, San Luis Drainage Project Study, Central Valley Project, California," Earth Sciences and Research Branch Laboratory Referral Number 8340-05-16, Bureau of Reclamation, Technical Service Center, Denver, Colorado, July 21, 2005

[2] Strauss, T, memorandum to Bob Davis, Geotechnical Engineering Group 2, D 8312, "Flexible Wall Permeability Test Results – San Luis Evaporation Pond Study, San Luis Drainage Project Study, Central Valley Project, Westlands, California," Earth Sciences and Research Branch Laboratory Referral Number 8340-05-28, Bureau of Reclamation, Technical Service Center, Denver, Colorado, December 6, 2005

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[4] Drainage Manual, Section 3.3 "Piezometer Test for Hydraulic Conductivity," Revised Re-Print 1993, U S Department of The Interior, Bureau of Reclamation, Denver.

[5] "D 4044 - Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Augers Volume 04.08, Construction, Soil and Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

[6] "D 5912 - Standard Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Over-damped Well Response to Instantaneous Change in Head (Slug)," Volume 04.09, Construction, Soil and Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

[7] "Geoprobe Pneumatic Slug Test Kit," Standard Operating Procedure, Technical Bulletin No. 19344, Geoprobe Systems, Salina, KS, February 2002.

[8] "D7242-06 Standard Practice for Performing Pneumatic Slug (Instantaneous Change in Head) Tests to Determine the Hydraulic Properties of Aquifers with Direct Push Ground Water Samplers," Volume 04.08, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

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[10] ASTM D 2487 “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System),” Volume 04.08, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

[11] ASTM D 2488 “Standard Practice for description and Classification of Soils (Visual Manual Procedure),” Volume 04.08, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

[12] ASTM D 6151 “Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling,” Volume 04.09, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

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Table 1 - Summary of Pneumatic Slug Test Results – Evaporation Pond Site B

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-25	(CL)s	9.0-10.0	7.1	**6.299E-04**	6.550E-04	6.124E-04	6.223E-04	**7.887E-04**	8.202E-04	7.668E-04	7.792E-04	
ESS-05-25	s(CL)	12.0-13.0	7.1	**5.772E-03**	5.219E-03	5.710E-03	6.387E-03	**6.496E-03**	5.873E-03	6.426E-03	7.188E-03	
ESS-05-25	CL	18.0-19.0	7.1	**7.869E-03**	7.809E-03	7.929E-03	NA	**8.494E-03**	8.429E-03	8.558E-03	NA	0.1 sCL layer
ESS-05-26	CL	8.3-9.3	4.5	**3.266E-04**	3.266E-04	3.266E-04	NA	**1.005E-04**	9.388E-05	1.071E-04	NA	fully penetrating
ESS-05-26	CH	12.0-13.0	4.5	**NO DATA**	no water recovery in 3 hours			**NO DATA**				no water in 3 hrs
ESS-05-27	CH	11.0-12.0	7.3	**6.334E-05**	6.470E-05	6.198E-05	NA	**8.321E-05**	8.515E-05	8.127E-05	NA	
ESS-05-27	s(CL)	14.4-15.4	7.6	**3.537E-03**	3.695E-03	3.370E-03	3.545E-03	**4.352E-03**	4.547E-03	4.147E-03	4.362E-03	
ESS-05-27	s(ML)	17.0-18.0	7.6	**6.506E-04**	6.082E-04	6.718E-04	6.718E-04	**7.462E-04**	7.187E-04	7.939E-04	7.259E-04	
ESS-05-28	CL	10.0-11.0	4.2	**5.149E-04**	3.106E-04	7.192E-04	NA	**6.385E-04**	3.851E-04	8.918E-04	NA	
ESS-05-28	s(CL)	13.5-14.5	4.2	**1.819E-04**	1.710E-04	1.927E-04	NA	**1.664E-04**	1.088E-04	2.240E-04	NA	
ESS-05-28	s(ML)	15.6-16.6	4.2	**1.156E-03**	1.186E-03	1.203E-03	1.079E-03	**1.289E-03**	1.323E-03	1.342E-03	1.203E-03	
ESS-05-29	(CL)s	5.1-6.1	3.6	**8.577E-04**	7.477E-04	9.222E-04	9.031E-04	**5.947E-04**	5.184E-04	6.394E-04	6.262E-04	fully penetrating
ESS-05-29	s(ML)	8.5-9.5	3.6	**3.298E-04**	3.182E-04	3.414E-04	NA	**3.459E-04**	3.337E-04	3.581E-04	NA	
ESS-05-29	CL	13.5-14.5	3.6	**2.380E-04**	3.235E-04	1.277E-04	2.627E-04	**2.801E-04**	3.808E-04	1.503E-04	3.091E-04	
ESS-05-30	CL	11.0-12.0	5.5	**2.385E-03**	2.367E-03	2.403E-03	NA	**2.877E-03**	2.855E-03	2.898E-03	NA	
ESS-05-30	(ML)s	18.0-19.0	5.6	**1.508E-02**	1.499E-02	1.539E-02	1.485E-02	**1.430E-02**	1.460E-02	1.422E-02	1.409E-02	

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HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-31	(CL)s	12.0-13.0	5.0	**7.571E-03**	7.452E-03	7.706E-03	7.556E-03	**9.092E-03**	8.897E-03	9.279E-03	9.099E-03	
ESS-05-31	(CL)s	14.0-15.0	5.0	**4.660E-03**	4.390E-03	5.136E-03	4.453E-03	**5.399E-03**	5.086E-03	5.951E-03	5.159E-03	
ESS-05-31	(CL)s	17.0-18.0	5.0	**2.059E-03**	2.341E-03	2.368E-03	1.468E-03	**2.203E-03**	2.504E-03	2.534E-03	1.571E-03	
ESS-05-32	(CL)s	8.0-9.0	4.7	**3.351E-05**	4.907E-05	2.685E-05	2.461E-05	**4.378E-05**	6.412E-05	3.508E-05	3.215E-05	
ESS-05-32	(ML)s	11.0-12.0	4.7	**6.116E-04**	1.662E-04	1.795E-04	1.489E-03	**1.991E-04**	2.007E-04	2.168E-04	1.798E-04	
ESS-05-33	s(ML)	10.0-11.0	8.9	**2.033E-04**	2.087E-04	1.978E-04	NA	**2.854E-04**	2.777E-04	2.930E-04	NA	0.7 s(ML) layer, near the top of water table
ESS-05-33	CL	11.0-12.0	9.1	**2.501E-04**	2.150E-04	3.295E-04	2.058E-04	**3.302E-04**	2.838E-04	4.350E-04	2.717E-04	
ESS-05-33	(ML)s	13.2-14.2	9.1	**5.665E-04**	5.417E-04	5.547E-04	6.030E-04	**6.249E-04**	5.976E-04	6.119E-04	6.652E-04	
ESS-05-33	CH	15.0-16.0	8.9	**4.502E-05**	4.802E-05	4.202E-05	NA	**5.538E-05**	5.907E-05	5.168E-05	NA	

Table 2 Summary of Pneumatic Slug Tests - Evaporation Pond Site A

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-01	SM	7.1-8.1	3.2	**3.094E-04**	1.303E-04	4.035E-04	3.945E-04	**3.432E-04**	1.446E-04	4.475E-04	4.376E-04	

Table 3 Summary Of Pnuematic Slug Tests - Evaporation Ponds Site C

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-04	s(ML)	10.0-11.0	8.5	**4.351E-04**	4.880E-04	3.479E-04	4.693E-04	**5.539E-04**	6.213E-04	4.430E-04	5.975E-04	
ESS-05-04	CL	17.0-18.0	8.5	**1.617E-04**	1.588E-04	1.646E-04	NA	**1.844E-04**	1.810E-04	1.877E-04	NA	
ESS-05-05	(CL)s	8.8-9.8	5.8	**1.314E-04**	1.513E-04	1.336E-04	1.093E-04	**1.656E-04**	1.906E-04	1.684E-04	1.377E-04	
ESS-05-06	(CL)s	13.6-14.6	10.1	**4.679E-04**	6.391E-04	2.967E-04	NA	**1.652E-04**	2.256E-04	1.048E-04	NA	
ESS-05-06	SM	17.5-18.5	10.1	**1.876E-04**	1.729E-04	2.022E-04	NA	**2.127E-04**	1.960E-04	2.293E-04	NA	

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Table 4 - Comparison of Pnuematic and USBR Piezometer Tests

Pnuematic Slug Tests					USBR Piezometer Test			
Hole Number	USDA Soil Texture	Top Interval ft	Bottom Interval ft	Hydraulic Conductivity cm/sec	USDA Soil Texture	Top Interval ft	Bottom Interval ft	Hydraulic Conductivity cm/sec
RSS05-1a	VFSL	10.8	11.8	8.5E-04	SiC	9.5	10	2.0E-03
RSS05-1b	FSL	13.8	14.8	2.9E-04				
RSS05-1C	FSL	13.8	14.8	9.1E-04				
RSS05-3-1a	VFSL	8.3	9.3	6.0E-03	VFSL	8.5	9.1	7.5E-03
RSS05-3b	SiC	15	16	3.1E-04	SiC	15.5	16	1.3E-04
RSS05-4b	L	9	10	NoTest	L	9	9.5	5.5E-04
RSS05-7a&b	LS	12	13	1.5E-03	SiC	7	7.5	1.2E-03
RSS05-7d	VFSL	24	25					
RSS05-8b	FSL	11.7	12.7	5.0E-03				
RSS05-8b1	L	14	15	3.6E-04	L	14	14.6	6.6E-03
RSS09c	SiC	10.5	11.5		SiC	11	11.5	4.3E-04
ESS02D&H	Clay	11.1	12.1	1.1E-03				
ESS02b&c	SiCL	10	11	3.7E-04	SiCL	10	10.5	6.1E-04
ESS05-3	SiCL	7.9	8.9	2.0E-03	SiCL	8	8.5	3.0E-03

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Table 5 Laboratory Flexible Membrane Test Results - #1 -2005

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-03-15	2.8-5.7	5.1-5.7	CL	2.15E-07	2.36E-07	2.27E-07	6	Vertical
EDC-03-15	8.6-11.5	9.1-9.6	CL	1.18E-05	1.48E-05	1.31E-05	7	Vertical
EDC-03-16	6.5-9.4	7.1-7.5	ML	4.09E-06	7.33E-06	**6.39E-06**	6	**Horizontal**
EDC-03-16	6.5-9.4	7.5-7.9	ML	1.73E-07	1.91E-07	1.79E-07	4	Vertical
EDC-03-16	6.5-9.4	7.9-8.4	ML	7.60E-07	8.67E-07	8.41E-07	6	Vertical
EDC-03-16	6.5-9.4	8.4-8.9	ML	1.04E-05	1.08E-05	**1.06E-05**	8	**Horizontal**
EDC-03-15	11.5-14.3	12.6-13.1	ML	2.58E-06	5.34E-06	4.45E-06	6	Vertical
EDC-03-15	17.1-20.0	18.0-18.6	CL	5.76E-08	9.25E-08	7.20E-08	4	Vertical
EDC-03-15	17.1-20.0	18.6-19.0	CL	1.20E-06	1.33E-06	**1.25E-06**	5	**Horizontal**
EDC-03-15	22.9-25.8	23.1-23.6	CH	9.27E-09	1.11E-08	2.65E-08	7	Vertical
EDC-03-15	22.9-25.8	23.6-24.2	CH	1.70E-08	5.13E-08	2.66E-08	7	Horizontal
EDC-03-16	3.60-6.50	4.5-5.0	CL	3.91E-07	4.49E-07	4.52E-07	7	Horizontal
EDC-03-16	15.1-18.0	16.3-16.8	SM	3.06E-05	6.68E-05	5.14E-05	12	Vertical
EDC-03-16	20.9-23.8	21.0-21.5	CL	5.25E-06	5.42E-06	5.32E-06	6	Horizontal
EDC-03-17	3.5-6.3	4.8-5.3	CL	3.40E-06	3.77E-06	3.65E-06	5	Vertical
EDC-03-17	9.3-12.2	10.3-10.7	CL	9.31E-07	1.01E-06	9.64E-07	6	Horizontal

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-03-17	9.3-12.2	10.7-11.2	CL	1.42E-06	5.69E-06	**4.62E-06**	4	**Vertical**
EDC-03-17	20.7-23.6	21.0-21.5	CL	5.27E-07	5.54E-07	5.40E-07	6	Vertical
EDC-03-17	29.4-32.5	26.9-27.3	?	3.03E-05	1.45E-04	**1.22E-04**	8	**Horizontal**
EDC-03-17	26.5-29.4	27.3-27.8	ML	8.85E-06	1.04E-05	9.42E-06	7	Vertical
EDC-03-18	3.5-6.4	4.8-5.3	CL	5.81E-08	8.80E-08	7.81E-08	7	Vertical
EDC-03-18	6.4-9.3	6.9-7.4	CL-ML	1.75E-06	7.64E-06	**5.47E-06**	7	**Horizontal**
EDC-03-18	6.4-9.3	7.4-7.9	CL-ML	3.99E-07	5.43E-07	4.31E-07	6	Vertical
EDC-03-18	20.9-23.8	21.8-22.3	CL	7.09E-07	7.95E-07	7.50E-07	7	Vertical
EDC-03-18	23.8-26.7	24.9-25.4	ML	1.24E-06	1.44E-06	1.35E-06	5	Vertical
EDC-03-18	23.8-26.7	24.5-24.9	ML	6.10E-05	1.04E-04	**7.12E-05**	6	**Horizontal**
EDC-04-21	4.3-7.2	4.8-5.3	CL	2.50E-07	2.88E-07	2.66E-07	6	Vertical
EDC-04-21	12.5-15.9	13.9-14.4	CL	1.76E-07	2.30E-07	1.95E-07	6	Vertical
EDC-04-22	3.9-6.9	5.2-5.7	CH	8.05E-08	1.21E-07	9.53E-08	6	Vertical
EDC-04-22	6.9-9.9	7.6-8.0	CH	1.07E-07	1.19E-07	1.11E-07	6	Horizontal
EDC-04-22	6.9-9.9	8.0-8.5	CH	5.12E-07	5.78E-07	5.36E-07	6	Vertical
EDC-04-22	18.9-21.9	19.4-19.9	SM	2.17E-04	2.68E-04	2.41E-04	6	Horizontal
EDC-04-22	18.9-21.9	19.9-20.4	SM	2.14E-04	2.31E-04	2.22E-04	6	Vertical

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-04-24	4.7-7.7	5.3-5.7	CH	2.58E-08	5.62E-08	3.72E-08	4	Horizontal
EDC-04-24	4.7-7.7	5.7-6.2	CH	2.20E-06	4.24E-06	**2.91E-06**	6	**Vertical**
EDC-04-24	13.7-16.7	14.8-15.3	ML	5.68E-06	7.40E-06	**6.42E-06**	10	**Vertical**
EDC-04-24	13.7-16.7	15.3-15.7	ML	1.82E-06	2.59E-06	2.13E-06	6	Horizontal
EDC-04-24	16.7-19.7	17.6-18.1	ML	5.40E-09	5.30E-08	**1.62E-08**	4	**Vertical**
EDC-04-24	16.7-19.7	18.1-18.5	ML	4.60E-09	1.17E-08	6.17E-09	4	Horizontal

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Table 6 - Summary of Laboratory Flexible Membrane Permeability Tests # 2 - 2005-2006

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-25	5.4-7.9	5.6-6.1	CL	1.3E-06	8.5E-06	6.9E-06	Vertical
EDC-05-25	5.4-7.9	6.1-6.4	CL	5.6E-05	7.9E-05	6.8E-05	Horizontal
EDC-05-25	8.1-10.6	8.7-9.2	CL	6.8E-07	8.4E-07	7.7E-07	Vertical
EDC-05-25	8.1-10.6	8.3-8.7	CL	1.2E-06	1.2E-06	1.2E-06	**Horizontal**
EDC-05-25	18.9-21.4	19.1-19.6	ML	1.7E-07	2.5E-07	2.2E-07	Horizontal
EDC-05-26	8.2-10.5	9.2-9.7	CH	9.3E-07	1.9E-06	1.3E-06	**Vertical**
EDC-05-26	8.2-10.5	9.7-10.1	CH	5.0E-07	6.0E-07	5.5E-07	Horizontal
EDC-05-26	16.2-18.7	17.1-17.6	CL	1.4E-06	1.7E-06	1.6E-06	Vertical
EDC-05-26	16.2-18.7	17.6-18.0	CL	9.7E-06	1.7E-05	1.4E-05	**Horizontal**
EDC-05-27	5.4-7.9	6.1-6.5	CL	1.6E-06	1.7E-06	1.7E-06	Horizontal
EDC-05-27	5.4-7.9	6.5-7.0	CL	5.1E-05	5.7E-05	5.5E-05	**Vertical**
EDC-05-27	11.0-13.1	11.1-11.5	MH	9.1E-07	1.0E-06	9.8E-07	Horizontal
EDC-05-27	11.0-13.1	11.5-12.0	MH	5.8E-07	6.8E-07	6.2E-07	Vertical
EDC-05-28	2.7-5.2	4.1-4.6	MH	1.5E-07	2.8E-07	2.0E-07	Vertical
EDC-05-28	2.7-5.2	4.6-5.0	MH	2.2E-07	4.1E-07	3.4E-07	Horizontal

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-28	5.4-7.9	6.1-6.6	CL	2.0E-07	3.1E-07	2.4E-07	Vertical
EDC-05-28	5.4-7.9	6.6-7.0	CL	1.3E-06	1.4E-06	1.4E-06	**Horizontal**
EDC-05-28	10.8-13.3	12.1-12.6	(CL)s	1.5E-06	1.7E-06	1.6E-06	Vertical
EDC-05-28	10.8-13.3	12.6-13.3	(CL)s	1.9E-05	2.8E-05	2.5E-05	Horizontal
EDC-05-29	2.7-5.2	3.0-3.5	CL	3.5E-07	4.0E-07	3.7E-07	Vertical
EDC-05-29	5.4-7.8	6.0-6.4	CL	3.6E-06	3.8E-06	3.7E-06	**Horizontal**
EDC-05-30	11.9-13.7	13.3-13.7	CL	1.9E-06	2.1E-06	2.0E-06	Horizontal
EDC-05-30	11.9-13.7	12.8-13.3	CL	1.3E-06	1.5E-06	1.4E-06	Vertical
EDC-05-30	17.3-19.8	17.8-18.2	ML	3.8E-06	3.5E-05	2.7E-05	Vertical
EDC-05-30	17.3-19.8	18.2-18.6	ML	4.8E-06	9.2E-05	7.4E-05	Horizontal
EDC-05-31	8.1-10.6	8.2-8.7	CL	1.2E-07	1.8E-07	1.5E-07	Vertical
EDC-05-31	8.1-10.6	8.7-9.1	CL	5.1E-07	9.0E-07	6.3E-07	Horizontal
EDC-05-31	10.8-13.1	12.0-12.4	S(CL)	3.5E-06	5.3E-06	3.9E-06	Horizontal
EDC-05-31	10.8-13.1	12.4-12.9	S(CL)	3.1E-06	3.8E-06	3.3E-06	Vertical
EDC-05-33	5.4-7.8	5.6-6.0	CH	3.4E-06	3.6E-06	3.6E-06	Horizontal
EDC-05-33	5.4-7.8	6.0-6.5	CH	1.4E-05	2.5E-05	1.8E-05	Vertical
EDC-05-33	10.8-13.2	12.5-13.0	CH	5.4E-07	5.7E-07	5.5E-07	Vertical

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-33	10.8-13.2	12.5-13.0	CH	4.0E-06	5.0E-06	4.6E-06	**Horizontal**
EDC-05-33	13.5-16.0	15.4-15.8	MH	5.0E-06	1.5E-05	1.3E-05	Horizontal

DRAFT

Table 7 - Comparison of Pneumatic Slug and Laboratory Flexible Membrane Hydraulic Conductivities.

P Slug Tests				Laboratory Flexible Membrane Test			
Drill Hole	Soil Type	Depth		Drill Hole	Soil Type	Depth	K
ESS-05-25	(CL)s		6.3E-04				
ESS-05-25	s(CL)	12.0-13.0	5.8E-03	EDC-05-25	CL	8.3-8.7	1.2E-06
ESS-05-25	CL	18.0-19.0	7.9E-03	EDC-05-25	ML	19.1-19.6	2.2E-07
ESS-05-26	CL	8.3-9.3	3.3E-04	EDC-05-26	CL	9.7-10.1	1.4E-05
ESS-05-27	CH	11.0-12.0	6.3E-05	EDC-05-27	MH	11.1-11.5	9.8E-07
ESS-05-27	s(CL)	14.4-15.4	3.5E-03				
ESS-05-27	s(ML)	17.0-18.0	6.5E-04				
ESS-05-28	CL	10.0-11.0	5.1E-04				
ESS-05-28	s(CL)	13.5-14.5	1.8E-04	EDC-05-28	(CL)s	12.6-13.3	2.5E-05
ESS-05-28	s(ML)	15.6-16.6	1.2E-03				
ESS-05-29	(CL)s	5.1-6.1	8.6E-04	EDC-05-29	CL	6.0-6.4	3.7E-06
ESS-05-29	s(ML)	8.5-9.5	3.3E-04				
ESS-05-29	CL	13.5-14.5	2.4E-04				
ESS-05-30	CL	11.0-12.0	2.4E-03	EDC-05-30	CL	13.3-13.7	2.0E-06
ESS-05-30	(ML)s	18.0-19.0	1.5E-02				
ESS-05-31	(CL)s	12.0-13.0	7.6E-03	EDC-05-31	s(CL)	12.0-12.4	3.9E-06
ESS-05-31	(CL)s	14.0-15.0	4.7E-03				
ESS-05-31	(CL)s	17.0-18.0	2.1E-03				
ESS-05-33	s(ML)	10.0-11.0	2.0E-04				
ESS-05-33	CL	11.0-12.0	2.5E-04	EDC-05-33	CH	12.5-13.0	4.6E-06

DRAFT

P Slug Tests				Laboratory Flexible Membrane Test			
Drill Hole	Soil Type	Depth		Drill Hole	Soil Type	Depth	K
ESS-05-33	(ML)s	13.2-14.2	5.7E-04				
ESS-05-33	CH	15.0-16.0	4.5E-05				

DRAFT

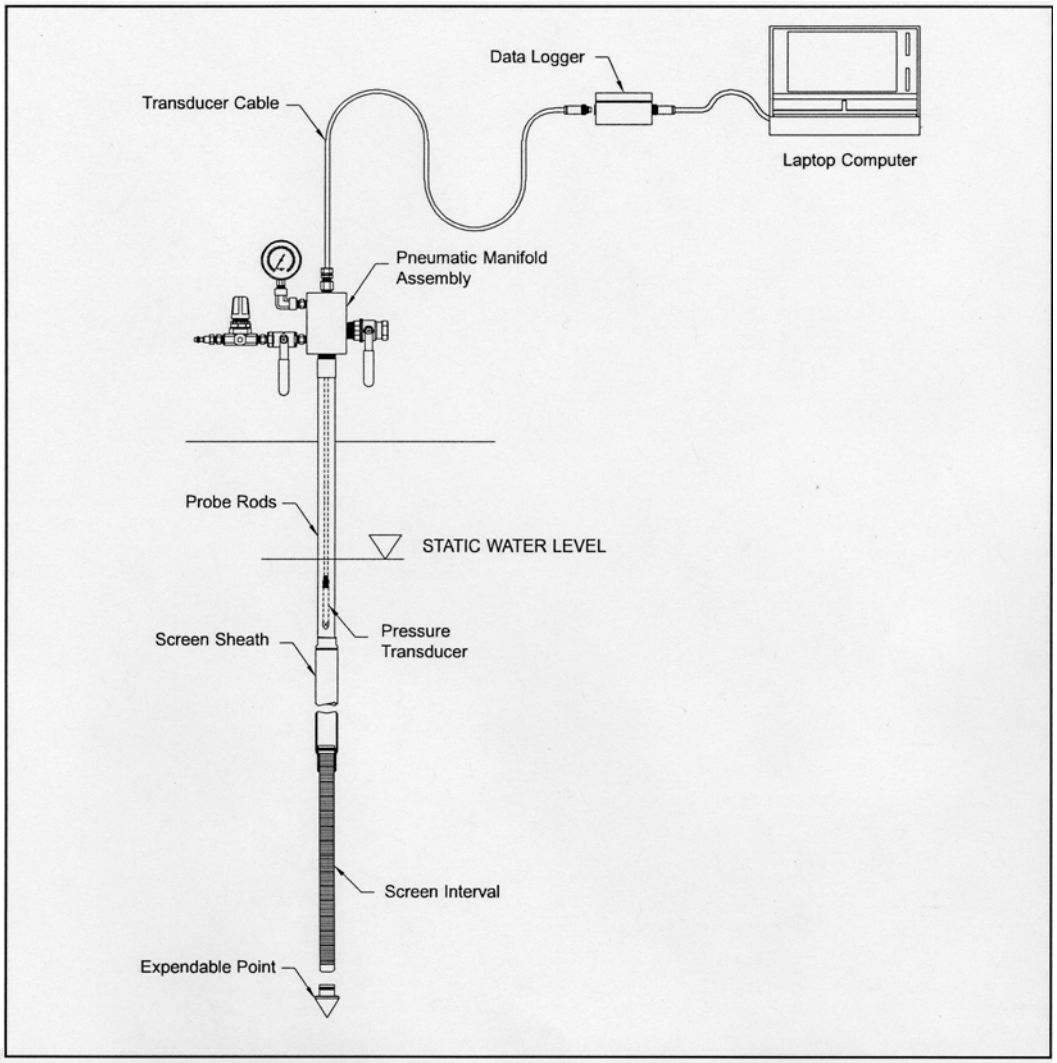


Figure 1 San Luis Drain
Evaporation Pond and Reuse Areas

Geoprobe Pneumatic Slug Test Diagram

Schematic depicts all the parts to the Geoprobe Pneumatic Slug Test. A field computer is connected to a data logger. A transducer connected to the data logger is lowered down the pneumatic manifold assembly. The transducer is lowered below static water level inside square threaded PVC rods. A PVC slotted screen with a one foot interval is located at the bottom of the PVC rods.

Figure 2 - Photograph of blocky soil structure in clayey soils.

Figure 3 Anisotropy ratios by area.

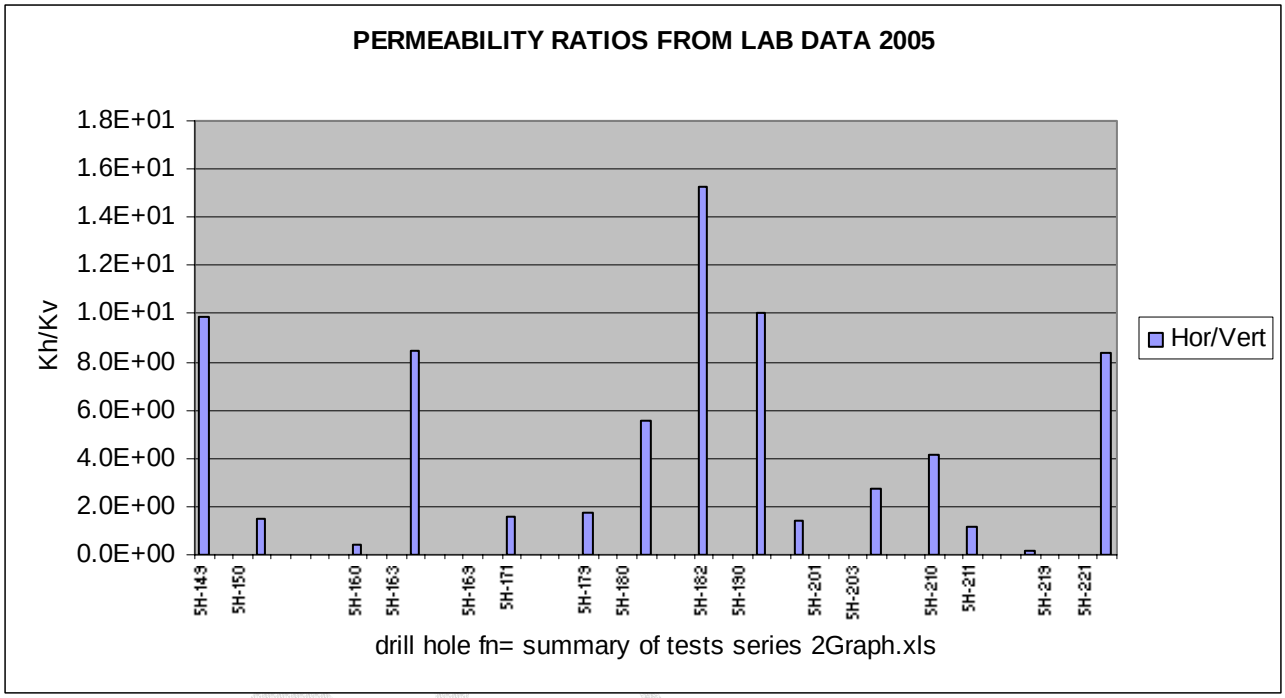


Figure 4 Anisotropy ratios by test

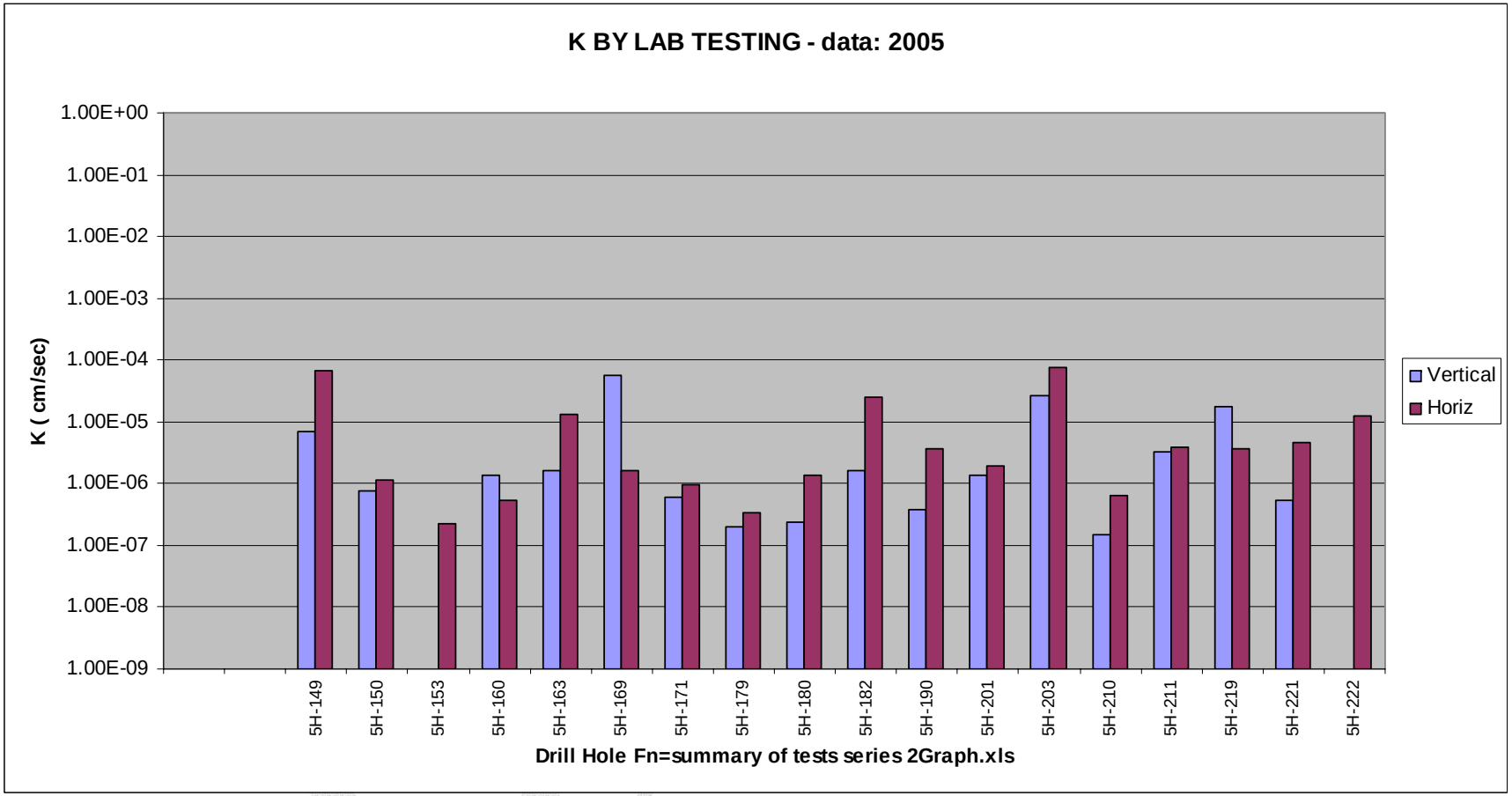
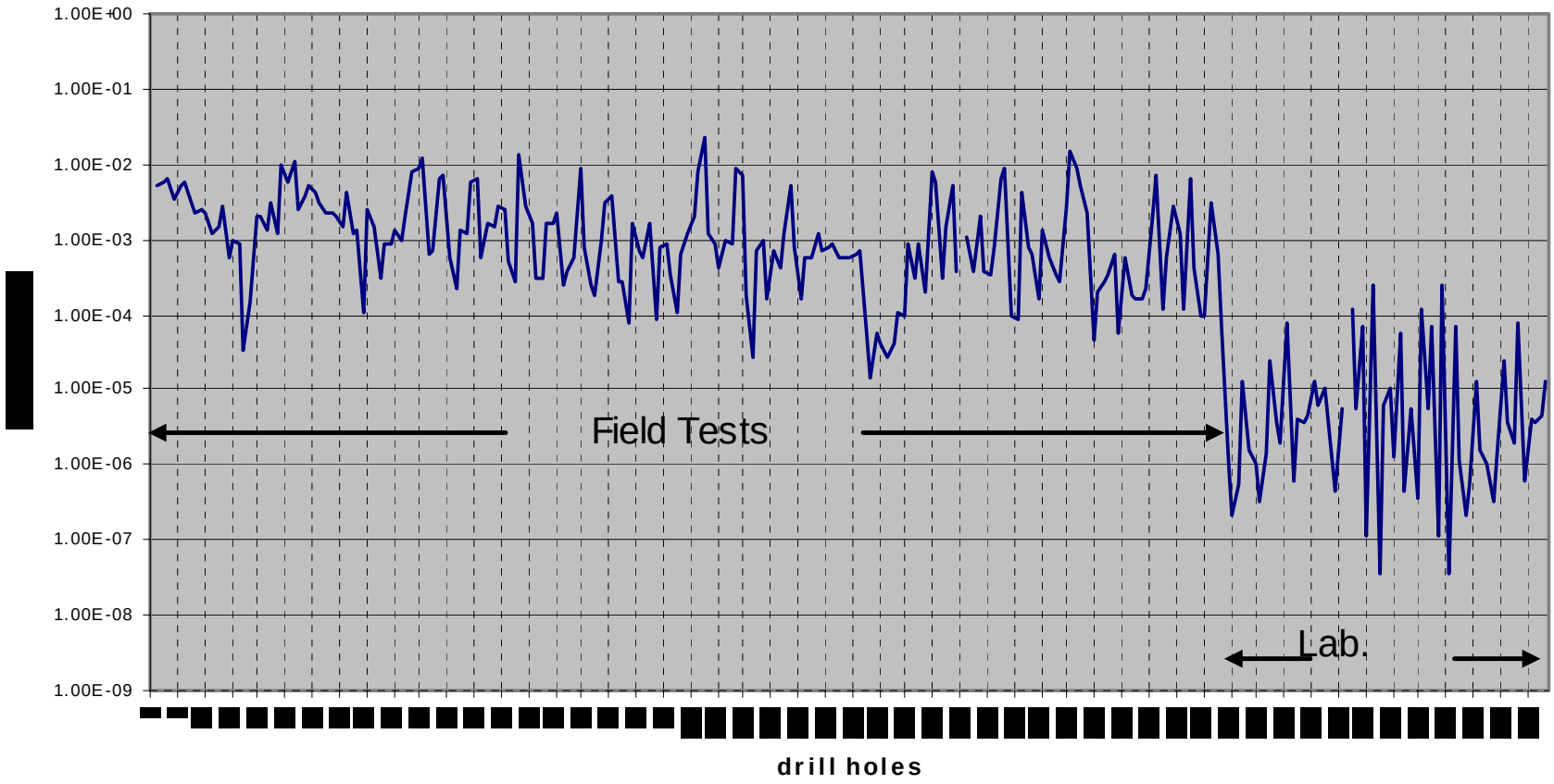


Figure 5 Comparison of field and laboratory data

Summary of GOOD HC Tests on San Luis Unit Drainwater



Appendix A

Examples of the Pneumatic Slug Test Software Output

STA version 1.0

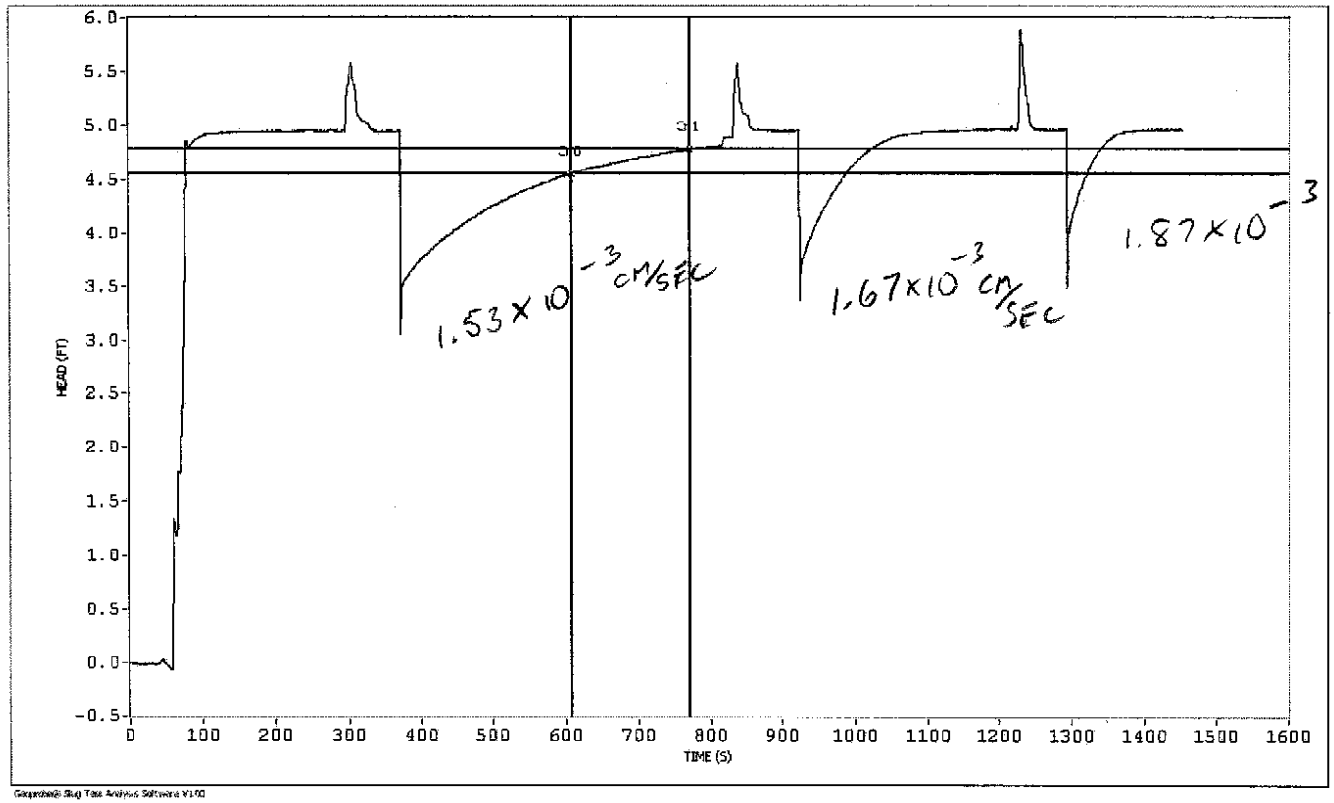
ESS05-25A 9.0 to 10.0 ft 10^{-4} cm/sec

ESS05-25B 12.0-13.0 ft 10^{-3} cm/sec

ESS05-28A 13.5-14.5 ft 10^{-5} cm/sec

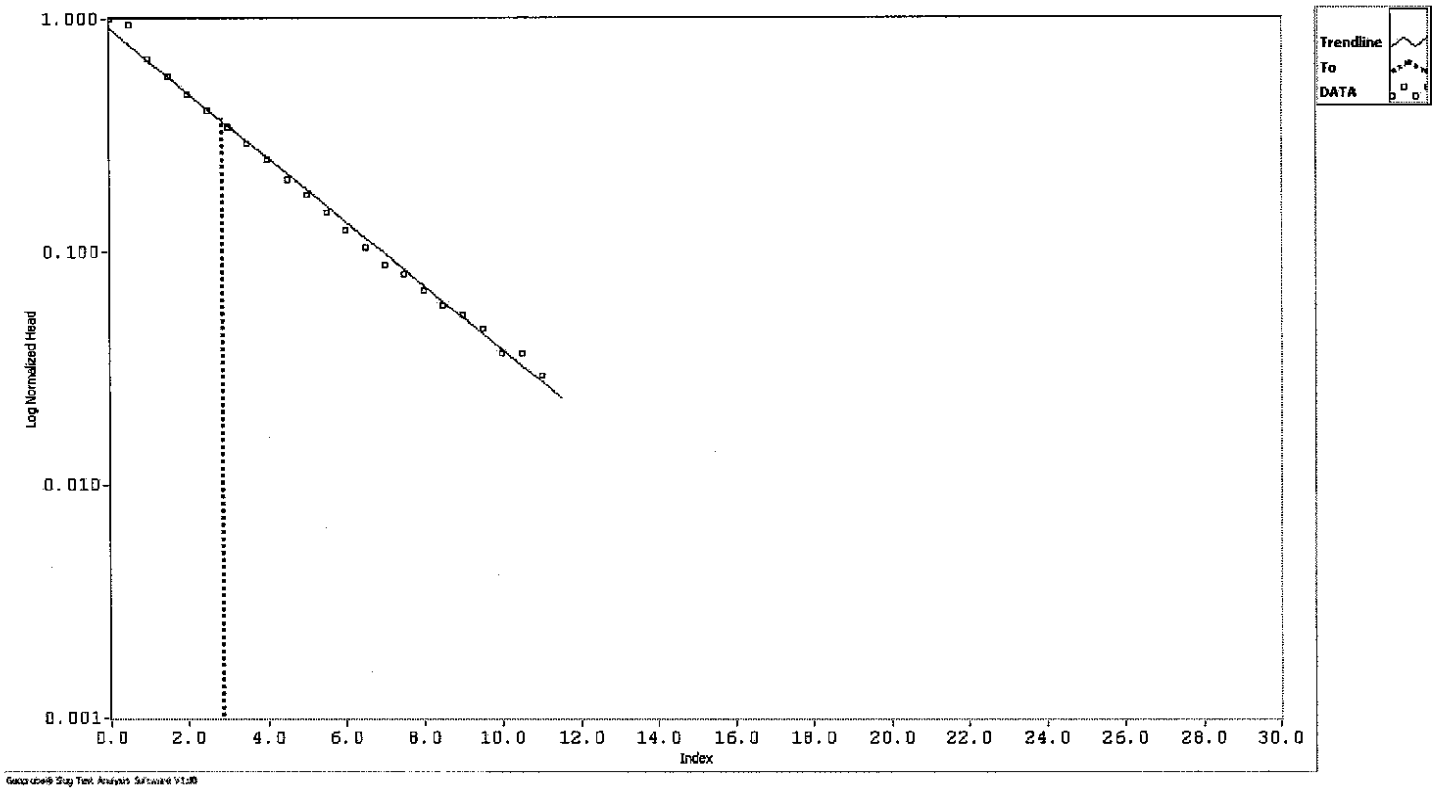
ESS05-28B 14.2-15.2 ft 10^{-5} to 10^{-6} cm/sec

Log Data Set
File Name: C:\dirim95\ESS28-B.dat Printed: Thursday, March 02, 2006 12:37:03



ESS25B 12-13'

Interval Data Set
Interval: 619.500 Sec to 638.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-1 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:37:29



Log | Interval | INP | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ES5-05-25 (B-1)
Test #:	ES52581 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525--B.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES5258-1 unconf .inv

Start Time	End Time
619.500	638.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	5.632
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.318	R-squared	9.53E-1
Amplitude	0.910	To	2.848

Calculated K

K (FT/Day)	4.336
K (cm/Sec)	1.530E-3
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

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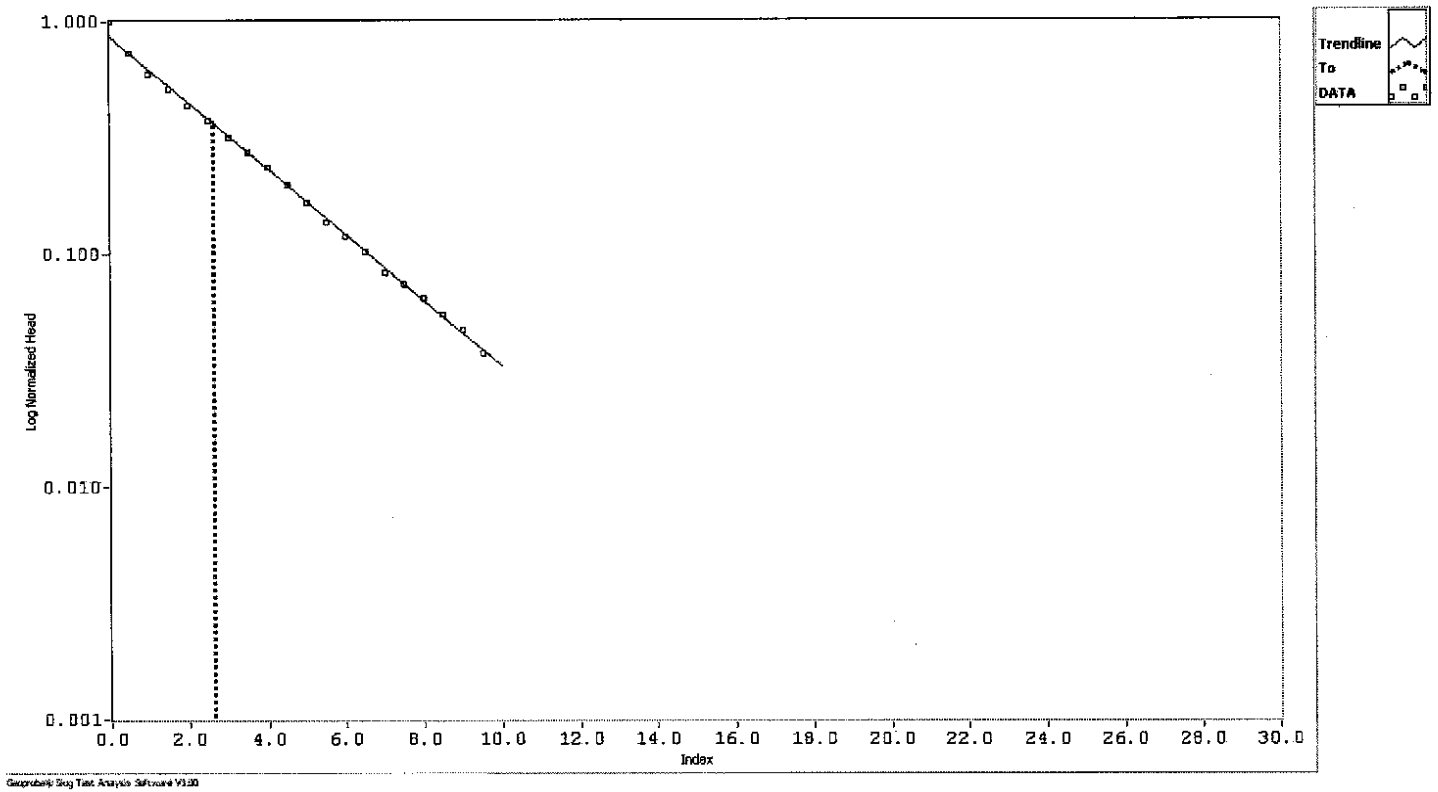
Interval Data Set
Interval: 761.000 Sec to 782.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:37:57



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ESS-05-25 (B-2)
Test #:	ESS25B2 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ ESS25--B.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ ESS25B-2 unconf .inv

Start Time: 761.000 **End Time**: 782.500

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 5.630
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff: -0.327 R-squared: 9.47E-1
Amplitude: 0.861 To: 2.603

Calculated K
K (FT/Day): 4.745
K (cm/Sec): 1.674E-3
Well: Fully Penetrating

Documentation and Reports

View Parameter Graphic
View Parameter Definitions
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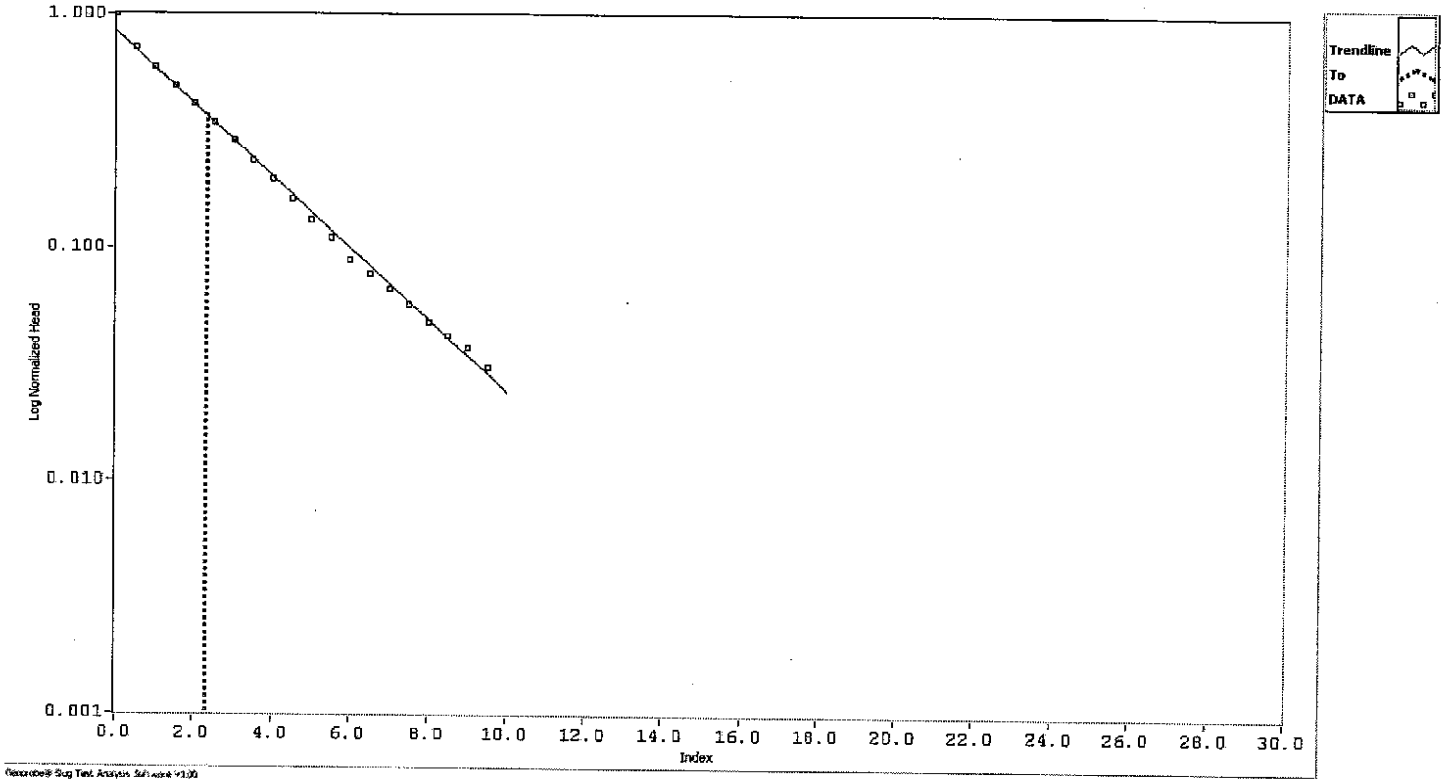
Interval Data Set
Interval: 1167.000 Sec to 1182.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:38:20



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ES5-05-25 (B-3)
Test #:	ES52583 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ ES525--B.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ ES5258-3 unconf .inv

Start Time	End Time
1167.000	1182.500

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 5.656
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff: -0.355 R-squared: 9.47E-1
Amplitude: 0.841 To: 2.327

Calculated K
K (FT/Day): 5.307
K (cm/Sec): 1.872E-3
Well: Fully Penetrating

Documentation and Reports
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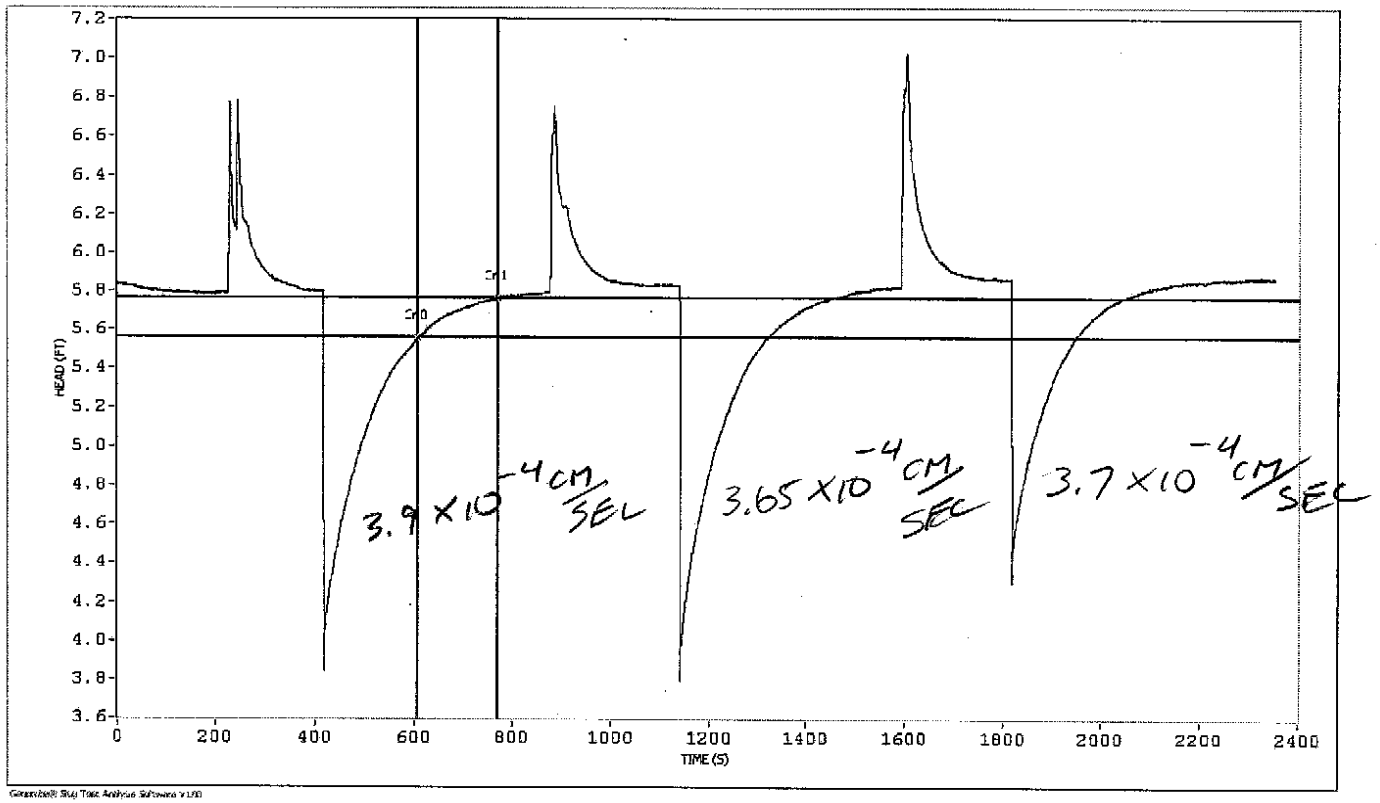
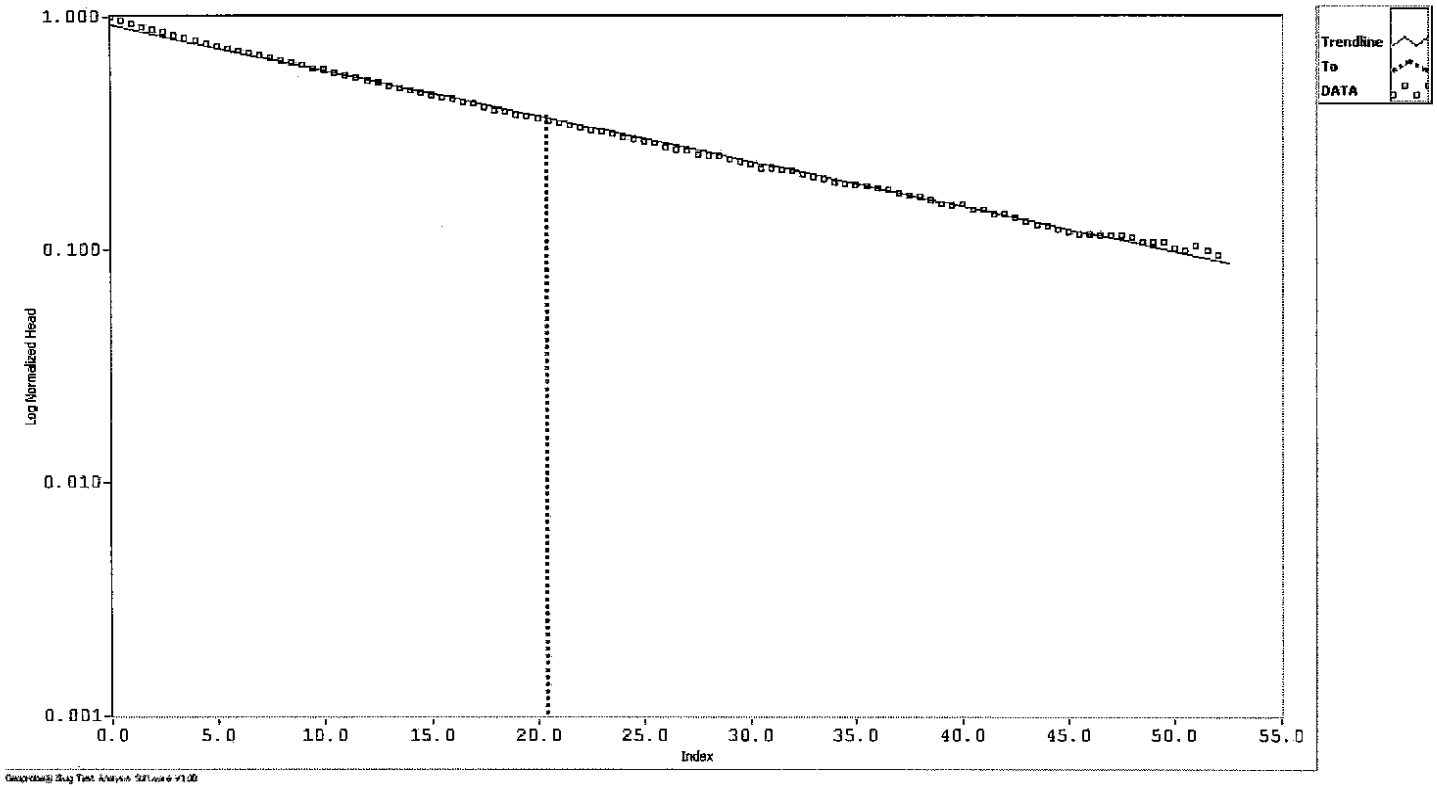
Log Data Set
File Name: C:\dirim95\ESS28-A.dat Printed: Thursday, March 02, 2006 12:42:10



ESS25 A 9-10'

Interval Data Set
Interval: 582.000 Sec to 680.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-1 unconf..inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
Printed: Thursday, March 02, 2006 12:42:27



Log | Interval | Inf | Parameter | Documentation/Reports

Required In Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND B
Project #:	San Luis Drain
Well #:	ES5-05-25 (A-1)
Test #:	ES525A1 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A-1 unconf..inv

Start Time	End Time
582.000	680.500

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.031
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.045	R-squared	9.89E-1
Amplitude	0.918	To	20.394

Calculated K

K (FT/Day)	1.107
K (cm/Sec)	3.907E-4
Well	Fully Penetrating

Documentation and Reports

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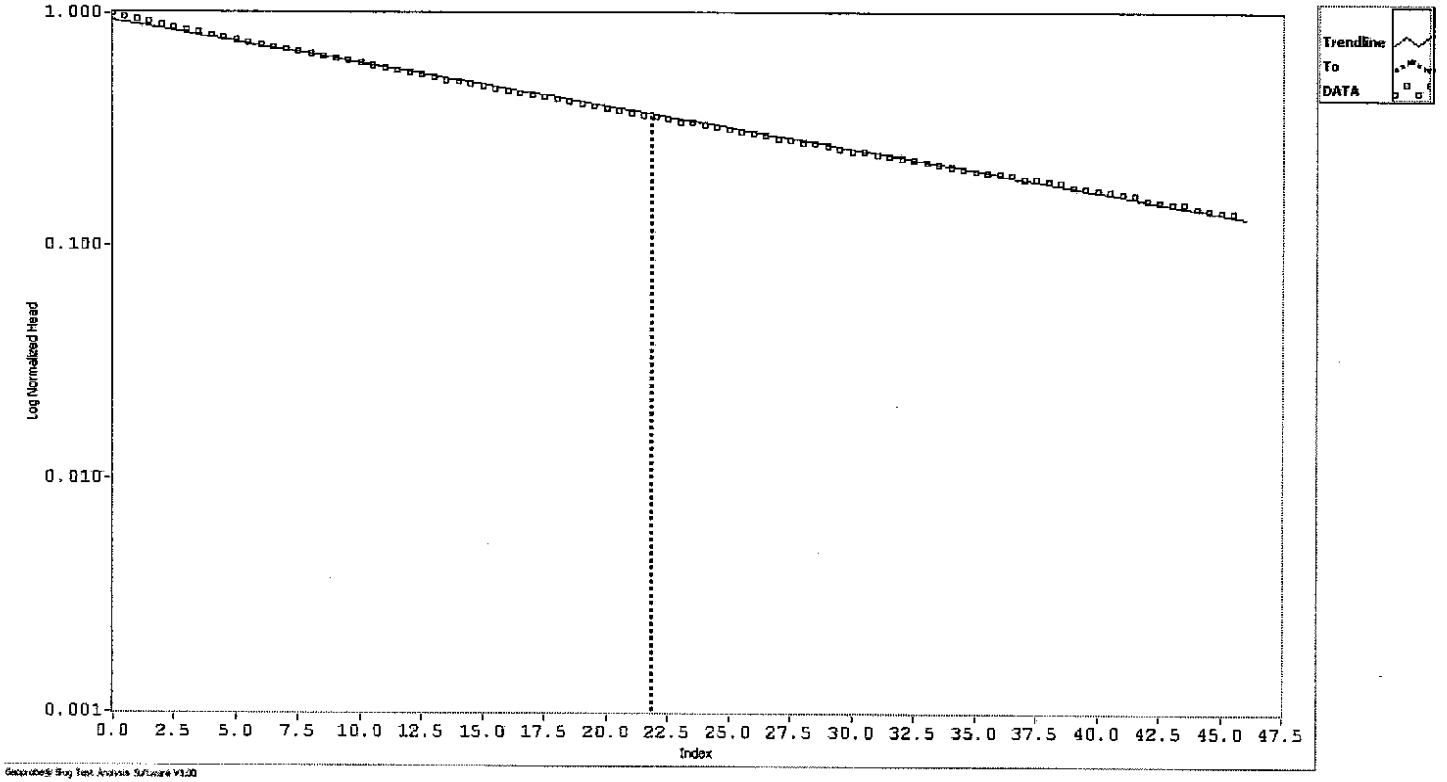
Interval Data Set
Interval: 949.000 Sec to 1049.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
Printed: Thursday, March 02, 2006 12:42:48



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND B
Project #:	San Luis Drain
Well #:	ES5-05-25 (A-2)
Test #:	ES525A2 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A-2 unconf .inv

Start Time: 949.000 **End Time**: 1049.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.067
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.043	R-squared	9.88E-1
Amplitude	0.936	To	21.613

Calculated K

K (FT/Day)	1.035
K (cm/Sec)	3.653E-4
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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Interval Data Set
Interval: 1311.500 Sec to 1432.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
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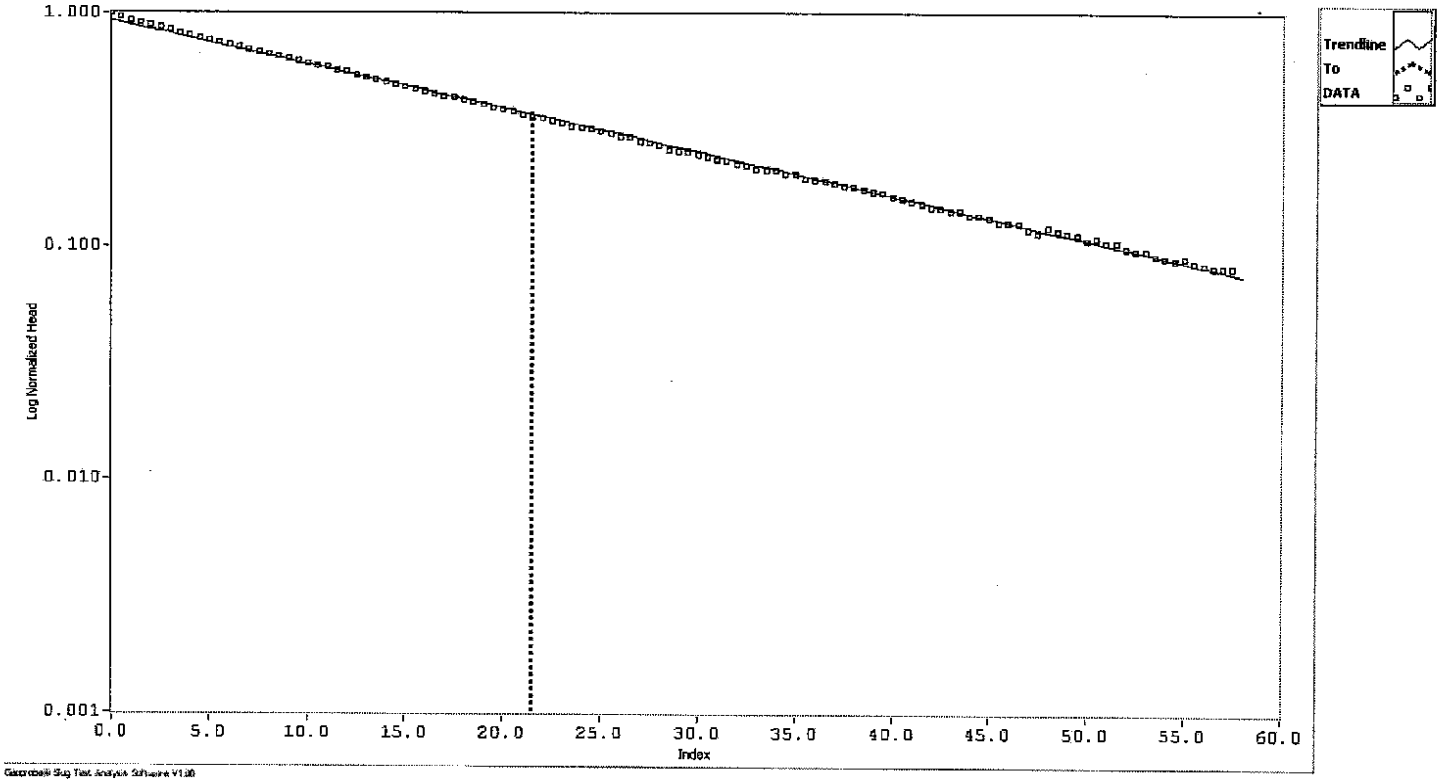

Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND B
Project #:	San Luis Drain
Well #:	ESS-05-25 (A-3)
Test #:	ESS25A3 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ ESS25A.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ ESS25A-3 unconf .inv

Start Time: 1311.500 **End Time**: 1432.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.066
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.043	R-squared	9.91E-1
Amplitude	0.932	To	21.467

Calculated K

K (FT/Day)	1.052
K (cm/Sec)	3.712E-4
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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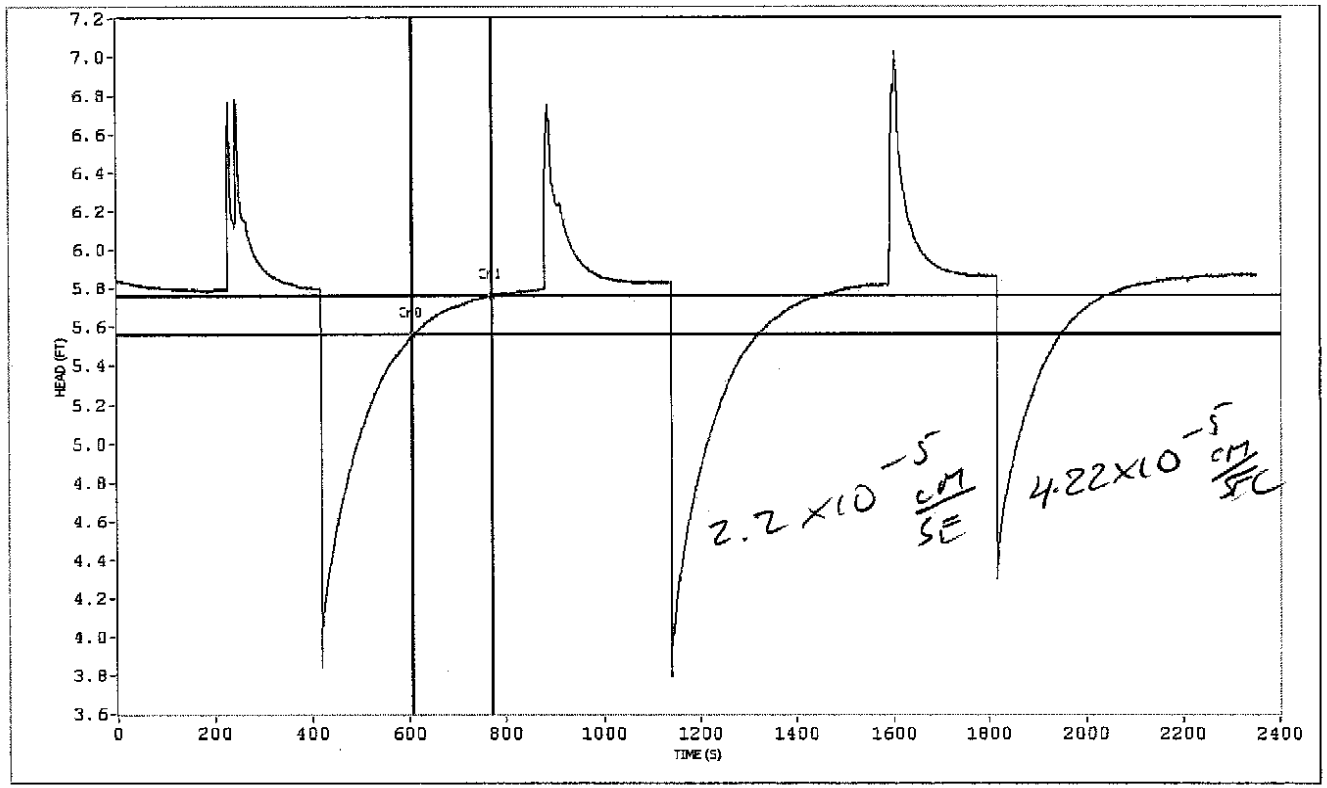
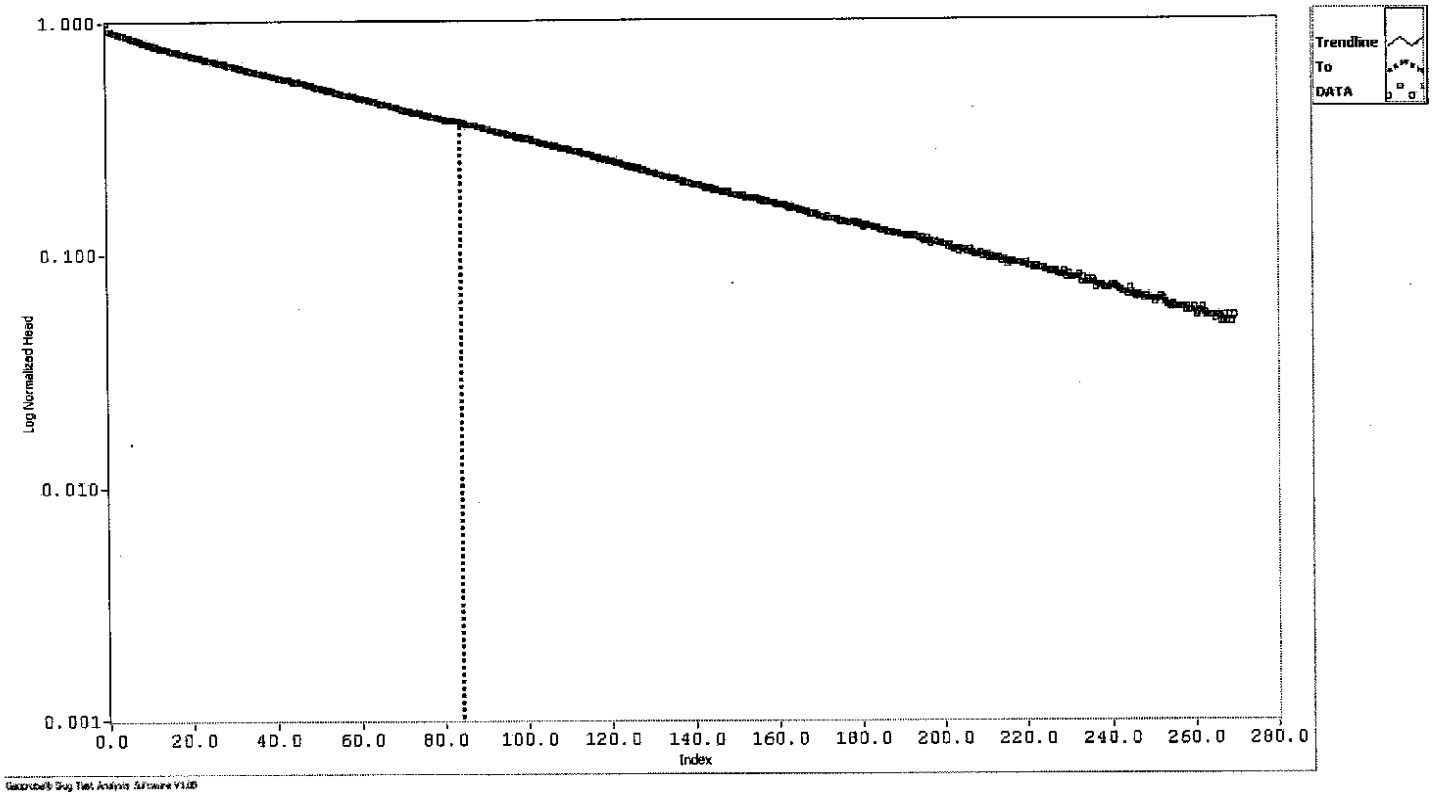
Log Data Set
File Name: C:\dirim95\ESS28-A.dat Printed: Thursday, March 02, 2006 13:22:30



ESS 05 28 A 13.5-14.5

Interval Data Set
Interval: 1141.000 Sec to 1435.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 A-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-A.dat
Printed: Thursday, March 02, 2006 13:24:31



A-2

Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	4.200
Lw (ft)	10.300	TD (ft)	14.500
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap pond B
Project #:	San Luis Drain
Well #:	ES5-05-28 (A-2)
Test #:	ES528A-2 (13.5-
Location:	Butte Ave.
Date:	10/6/05
Field Tech:	J. Vauk
Analyst:	J. vauk

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528-A.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528 A-2 unconf .inv

Start Time	End Time
1141.000	1435.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.411
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.011	R-squared	9.98E-1
Amplitude	0.899	To	84.123

Calculated K

K (FT/Day)	0.062
K (cm/Sec)	2.181E-5
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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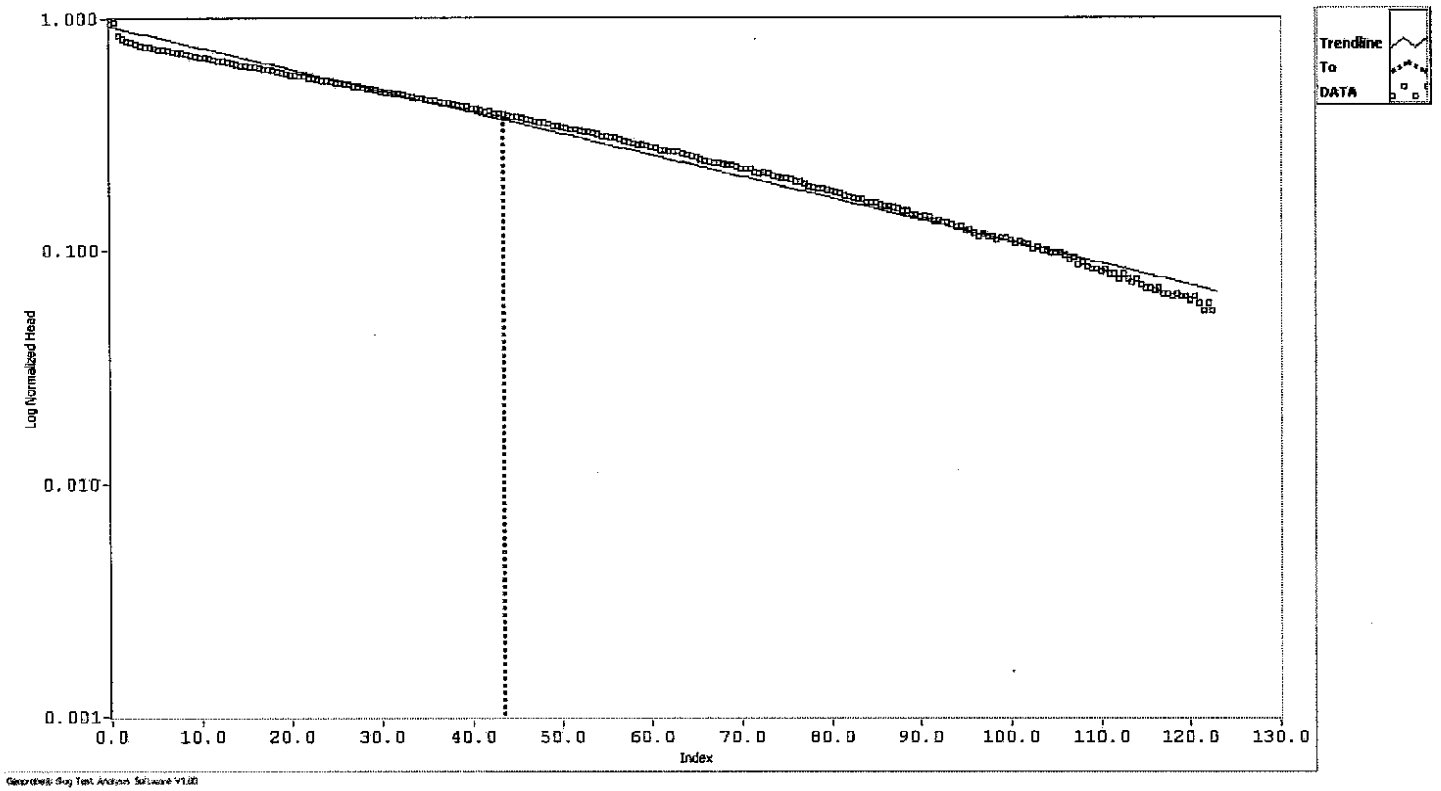
Interval Data Set
Interval: 923.500 Sec to 1192.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 A-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 13:25:09



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	-1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ESS-05-28 (B-2)
Test #:	ESS28B-2 (10.0-
Location:	Butte and Cerini
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name: C:\drim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat

Interval Name: C:\drim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 A-3 unconf .inv

Start Time: 923.500 **End Time**: 1192.500

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 4.960
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff: -0.021 R-squared: 9.91E-1
Amplitude: 0.932 To: 43.439

Calculated K
K (FT/Day): 0.120
K (cm/Sec): 4.223E-5
Well: Fully Penetrating

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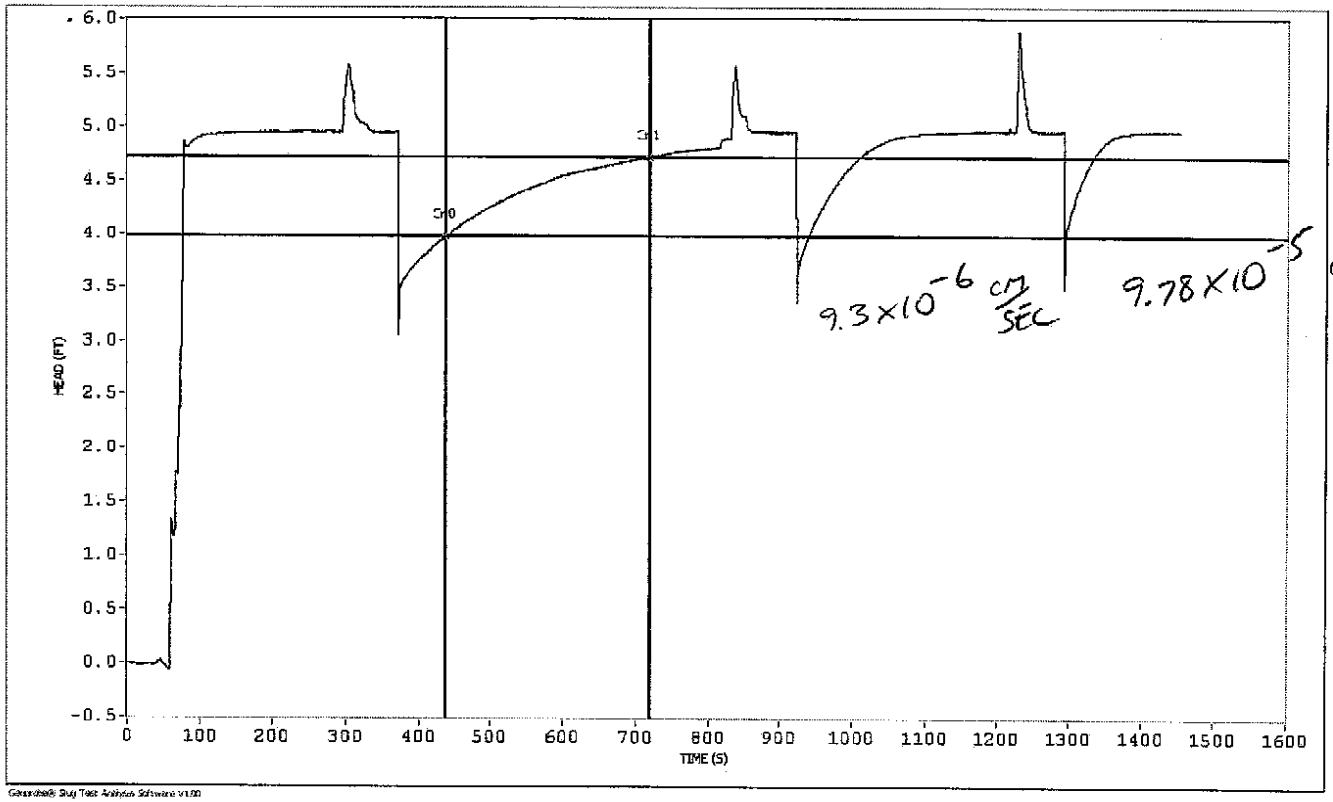
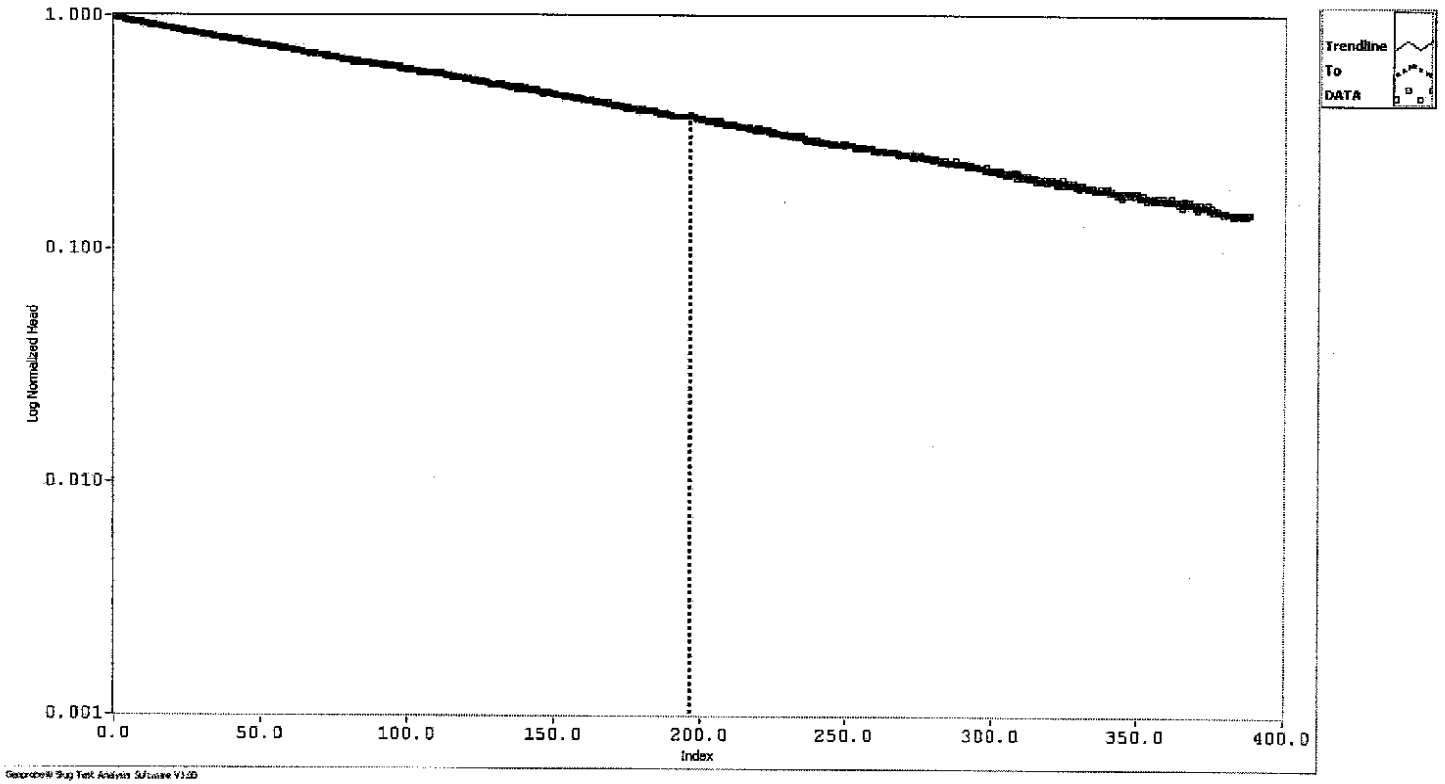
Log Data Set
File Name: C:\dirim95\ESS28-B.dat Printed: Thursday, March 02, 2006 14:04:03



ESS05 28B 14.2-15.2 FT

Interval Data Set
Interval: 923.500 Sec to 1088.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 B-1 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 14:04:41



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap pond B
Project #:	San Luis Drain
Well #:	ES5-05-28 (B-1)
Test #:	ES527B-1 (10.0-
Location:	Butte Ave.
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ES528-B.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ES528 B-1 unconf .inv

Start Time	End Time
923.500	1068.000

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 3.411
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff: -0.005 R-squared: 9.99E-1
Amplitude: 0.978 To: 196.525

Calculated K
K (FT/Day): 0.026
K (cm/Sec): 9.335E-6
Well: Fully Penetrating

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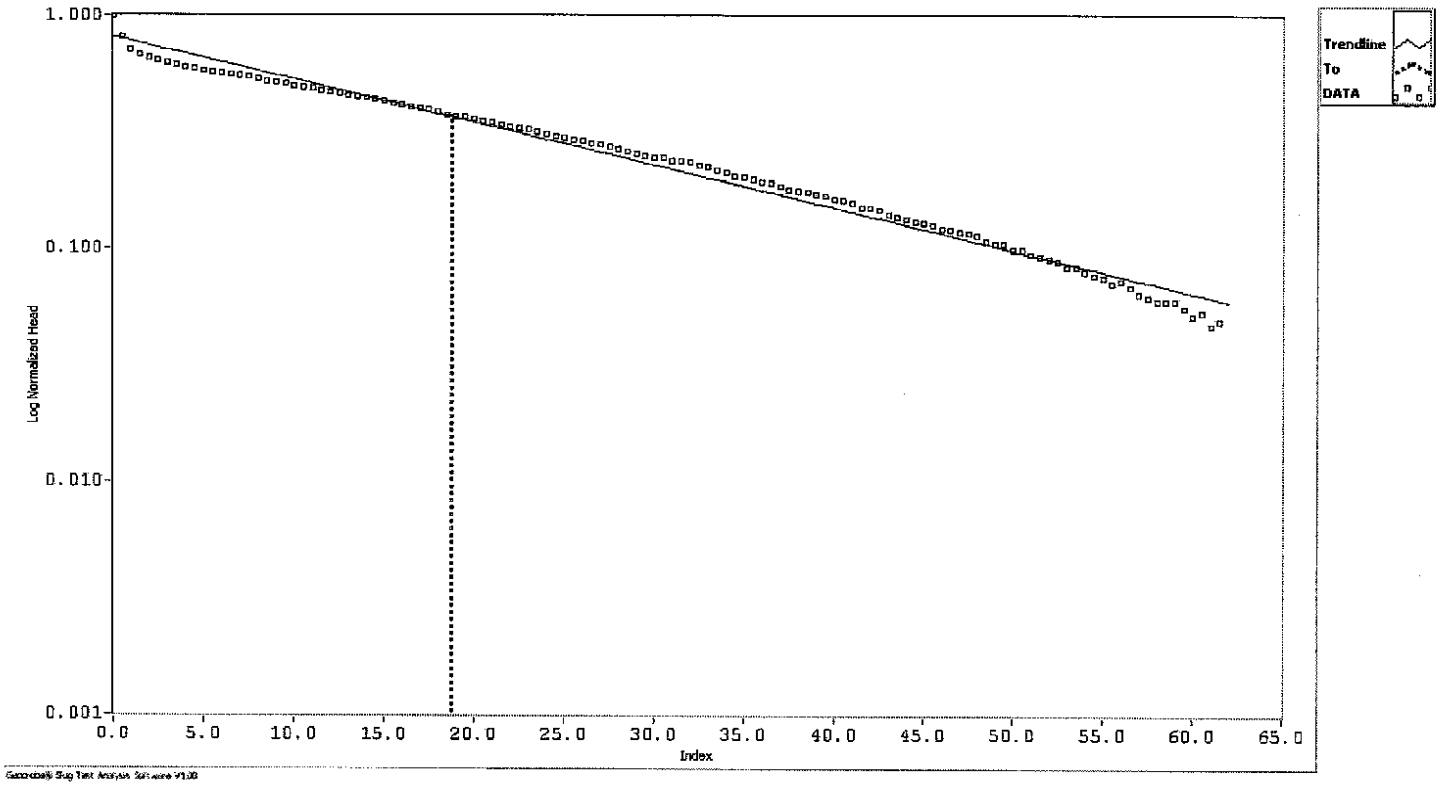
Interval Data Set
Interval: 1294.000 Sec to 1452.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 B-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 14:05:09



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	-1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ESS-05-28 (B-3)
Test #:	ESS28B-3 (10.0-
Location:	Butte and Cerini
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat

Interval Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 B-2 unconf .inv

Start Time: 1294.000 **End Time**: 1452.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	4.960
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.042	R-squared	9.81E-1
Amplitude	0.816	To	18.757

Calculated K

K (FT/Day)	0.277
K (cm/Sec)	9.781E-5
Well	Fully Penetrating

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Appendix I – ASTM Pneumatic Slug Test

Designation: D 7242 – 06

Standard Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Ground Water Samplers[1]

This standard is issued under the fixed designation D 7242; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard practice covers the field methods used to conduct an instantaneous change in head (slug) test when pneumatic pressure is used to initiate the change in head pressure within the well or piezometer. While this practice specifically addresses use of pneumatic initiation of slug tests with direct push tools these procedures may be applied to wells or piezometers installed with rotary drilling methods when appropriate.

1.2 This standard practice is used to obtain the required field data for determining hydraulic properties of an aquifer or a specified vertical interval of an aquifer. Field data obtained from application of this practice are modeled with appropriate analytical procedures (Test Methods D 4104, D 5785, D 5881, D 5912, Ref (**1**)[2]).

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "standard" in the title means that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 2434 Test Method for Permeability of Granular Soils (Constant Head)

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4104 Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)

D 5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells

D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers

D 5785 Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)

D 5856 Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter

D 5881 Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug)

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

Current edition approved March 1, 2006. Published March 2006.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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D 5912 Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug)
D 6001 Guide for Direct-Push Ground Water Sampling for Environmental Site Characterization
D 6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D 6724 Guide for Installation of Direct Push Ground Water Monitoring Wells
D 6725 Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers

3. Terminology

3.1 Terminology used within this practice is in accordance with Terminology D 653 with the addition of the following:

3.2 *Definitions:*

3.2.1 *direct-push (DP) sampling*—sampling devices that are directly inserted into the soil without drilling or borehole excavation. **D 6001**

3.2.2 *two-tube system*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample, sometimes referred to as dual-tube. The outer tube is used for borehole stabilization. The inner tube for sampler insertion and recovery. **D 6282**

3.2.3 *single-tube system*—a system whereby single extension/drive rods with samplers attached are advanced into the subsurface strata to collect a soil sample. **D 6282**

3.2.4 *slug test*—a single well test to measure aquifer properties such as transmissivity and hydraulic conductivity. A slug test is conducted by inducing a near instantaneous change in the static water level in a well and observing the recovery of the water level to static condition over time. Also called an instantaneous change in head test.

4. Summary of Practice

4.1 This practice describes the field procedures used to conduct an instantaneous change in head (slug) test in a direct push (DP) installed ground water sampling device or monitoring well using air pressure to cause a sudden change in the water level. A pneumatic manifold is installed on a developed well or DP installed device to control the pressure in the wellhead. Positive pressure or vacuum may be applied with the pneumatic manifold to induce a rising head test or falling head test, respectively. The changing water level in the well is monitored with a transducer and data acquisition device and the data is saved for curve fitting and analysis.

4.2 Appropriate well design and construction is necessary to obtain representative slug test results. Furthermore, without adequate development (Practice D 6725, Guide D 5521, Refs (**1, 2**)) of the well or ground water sampling device slug tests may yield biased data. Field quality control may be monitored by conducting replicate tests after development and visually comparing the replicate data sets.

4.3 Aquifer response data obtained from the pneumatic slug tests are modeled with the appropriate analysis method (Test Methods D 4104, D 5785, D 5881, D 5912, Refs (**1, 3**)) to calculate the transmissivity and/or hydraulic conductivity of the screened formation.

5. Significance and Use

5.1 Combining slug test methods with the use of direct push installed ground water sampling devices provides a time and cost-effective method that was previously not available for evaluating spatial variations of hydraulic conductivity (K) in unconsolidated aquifers. Current research (Ref (**4**)) has found that small (decimeter) scale variations in hydraulic conductivity may have significant influence on solute transport and therefore design of ground water remediation systems. Other investigators (Ref (**5**)) report that spatial variation in K is believed to be the main source of uncertainty in the prediction of contaminant transport in aquifers. They found that increasing the data density for K in model input noticeably reduced the uncertainty of model prediction. Because of increased efficiency and reduced costs, the combination of slug test methods with DP ground water sampling devices makes it possible to obtain the additional information required to reduce uncertainty in contaminant transport models and improve remedial action design.

5.2 The data obtained from application of this practice may be modeled with the appropriate analytical method to provide information on the transmissivity and hydraulic conductivity of the screened formation in a timely and cost effective manner.

5.3 The appropriate analytical method selected for analysis of the data will depend on several factors, including, but not limited to, the aquifer type (confined, unconfined, leaky) well construction parameters (partially or fully penetrating), and the type of aquifer response observed during the slug test (overdamped or underdamped). Some of the appropriate methods may include Test Methods D 4104, D 5785, D 5881 and D 5912. A thorough review of many slug test models and analytical methods is provided in Ref (**1**).

5.4 Slug tests may be conducted in materials of lower hydraulic conductivity than are suitable for pumping tests. Slug tests may be used to obtain estimates of K for aquitards consisting primarily of silts and clays. Special field procedures may be required.

5.5 The pneumatic slug test provides some advantages when compared to pumping tests or slug tests conducted by other methods.

5.5.1 Some of the advantages relative to pump tests include:

5.5.1.1 No water added to or removed from the well. An important consideration when water quality must not be altered for purposes of environmental sampling.

5.5.1.2 Large volumes of water not removed from the well as during a pumping test. An important consideration if the groundwater is contaminated and will require disposal as a regulated waste.

5.5.1.3 Slug tests usually require only a fraction of the time needed to complete a pump test.

5.5.1.4 No large diameter pumping well or down well pump required.

5.5.1.5 Slug tests provide information on K for the formation in the vicinity of the well.

5.5.2 Some advantages relative to slug tests using water or a mechanical slug include:

5.5.2.1 No water added to or removed from the well or DP sampler to conduct the test. Generally does not change water

quality for sampling. Use of vacuum to induce a falling head test could result in loss of volatiles from water in the well column. Additional purging may be required before sampling for volatile contaminants.

5.5.2.2 Pneumatic initiation of the slug test provides clean, high quality data with minimal noise, especially important in high hydraulic conductivity formations and small diameter wells.

5.5.2.3 In small diameter DP tools, inserting a mechanical slug or adding water may be difficult or even preclude accurate measurement of changing water levels.

5.5.3 Some disadvantages of slug tests as compared to pumping tests include:

5.5.3.1 Slug tests provide information on K for the formation only in the vicinity of the well, not a large scale average value as obtained from a pumping test.

5.5.3.2 Most slug test analytical methods can provide information only on aquifer transmissivity and hydraulic conductivity. Pumping test analysis can provide additional information on aquifer parameters such as specific storage, etc.

5.5.4 Some disadvantages of the pneumatic slug test relative to slug tests using water or a mechanical slug include:

5.5.4.1 Airtight seals needed on the well casing or drive rods.

5.5.4.2 The screen must remain below the water level throughout the slug test. Wells screened across the water table cannot be slug tested with the pneumatic method.

5.5.4.3 Pressure transducers and electronic acquisition methods usually required for pneumatic slug testing. Not always needed for manual methods.

5.5.4.4 Equilibration of water level after pressure (or vacuum) applied to the wellhead increases time required to complete the slug test, especially important in low-K formations.

5.6 Direct push methods provide some advantages as compared to conventional drilling methods for the installation of wells and temporary groundwater monitoring devices to be used for slug testing. Some of the advantages include:

5.6.1 DP methods minimize generation of soil cuttings reducing waste handling and disposal costs at contaminated sites during the installation of permanent wells (Guide D 6724, Practice D 6725) and temporary groundwater monitoring devices (Guide D 6001).

5.6.2 Several types of temporary groundwater monitoring devices may be installed by DP methods (Guide D 6001). These tools may be installed at various depths and various locations for slug testing and groundwater sampling in unconsolidated materials. Most of these tools are extracted for decontamination and multiple re-use. Minimizes the need for permanent well installations.

5.6.3 Short screens may be used to slug test discrete depth intervals to document vertical and lateral variations of K within an aquifer in a cost and time effective manner.

5.6.4 Equipment required to install DP wells and temporary groundwater samplers are often smaller and more mobile than conventional rotary drilling equipment. This can make site access easier and more rapid.

5.6.5 Other direct push screening and sampling methods, for example Guide D 6282 on soil sampling, can be used to detect test zones in advance of slug testing, which helps with knowledge of test location.

5.6.6 Direct push tests are minimally intrusive.

5.6.7 Direct push tests are generally more rapid and less expensive than other drilling methods.

5.7 Some disadvantages of DP methods as compared to conventional rotary drilling include:

5.7.1 DP methods generally provide a smaller diameter bore hole than traditional rotary drilling. This may limit the size of equipment than can be placed down hole.

5.7.2 Direct push tools are designed to penetrate unconsolidated materials only. Other rotary drilling methods will be required to penetrate consolidated rock.

5.7.3 Some subsurface conditions my limit the depth of penetration of DP methods and tools. Some examples include thick caliche layers, cobbles or boulders, or very dense materials, such as high density glacial tills.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors. Practice D 3740 was developed for agencies engaged in the testing and/or inspection of soils and rock. As such, it is not totally applicable to agencies performing this practice. However, users of this practice should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this practice. Currently there is no known qualifying national authority that inspects agencies that perform this practice.

6. Apparatus

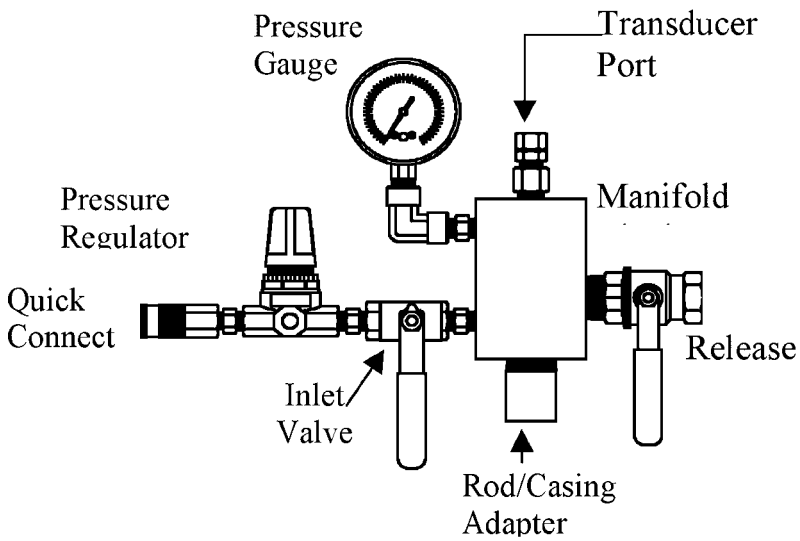
6.1 *General*—The following discussion provides descriptions and details for one pneumatic slug test system. Many geologists and hydrologists have fabricated their own pneumatic slug test equipment. While the descriptions below are specific to one particular system other pneumatic systems may be suitable if they can provide appropriate data quality and data density for the aquifer response to be monitored in the field. Professional experience and judgment should be used to evaluate whether the pneumatic slug test system is adequate for the aquifer and well conditions to be tested. Not all wells or temporary groundwater monitoring devices are appropriate for pneumatic slug testing.

6.2 *Pneumatic Manifold*—The pneumatic manifold is an airtight system to allow for control of air pressure inside the wellhead. The primary features of a pneumatic manifold are depicted in Fig. 1 and include:

6.2.1 Inlet valve connecting to an air or vacuum source.

6.2.2 Pressure regulator to modulate the rate of pressurization of the well head.

6.2.3 Pressure/vacuum gauge to monitor pressure in the wellhead. May be graduated in inches or centimeters of water pressure. Used for leak testing and monitoring the amount of water level change in the wellhead.



NOTE—Various rod and casing adapters are used to connect to different size casing or DP drive rods. Inside diameter of the release valve should be the same or larger than the diameter of the well casing to be tested.

FIG. 1 Example of a Pneumatic Manifold Used to Conduct Slug Tests on DP Ground Water Samplers or Conventional PVC Wells

6.2.4 Air tight fitting (transducer port) that allows the transducer and cable to move up and down for placement at various depths within the well. An additional airtight fitting may be available for a second transducer to monitor the air pressure inside the wellhead.

6.2.5 Release valve that may be opened rapidly to allow for quick exchange of air between the wellhead and ambient atmosphere. The release valve opening should be approximately the same diameter or larger than the well casing to be tested. This will provide for unhampered airflow and minimize generation of any noise as the pressure in the wellhead changes rapidly.

6.2.6 Casing adapter that will allow the pneumatic manifold to attach to the well casing with an airtight connection. The casing adapter should attach to the well casing or drive rod in such a way as not to reduce the ID below that of the ID of the casing to be tested.

6.3 *Pressure Transducer*—Several pressure transducers suitable for use in slug testing are commercially available. Pressure ratings may be reported in pounds per square inch (psi) or kiloPascal (kPa). Be sure that baseline noise levels and hysteresis characteristics of the transducer are suitable for the range of pressure change to be monitored. Pressure transducers rated at 5 to 10 psi (35 to 70 kPa) are generally suitable because the transducer is placed approximately 3 to 5 ft (1 to 1.5 m) below the water level for most test conditions. Pressure ratings of 20 psi (140 kPa) or higher may be acceptable, but if small head changes are used, resolution of higher pressure transducers may be inadequate. The diameter of the transducer and cable should allow its insertion down hole without interference. Dark cables on pressure transducers are subject to heating when exposed to sunlight. This may cause fluctuations in transducer response (Ref (**6**)) and errors in slug test data analysis. Minimize exposure of transducer cables to sunlight. Also allow pressure transducer to equilibrate to ambient water temperature as specified by manufacturer before initiating slug tests.

6.4 *Data Logger/Analog to Digital Inverter*—Several portable data loggers are commercially available that may be used to capture the transducer signal and store it for later down load to a computer for plotting and analysis. Some systems use an analog to digital inverter to acquire the analog signal from the pressure transducer and convert it to digital format for direct upload to a portable computer. Some data acquisition systems allow the user to observe the slug test response as the test is conducted in the field. Be sure the data acquisition system will provide for sufficient sampling rate to capture fast recovering water levels or oscillatory responses if these conditions are anticipated. Sampling rates of 5 to 10 Hz may be needed when oscillatory responses occur.

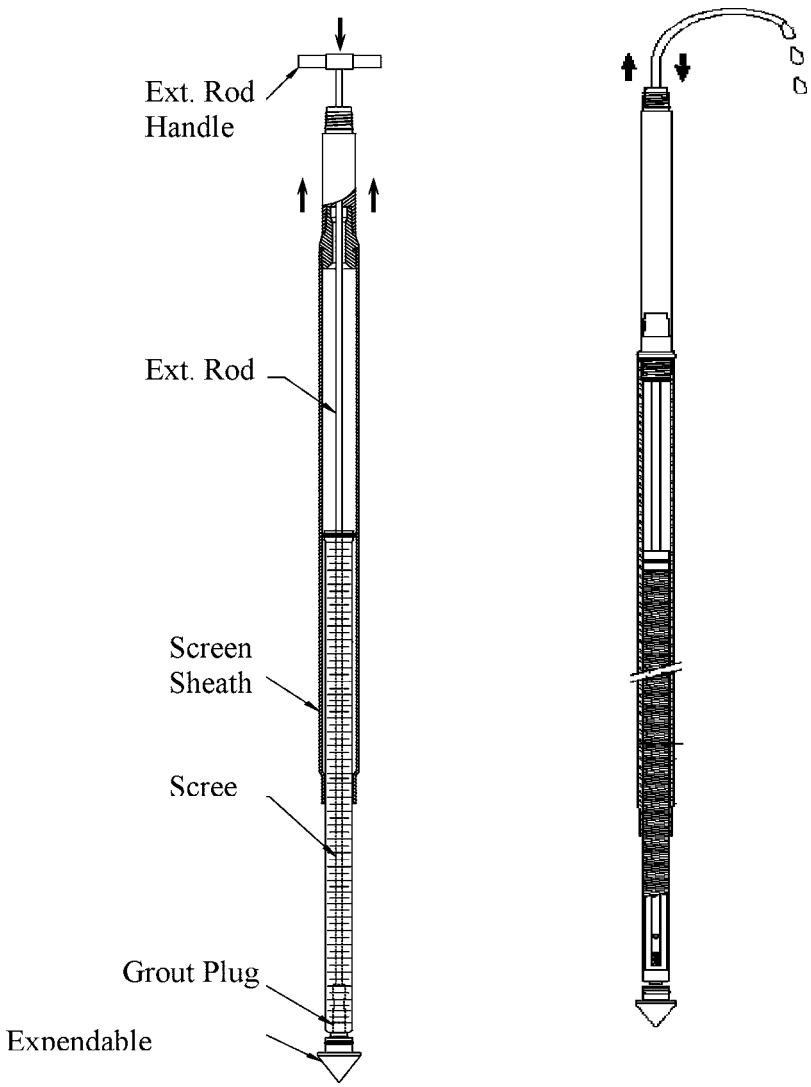
6.5 *Air/Vacuum Supply*—As the pressure inside the well head required to depress the water level a sufficient amount to conduct a slug test is not more than 1 to 2 psi (3 to 7 kPa), a large compressor is usually not required, especially for wells of 2-in. diameter or less and the smaller DP tools. For larger diameter wells and wells with deep water levels a compressor or other clean gas supply may be preferred. In the smaller wells and tools, a foot-operated pump or manually operated pump can be used to provide sufficient air pressure or vacuum with minimal effort. Small 12 Volt electric pumps are available and may be used if desired. Some field technicians prefer to use cylinders of compressed gas. This is suitable, but does present some additional safety hazards for transportation of the compressed gas cylinders. Whatever the source of air for pressurization of the wellhead, ensure the air is clean and will not contain potential contaminants. If a compressor is required, use an oil-less compressor.

6.6 *Casing Adapters*—Verify the pneumatic manifold is specifically designed to provide an airtight fitting for the casing diameter on the well(s) to be tested. Adapters may be used to attach the pneumatic head to larger or smaller casing sizes if necessary. Be sure the adapters do not obstruct the ID of the well casing.

6.7 *Miscellaneous Supplies and Accessories*—Various hand tools, supplies and accessories will make field activities more efficient and easier. Plumber's tape and O-rings may be required to make up airtight fittings. A soapy liquid to conduct leak testing on exposed fittings and connections will help if system leaks do occur.

7. Preparation/Conditioning

7.1 Well construction (Practice D 5092, Guide D 6725) and DP groundwater sampler installation (Guide D 6001, Refs (**7, 8**)) must be completed appropriately to assure that representative data is obtained from slug tests. In general, PVC monitoring wells with filter packs are installed and developed some time before slug testing is conducted. Alternatively, DP groundwater sampling tools (Fig. 2) may be installed and developed immediately before slug tests are conducted. If the well screen and/or filter pack are improperly designed for the formation monitored it may be difficult or impossible to achieve good well development. Boring logs and well construction diagrams should be reviewed prior to mobilization to evaluate possible well design problems. Alternatively, cone penetration test (CPT) or coring logs could be performed near the well to verify subsurface conditions. One common problem is that the filter media and screen slot size are too large for the natural formation conditions. This may result in continued movement of fines into the well even after significant development is conducted. Such movement of fines may cause erratic recovery rate in the well or curvature of normalized data



NOTE—Screen is protected with a sheath during advancement. Small extension rods inserted after driving (a) to expose screen desired amount for slug testing and sampling. Development must be conducted (b) to assure that natural flow is established between the formation and sampling device. Simple inertial pump often effective for surging and purging to develop the sampler.

FIG. 2 Direct Push Installed Single Tube Ground Water Sampling Device

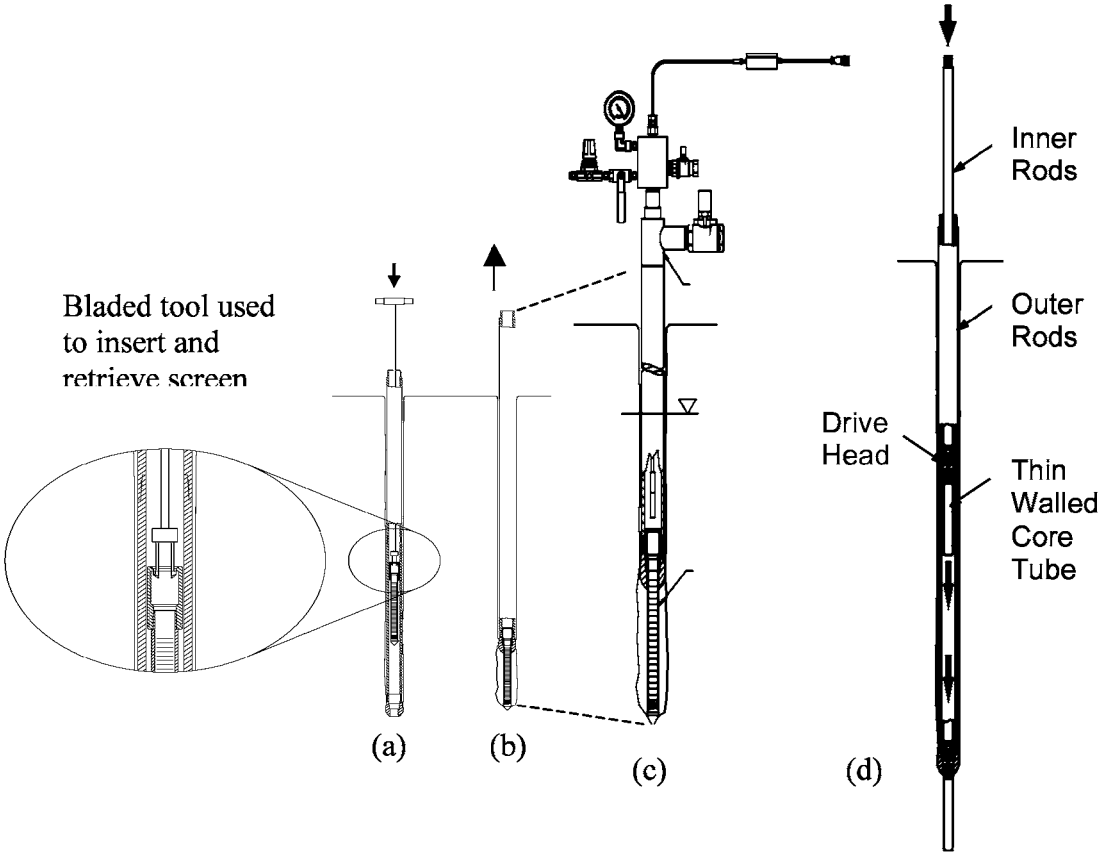
plots. This will hinder accurate modeling of the slug test response and calculation of aquifer parameters. Clearly note any suspected well design problems in the field log book and later reporting.

7.2 When slug tests are to be conducted in fine-grained formations special procedures may be required to minimize compression and damage to the natural formation. DP Dual tube methods (Fig. 3) may provide an effective means to access the formation and conduct slug tests under these conditions. A thin-walled sampler should be used to core the formation beneath the dual tube rods. A brush or other suitable means is then used to relieve smearing on the core hole wall in cohesive formations. Relief of smearing is comparable to development in coarse-grained materials. A screen is then inserted into the cored hole in preparation for slug testing. A small casing (for example, 0.5-in. PVC riser pipe) may be used to connect the screen to the surface. The smaller casing will help reduce the recovery time required for the slug tests in fine-grained materials. An alternative to use of the screen is to fill the cored and brushed hole with sand having a much higher permeability and K than the formation.

7.3 *Well Development*—Slug test results in granular formations are particularly susceptible to well development. If the well or temporary groundwater sampling tool is not adequately developed before slug tests are conducted the observed response will be biased and inaccurate. Use adequate well development methods (Guide D 5521, Guide D 6724, Practice D 6725, Refs (**1**, **2**)) to assure that natural flow has been established between the well and granular aquifer so that representative slug test results are obtained. Some basic well development procedures for sandy formations include over pumping, surging with a surge block followed by purging, surging and purging with an inertial pump. Older wells may require redevelopment prior to slug testing to obtain accurate results. In fine-grained formations any purging for development should be gentle and surging should be avoided to prevent damage. In cohesive formations brushing the core hole to relieve smearing from core sampling may be an integral part of the development process.

7.4 *Static Water Levels*—Measure and record the water level in the well (Test Method D 4750) to be slug tested before starting the tests. When possible, monitor the water level over a period of time similar to the duration of the slug test recovery. Measure and record the water level after testing is complete.

7.5 *Verify Development*—Probably the most effective way to verify that adequate development has been conducted on the



NOTE—Dual tube soil sampling procedures may be combined with simple ground water sampling devices to conduct sampling and slug testing at multiple depths in one boring. After removal of the soil sample or center rod a simple slotted screen may be installed through the open bore of the casing (a). In coarse grained sediments the rods are retracted to expose the screen (b). Following development an adapter attaches the pneumatic manifold (c) to the large drive rods for slug testing. In fine grained materials a thin walled tube may be used to core below the outer rods to minimize compression of the formation (d). The screen is then set in the open core hole below the drive rods.

FIG. 3 DP Dual Tube Methods for Pneumatic Slug Tests

well is to run preliminary slug tests. In wells that recover quickly, running three preliminary slug tests performed with the same initial head displacement are recommended. Plot the recovery curves for visual inspection (Fig. 4) or view onscreen if possible. When the well is adequately developed the initial change in head (H_o) and the symmetry of the recovery curves should be very similar. If preliminary slug tests of the same magnitude do not show a similar H_o and symmetry, further development may be required. Verification of development in fine-grained formations will be time consuming. Project objectives and economics must be considered under these circumstances.

7.6 *Documentation of Well and Aquifer Parameters*—To facilitate accurate modeling of the slug test results well construction details must be known. These include parameters such as casing diameter, screen diameter and screen length. Well construction logs may provide much of this data. In addition, boring logs and water level data must be reviewed to determine the thickness of the aquifer and whether the aquifer is confined or unconfined. An easy way to assure that all of the required data is recorded is to prepare a diagram (Appendix X1) or list of the pertinent data to be gathered in the field for each well tested. This will assure that consistent and complete records are maintained.

8. Procedures

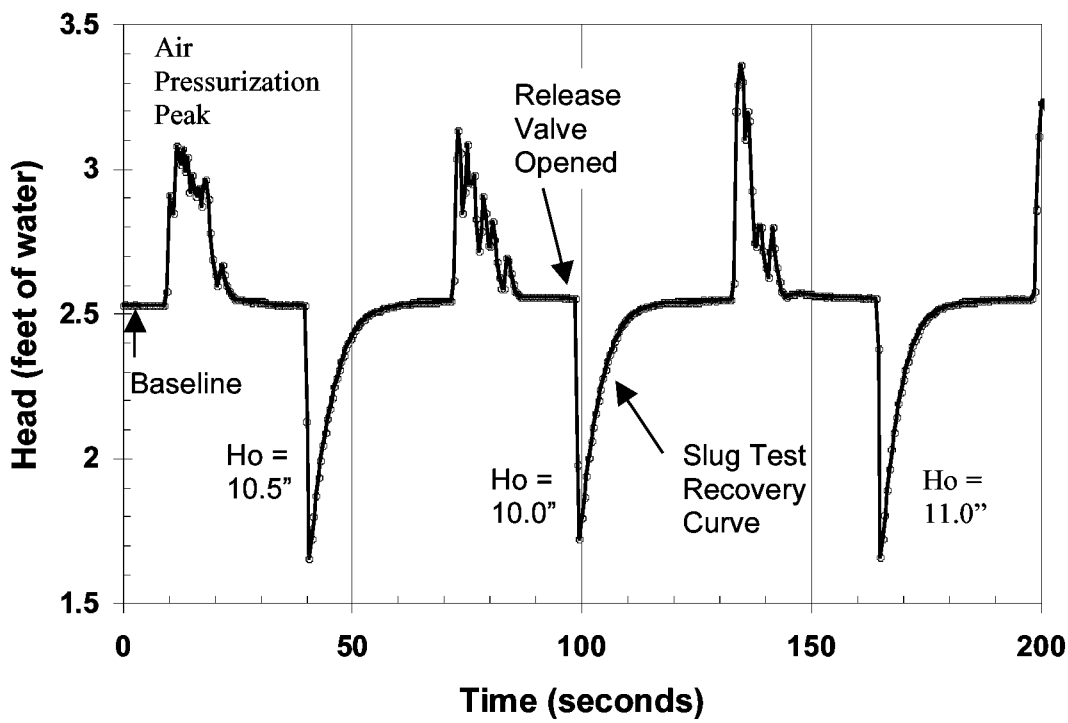
8.1 *General*—A typical field setup for pneumatic slug testing with a DP installed groundwater sampling tool is provided in Fig. 5. Refer to this figure for clarification of the procedures discussed below.

8.2 *Install Pneumatic Manifold*—The pneumatic manifold is fitted to the well casing or DP drive rod to provide an airtight fit. In some cases, adapters may be required to attach the pneumatic manifold to the casing. Use appropriate O-rings or other materials to assure an airtight seal is obtained.

8.3 *Install Transducer*—Insert transducer down the well or DP tool through airtight fitting on the manifold. Lower the transducer below the static water level to allow for temperature equilibration. The transducer should be placed below the water level further than the water level will be lowered during the slug tests, usually 3 to 5 ft (1 to 1.5 m). Critical early time data will not be obtained if the water level is lowered below the transducer during a slug test. Follow manufacturer's recommendations to zero or set baseline on the transducer before initiating tests.

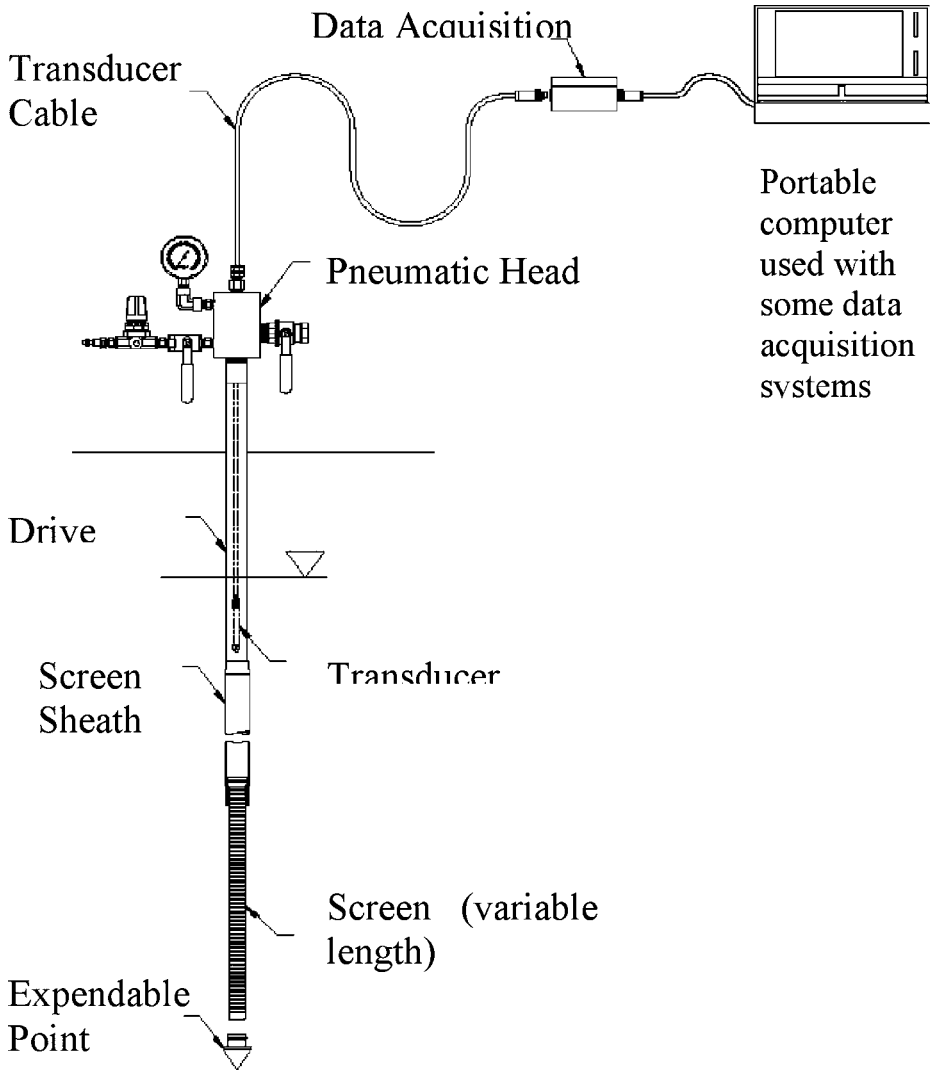
8.4 *Data Acquisition*—Attach transducer to data acquisition system. This system may be a simple data logger or analog-to-digital (A-D) inverter and portable computer or other appropriate system. Prepare system for acquisition of data based on manufacturer's recommendations. From preliminary slug tests determine appropriate data acquisition rate to provide acceptable data density for recovery rate of the well. For highly permeable aquifers, especially when oscillatory responses occur, data acquisition rates of 5 to 10 Hz may be needed to provide sufficient data density for accurate modeling and curve fitting.

8.5 *Pressurize (or Evacuate) Wellhead*—Connect supply of compressed air (or vacuum pump) to the inlet valve of the pneumatic manifold. Use pressure regulator or suitable valve to



NOTE—Replicate slug tests with approximately the same initial head value (H_o) performed through a single tube ground water sampler at a depth of 91 ft with 1 ft of screen exposed to formation. Proportional peak height and symmetry of the recovery curves for these overdamped responses indicate development is adequate and data quality acceptable.

FIG. 4 Replicate Slug Tests Displaying Overdamped Response



NOTE—Appropriate development must be performed before slug tests are conducted.

FIG. 5 Example of Field Setup Used for Performing a Pneumatic Slug Test with a Direct Push Installed Ground Water Sampler

regulate rate of airflow into the wellhead. Do not over pressurize the wellhead. If air is injected into the formation, non-representative results will occur during slug testing due to compressibility of air trapped in the formation. Observe the pressure (or vacuum) gauge on the pneumatic manifold to determine when the desired water level change is obtained. Adding more air (or increasing vacuum) incrementally may be done to obtain the desired initial head change value. Allow the water level in the wellhead to stabilize before starting the slug test. Initial head pressures that provide a water level change in the range of 1 to 3 ft (30 to 100 cm) are generally recommended (Ref (**1**)). Larger head changes may be suitable for under damped formations.

8.6 *Leak Testing*—Testing the pneumatic manifold and well system for leaks is often done while conducting a preliminary slug test. After pressurizing (or evacuating) the wellhead, the air pressure inside the wellhead will drift back to an equilibrium point. Observe the pressure gauge on the pneumatic head to determine when the pressure has stabilized. If the pressure in the wellhead continues to drop (or rise) until it approaches ambient air pressure then the system has a leak. Readjust pressure in the wellhead and use a suitable leak detection fluid to check each fitting for possible leaks. Make necessary adjustments to eliminate leaks. Leaks may occur not only at the pneumatic head, but down hole. PVC casing joints may be damaged, or O-rings may be missing. For DP tools, be sure to use O-rings on every rod connection and keep the tool string tightened as it is advanced to depth.

8.7 *Initiate Slug Test*—Once the wellhead is pressurized (or evacuated) to the desired level and the water level in the well has stabilized the pressure release valve on the pneumatic head is quickly and smoothly opened to start the slug test. The duration required for recovery of the water level to its equilibrium level will depend on the transmissivity of the screened formation, length and diameter of the screen and diameter of the casing where the water level change occurs.

The duration of water level recovery is independent of the magnitude of the initial change in the water level (H_o) used to induce the slug test. Pressurization and slug test recovery curves for a typical over damped slug test response may occur in a matter of seconds (Fig. 4), minutes or even hours for fine-grained formations. Under damped slug test responses (Fig. 6) are typical of high hydraulic conductivity formations and are often completed in less than a minute.

8.8 *Field Quality Check*—When duration of tests permit, a minimum of three slug tests should be performed using the same initial head displacement (for example, 20 in. or 50 cm) (Ref (**1**)). Plot the results of the three tests, or observe onscreen, and compare peak height and curve symmetry (Fig. 4). If all tests have very similar peak height and curve symmetry this suggests test results are repeatable and well development adequate. For additional quality control in the field and during later data analysis, conduct tests with greater and lesser head displacement values (for example, 10 in., 20 in., 30 in. [25 cm, 50 cm, 75 cm]) (Ref (**1**)). Visual inspection of peak height and symmetry should reveal all three to be proportional (Fig. 7). If the peak height for the 30 in. (~75 cm) slug test is proportionally small compared to the other tests, it suggests that slug tests at the larger magnitude are not providing accurate responses. Recommend conducting a slug test of intermediate head (for example, 15 in. or 35 cm) to determine if the slug test response over this smaller range is accurate.

8.9 *Field Notes and Data Storage*—Save electronic data files to diskettes, compact disks, etc. for storage and archival, label appropriately. Maintain complete and accurate field notes to document methods, field quality control, anomalous results and any deviations from planned procedures.

9. Report

9.1 The following information should be included in the field report. Much of this information is included on the diagram in Appendix X1. Refer also to D 5434 for further guidance and information.

9.1.1 Facility name, location and address information, site contacts.

9.1.2 Well number, location, depth and well construction information as listed in Appendix X1.

9.1.3 Names of drilling company, driller, helper and field technician conducting the slug test.

9.1.4 File names of slug test data files.

9.1.5 Specifications of equipment used to conduct the slug test (transducer, data logger, screen specifications, DP ground water sampler specifications, etc.).

9.1.6 Rising head or falling head test, magnitude of head change used to initiate the test.

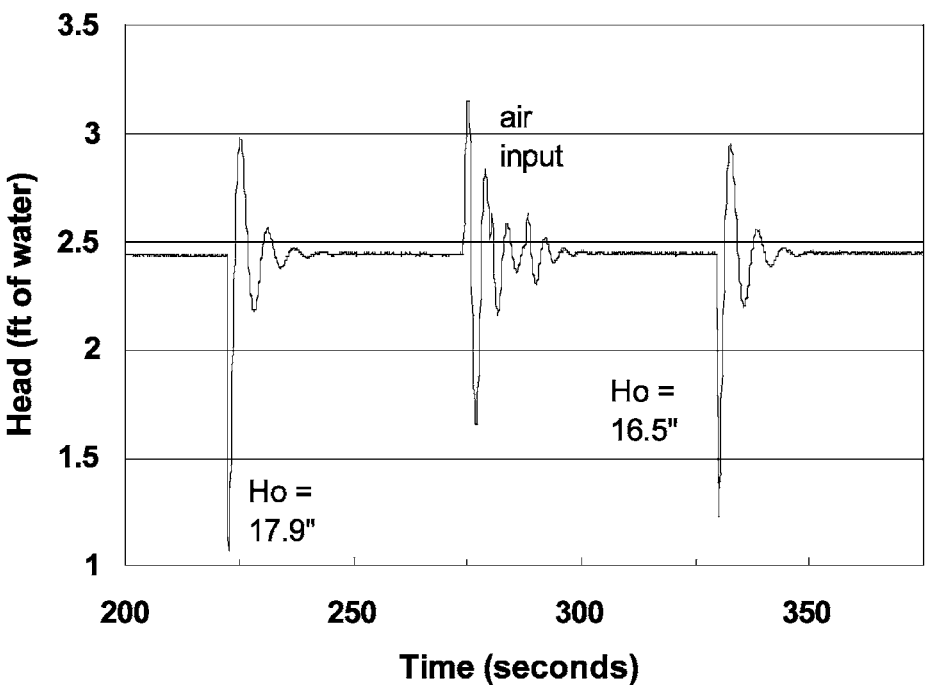
9.1.7 Recommend including copies of boring logs and well construction logs and development logs for each well tested.

9.1.8 Field notes completed as slug tests conducted.

9.1.9 Site-specific information relevant to the project.

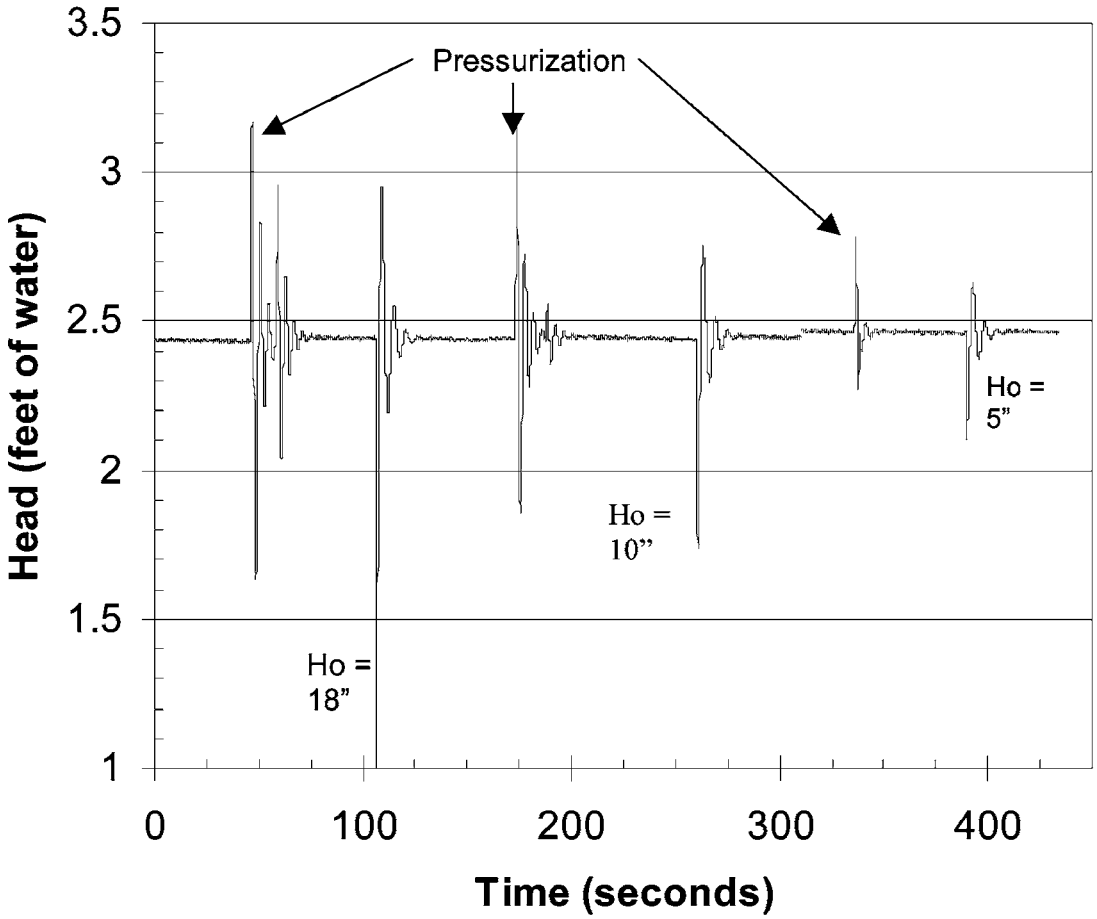
10. Data Analysis Considerations

10.1 *Casing Radius Correction*—When conducting slug tests in smaller diameter wells or DP tools (for example, ID <



NOTE—High hydraulic conductivity formations may yield an underdamped response to an instantaneous change in head resulting in an oscillatory movement of water in the well. The slug tests in this figure were performed in a DP installed prepacked screen monitoring well with 0.5-in. nominal casing diameter and effective screen length of 10 ft. A sampling rate of 10 Hz was used to provide good definition of the aquifer response so that curve fitting and determination of K could be done accurately. Visual inspection of peak height and curve symmetry for repeat tests may be used to conduct field quality control.

FIG. 6 Slug Tests Displaying the Underdamped (Oscillatory) Response



NOTE—A series of slug tests using different initial head values may be used in the field to provide a qualitative evaluation of the data and aquifer-well system response. Visual inspection indicating proportional peak heights and symmetry of response curves suggests system response is linear over the range of head values tested. See Fig. 8 for post acquisition QC measures.

FIG. 7 Proportional Response of Underdamped Slug Tests Conducted With Different Initial Head Values

2 in. or 50 mm), the diameter of the transducer cable will displace a significant proportion of the well volume. This will result in faster recovery of the water level and an error in the determined K if the displaced volume is not corrected for during calculation. To account for the volume displaced by the transducer cable the casing radius is corrected as follows:

$$Rcc = (R_c^2 - r_t^2)^{1/2} \quad (1)$$

where:

Rcc = the corrected casing radius,

R_c = actual measured radius of the casing (or drive rod) where the measured change in water level occurs during the slug test, and

r_t = actual measured radius of the transducer cable.

10.2 *Correction for Frictional Losses in High K Media*—Field research (Ref (**8**)) found that frictional losses became significant in smaller diameter casings (ID < 2 in. [50 mm]) when under damped (oscillatory) responses were encountered. Comparison of results with tests conducted in adjacent larger diameter wells revealed that the frictional losses began to appear when the formation hydraulic conductivity exceeded about 200 ft/day (60 m/day). Additional analysis (Ref (**9**)) resulted in development of a simple correction factor to account for frictional losses in the smaller diameter casing. The correction procedure for the calculation of hydraulic conductivity described therein should be followed when the casing diameter is less than 2 in. (50 mm) and the hydraulic conductivity exceeds 200 ft/day (60 m/day).

10.3 *Analytical Models*—Both formation conditions and the type of slug test response obtained during the slug test will determine the analytical model that should be used to calculate the formation hydraulic conductivity. Boring logs, CPT logs or similar information must be reviewed along with observed water levels to determine if the aquifer is confined or unconfined. Review of the slug test data plot will readily indicate if the aquifer response is over damped (for example, Fig. 4) or under damped (for example, Fig. 6). This information is used in conjunction with Guide D 4043 to select the appropriate analytical model for calculation of hydraulic conductivity or

transmissivity. A thorough review of analytical models used for determination of hydraulic conductivity is provided in Ref (1).

11. Precision and Bias

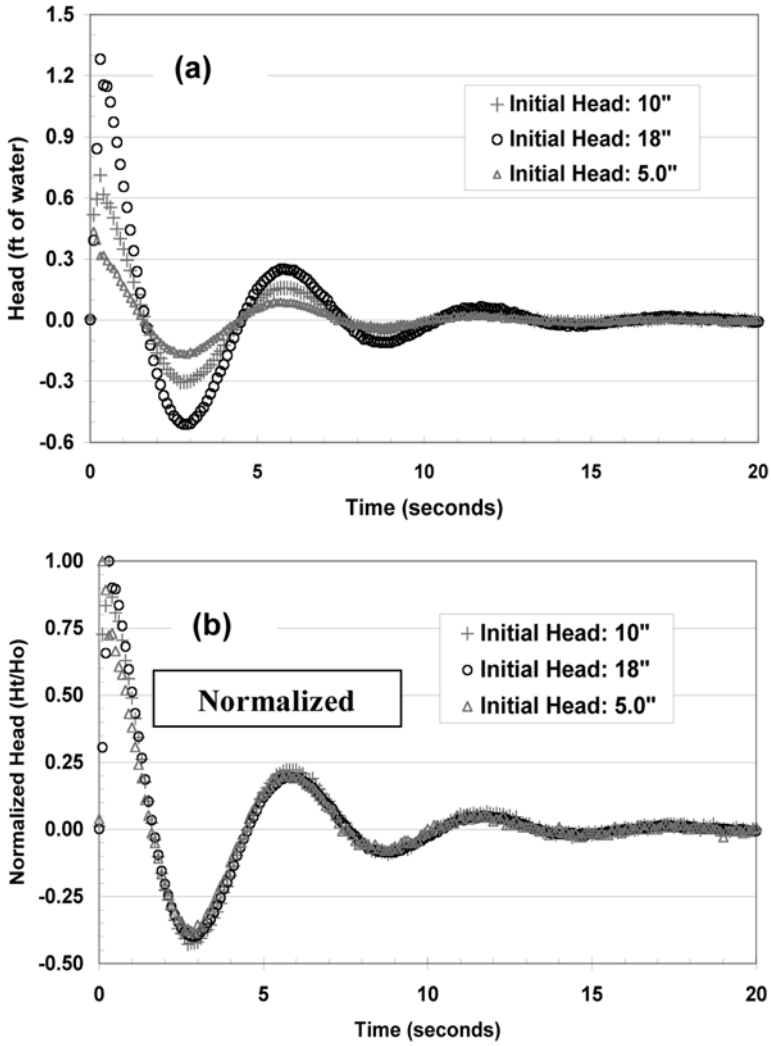
11.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have 10 or more agencies participate in an in situ testing program at a given site.

11.2 The subcommittee (D18.21) is seeking any data from the users of this test method that might be used to make a limited statement on precision.

11.3 Slug tests conducted in situ in the field are generally regarded as providing semi quantitative estimates of transmissivity and/or hydraulic conductivity. The results are usually considered semi-quantitative because of the heterogeneous nature of almost all aquifers and natural formations. However, methods do exist for qualitatively and quantitatively assessing precision and bias for multiple slug tests conducted in a single well using the same methods.

11.4 *Location Specific Precision*—Precision of location specific slug tests may be evaluated on a qualitative level in the field, and later, quantitatively during modeling and calculations.

11.4.1 Precision in the Field is most often evaluated by conducting several pneumatic slug tests initiated using the same initial head. Visual comparison is made of data plots from



NOTE—Three slug tests were performed in the same well using differing initial head values (see Fig. 7). Non-normalized plot (a) with start times aligned shows time correlation of peaks and troughs with different initial displacements. Normalized plot (b) demonstrates that for the range of head values tested the system responds in a linear fashion and therefore no bias of method over the range tested. These tests conducted in a nominal ½-in. diameter PVC prepacked screen well with 10ft effective screen interval using pneumatic methods.

FIG. 8 Example of Post Acquisition Quality Control

three or more slug tests initiated with the same initial head (Fig. 4). The initial change in the head for each test should be comparable. The rate of the water level recovery and the symmetry of the recovery curve should be similar for all the tests based on visual inspection of the data plots. If these qualitative measures of precision are not met in the field, corrective action should be considered. Most often the well is redeveloped to remove a well skin or to remove mobile fines from the screened interval in order to obtain repeatable results. Note any anomalous slug test response in field notes and report appropriately.

11.4.2 *Quantitative Precision*—Precision may be quantitatively evaluated after the slug test response data are obtained. Results from three or more slug tests initiated with the same initial head may be plotted over each other for graphical comparison. Furthermore, the appropriate analytical method (Test Methods D 4104, D 5785, D 5881, D 5912, Refs **(1, 3)**) should be used to calculate the hydraulic conductivity from each repeat test conducted with the same initial head in one well. The precision of the method may then be evaluated by calculation of the percent relative standard deviation (%RSD) between the calculated hydraulic conductivity values where:

$$\% \, RSD = [\{(\mathrm{Sum}(x_i - \mathrm{mean})^2)/(n-1)\}/\mathrm{mean}] \times 100 \qquad (2)$$

The percent relative standard deviation for slug tests conducted in the same well with the same initial head should not exceed 10 %. This assumes the slug tests are conducted over the same screen interval, applying the same method.

11.5 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

11.5.1 Unlike laboratory analytical methods, objective standards do not exist for (pneumatic) slug tests conducted in the field. However, some methods for qualitative evaluation of bias may be applied, either in the field or later by comparison of data plots from replicate tests from the same well. Due to the influence of scale (Ref **(10)**) it is generally not appropriate to compare slug tests to pumping tests to assess bias. Additionally, comparison of slug tests to laboratory tests for K on soil cores (for example, Test Methods D 2434, D 5084, D 5856) is generally not effective. Again the influence of scale of measurement as well as laboratory and sampling procedures will result in differences in measured values of K between lab tests and slug tests often approaching an order of magnitude. Some lab procedures measure vertical K as compared to the horizontal K measured by slug tests. Other lab methods use remolding of the sample that will change natural texture and structure causing differences between the lab measurements and field slug tests.

11.5.2 A quality check may be performed for evaluation of bias in the field by conducting three or more slug tests using differing initial head values (Fig. 7, Fig. 8). Visual comparison of the data plots may be made in the field to determine if the change in initial head used to start the tests results in a proportional change of response observed in the output data (Fig. 7). If the change in peak height from smaller to larger initial head values is not proportional corrective measures should be considered. Additional well development may be required or the magnitude of head over which the tests are conducted may need to be reduced. Use of large initial head values in small diameter wells or ground water samplers will result in attenuation of response due to frictional losses in the well bore (Refs **(8, 9)**) causing a bias in the test result.

11.5.3 Results from repeat slug tests with differing initial head values (Fig. 8a) (for example 10, 20 and 30 in. or 25, 50 and 75 cm) may be normalized (H_t/H_o) and plotted together (Fig. 8b) for a graphical evaluation of bias. When the aquifer and well are responding appropriately the normalized results should closely overlay one another on the plot (Fig. 8b). This indicates a lack of bias in the testing method under the existing aquifer and well conditions for the range of head values tested. Use of extremely large head values (5 to 10 ft or 2 to 3 m) will often result in nonlinear results (Ref **(9)**) when compared to smaller head values, especially in aquifers that display oscillatory responses to slug testing.

12. Keywords

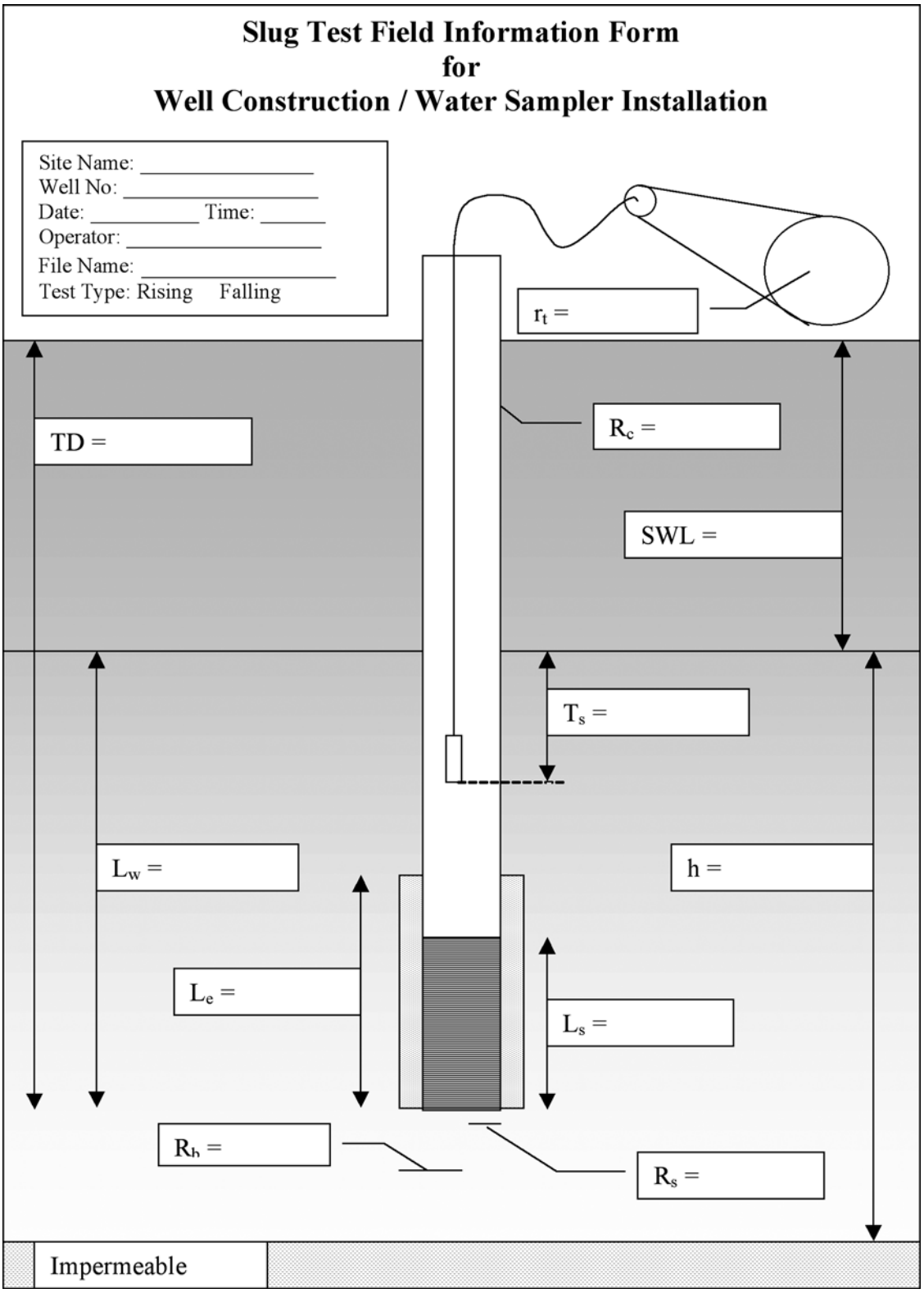
12.1 aquifer; direct push; hydraulic conductivity; pneumatic; slug test

APPENDIX

(Nonmandatory Information)

X1. SLUG TEST FIELD INFORMATION FORM FOR WELL CONSTRUCTION / WATER SAMPLER INSTALLATION

See Fig. X1.1.



H_o = Initial change in head at instant the slug test is started. For pneumatic slug tests, this may be estimated from the stabilized pressure (or vacuum) gauge readout on the manifold just before the slug test is started.

h = Saturated thickness of aquifer.

L_e = Effective screen length: This will include length of any artificial sand pack extending above the well screen.

L_s = True screen length. The length of slotted or perforated screen exposed to the formation.

L_w = Length of water column in the well (L_w = TD – SWL).

R_b = Radius of filter pack or borehole over the screen interval.

R_c = Casing radius. True internal radius of casing where the water level occurs.

Note—Casing radius must be constant over the interval where water level change occurs during the slug test. If the casing radius is not constant over this interval, the rate of water level change observed by the transducer will be distorted causing errors in modeling and determination of aquifer parameters.

Rcc = $(R_c^2 - r_t^2)^{1/2}$ (Ref **(8)**). For wells or DP casing less than 1-in. (25-mm) radius the casing radius must be corrected for the radius of the transducer cable. In smaller wells, the transducer cable begins to displace a significant volume and will result in increased rate of water level recovery. If not accounted for this will cause a systematic error in calculation of aquifer parameters.

R_s = Screen radius. Radius of the slotted or perforated casing where water enters the well during the slug test.

r_t = Radius of the transducer cable. Specifically, the radius of the cable over which the water level change occurs during the slug test.

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Appendix J – Drawings

805-208-3946

Central Reuse Area
8300 Acres

Evaporation Pond B

Reuse Area G

Reuse Area D

Reuse Area E

Reuse Area F

Five Points Field Office

FIVE POINTS

SAN LUIS DRAIN

CRESCENT DITCH

COALINGA RD.

CONEJO AVE.

CLARKSON AVE.

ELKHORN AVE.

DAVIS AVE.

CERNI AVE.

HARLEN AVE.

W. MT. WHITNEY AVE.

JEFFREY AVE.

CADILLAC AVE.

LASSEN AVE.

AMADOR AVE.

SONOMA AVE.

NAPA AVE.

EL DORADO AVE.

COLUSA AVE.

YUBA AVE

BUTTE AVE

LAKE AVE.

TRINITY AVE.

SISKIYOU AVE.

MADERA AVE.

GOLDENROD AVE.

HOWARD AVE.

BISHOP AVE.

T.16S.

T.17S.

T.18S.

R.16E.

R.17E.

R.18E.

N1650000

N1635000

N1620000

N1605000

N1590000

E6630000

E6645000

E6660000

E6675000

E6690000

E6705000

RSS-03-24
RSS-03-31
RSS-03-25
RSS-03-26
RSS-03-27
RSS-03-28
WWD-03-41
WWD-03-42
WWD-03-43
WWD-03-44
WWD-03-45
WWD-03-46
WWD-03-47
WWD-03-48
WWD-03-49
WWD-03-50
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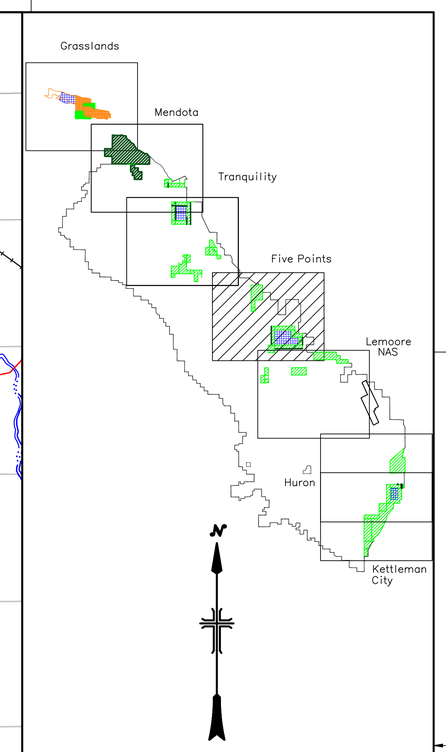


PROPOSED EVAP. POND B

WWD-03-14 CPT HOLES

EDC-03-01 EDC/ESS DRILL HOLES

RSS-03-37 CME 45 AUGER HOLES

CITY

REUSE AREAS

CENTRAL REUSE AREA

SOUTHERN REUSE AREA

STREAMS & CREEKS

MAJOR DRAINS, CANALS & AQUEDUCTS

PAVED ROADS

HIGHWAYS

3000 0 3000 6000 9000
SCALE OF FEET

REV NO		
1	2007-03-14 MP-220 T.R.	2005 DRILL HOLE LOCATIONS ADDED TO SHEETS 1, 2, 3, 4 & 7.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION
SAN LUIS UNIT
SAN LUIS DRAIN

LOCATION OF GEOLOGIC EXPLORATIONS FIVE POINTS AREA

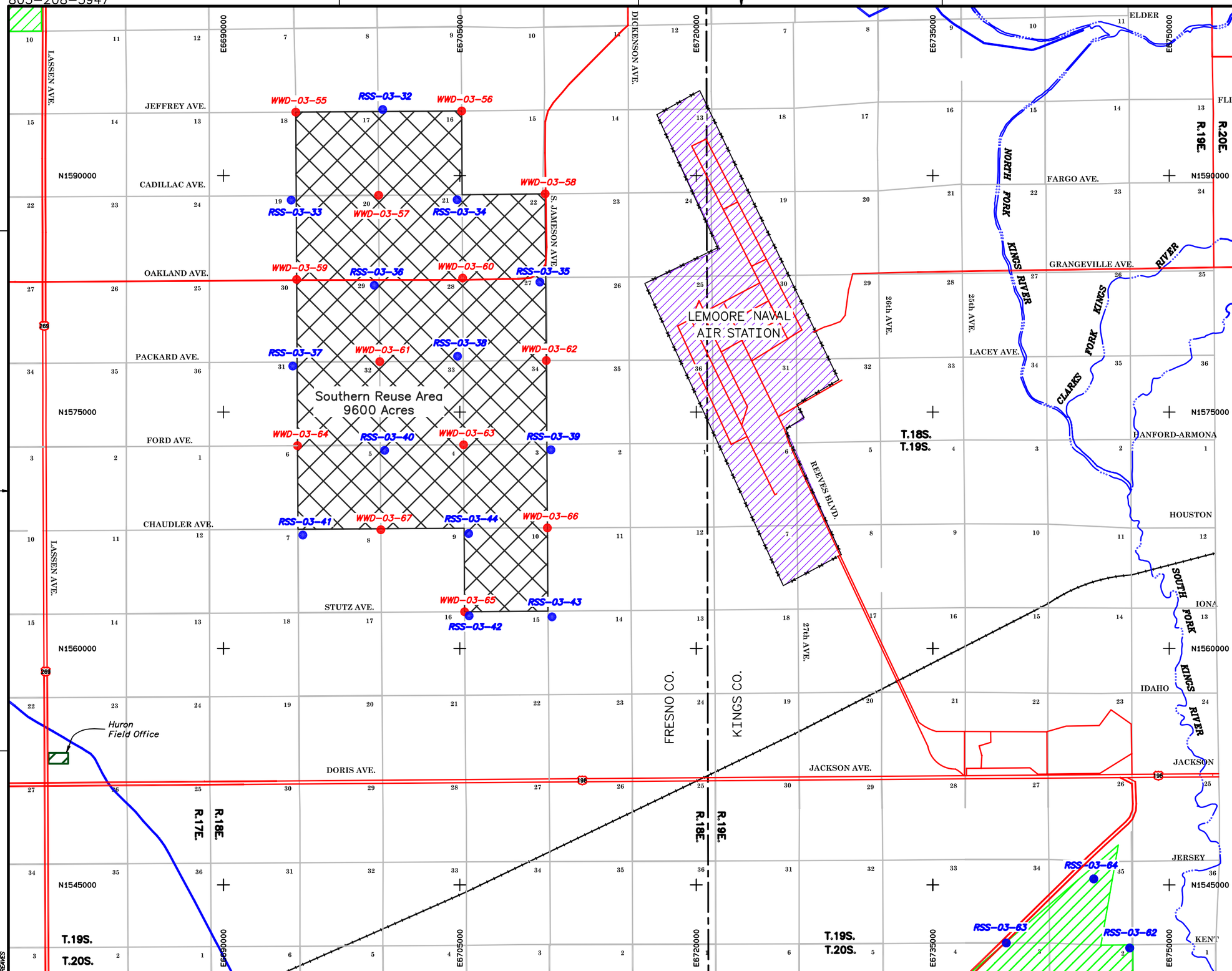
GEOLOGY Steven G. Sherer CHECKED Steven G. Sherer
DRAWN John Say TECH. APPR. Terri Reeves
APPROVED Joel F. Sturm
ADMINISTRATIVE APPROVAL

CADD SYSTEM AutoCAD Rel. 17.0s
CADD FILENAME EXPLORATION_LOCLALS_MASTER.DWG
SACRAMENTO, CALIFORNIA 09-29-03
SHEET 4 OF 7

805-208-3946

DATE AND TIME PLOTTED MARCH 15, 2007 14:00
PLOTTED BY TREAVES

805-208-3947



REV NO		
1	2007-03-14 MP-220 T.R.	2005 DRILL HOLE LOCATIONS ADDED TO SHEETS 1, 2, 3, 4 & 7.

ALWAYS THINK **SAFETY**

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION

SAN LUIS UNIT

SAN LUIS DRAIN

LOCATION OF GEOLOGIC EXPLORATIONS
LEMOORE AREA

GEOLOGY Steven G. Sherer CHECKED Steven G. Sherer
DRAWN John Say TECH. APPR. Terri Reeves
APPROVED Joel F. Sturm
ADMINISTRATIVE APPROVAL

CADD SYSTEM AutoCAD Bld. 17.0s
SACRAMENTO, CALIFORNIA 09-29-03
SHEET 5 OF 7

CADD FILENAME EXPLORATION_LOC1ALS_MASTER.DWG

805-208-3947

DATE AND TIME PLOTTED MARCH 15, 2007 14:02
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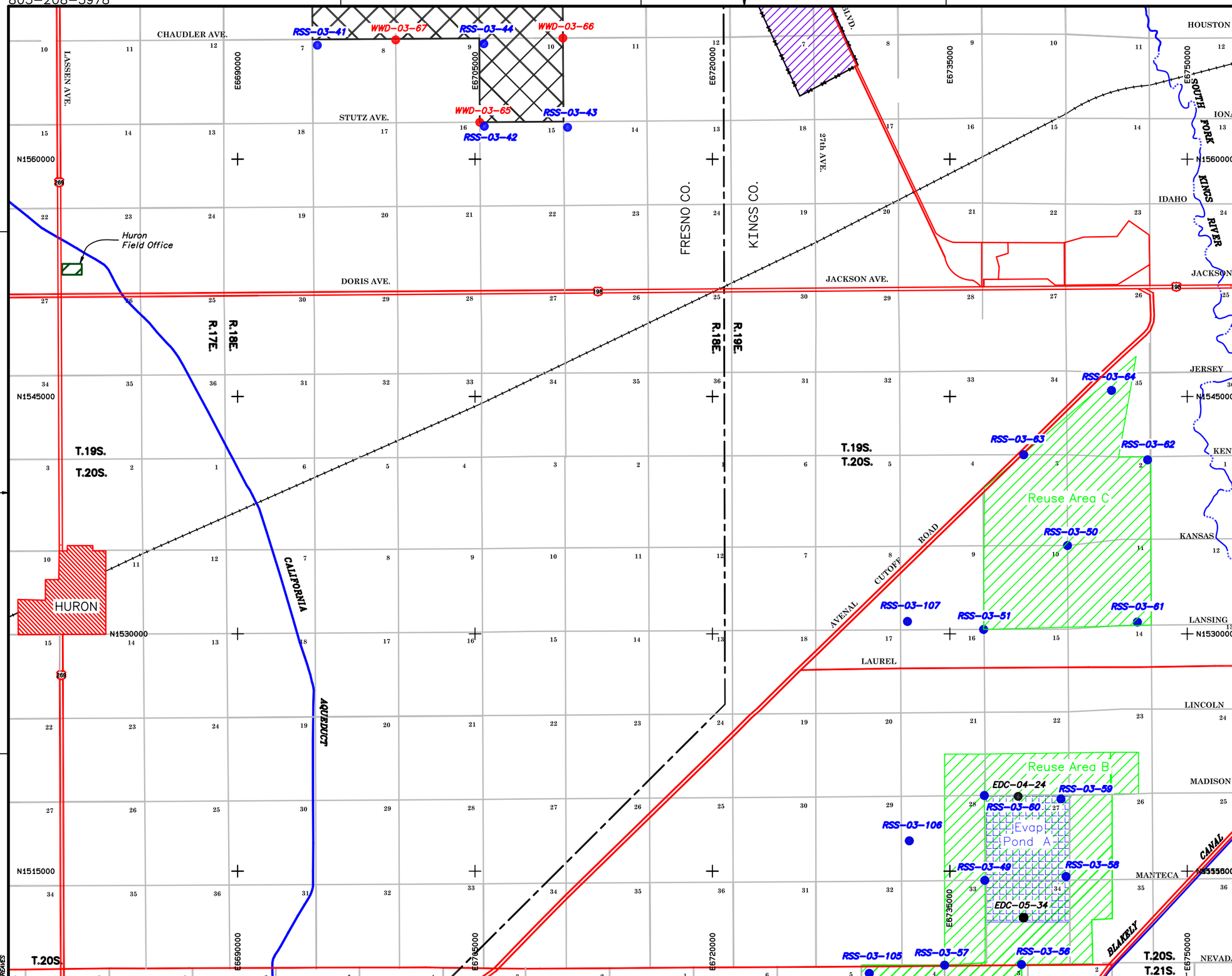
805-208-3978



REV NO		
1	2007-03-14 MP-220 T.R.	2005 DRILL HOLE LOCATIONS ADDED TO SHEETS 1, 2, 3, 4 & 7.

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
WEST SAN JOAQUIN DIVISION

SAN LUIS UNIT

SAN LUIS DRAIN

LOCATION OF GEOLOGIC EXPLORATIONS
HURON AREA

GEOLOGY Steven G. Sherer CHECKED Steven G. Sherer
DRAWN John Say TECH. APPR. Terri Reeves
APPROVED Joel F. Sturm
ADMINISTRATIVE APPROVAL

CADD SYSTEM AutoCAD Rel. 17.0s
CADD FILENAME EXPLORATION_LOCIALS_MASTER.DWG
SACRAMENTO, CALIFORNIA SHEET 6 OF 7 09-29-03
805-208-3978

DATE AND TIME PLOTTED MARCH 15, 2007 14:09
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