NOTICE

All drawings located at the end of the document.

INTERIM REPORT

GROUND-WATER RECHARGE STUDY
ROCKY FLATS PLANT SITE

Prepared For:

EG&G ROCKY FLATS

Prepared By:

ADVANCED SCIENCES, INC.

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FINAL
INTERIM REPORT

GROUND-WATER RECHARGE STUDY

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EXECUTIVE SUMMARY

The purpose of this Interim Report is to present the procedures used and to interpret the results of data gathered to date as a result of a ground-water recharge study conducted by Advanced Sciences, Incorporated (ASI) at the Rocky Flats Plant beginning July, 1993. This study is being conducted at two locations, Sites 1 and 2, located within the boundaries of Operable Unit 2. It involved drilling a number of boreholes at each location and observing the rates and destinations of infiltration of precipitation through the Rocky Flats Alluvium at each of these locations. These field experiments are being conducted to provide quantitative field measurements of vertical flux in the uppermost hydrostratigraphic unit and the underlying bedrock at the two sites, and to provide the basis for Rocky Flats local ground-water modeling applications.

At the present time, little in known about the nature and timing of recharge at the Rocky Flats Plant. For this reason, this recharge research is important to enable Rocky Flats Plant managers to better manage the plant water resources, to predict any contaminant migration, and to address remediation of any ground-water contamination problems.

Section 1.0 of the Ground-Water Recharge Study provides an introduction to the Interim Report. It also describes the hypothesis and conceptual model, provides a site description and the site geology and hydrology, and discusses the literature review that was conducted prior to beginning the field study. Section 2.0 presents the drilling, soil sampling, and soil testing methods that were employed for this research. Section 3.0 describes the field instrumentation and data collection methods used. These included the monitoring of tensiometers, hydroprobes, and meteorological data. Section 4.0 integrates the data interpretation and analysis. Section 5.0 summarizes the conclusions of the Ground-Water Recharge Study. Section 6.0 identifies the authors, field investigators and technicians, editors, task managers, and technical direction of this Interim Report. Section 7.0 relates the references used to write this Interim Report.

INTERIM REPORT
GROUND-WATER RECHARGE STUDY

1.0 INTRODUCTION

The purpose of this Ground-Water Recharge Study is to assess rates and fate of infiltration of precipitation into and through the Rocky Flats Alluvium at two locations underlying Operable Unit 2 (OU2) at the Rocky Flats Plant (RFP) (Figure 1). The Rocky Flats Alluvium, along with limited occurrences of bedrock sandstones which outcrop and subcrop beneath the Rocky Flats Alluvium, comprise the uppermost hydrostratigraphic unit (UHSU) in OU2. Understanding the nature of recharge conditions at the RFP is important relative to managing its water resources, predicting contaminant migration, and addressing remediation of ground-water contamination problems. Potential users of this research study include modelers, operable unit (OU) managers, and site-wide study managers.

Numerical models, such as MODFLOW (McDonald and Harbaugh, 1984), are being used by modelers at the RFP to solve water management problems. Recharge rates are a key input to these numerical models. To date, this variable has not been studied and determined specifically for the vicinity of the RFP. If the recharge rates are inaccurate, errors occur in calibrated parameters of the model. This situation leads to the potential for erroneous model simulations and poor management decisions. At contaminated sites, where contaminants can be transported through the alluvial zone by infiltrating water, it is currently uncertain whether the contaminants migrate vertically downward into the bedrock, move laterally in the alluvial zone, accumulate in the root zone, or a combination of these. Different remedial actions are appropriate for each of these possible transport paths. In addition, ground-water models require knowledge or estimates of the quantities and distribution of evapotranspiration. Prior to this study, quantitative evapotranspiration measurements have not been performed at the RFP (ASI, 1993a).

Currently, little is known about the nature and timing of recharge at the RFP. It is uncertain whether recharge is a continuous process throughout the year at a nearly constant rate, or episodic and seasonal in nature. Alluvial well hydrographs at the RFP have indicated dramatic increases in water levels that may be due to non-uniform percolation through the unsaturated zone to the water table (EG&G, 1991; 1992a; ASI, 1992). The combined influence of soils, precipitation, vegetation, and climate suggest that higher rates of recharge occur to the UHSU than the bedrock aquifers. If recharge estimates from both of these assessments are correct, then infiltration to the UHSU zone may discharge from the ground-water system without flowing through underlying bedrock. It is probable that this discharge occurs via lateral flow above the underlying bedrock accompanied by evapotranspiration and seepage to surface water (ASI, 1993a).

Because past assessments of the fate of recharge have been based upon indirect evidence, field experiments are being conducted to assess the nature and timing of recharge. These assessments might also test the hypothesis that, in general, recharge to the UHSU in general is higher than recharge to the underlying bedrock at the RFP. This research study is attempting to provide quantitative field measurements of vertical flux in the UHSU and the underlying bedrock at specific sites within the RFP and to provide data upon which to provide the basis for RFP local ground-water modeling applications.

1.1 HYPOTHESIS AND CONCEPTUAL MODEL

Ground-water recharge occurs when percolation exceeds the demands of evapotranspiration. Water drains from the root zone and flows downward to replenish the underlying ground-water resources. Typically, percolation does not exceed evapotranspiration for most of the year in arid and semiarid regions. Recharge is often episodic or seasonal in nature (Balek, 1988). There may be only a few times during the year when precipitation is high enough to exceed evapotranspiration. For example, some regions have high precipitation in winter or early spring

when the water needs of vegetation and evaporation rates are relatively low. In some areas of the RFP, net recharge to the underlying groundwater aquifer may not occur every year (ASI, 1993a).

Gee and Hillel (1988) make a distinction between two modes of recharge: continuous, diffuse recharge from widespread percolation through the unsaturated zone, and transient recharge from short-term penetration of water through preferred subsurface pathways. Diffuse recharge is often localized and only occurs in limited areas of a region. Localized recharge may be controlled by a number of factors including topography, vegetation, soil hydraulic properties, heterogeneities, and depth to the water table (Rushton, 1988).

A constant soil-moisture profile does not necessarily indicate a static water condition. Vertical gradients are often found to be near unity in homogeneous soils with flow occurring under the gravity gradient (Gee and Hillel, 1988). Steady-state conditions also may be present in heterogeneous soil. Under these conditions, the gradient is not unity. Static moisture profiles have been reported in heterogeneous soil conditions by Davis and Pittman (1990) and Hammermeister and others (1985).

A conceptual model for RFP unsaturated-zone recharge is based in part on a similar study conducted at a site near Golden, Colorado (Kiusalaas, 1992). This study revealed that static moisture profiles existed below 3.0 feet (ft) throughout most of the monitoring period (September 1991 through September 1992). During this time, large quantities of water appeared to infiltrate the soil surface and percolate short vertical distances. However, this water generally did not progress beyond the effective extraction depth of the native vegetation root system. Substantial percolation below this depth occurred during the month of March 1992. This percolation corresponded to a period of heavy precipitation and low evapotranspiration demands. However, the wetting front did not progress past a depth of 7.0 ft, which is within the effective root depth

of some of the native vegetation. It was judged that this water was depleted by evapotranspiration demands (Kiusalaas, 1992). Saturated hydraulic conductivities at the Golden site ranged from 10^{-3} to 10^{-6} centimeters per second (cm/sec). These values are compatible with hydraulic conductivities previously evaluated at the two RFP study sites, and those anticipated from this study (ASI, 1992). Based on the Kiusalaas (1992) study, the working hypothesis is that percolation resulting from precipitation is unlikely to reach either the water table or bedrock at the RFP study sites as a result of uniform moisture redistribution. Additionally, it is hypothesized that if water does reach bedrock at an unsaturated interface, it may do so through macropores, not entering bedrock but preferentially flowing laterally along the alluvium-bedrock interface (ASI, 1993a).

1.2 SITE DESCRIPTION

Two RFP study sites were selected based upon the occurrence of subsurface conditions, which included an inferred bedrock surface underlying an alluvial covering. The sites are located north of the RFP East Access Road in an area just east of the RFP Controlled Area (Figure 1) in OU2. These sites were chosen by EG&G and ASI personnel, based upon borehole logs and a geologic depositional model (EG&G, 1991; 1992a; ASI, 1993a). This depositional model indicated that these sites were located on top of discontinuous sandstone bodies of fluvial origin.

Information contained in well and borehole logs indicate that the Rocky Flats Alluvium is approximately 10 ft thick at Site 1 and separated from the underlying sandstone by claystone (Figures 2 and 3). At Site 2, the Rocky Flats Alluvium is about 30 ft thick and is in direct hydraulic connection with the underlying sandstone (Figures 4 and 5). Ground-water monitoring data indicate that the water table is consistently below the alluvium at Site 1 and within the alluvium only during the wetter months at Site 2 (ASI, 1992; 1993a). These data indicate that the Site 2 alluvium is much thicker.

1.3 SITE GEOLOGY AND HYDROLOGY

1.3.1 Site Geology

Boreholes drilled as a result of this study revealed geology consistent with that described in previous studies for this area (ASI, 1992; EG&G, 1991; 1992a). The Rocky Flats Alluvium was encountered at Site 1 from the ground surface to approximate depths ranging from 7.4 to 9.4 ft, and at Site 2 from the ground surface to approximate depths of 29.4 to 31.4 ft. The bedrock underlying Rocky Flats Alluvium at both Sites 1 and 2 consists of sandstones/claystones of the Cretaceous age Arapahoe Formation (EG&G, 1991). Precise depths to bedrock could not be measured because all core recovery was contained in brass liners for potential geotechnical analysis; thus, the exact location of the contact could not be noted. The lithology was described very generally from the ends of the brass liners and recorded on the Preliminary Well-Site Logs. Copies of these logs are included in Appendix A. The Rocky Flats Alluvium is generally described as being composed of light brown to dark yellowish-orange, grayish-orange to dark gray, poorly sorted (well-graded), angular to subrounded cobbles, coarse gravel, coarse sand, and gravelly clay with varying amounts of caliche (EG&G, 1991).

1.3.2 Surficial Materials and Vegetation

Vegetation is relatively sparse at both Sites 1 and 2, due in part to the semi-arid climate of the area. Field activities, including heavy equipment drilling, monitoring-well and borehole installation, and hydroprobe access-tube installation, have damaged the vegetation and may have compacted the surficial materials. The topsoil at these sites consists primarily of silty to sandy clay and gravel.

1.4 LITERATURE REVIEW

A literature search of previous research related to recharge in arid and semiarid environments was undertaken. Few field studies using quantitative field measurements to calculate recharge in this type of environment have been documented in this literature. No studies conducted in the western part of the Denver Basin or the RFP were revealed (ASI, 1993a).

Of the previous work reviewed, a study by Klute and others (1972) was conducted under conditions most closely resembling those at the RFP. The purpose of that study was to assess the impact of agricultural land management practices on ground-water recharge to the Ogallala aquifer near Burlington, Colorado. The authors cited studies that reported average recharge rates to the high plains of approximately 0.8 inches per year (in/yr) (Boettcher, 1966; Cardwell and Jenkins, 1963; McGovern, 1964,; Weist 1964) and 0.4 in/yr for Kit Carson County (Reddell, 1967), where the Klute study was conducted.

To assess ground-water recharge rates and the impact agricultural surface treatments have on them, a site was established that consisted of Peorian loess overlying the Ogallala Formation. The site was divided into 12 100- x 80-ft plots. Each was assigned one of six surface treatments consisting of native rangeland, mechanical fallow, pitting, chemical fallow, gravel mulch, and gravel mulch with herbicide. Soil-moisture content was monitored using a hydroprobe to a depth of 9.5 ft in all plots, except for the gravel mulch with herbicide. This plot was monitored to a depth of 18 ft. Readings were taken at 1-ft intervals. Moisture- characteristic curves were developed for selected samples using 1-, 5-, and 15-bar measurements. In addition to moisture characteristic curves, matric potential was determined using thermocouple psychrometers installed in the native rangeland plots (Klute and others, 1972).

Throughout the monitoring period, the native rangeland showed no significant change in moisture content below 4 ft. *In-situ* matric potentials, determined from the moisture-characteristic curves, were less than negative 15 bars from 2 ft to the bottom of the measured interval. Thermocouple psychrometer measurements indicated very large negative matric potentials throughout most of the year. These readings are summarized in Table 1 (Klute and others, 1972).

The authors concluded that no significant recharge occurred from precipitation at that site under natural rangeland conditions. If previous recharge estimates of 0.8 in/yr are correct, substantially larger rates must occur at isolated areas such as playa lakes, stream beds, terrace channels, or irrigated farmland (Klute and others, 1972).

TABLE 1

MATRIC POTENTIALS FROM THERMOCOUPLE PSYCHROMETER READINGS IN NATIVE RANGELAND NEAR BURLINGTON, COLORADO

Depth (ft)	Matric Potential (bars) Date		
	7/20/71	12/15/71	5/20/72
20	-23.0	-23.5	-20.5
20	-23.5	-22.0	-20.5
20	-18.0	-17.5	-16.0
10	-16.0	-11.5	-13.0
10	-14.0	-8.5	-7.0

Source: Klute and others, 1972

Other relevant studies conducted in semiarid regions include that by Stephens and McOrd (1987) near Socorro, New Mexico. Fluxes were calculated in the vadose zone by applying Darcy's equation to *in-situ* pressure-head data from tensiometers. These calculations assumed only vertical flow. Fluxes ranged from 0.7 to 3.66 centimeters per year (cm/yr) using the harmonic mean and geometric mean, respectively, to calculate hydraulic conductivity. Summer rains were found to take up to 4 months to penetrate 2.4 meters in this "relatively uniform, unconsolidated, dry sand" (Stephens and McOrd, 1987).

Stephens and McOrd (1987) continued their work by examining the effect of topography on recharge. They concluded that recharge can be very localized in arid and semiarid climates with a higher potential for recharge existing in topographically concave locations as opposed to hilltops or slopes. Large lateral flow components were found in the Socorro, New Mexico study area, using tracer tests on apparently uniform sandy hill slopes even with the absence of horizons of low permeability. The lateral flow was believed to have been due to the anisotropy of hydraulic conductivity.

Nixon and others (1972) conducted a 10-year study in a semiarid watershed. They found that rain penetrated as a wetting front during the rainy season but did not reach the bottom of the root zone every year. Extrapolation of the data collected at four sites indicated that recharge resulting from precipitation occurred on an average of once every 7 years. The wetting front at a grass-weed site only penetrated below the root zone three times in the 10 years of monitoring to contribute to recharge. The strongest wetting front that contributed to recharge took 2 months to travel 8.5 ft from the bottom of the root zone to the full monitored depth in this sandy soil. The authors concluded that recharge occurred at irregular intervals that depended upon the sequence and amount of precipitation events and the moisture holding capacity of the root zone.

Van Tonder and Kirchner (1990) conducted a recharge study of the Karoo Aquifer in South Africa using hydroprobe measurements. They found no increase in soil-moisture content below a depth of one meter despite "exceptionally high rainfall" during part of study duration and a corresponding rise in the water table. They attributed this to recharge along preferential pathways (cracks) that were not detected with the hydroprobe.

Enfield and others (1973) applied thermocouple psychrometer data to a site at the Hanford Reservation in the state of Washington. They used a modified version of the Quirk and Millington equation to allow for thermal gradients and hydraulic conductivity values calculated using the method outlined by Jackson and others (1965). Steady-state conditions were believed to exist throughout the monitored interval (10 to 80 meters). Vertical flux was calculated at 80 meters where matric potential was 1 bar and a gradient of 0.04 bars was inferred from other psychrometers. The authors concluded that the rate and direction of flux was uncertain, although if it did exist, it was less than 1 cm/yr. They attributed the uncertainty to limitations of calculated hydraulic-conductivity values and thermal diffusivities and neglecting osmotic potentials.

2.0 DRILLING, SOIL SAMPLING, AND SOIL TESTING

2.1 METHODS

EG&G Rocky Flats, Inc. standard operating procedure (SOP) guidance does not exist for this specific study. Therefore, to the extent existing EG&G SOPs were applicable, all tasks were performed in accordance with the appropriate SOPs for drilling, sampling, and analyses. All data were collected in a manner to maximize precision, accuracy, completeness, and representativeness.

Six boreholes were drilled at each of the two sites using a solid-stem auger to depths of 8 to 10 ft at Site 1, and 31 to 32 ft at Site 2. Locations of these boreholes are shown on Figures 2 and 4 for Sites 1 and 2, respectively. A standard 140-pound drive sampling system was used to obtain a continuous length of "undisturbed" core contained in brass liners. Samples were visually inspected to choose specific segments for geotechnical analyses. Criteria for selection of samples for analysis included amount of recovery, lack of void space within the liner (to minimize *in-situ* moisture loss), and grain size. No samples were collected for chemical analyses because both sites had been characterized as a result of previous investigations associated with OU2. Soil samples extracted from 5 of the 12 boreholes (02293, 02393, 02493, 02693, and 02993) were used to provide material for physical analyses of the soils and to calibrate the hydroprobe.

Aluminum casing was installed along the lengths of Boreholes 02293 and 02493 and polyvinyl chloride (PVC) casing was installed along the lengths of the other ten boreholes. Casing was needed to prevent collapse of a given borehole following withdrawal of the auger. This casing also served as hydroprobe access tubes for measuring soil-moisture versus depth at the sites. Ideally, aluminum casing would have been used in all boreholes, because it is stronger than PVC and does not interfere with hydroprobe measurements. However, availability and cost of aluminum casing prevented its use. However, aluminum casing was used in two boreholes when PVC casing could not be pushed to the needed depth without breaking. Drilling-rig augers decontaminated in accordance with the applicable SOPs (EG&G, 1992b and 1992c) were used for each boring. Down-hole sampling equipment was decontaminated between the collection of each sample.

Twenty-six soil samples were submitted to two different geotechnical laboratories for determination of physical properties. Sampled intervals were chosen to correspond as closely as possible to hydroprobe count locations. Tests, including moisture content, specific gravity, grain-

size distribution, unsaturated hydraulic conductivity/moisture-characteristic curves, and diffusivity (Bruce-Klute), have been or are currently being run on the collected borehole samples.

ASTM (1992) procedures were used by the two laboratories for routine geotechnical tests such as moisture content, specific gravity, and grain-size distribution. The unsaturated properties determined as a result of this study will be used to assess the movement of water and possibly contaminants in unsaturated soils similar to those characterized in this Interim Report. Additionally, unsaturated hydraulic properties of the five soil samples analyzed by Advanced Terra Testing, Inc. (ATT, Inc.) will be compared to unsaturated soil properties from similar samples from the same boreholes analyzed by the combined United States Geological Survey/Colorado School of Mines (USGS/CSM) laboratory located in Golden, Colorado.

Moisture-characteristic curves and hydraulic conductivity versus moisture content were measured on "undisturbed" samples in the USGS/CSM laboratory. This testing used a new procedure developed jointly by the USGS and CSM (Olsen and others, 1993). A copy of the draft procedure is included as part of Appendix C-1. This new procedure had not been used on field samples prior to this study. The procedure consists of concurrent measurements of unsaturated hydraulic conductivity and pore-water tension (capillary pressure) on undisturbed soil samples. The basis for this new procedure is the use of flow pumps to simultaneously inject and withdraw equal, known amounts of fluid from the unsaturated sample, thus inducing steady-state flow conditions. At this time, this procedure is only capable of measuring unsaturated soil variables to capillary pressures of approximately 4 bars. In our judgement, this capillary pressure is adequate to measure important unsaturated flow variables at the RFP sites.

Diffusivity (Bruce-Klute) tests were performed by ATT, Inc. to provide information necessary to calculate unsaturated hydraulic conductivity versus volumetric moisture content as an alternative to the CSM procedures. The coupling of Bruce-Klute diffusivity test results with the

moisture-characteristic curves from pressure-plate data has traditionally been used to calculate unsaturated hydraulic conductivity versus moisture-content relationships. Results from ATT, Inc.'s traditional testing methods are being compared to the new CSM procedure results in an effort to evaluate the accuracy of the two methods. Table 2 lists the samples submitted for testing and provides a summary of the tests being performed on each sample.

Currently, standard laboratory methods designed for measurement of moisture-characteristic curves and hydraulic properties of disturbed soil samples stipulate that the fraction of sample composed of fragments that pass the #10 (2-mm) sieve, hereinafter referred to as the minus 2-mm fraction, be used (Klute and others, 1972). This stipulation is based on a variety of concerns associated with the experimental techniques including packing homogeneity and test reproducibility. Generally, use of the minus 2-mm fraction poses no concern to studies involving agricultural soils because this size fraction comprises over 90 percent of the sample. Of the samples obtained for standard testing (ATT, Inc. samples) in this study, three had over 50 percent of their weight comprised of the fraction greater than 2 mm (Table 3); the remaining two samples had over 90 percent of their size fraction less than 2 mm (Table 3).

While the fragments greater than 2 mm constitute a large fraction of some of the samples used in this study, various investigators (Bouwer and Rice, 1983; Mehuys et al., 1975; Reinhart, 1961) indicate that such fragments play a relatively insignificant role in the moisture retention and unsaturated hydraulic properties of the sample. These investigators further outline simple correction procedures accounting for the volume of large fragments relative to the total sample volume. This is necessary to adjust data obtained from measurements on the minus 2-mm fraction to that of the total sample.

TABLE 2

SUMMARY OF SOIL PHYSICAL AND HYDRAULIC TESTS BY SAMPLE

Borehole	Sample Interval (ft below ground surface)	Sample Number	Moisture Content	Specific Gravity	Grain-Size Distribution	Moisture Charact./ Unsaturated Hydr. Cond.[1)]	Diffusivity (Bruce-Klute)	Laboratory[2)]
Site 1								
02293	2.9-3.4	1-2	X	X				CSM
02393	3.9-4.4	1-3	X	X				CSM
	5.4-5.9	1-4	X	X				CSM
	9.4-9.9	1-5	X	X				CSM
02393	2.0-4.0	ATT-1				X	X	ATT
	4.4-4.9	ATT-2	X			X	X	ATT
	4.9-5.4	ATT-2	X			X	X	ATT
02493	4.9-5.4	1-6	X	X				CSM
	5.9-6.4	1-7	X	X				CSM
	8.9-9.4	1-8	X	X				CSM
02693	8.4-8.9	ATT-3	X					
Site 2								
02993	1.0-1.5	2-1	X	X	X	X		CSM
	4.5-4.9	2-2	X	X	X	X		CSM
	11.4-11.9	2-3	X	X	X	X		CSM
	13.4-13.9	2-4	X	X	X	X		CSM
	14.4-14.9	2-5	X	X	X	X		CSM
	16.5-17.0	2-6	X	X	X	X		CSM
	18.4-18.9	2-7	X	X	X	X		CSM
	21.6-22.1	2-8	X	X	X	X		CSM
	22.9-23.4	2-9	X	X	X	X		CSM
	7.9-9.9	2-10	X	X	X	X		CSM
	19.4-21.5	2-11	X	X	X	X		CSM
	7.9-9.9	ATT-4				X	X	ATT
	19.4-21.5	ATT-5				X	X	ATT
	17.0-17.5	ATT-6	X			X	X	ATT
	17.5-18.0	ATT-6	X			X	X	ATT

1) CSM test for both moisture characterisic curves and unsaurated hydraulic conductivity curves.
ATT test was for moisture characteristic curves only.
2) CSM = Colorado School of Mines.
ATT = Advanced Terra Testing.

TABLE 3

VOLUME FRACTION OF LARGE FRAGMENTS FOR FIVE SOIL SAMPLES AT ROCKY FLATS PLANT RECHARGE SITES

Borehole No.	Sample Designation	W[1)] (percent)	1-W (percent)	Bulk Density[2)] (gm/cm^3)	V_r[3)] (decimal)
Site 1					
02393	ATT-1	46.1	53.9	1.90	0.386
	ATT-2	48.0	52.0	1.85	0.363
Site 2					
02993	ATT-4	47.8	52.2	1.49	0.294
	ATT-5	97.4	2.6	1.49	0.015
	ATT-6	96.7	3.3	1.48	0.018

1) Weight fraction of the fine (minus 2-mm) portion of the sample.
2) From Bruce-Klute test results. Particle density assumed to be 2.65 gm/cm^3.
3) Volume fraction of the coarse (plus 2-mm) portion of the sample.

Based upon the above considerations, the ATT, Inc. soil samples were sieved to separate the minus 2-mm fraction from the rest of the sample. Samples of material passing the #10 (2-mm) sieve were used for the moisture-characteristic curve and unsaturated hydraulic conductivity tests.

2.2 SOIL PHYSICAL CHARACTERISTICS

It is suspected that sample compaction may have occurred during drive sampling, which may have increased the *in-situ* soil moisture and decreased the hydraulic conductivity. In a similar manner, moisture-characteristic curves/unsaturated hydraulic conductivity curves may well be altered, due to compaction of the samples collected with the drive sampler.

2.2.1 Moisture Content and Grain-Size Distribution

Soil-moisture contents of each sample were the first analyses to be run by the respective laboratories, because they were needed to calibrate the hydroprobe. Table 4 summarizes soil-moisture contents in percent by volume by sample. Complete grain-size analyses (other than to separate the minus 2-mm fraction) were not included in the tests on the five samples analyzed by ATT, Inc. To date, grain-size analyses results have not been received for 18 of the 20 samples being analyzed by the USGS/CSM laboratory; thus, they could not be evaluated in time to be included in this Interim Report. Additional discussion and analysis will be provided upon receipt of the remaining geotechnical laboratory data, as well as a summary of grain-size distribution by sample to be presented as Table 5.

2.2.2 Moisture-Characteristic Curves

Soil-moisture contents of disturbed soil samples associated with various matric potentials define a unique moisture-characteristic curve for each soil sample. The methods used to obtain these

TABLE 4

SUMMARY OF SOIL-MOISTURE CONTENTS BY SAMPLE

Borehole	Sample Interval (ft below ground surface)	Sample Number	Laboratory[1)]	Laboratory Moisture Content (% Vol.)
Site 1				
02393	2.0-4.0	1-1	CSM	Disturbed
02293	2.9-3.4	1-2	CSM	9.98
02393	3.9-4.4	1-3	CSM	13.71
	5.4-5.9	1-4	CSM	9.49
	9.4-9.9	1-5	CSM	19.81
02493	4.9-5.4	1-6	CSM	12.04
	5.9-6.4	1-7	CSM	6.02
	8.9-9.4	1-8	CSM	25.97
02393	2.0-4.0	ATT-1	ATT	Disturbed
	4.4-4.9	ATT-2	ATT	9.59
	4.9-5.4	ATT-2	ATT	13.03
02693	8.4-8.9	ATT-3		24.58
Site 2				
02993	1.0-1.5	2-1	CSM	31.18
	4.5-4.9	2-2	CSM	22.33
	11.4-11.9	2-3	CSM	7.72
	13.4-13.9	2-4	CSM	24.92
	14.4-14.9	2-5	CSM	27.13
	16.5-17.0	2-6	CSM	32.04
	18.4-18.9	2-7	CSM	34.85
	21.6-22.1	2-8	CSM	
	22.9-23.4	2-9	CSM	31.87
	7.9-9.9	2-10	CSM	Disturbed
	19.4-21.5	2-11	CSM	Disturbed
	7.9-9.9	ATT-4	ATT	Disturbed
	19.4-21.5	ATT-5	ATT	Disturbed
	17.0-17.5	ATT-6	ATT	35.95
	17.5-18.0	ATT-6	ATT	39.94

1) CSM = Colorado School of Mines. ATT = Advanced Terra Testing.

TABLE 5

SUMMARY OF GRAIN-SIZE DISTRIBUTION BY SAMPLE

(TO BE PROVIDED IN NEXT INTERIM REPORT)

measurements are outlined in ASTM procedures D2325 and D3152 (ASTM, 1992). As discussed in Section 2.2.1 above, results from these measurements are a reflection of the moisture content of the fraction of sample composed of fragments that pass the #10 (2-mm) sieve.

Reinhart (1961) presents a procedure which adjusts the moisture contents obtained for the minus 2-mm fraction to that of the total sample. Given the weight fraction of the minus 2-mm fraction, W, then the volume fraction of large fragments, V_r, is given by

$$V_r = \frac{\rho_b}{\rho_s}(1-W) \tag{1}$$

where: ρ_b = the dry bulk density (gm/cm^3) of the total sample, and

ρ_s = the density of the large fragments (gm/cm^3).

With values of V_r, the volumetric moisture content based upon the total sample volume, θ_b, may be calculated from

$$\theta_b = (1-V_r)\theta_f \tag{2}$$

where: θ_f = the volumetric moisture content of the minus 2-mm fraction (cm^3/cm^3).

Values of W and V_r for bulk densities near those found for the samples in the field are given in Table 3. Values of V_r were calculated using the large fragment density of ρ_s = 2.65 gm/cm^3. This value is assumed typical of the large fragments in the soil at the RFP and has been previously used there by Fedors and Warner (1993).

Values of W were taken from the gradation analyses of the five soil samples done by ATT, Inc. The corrected moisture-characteristic curves are given in Appendix C. A discussion of the moisture-characteristic curve data is presented in Section 4.1.1.

2.2.3 Unsaturated-Saturated Hydraulic Conductivity

Extensive review of the literature by Klute and others (1972) and Klute and Dirksen (1984) have identified that, as yet, there are no standard measurement techniques for determining unsaturated hydraulic conductivities in soils. Specification of such standard techniques may remain elusive because no single set of techniques may be satisfactory for the large variety of available porous media of interest.

Again, problems associated with the presence of large fragments in some of the five soil samples analyzed during this study, and their effect upon unsaturated hydraulic conductivity, should be addressed. Mehuys and others (1975) found that if the unsaturated hydraulic conductivity is expressed as a function of capillary pressure, values of conductivity are primarily dependent on the minus 2-mm fraction alone. When unsaturated hydraulic conductivity is expressed as a function of volumetric moisture content, as in the case of this study, it is necessary and satisfactory to adjust for the volume of large fragments as outlined in equations (1) and (2) (Section 2.2.2). Bouwer and Rice (1983) reported similar findings concerning the effects of boulders on unsaturated hydraulic conductivities.

The laboratory measurement techniques used in this study by ATT, Inc. involved measuring the hydraulic diffusivity function of the minus 2-mm fraction, and subsequent calculation (by ASI) of unsaturated hydraulic conductivities using the diffusivity function and moisture-characteristic curve for each soil. Advantages of this technique include the relative simplicity and rapidity with which the tests can be conducted.

Combination of the one-dimensional Darcy flux equation for horizontal flow with a volumetric balance for soil moisture, and the assumption that a unique relationship between moisture content and capillary pressure exists for the soil samples, results in

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[K\left(\frac{\partial h_c}{\partial x}\right)\right] = \frac{d}{dx}\left[D\left(\frac{d\theta}{dx}\right)\right]. \tag{3}$$

In equation (3), K represents the hydraulic conductivity, h_c is the capillary pressure head, and D is the hydraulic diffusivity. Hydraulic diffusivity is related to hydraulic conductivity by the relationship

$$D = K\left(\frac{dh_c}{d\theta}\right). \tag{4}$$

Bruce and Klute (1956) solved equation (3) for hydraulic diffusivity using the Boltzmann transform, $B = xt^{1/2}$. This equation assumes that the initial and infiltration boundary moisture contents, θ_i and θ_s, respectively, were constant. Integration of equation (3) under the above conditions yields

$$D(\theta') = -\frac{1}{2}\left(\frac{dB}{d\theta}\right)_{\theta=\theta'} \int_{\theta_i}^{\theta'} B d\theta \qquad (5)$$

where: $D(\theta')$ is the diffusivity at moisture content θ'.

The experimental methods of Bruce and Klute (1956) were used in this study to measure the hydraulic diffusivity (Appendix C). Unsaturated hydraulic conductivity of the soil samples was calculated using a finite-difference form of equation (4) and the data obtained for the moisture-characteristic curves described in Section 2.2.2. Soil-moisture contents obtained for the minus 2-mm fraction in the soil samples were adjusted using equation (2) with values of V_r from Table 3. These results will be compared to the USGS/CSM laboratory unsaturated hydraulic conductivity tests results once they are completed. Table 6 (to be provided) will present a summary of saturated/unsaturated hydraulic conductivity tests by sample.

TABLE 6

SUMMARY OF SATURATED/UNSATURATED HYDRAULIC CONDUCTIVITY TESTS

(TO BE PROVIDED IN NEXT INTERIM REPORT)

3.0 FIELD INSTRUMENTATION AND DATA COLLECTION

3.1 TENSIOMETERS

Porous-cup tensiometers were installed and are being used at both monitoring locations (Sites 1 and 2) in an effort to characterize soil capillary-pressure profiles due to infiltration, percolation, and subsequent evapotranspiration of water from subsurface depths of approximately 6 to 36 inches. Four tensiometers were installed at varying depths at Site 1 (Figure 2) and five were installed at varying depths at Site 2 (Figure 4).

3.1.1 Description

A tensiometer consists of a porous cup, generally of ceramic material, connected through a tube to a manometer. Figure 6 is a diagram of the tensiometer used for this study. All parts are filled with water. When the cup is placed in the soil where the suction measurement is to be made, the bulk water inside the cup comes into hydraulic contact with soil water through the pores in the ceramic walls. The bulk water and the soil water tend to equilibrate. When initially placed in the soil, the water contained in the tensiometer is generally at atmospheric pressure. Soil water, being generally at less-than-atmospheric pressure, exercises a suction which draws out a certain amount of water from the rigid airtight tensiometer. This causes a drop in hydrostatic pressure. This pressure is indicated by the manometer which is a vacuum gauge in this case (Hillel, 1980).

A tensiometer tends to follow the changes in the matric suction of soil water. As soil moisture is depleted by drainage or plant uptake, or as it is replenished by rainfall or irrigation, corresponding changes in readings on the tensiometer gauge occur (Hillel, 1980).

Suction measurements by tensiometry are generally limited to matric suction values of below 1 atm (1.01 bar). This is due to the fact that the vacuum gauge or manometer measures a partial vacuum relative to the external atmospheric pressure, as well as to the general failure of water columns in macroscopic systems to withstand tensions exceeding 1 bar. Furthermore, as the ceramic material is generally made of the most permeable and porous material possible, too high a suction may cause air entry into the cup, which would equalize the internal pressure to the atmospheric. Under such conditions, soil suction will continue to increase even though the tensiometer fails to show it. In practice, the useful limit of most tensiometers is at about 0.8 bar of maximum suction. Though the suction range of 0 to 0.8 bar is but a small part of the total range of suction variation encountered in the field, it generally encompasses the greater part of the soil-wetness range (Hillel, 1980). The maximum measurable values of soil suction using the tensiometers installed at Sites 1 and 2 are approximately 60 centibars (cb). Soil-suction values greater than 60 cb, although reflecting lower moisture contents, may not be accurate, because some of the pores in the ceramic porous cup may have reached their air-entry pressure limit. The use of several tensiometers at different depths can indicate the amount of water needed in irrigation, and that can also allow calculation of the hydraulic gradients in the soil profile (Hillel, 1980).

Air diffusion through the porous cup into the vacuum gauging system requires frequent purging with de-aired water. Tensiometers also are sensitive to temperature gradients between their various parts. Hence, the above-ground parts should preferably be shielded from direct exposure to the sun. When installing the tensiometer, it is important that good contact be made between the cup and the soil so that equilibration is not hindered by contact-zone impedance to flow (Hillel, 1980).

The tensiometers used for this study were Soilmoisture Equipment Corp.'s (1985) Model 2725A Jet Fill Tensiometer (Figure 6). Figure 6 is a detailed illustration of the Model 2725A.

Originally, five tensiometers were installed at each site at depths of 6 inches, 12 inches, 18 inches, 24 inches, and 36 inches below ground surface. However, the 36-inch tensiometer at Site 1 was removed after installation, because it was not functioning properly. The geometry of the tensiometer installations at Sites 1 and 2 are presented on Figures 2 and 4, respectively.

3.1.2 Tensiometer Assembly

All of the tensiometers used in this study were assembled and primed according to the manufacturer's operating instructions. A copy of the Model 2725A Jet Fill Tensiometer Operating Instructions is provided in Appendix B-1.

3.1.3 Field Installation

Tensiometers were installed at both Sites 1 and 2 in boreholes advanced with an all-terrain vehicle (Scorpion) rig equipped with a Stanley sinker drill. The Stanley sinker drill is hydraulically powered from the vehicle's power take-off. Probe rods measuring 1-inch outside diameter were hydraulically advanced to varying depths ranging from 6 to 36 inches, corresponding to the varying lengths of the tensiometers to be installed. This process produces no cuttings. The probe rod then was removed, leaving the open boring. A slurry of 200-mesh silica flour and water was then poured into the boring to a level above the porous cup to ensure good contact between the cup and the surrounding soil, followed by the placement of the appropriately sized tensiometer. A concrete collar was installed around each tensiometer from a depth of approximately 4 to 6 inches below ground surface to approximately 2 inches above ground surface. The collar was installed to deter surface water seepage into the soil immediately adjacent to the tensiometer (i.e., to prevent surface water from channelling down the side of the tensiometer in the borehole) (Figure 7). Figures 8 and 9 show the tensiometer installation depths at Sites 1 and 2, respectively.

3.2 HYDROPROBE

A soil-moisture gauge, commonly known as a hydroprobe, is being used to detect and measure soil-moisture profiles within the two monitoring sites associated with this study. Hydroprobe access tubes were installed in boreholes drilled and sampled specifically for this study.

3.2.1 Hydroprobe Theory

A hydroprobe uses the principle of neutron moderation, or slowing, to measure water content in soils. Hydroprobes contain a radioactive source, commonly americium/beryllium, which emits high-energy (fast) neutrons, and a detector that senses thermal (slow) neutrons. Through collisions with atoms in the soil, the high-energy neutrons are thermalized (slowed).

The volume of soil sampled by the hydroprobe, sometimes known as the zone of thermalization, has been reported as a sphere with a radius of 5.9 to 7.1 inches by Shirazi and Isobe (1976), 2.95 inches in wet soils to 9.8 inches in dry soils by van Bavel (1956), and approximately 6 inches by CPN Corporation (Pers. Commun., 1991). The zone of thermalization also varies with the size of the source. It requires an average of 17 collisions with a hydrogen atom for a neutron to become thermalized, compared to an average of 136 collisions with an oxygen atom (Stone, 1990). Seventy percent of the slowing is due to collisions with hydrogen atoms, 10 percent is due to collisions with oxygen atoms, and 20 percent is due to collisions with other atoms (Dickey, 1990a). Because the primary source of hydrogen atoms in soil is in water molecules, a relationship can be derived between water content and thermalized neutrons. This relationship is usually linear for moisture contents commonly encountered in soils.

3.2.2 Description

The hydroprobe used in this study is a 503 DR Hydroprobe manufactured by CPN Corporation. It contains a 50 milli-Curie Americium-241/Beryllium source (CPN Corporation, 1985). A summary description of the 503 DR Hydroprobe is given in Appendix B-2.

3.2.3 Standard Count

The standard count is the most important test to judge whether the electronics and other components of the hydroprobe are functioning properly (Dickey, 1990a). The standard count is the average of a series of neutron counts taken under a standard set of conditions. These readings are checked for normality using a chi-squared test to verify that noise is not influencing the count. A standard count is also compared to the previous standard count to evaluate whether or not the probe is functioning correctly. If the probe is functioning properly, the difference between the two standard counts should fall within 0.707 times the square root of their average value 95 percent of the time (CPN Corporation, 1985).

The 503 DR Hydroprobe takes 32 counts (each count is 8 seconds long) and displays the chi-squared ratio to check for normality. This value should fall between 0.75 and 1.25, 95 percent of the time for 31 degrees of freedom (CPN Corporation, 1985). However, even if the probe is functioning correctly, the chi-squared ratio would tend to fall outside this range approximately 5 percent of the time. CPN recommends that the standard count be taken for hydrogen in the paraffin shield that surrounds the probe when it is in the retracted position inside the carrying case. Because the shield is not 100 percent effective, the standard count is subject to surrounding conditions, such as surface moisture on nearby objects. Therefore, this method requires standard counts be taken under identical conditions. Dickey (1990a) recommends that standard counts be taken 3 to 6 ft above the ground in access-tube material identical to that used in the field (ASI,

1993b). Because this method was not practical for this study and because it is believed to expose the worker to excessive amounts of radiation, the paraffin-shield method was used.

Two primary sources of error from estimating soil-moisture content with hydroprobes are: the calibration, and the decay of the radioactive source in the probe. The calibration component is the largest individual source of error (Haverkamp and others, 1984). Calibration accuracy can be improved by plotting the data and then eliminating the outlying points before applying regression techniques (Dickey, 1990a).

Hydroprobes sample a spherical volume of soil; whereas, point soil samples (taken at the time of access-tube drilling) represent a much smaller volume and are used to construct a calibration curve. Outliers may be due to point samples not being representative of the moisture content of the volume sampled by the hydroprobe. Dickey (1990a) reported significant improvements in correlation coefficients by using average moisture contents from an interval as opposed to point samples taken from the same depth as the neutron reading.

Because radioactive decay is a random process, some degree of uncertainty is attached to the moisture readings obtained using hydroprobes. This uncertainty can be reduced by using longer count times or taking multiple readings at each point (Haverkamp and others, 1984). The distribution of repeated neutron counts taken at a point may be approximated by a normal distribution for a large population (CPN Corporation, 1985). Therefore, normal statistical methods may be used to quantify the uncertainty associated with moisture readings.

3.2.4 Access-Tube Installation

Hydroprobe access tubes were installed in six boreholes at each of Sites 1 and 2 (Figures 2 and 4, respectively). Boreholes for the hydroprobe access tubes were drilled using a 4-inch solid

stem auger. The auger stem was removed from the hole at approximately 24-inch intervals so that soil samples could be extracted using a standard 140-pound slide-hammer sampling system.

Two-inch diameter, 6-inch long samples were taken at the designated intervals in brass liners. Samples were immediately scanned for radioactivity and organic vapors, capped after removal, and temporarily stored in a shaded area to minimize moisture loss. At the end of each day of field work, samples were stored in a connex at the RFP until they could be transported to a humidity room. Samples were stored on their sides to minimize redistribution of moisture due to gravity.

The hydroprobe access-tube materials used at Site 1 were 3.5-inch outside-diameter (O.D.) threaded flush-joint schedule 40 PVC pipe with PVC drive points (02093, 02393, 02593, and 02693) and 3.5-inch O.D. aluminum pipe with PVC drive points (02293 and 02493). At Site 2, 2.9-inch O.D. PVC casing was used in Boreholes 02793 through 03193, and 3.5-inch O.D. PVC casing was used in Borehole 03293. Upon completion of the hole, the assembled casing was inserted into the hole and capped. Any depressions or void spaces surrounding the top of the access tube were filled with compacted soil to minimize channeling or ponding of water in the depressions. Concrete collars were installed at ground surface around each hydroprobe access tube to minimize damage from other RFP activities and to deter surface-water seepage into the soil around the access tube. Table 7 provides a summary of completion information for all hydroprobe access tubes. Figures 10 and 11 show the completion of the hydroprobe access-tube boreholes at Sites 1 and 2, respectively. As shown on Figures 10a and 10b and Table 7, no ground water was encountered at Site 1 during drilling. At Site 2, ground water was encountered in Boreholes 02993, 03093, 03193, and 03293 (Figures 11a and 11b and Table 7). Adjacent alluvial wells (Figures 1 through 5) provide historical and recent water-level data for assessing the seasonal changes in ground-water levels at both Sites 1 and 2.

TABLE 7

HYDROPROBE ACCESS-TUBE COMPLETION SUMMARY

Borehole	Total Depth Sampled (ft below ground surface)[1]	Bedrock Depth (ft below ground surface)	Access Tube Depth (ft below ground surface)	Ground-Water Depth (ft below ground surface)[2]	Access Tube Material[3]	Access Tube Stickup (ft above ground surface)
Site 1						
02093	8.0	7.4-7.9	~7.2	>8.0	PVC	1.0
02193	6.0	Borehole abandoned due to excessive cobbles and rocks.				
02293	8.7	7.7-8.2	~7.9	>8.7	aluminum	2.1
02393	10.0 11.0 (sump)	8.9-9.4	~8.0	>11.0	PVC	1.0
02493	9.5 (10.5)	8.4-8.9	~9.6	>10.5	aluminum	0.4
02593	11.0	7.9-8.4	~8.3	>11.0	PVC	1.0
02693	9.0	7.9-8.4	~9.2	>9.2	PVC	0.9
Site 2						
02793	31.0	29.9	>31.4	>31.4	PVC	1.0
02893	30.8	30.3	~23.0	>30.8	PVC	1.0
02993	30.9	30.4	>31.4	29.15	PVC	1.0
03093	30.9	29.4	~28.8	28.55	PVC	1.0
03193	31.9	30.9	~30.0	30.00	PVC	1.0
03293	31.9	31.4	~31.9	29.40	PVC	1.0

1) Numbers in parentheses indicate total depth sampled. Boreholes were drilled from 1.5 to 2.0 feet deeper than this depth to accommodate sluff from cave-in.
2) Static water level at the time of drilling.
3) PVC = polyvinyl chloride

3.2.5 Hydroprobe-Calibration Procedure

The hydroprobe was calibrated by following, as closely as possible, the method of the Soil Conservation Service (Dickey, 1990b). The hydroprobe cable was pre-marked at locations that would place the neutron source and detector within each sample interval. The operating manual provides information on the location of the neutron source and detector with respect to the bottom of the probe. A standard count was taken according to manufacturer's specifications and checked for accuracy using the previously mentioned tests.

The hydroprobe case was placed on top of the access tube and the probe lowered down the tube to each sampling interval. A 32-second count was taken at each interval to be used later for calibration. The deepest measurement was taken at least 2 ft above the bottom of the access tube, because the hydrogen in the solid PVC drive point would cause high and inaccurate moisture readings.

Soil-moisture content of the samples was analyzed in the laboratory. Average soil-moisture contents were plotted against initial count ratios, and a least-squares linear regression was used to determine the y intercept, slope, and the coefficient of determination (R^2). Outliers then were eliminated using engineering judgement, and the regression was performed again.

3.2.6 Calibration Results

Three separate calibrations had to be performed due to variations in casing size and/or material. Casing material such as PVC contains hydrogen and chlorine which both affect count ratios. Similarly, differing annulus sizes resulting from differing casing sizes affect count ratios. Thus, separate calibration curves must be constructed for each variation in access-tube completion. Separate calibrations must also be run if differing lithology is encountered. Calibration data were

analyzed as a single calibration for the following groups of boreholes based on casing differences:

Site 1:	02093	(3.5-in. O.D. PVC casing)
	02393	
	02593	
	02693	
Site 1:	02293	(3.5-in. O.D. aluminum casing)
	02493	
Site 2:	02793	(2.9-in. O.D. PVC casing)
	02893	
	02993	
	03093	
	03193	
	03293	

The lithology underlying both sites was generally consistent from hole to hole; thus, lithology was not a factor in grouping the boreholes for the purposes of hydroprobe calibration. Samples were analyzed from Boreholes 02393 and 02693, and the resulting moisture contents were used to construct a calibration curve for the boreholes with 3.5-in O.D. PVC access tubes at Site 1. Samples from each of the aluminum cased access tubes at Site 1 (Boreholes 02293 and 02493) were used to construct this group's calibration curve. Samples analyzed from Borehole 02993 were used for the calibration of all Site 2 access tubes, though the casing size of Borehole 03293 was different. This was due to a limit on the number of samples that could be analyzed and because the difference in the size of casing did not appear to be reflected in the field counts.

Soil-moisture content and corresponding neutron counts for the three calibrations are presented in Appendix D (Tables D-1 through D-4), for the resulting calibration curves with outliers, and with the outliers removed, (Figures D-1 through D-4, respectively). The shaded regression statistics are the calibrations (with outliers removed for Site 1 - PVC casing and Site 2 - PVC

casing) that were used in all further measurements and analyses for this study. Soil-moisture laboratory results used for hydroprobe calibration are presented in Appendices C-2 and C-3.

3.3 METEOROLOGICAL DATA

Naturally-occurring precipitation, augmented with artificial precipitation, is the source of potential infiltration and percolation at the two recharge monitoring sites associated with this study. Meteorological data was acquired from the RFP meteorological station in the West Buffer Zone, approximately 1.5 miles west of the recharge sites. Data collected at the West Buffer Zone meteorological station include solar radiation, wind speed, maximum temperature, minimum temperature, relative humidity (or wet-bulb temperature), and barometric pressure.

In addition to the data collected from the RFP meteorological station, eight storage rain gauges have been placed at Site 1 and seven have been placed at Site 2 to obtain site-specific precipitation data. These rain gauges were placed at numerous locations at each site, not only to collect naturally-occurring precipitation data, but also to measure the evenness of coverage of artificial precipitation applied in the form of sprinkled water as described in Section 3.3.1.1. Precipitation data collected at the two meteorological stations will be used for fill-in and comparison purposes.

Artificial precipitation in the form of sprinkled water was applied at both sites in an effort to simulate recharge that might occur over a longer period from natural precipitation. This was necessary, due to the short period of time available for the study relative to the time needed to study recharge associated with natural precipitation. A longer period of time is needed to study natural precipitation recharge because of the infrequency of natural precipitation events, particularly during the time of year in which this study is being performed. It was hoped that

a controlled precipitation simulation would result in an observable wetting front. In addition, known parameters such as amount of artificial precipitation and estimated parameters such as evapotranspiration would then be used to calculate recharge rates through the use of a water budget as discussed in Section 4.

EG&G personnel sprinkled water twice at each of the two sites. Artificial precipitation was applied on August 4 to both Sites 1 and 2 with the goal of simulating an equivalent of approximately 1 inch of natural precipitation. Artificial precipitation was again applied during the week of September 20 through 25 with the goal of simulating an equivalent of 3 inches of natural precipitation. Soil-moisture measurement results associated with this precipitation simulation are presented in Section 3.4.2.2.

3.4 MONITORING

3.4.1 Tensiometers

The Project Management and Work Plan (ASI, 1993a) anticipated that soil moisture during much of the year would be less than the operating range of the tensiometers (0 to 60 cb). Tables 8 and 9 are summaries of tensiometer readings taken at Sites 1 and 2, respectively, since their installation. Readings were taken as often as was practicable.

TABLE 8

SUMMARY OF SITE 1 TENSIOMETER READINGS

Date	Time	Soil-Moisture Tension[2] (centibars) at a Depth of 6 inches	12 inches	18 inches	24 inches
6/25/93		30	22	50	36
6/28/93	Initial Reading	68	60	78	6
	After Priming Tensiometer	70	62	70	22
6/29/93	a.m.	74	68	76	10
7/19/93		dry[3]	76	dry	74
7/26/93	Initial Reading	64	70	42	58
	After Priming Tensiometer	64	70	50	60
7/27/93		28	76	2/44	74
8/2/93	Initial Reading	dry	dry	dry	dry
	After Priming Tensiometer	54	62	57	40
8/3/93		72	74	72	72
8/4/93		74	76	78	72
	Pre-Recharge	68	68	70	62
	Artificial Precip.	1-inch of water applied.			
8/5/93	0935	38	75	79	75
8/6/93	0808	40	75	79	76
8/7/93	0857	48	66	80	76
8/9/93	1440	66	75	80	76
8/11/93	1314	72	75	80	76
8/13/93	0810	76 dry	75 dry	78 dry	76 dry
8/16/93	Initial Reading	75 dry	76 dry	dry	dry
	After Priming Tensiometer	70	70	64	60
8/18/93	0940	75	76	dry	57 dry
8/23/93	Initial Reading	dry	dry	dry	dry
	After Priming Tensiometer	56	62	52	56
8/24/93	0935	70 dry	73 dry	72	70
8/25/93		74	73	75	72
9/2/93	0929	dry	dry	dry	dry
9/8/93	0840	dry	dry	dry	dry
9/15/93	Initial Reading	dry	dry	dry	dry
	After Priming Tensiometer	46	52	58	42
9/17/93	Initial Reading	59	68	72	72
	After Priming Tensiometer	56	58	59	52
9/20/93		68	72	78	54
9/21/93	Daily Artificial Precip.	44	52	76	48
9/22/93		34	38	72	dry
9/24/93		24	18	76	dry
9/27/93	Initial Reading	30	20	78	broken[4]
	After Priming Tensiometer	20	24	58	broken[4]
9/29/93	Initial Reading	32	24	74	broken[4]
	After Priming Tensiometer	32	26	62	56
10/1/93	Initial Reading	38	30	74	70
	After Priming Tensiometer	40	30	68	60
10/8/93	Initial Reading	58	42	dry	dry
	After Priming Tensiometer	56	42	48	50
10/15/93	Initial Reading	68	58	74	68
	After Priming Tensiometer	64	58	62	56
10/19/93	0830	8	9	76	72
10/20/93	Initial Reading	10	8	34	68
	After Priming Tensiometer	8	8	34	50
10/22/93	Initial Reading	12	12	48	74
	After Priming Tensiometer	12	12	46	52

1) Tensiometers installed on 6/24/93.
2) Porous cup maximum tension is 60 centibars (air-entry pressure). Tensiometer readings greater than 60 centibars indicate tensions greater than 60 centibars, but may not necessarily be accurate.
3) "Dry" means the tensiometer apparatus appeared to be dry; however, it may still register a tension.
4) Tensiometer reservoir was broken and subsequently replaced.

TABLE 9

SUMMARY OF SITE 2 TENSIOMETER READINGS

Date	Time	Soil-Moisture Tension[2] (centibars) at a Depth of 6 inches	12 inches	18 inches	24 inches	36 inches
7/19/93		47	64	42	dry[3]	36
7/26/93		42	74	50	38	42
7/27/93		70	75	50	46	40
7/29/93		72	78	52	46	42
8/2/93	0912	dry	75	58	31	44
8/3/93		69	77	58	10	44
8/4/93	Pre-Artif. Precip.	72	78	62	3 dry	47
	Artificial Precip.	1-inch of water applied.				
	Post-Artif. Precip.	62	70	62	dry	
8/5/93	0757	48	48	62	48	47
8/6/93	0825	33	60	62	52	48
8/7/93	0955	41	55	64	54	50
8/9/93	1450	72 dry	74	66	55	51
8/11/93		74 dry	78	68	57	52
8/13/93	0914	73 dry	79 dry	68	57	54
8/16/93	Initial Reading	dry	76	71	60	55
	After Priming Tensiometer	56	68	64	44	49
8/18/93	1056	dry	dry	74	62	54
8/23/93	Initial Reading	dry	dry	76	64	58
	After Priming Tensiometer	62	58	64	44	52
8/25/93	0845	dry	dry	76	66	59
9/2/93		dry	dry	62	68	62
9/8/93		dry	dry	74	76	68
9/15/93	Initial Reading	dry	dry	72	70	69
	After Priming Tensiometer	46	24	52	42	60
9/17/93	Initial Reading	64	dry	68	58	64
	After Priming Tensiometer	54	40	62	52	60
9/20/93		46	24	58	56	61
9/21/93		11	11	26	51	57
	Daily Artificial Precip.	5	10	28	48	58
9/22/93		8	11	20	38	51
9/24/93		10	15	20	25	42
9/27/93	Initial Reading	16	20	24	26	38
	After Priming Tensiometer	18	22	24	26	38
9/29/93	Initial Reading	21	28	28	28	38
	After Priming Tensiometer	22	28	28	28	38
10/1/93	Initial Reading	28	30	30	30	38
	After Priming Tensiometer	28	30	30	30	36
10/8/93	Initial Reading	52	40	38	36	38
	After Priming Tensiometer	50	40	40	34	38
10/15/93	Initial Reading	60	52	50	48	46
	After Priming Tensiometer	58	50	48	44	46
10/20/93	Initial Reading	8	12	16	22	36
	After Priming Tensiometer	8	12	16	20	34
10/22/93	Initial Reading	12	18	20	24	36
	After Priming Tensiometer	12	18	22	22	32

1) Tensiometers installed on 7/16/93.
2) Porous cup maximum tension is 60 centibars (air-entry pressure). Tensiometer readings greater than 60 centibars indicate tensions greater than 60 centibars, but may not necessarily be accurate.
3) "Dry" means the tensiometer apparatus appeared to be dry; however, it may still register a tension.

3.4.1.1 Site 1 Tensiometers

As can be seen from Table 8, the tensiometers at Site 1 were at potentials above the operating range of the tensiometers (or dry) over 80 percent of the time prior to September. This is not surprising, when considering the lack of natural precipitation in the month of August. This indicates that not much soil moisture is retained in the top 24 inches of soil at the site. Potentials within the operating range of the tensiometers were frequently recorded beginning in early September. This correlates to increased precipitation recorded in September resulting from both natural precipitation and the precipitation simulations discussed in Section 3.3. The frequent drying out of the tensiometers and the lack of response to the August 4, 1993 precipitation-simulation event raised initial doubts as to the reliability of the tensiometer data. The soil at both sites appears to be too dry and/or coarse to be effectively monitored by the tensiometers; however, their response in September and October is encouraging because they did not dry out as often.

3.4.1.2 Site 2 Tensiometers

Table 9 reveals that the tensiometers at Site 2 were also at potentials above the operating range of the tensiometers (or dry) a majority of the time in August. It appears that the soil suction was generally greater than the operating capacity of the tensiometers in all instances with the possible exceptions of the 24- and 36-inch tensiometers at Site 2. Like the tensiometers as Site 1, the Site 2 tensiometers' data appeared to be questionable in August, but showed more encouraging results in September and October because they did not dry out as often.

3.4.2 Hydroprobe

3.4.2.1 Procedure

No specific EG&G SOP exists for monitoring soil moisture using a hydroprobe. Accordingly, the following field procedure was followed to monitor soil moisture for this study:

- A standard count is taken in the paraffin shield which surrounds the probe when it is in the retracted position inside the carrying case. The standard count and chi-square ratio are checked and recorded. If the ground surface is wet, the monitoring is done without a standard count because the wet ground would result in higher standard count readings.

- The caps are removed, and when monitoring at Site 2, each access tube is checked for water accumulation at the bottom. The water table was not encountered at Site 1 during drilling and the monitoring wells in the area indicate the alluvium is dry; thus, water accumulation at the bottom of the access tubes at Site 1 is not a problem.

- The hydroprobe is placed on the top of the access tube and the probe is lowered to the first measurement interval (0.5 to 1.0 ft depending on the height of the casing above ground surface). Readings are taken for 32 seconds at 0.5-ft intervals from 0.5 to 3.0 ft and 1.0-ft intervals from 3.0 ft to approximately 2 ft above the solid PVC drive point or the water table, whichever is encountered first. The counting time interval determines the precision of the count. Correspondingly the longer the counting time, the fewer the number of measurements that can be made. Thus the 32-second time interval was selected as the minimum time that

would allow all data points to be measured on the same day and ensure sufficient precision.

- After each access tube is logged, the PVC cap is replaced on the access tube.

- After all logging is complete, the hydroprobe is returned to its designated storage area at the RFP.

3.4.2.2 Soil-Moisture Measurement Results

As of the date of this Final Interim Report (October 31, 1993), a minimum of 21 soil-moisture measurement surveys have been made at both Sites 1 and 2, or at least once per week since late July 1993. More frequent measurement surveys were taken immediately following significant precipitation events (greater than 0.2 inches) with the objective of detecting a wetting front. Some boreholes were surveyed a few extra times to assess whether a full survey of all boreholes would be beneficial. These soil-moisture measurement surveys are shown graphically on Figures 12 through 17 for Site 1 and on Figures 18 through 23 for Site 2. In addition, time series of the soil-moisture measurement surveys at selected depths (for the July through October 1993 period) are presented on Figures 24 through 29 (Site 1) and on Figures 30 through 35 (Site 2).

The shapes of the soil-moisture profiles were generally consistent over time for an individual borehole, but varied somewhat from borehole to borehole. It is hypothesized that this variation occurs because the shape of the soil-moisture profile is not only dependant on moisture variations with depth, but is also influenced to a certain degree by non-uniformities in the surrounding soils. Non-uniformities may be in the form of varying lithologies or may have resulted from differential compaction and void spaces caused by the auger drilling of the access tubes, especially in cobblely soils characteristic of those encountered in this study area.

3.4.2.2.1 Site-1 Soil-Moisture Conditions

Boreholes at Site 1 were surveyed 22 times, with the exception of Borehole 02093 which was surveyed 23 times, beginning in late July 1993. Results of these measurements are summarized in Tables 10 and 11. Soil-moisture measurements versus depth were plotted and are represented as soil-moisture profiles on Figures 12 through 17.

The soil-moisture measurements corresponding to depths of 0.5 and 1.0 ft for Borehole 02093 and 1.2 and 1.7 ft for Borehole 02493 are higher than those of the other four boreholes at Site 1. The cause of these two anomalies presently is unknown. Possible explanations include non-uniformities of borehole diameter and disturbance of natural compaction (as discussed above), leading to possible errors in hydroprobe readings. In addition, readings above a depth of approximately 0.75 ft below ground surface are frequently questionable because of loss of neutrons to the atmosphere.

Surveys at Site 1 were generally consistent below 1.0 ft for the monitoring period of July 26 to August 25, 1993 represented on Figures 12 through 17 (a and b series). A range of soil moisture could be seen above the 1.0-ft depth in Boreholes 02293, 02393, and 02593. Moisture content was generally greater for the measurements made on August 4 and 5, 1993. This is to be expected because the ground surface was wet from the precipitation simulation conducted on August 4, 1993. The soil-moisture profiles show a drying trend at ground surface, as would be expected with no additional precipitation.

Figures 12 through 17 (c and d series) show moisture profiles for the September 2 through October 22, 1993 monitoring period. This encompasses two significant natural precipitation

TABLE 10

SUMMARY OF SITE 1 SOIL-MOISTURE MEASUREMENTS BOREHOLES 02093, 02293, AND 02393

Borehole 02093

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																						
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/15	10/20	10/22
0.5	27.9	27.4	28.4	28.8	28.9	28.4	27.3	27.3	26.3	25.9	26.8	26.0	24.9	26.0	26.8	27.4	30.6	30.6	30.0	30.1	28.9	33.3	32.8
1.0	23.3	21.0	20.0	20.5	19.2	19.6	18.6	19.3	19.1	18.7	17.6	17.6	19.9	15.6	14.7	14.7	14.4	14.8	14.9	14.6	12.3	13.2	13.5
1.5	10.7	9.4	9.1	9.1	9.0	9.6	10.2	9.2	9.7	10.0	8.8	8.2	8.8	8.6	9.1	9.4	9.1	8.8	9.5	9.1	8.7	9.3	10.2
2.1	17.5	15.6	16.3	15.1	16.0	15.8	15.4	16.2	14.9	16.0	14.4	14.1	14.1	14.4	14.3	13.4	13.9	13.6	14.4	14.3	14.6	14.0	14.2
2.5	16.4	15.5	15.2	15.0	14.7	14.0	14.2	15.0	15.2	14.4	14.4	14.3	13.1	13.2	13.4	13.2	13.7	13.4	13.1	13.6	12.7	12.9	13.7
3.5	11.6	11.5	11.9	11.3	12.3	12.0	12.2	11.5	11.2	11.8	11.3	11.2	13.0	12.6	12.5	12.3	11.8	12.9	12.3	11.8	9.6	12.0	10.7
4.5	16.0	16.3	15.6	15.2	16.2	14.9	15.0	15.3	15.7	16.0	14.9	15.1	11.0	11.4	11.5	11.9	11.1	11.6	11.5	11.2	10.8	11.1	10.2
5.5	11.1	11.1	11.7	11.4	11.8	11.2	11.4	10.9	11.2	11.5	10.7	11.1	14.7	14.2	14.6	14.7	14.6	13.2	14.2	14.5	13.6	15.3	14.0
6.5	17.4	16.9	16.8	16.6	16.5	16.3	16.8	16.9	16.7	17.2	17.5	16.7	11.0	11.3	11.6	10.8	10.2	10.2	10.9	11.1	17.3	11.3	11.2
																					17.7	17.9	18.3

[illegible]MOISA.WK3

Borehole 02393

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																						
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	2.2	2.0	9.0	9.8	9.4	8.3	9.4	7.0	5.8	5.4	4.2	3.3	3.5	5.4	9.3	8.6	10.6	10.2	10.1	8.7	12.2	12.4
1.1	11.1	10.7	12.1	12.0	11.8	11.2	11.8	12.0	11.9	12.0	11.8	11.0	12.3	11.0	12.9	11.7	14.5	14.6	14.1	14.0	17.0	16.1
1.6	17.2	16.4	16.8	15.7	15.8	16.3	15.8	16.3	16.4	15.8	15.2	16.4	15.3	15.4	14.9	14.9	15.4	14.7	15.1	15.1	17.2	15.8
2.2	15.5	15.0	14.9	15.5	14.0	14.7	14.0	13.6	13.8	14.9	14.0	13.7	13.0	13.1	13.1	12.8	12.6	13.1	12.0	12.9	12.2	12.7
2.6	13.9	14.1	14.3	13.5	13.2	13.3	13.2	13.8	13.2	13.6	12.6	13.0	12.3	11.9	12.7	13.0	11.9	12.1	11.9	12.1	11.8	11.5
3.2		15.2	15.1	14.3	14.7	13.8	14.7	14.8	14.6	14.2	14.1	13.3	13.9	12.8	13.7	14.0	12.9	13.5	13.1	12.4	12.8	12.8
3.6	16.0	16.3	15.8	16.0	15.8	16.2	15.8	15.5	14.6	14.5	14.2	15.5	15.5	14.5	14.1	13.9	13.8	13.4	14.2	12.0	14.1	13.8
4.6	13.0	13.2	13.3	12.5	13.9	13.2	13.9	13.2	12.8	12.7	13.1	13.4	12.2	12.4	12.8	12.9	12.7	13.9	12.6	12.4	13.4	13.0
5.6	14.0	14.0	14.7	14.7	13.9	14.3	13.9	13.6	14.4	14.1	14.0	13.9	14.4	14.1	14.5	14.2	13.1	11.8	12.1	14.4	12.5	13.5
6.6	13.1	12.9	12.3	12.2	12.4	12.4	12.4	13.3	11.8	12.3	13.0	12.5	12.1	12.2	11.9	11.2	11.3	10.0	12.4	12.1	12.2	12.3
7.6	11.4	11.8	11.7	11.4	11.2	12.3	11.2	11.5	11.6	11.1	11.4	11.6	11.6	11.0	11.9	11.6	11.6	11.4	10.2	11.1	10.8	11.7
8.6	9.7	8.8	9.5	9.9	8.8		8.8	10.1	9.4	9.4	8.4	9.8	9.9	9.2	9.2	9.4	8.9	10.0	9.8	9.8	10.1	10.2
													25.8	27.1	28.0	26.6	27.7	27.5	26.3	26.7	26.9	27.1

023MOISA.WK3

Borehole 02293

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																						
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.5	4.9	2.8	11.8	10.2	10.5	10.3	8.8	7.5	6.4	5.5	5.3	4.4	3.2	7.7	11.5	10.9	14.4	14.1	13.1	13.5	15.6	15.6
1.1	6.2	5.0	5.4	5.5	5.8	6.1	5.5	5.6	4.6	4.4	4.5	4.4	4.1	5.4	6.2	6.1	10.9	10.6	9.9	9.7	11.6	11.6
1.5	9.7	9.8	10.8	10.0	10.0	10.2	9.6	9.5	9.4	9.7	9.8	9.3	10.0	9.7	9.8	9.4	13.7	14.0	13.3	12.2	14.4	14.4
2.1	13.6	14.1	13.5	13.4	12.7	12.9	12.3	12.8	12.1	12.0	11.5	10.9	11.9	11.6	11.3	11.6	12.4	12.3	11.7	11.6	12.2	12.2
2.5	9.2	9.4	8.5	8.8	8.7	9.0	9.0	8.4	8.7	8.6	7.5	7.4	7.6	7.8	6.9	7.4	7.3	7.1	7.3	7.4	7.3	7.3
3.5	8.4	8.7	8.3	8.1	8.0	8.1	7.9	8.1	8.1	8.2	7.5	8.3	7.7	7.8	7.8	8.0	6.9	7.3	7.3	7.1	7.7	7.7
4.5	3.1	2.6	2.8	2.7	3.1	2.9	2.5	2.5	2.8	2.6	2.3	2.4	2.3	2.6	3.0	2.7	2.9	2.4	2.2	2.1	2.7	2.7
5.5	8.2	8.2	8.2	8.1	8.2	8.6	8.8	8.1	8.1	8.2	8.5	8.3	8.1	7.6	8.2	8.0	8.1	7.6	10.2	8.5	8.2	8.2
6.5	7.7	8.1	8.1	7.1	7.4	7.4	7.9	7.4	6.9	7.0	7.3	7.5	7.3	7.2	7.4	7.7	8.2	7.7	7.6	7.7	7.2	7.2
7.1	9.4	8.4	8.6	7.7	7.3	6.8	7.1	8.9	5.7	7.9	8.5	5.8	8.6	8.1	8.9	4.5	3.7	4.3	2.6	2.8	2.1	2.1

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TABLE 11

SUMMARY OF SITE 1 SOIL-MOISTURE MEASUREMENTS BOREHOLES 02493, 02593, AND 02693

Borehole 02493

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																					
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
1.2	29.1	28.7	28.7	28.6	28.0	28.2	26.1	26.2	26.2	25.6	26.2	26.0	25.8	26.2	29.2	28.2	29.6	29.3	28.6	27.7	31.2	30.6
1.7	22.7	21.8	21.9	22.3	22.4	22.2	25.2	24.5	24.5	24.9	24.0	23.5	23.6	23.6	22.8	23.6	22.7	22.7	21.7	22.3	23.0	22.8
2.2	16.4	16.4	16.0	15.2	16.0	15.7	15.6	16.1	16.4	15.5	14.9	15.3	15.0	14.9	14.6	14.1	14.6	13.9	13.8	14.8	14.3	15.1
2.8	11.0	10.5	11.2	11.0	11.2	11.0	11.1	10.6	10.4	10.7	10.2	10.0	9.9	9.7	10.6	9.6	9.9	9.4	9.1	9.3	10.1	9.5
3.2	13.8	13.5	13.5	13.7	13.6	13.9	12.0	12.1	12.0	12.3	12.3	11.7	12.1	12.1	11.8	12.3	11.5	11.3	11.8	13.4	11.9	11.8
3.8		10.5	10.7	11.3	10.7	10.9	11.8	11.1	11.8	11.3	11.6	11.2	10.3	11.1	11.5	11.0	11.2	10.8	10.4	10.3	10.9	11.3
4.2	10.2	9.8	10.5	10.6	10.8	10.7	10.1	10.0	10.1	10.0	9.9	9.8	9.7	10.3	10.1	10.4	10.2	9.5	9.8	13.3	9.9	9.5
5.2	12.7	12.6	12.5	12.8	13.0	12.6	13.1	13.3	13.4	13.5	12.4	13.1	13.4	13.7	12.8	12.7	13.3	12.6	12.9	9.7	13.1	13.6
6.2	10.5	10.3	10.3	10.4	9.8	9.8	9.7	10.2	9.7	9.6	9.5	9.7	9.2	9.7	9.4	14.5	9.7	10.3	10.2	8.0	9.7	9.5
7.2	8.3	8.1	7.9	8.3	8.6	8.3	8.7	8.5	9.0	9.0	8.8	8.6	8.5	8.4	8.1	8.7	8.2	8.7	8.3	18.5	9.2	8.7
8.2	21.3	21.5	21.4	22.4	21.3	21.0	18.3	18.7	18.1	18.6	18.6	18.4	19.2	18.6	18.4	18.6	18.9	19.4	18.8	18.7	19.2	19.3
9.2	18.3		18.0	17.5	16.9	16.7	24.4	22.9	23.5	22.6	21.5	21.7	20.3	20.3	19.6	18.5	17.4	17.2	15.7	16.6	19.7	20.0

Borehole 02593

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																					
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	5.4	5.5	8.5	8.8	8.5	8.5	8.3	8.1	7.9	6.6	6.8	6.6	6.8	7.2	10.1	8.2	11.7	11.2	10.7	10.6	13.2	12.4
1.1	8.1	6.9	8.6	8.0	8.6	8.1	8.4	7.6	7.3	7.5	7.5	8.4	7.5	7.7	9.0	8.9	9.9	10.4	9.8	9.5	11.3	11.7
1.6	13.1	14.5	14.1	13.9	14.0	15.0	14.3	15.4	14.5	15.3	13.9	14.1	13.7	14.2	14.2	14.7	14.0	13.4	14.7	14.2	16.2	16.2
2.2	20.8	19.8	19.4	19.3	19.1	19.1	18.9	18.7	18.3	19.1	18.5	18.4	18.5	18.6	18.3	17.5	17.1	16.8	17.3	16.9	17.9	16.6
2.6	15.9	16.0	15.4	16.4	16.2	15.5	15.6	14.6	15.4	15.7	15.5	15.5	14.0	14.8	13.7	15.2	14.0	13.8	14.5	13.6	14.4	13.7
3.6	12.4	12.7	13.1	13.5	12.4	13.1	12.5	12.8	11.7	12.1	11.9	12.6	13.4	14.9	13.6	12.9	13.4	13.4	13.8	14.7	13.6	14.0
4.6	10.6	11.0	11.4	11.8	11.1	11.3	12.1	12.1	10.3	10.7	11.5	10.6	11.9	11.5	27.8	11.0	11.3	11.1	11.1	11.3	12.1	11.4
5.6	13.0	13.2	12.2	14.0	13.1	13.2	13.4	13.0	13.9	12.8	13.2	12.8	11.2	11.1	11.1	11.5	10.8	11.2	11.7	11.3	11.6	10.7
6.6	11.5	12.3	11.6	11.3	11.5	11.1	11.7	11.9	11.5	11.7	12.1	12.0	14.0	13.6	13.2	13.3	12.7	13.6	12.8	13.6	12.3	13.5
7.6	12.0	11.7	11.6	12.9	13.0	12.1	11.8	12.7	12.8	12.6	12.6	12.3	11.5	12.0	12.0	12.2	12.2	11.2	11.7	12.6	12.1	11.8

Borehole 02693

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																					
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	9/2	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.7	9.0	7.9	8.4	7.9	8.6	8.3		8.4	8.1	8.0	7.3	8.4	7.4	10.4	13.3	12.8	14.6	14.8	13.6	13.6	15.9	16.2
1.2	7.5	7.9	7.1	7.6	6.8	7.6	7.2	7.3	7.2	7.4	7.3	7.3	5.8	7.0	7.2	7.3	9.6	9.4	9.3	9.4	9.1	8.9
1.7	6.1	5.3	5.5	5.9	5.3	5.1	4.9	5.3	5.3	5.2	4.9	5.1	4.2	4.8	4.8	3.9	4.8	4.7	4.9	4.2	5.0	4.7
2.3	9.8	10.1	9.3	9.5	9.9	9.5	9.2	9.7	8.6	9.0	8.6	8.7	8.7	8.2	8.8	8.3	9.1	9.2	8.2	8.4	8.4	8.4
2.7	12.3	11.7	11.9	10.9	11.1	12.0	10.9	10.7	11.5	11.1	11.1	10.6	10.6	10.6	10.3	10.8	10.4	10.3	10.3	10.7	11.4	10.4
3.3		12.8	13.0	12.6	11.9	12.5	12.3	12.7	12.8	11.8	12.5	11.8	11.5	11.3	11.8	11.0	12.0	11.5	11.7	12.0	10.4	11.7
3.7	14.1	13.5	14.1	14.7	13.9	13.8	13.8	14.4	13.6	13.4	13.3	13.7	13.4	15.0	12.6	12.7	13.6	12.2	12.4	12.2	12.8	12.7
4.7	14.1	14.7	12.8	13.4	13.2	13.5	12.9	13.6	12.9	13.4	12.9	13.3	13.4	13.6	13.8	13.2	12.5	13.2	13.1	12.4	13.5	13.0
5.7	13.5	13.1	13.5	13.1	14.1	13.3	13.3	13.8	14.2	13.4	12.3	13.8	13.6	13.6	13.3	12.6	13.6	13.9	13.3	14.2	13.9	13.7
6.7	11.2	12.5	12.5	11.9	12.3	13.1	12.7	12.6	13.3	12.0	12.6	12.4	12.4	13.1	13.3	13.0	12.6	12.8	12.3	13.9	13.2	12.9
7.7	18.8	17.7	18.7	17.5	18.7	18.3	18.8	18.7	18.8	18.3	18.3	18.5	18.3	19.2	18.7	18.8	19.2	18.8	19.2	17.5	18.9	19.1
8.8	26.7	26.9	27.7	28.2	27.6	27.1	27.4	27.2	27.6	27.0	28.8	27.6	27.6	22.6	28.8	22.2	21.4	22.2	22.8	22.3	21.8	22.0

events occurring on September 7 and 13, 1993, and the second precipitation simulation conducted during the week of September 20 through 24, 1993. Again, the profiles were generally consistent below 1.0 ft, with the exception of an anomalous point on the profile of Borehole 02493. Based on the fact that this outlier is a single data point, this anomaly is judged to be the result of hydroprobe operator error and not from movements of a wetting front. The soil-moisture profile surveyed on October 8, 1993 for Borehole 02493 was not presented on Figure 15d. This profile appeared to be erroneously out of phase, probably due to a data-reduction error. A single outlier data point was deleted from the September 15 profile of Borehole 02593 because it was also an obvious error (see Table 11). As expected, the highest soil-moisture readings above 1.0 ft occurred immediately following the September 20 through 24 precipitation simulation. A drying trend was then observed through October 22, 1993, the last survey conducted for this Interim Report. Evidence of a wetting front was not noted on any of the profiles, with the possible exception of the profile of the soil-moisture measured on October 20, 1993 at Borehole 02393 (Figure 14d). The increased soil-moisture content between 1.0 and 2.0 ft below ground surface may be the result of a wetting front. However, it did not appear to move below the 2.0-ft depth.

Figures 24 through 29 show soil-moisture content versus time (soil-moisture time series) at 0.5 ft, 1.0 ft, and 5.5 ft below ground surface for Site 1. Increases in soil moisture ranging from approximately 4 to 10 percent can be seen at 0.5 ft below ground surface in Boreholes 02293, 02393, and 02593 from August 3 (pre-artificial precipitation) to August 4, 1993 (post-artificial precipitation). These soil-moisture contents diminish with time until the beginning of September, where all six boreholes show a response to the precipitation events that occurred in September. Soil-moisture at 0.5 ft increased as much as approximately 13 percent. Increases in soil-moisture of as much as 7 percent were also noted at the 1.0 ft depth (Borehole 02293) in September. No other notable changes in soil-moisture content are observable at other depths or times.

3.4.2.2.2 Site-2 Soil-Moisture Conditions

The six Boreholes at Site 2 were surveyed a total of 21 times. Results of these soil-moisture measurement surveys are summarized in Tables 12 through 17 and shown graphically on Figures 18 through 23. The ranges of soil-moisture contents are not as obvious in the case of the soil-moisture profiles for Site 2 as those for Site 1, due to the increased vertical and horizontal scales of the profiles. Because of field-survey time constraints, surveys were not measured all the way to total depth each time at Site 2. An apparent wetting front would be detected in the first 10 ft in the form of an anomalous pulse. Had a pulse been identified and subsequent measurements indicated moisture movement past the 10-ft depth, surveys would have been scheduled more frequently as this pulse proceeded to the water table or to bedrock, whichever was encountered first. However, surveys to total depth were taken at Site 2 at least once per week (11 of 21 surveys during the reported monitoring period.

As discussed in Section 3.4.2.2, measurement results are generally consistent over time for each individual borehole at Site 2. Outliers such as those noted on Figures 19c, 20d, 21c, and 22d; and out-of-phase profiles such as those observed on Figures 19a, 22c, and 23b, are judged to be the result of field measurement and/or data-reduction errors, and not the result of a pulse moving downward.

All of the Site 2 soil-moisture profiles indicate an approximate increase in moisture content of from 20 to 25 percent at approximately 12.5 ft below ground surface. This increase in moisture content correlates with a dramatic change in lithology from a relatively dry sandy gravel with some clay, to a relatively moist clayey sand that was noted during drilling. Another zone of relatively dry sandy gravel was encountered at approximately 25 ft below ground surface. The

TABLE 12

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 02793

Borehole 02793

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	18.5	16.5	31.6	29.4	31.4	32.0	30.0	28.4	27.1	27.5	27.0	25.0	25.5	31.8	30.9	36.1	33.4	34.1	32.2	38.5	37.1
1.1	26.1	27.1	28.1	28.4	29.2	28.7	27.1	26.4	26.8	26.7	26.3	24.5	23.0	24.3	25.7	30.1	28.3	28.7	27.7	31.1	29.2
1.6	24.5	23.3	23.6	23.4	22.2	23.1	21.0	21.1	21.6	21.5	20.6	19.2	17.7	18.3	16.8	21.8	20.2	20.7	22.5	24.2	23.9
2.2	23.3	21.9	22.4	21.6	21.1	21.6	19.7	20.9	21.3	20.9	18.8	20.1	19.4	17.7	17.8	18.8	18.3	20.1	19.9	22.0	23.5
2.6	20.0	18.2	17.6	19.1	18.7	17.8	16.9	18.3	18.0	16.8	15.7	15.3	13.7	14.3	14.5	16.2	14.6	15.0	16.7	16.4	15.5
3.2	13.6	13.3	14.0	14.1	13.5	13.1	11.6	12.8	13.6	13.1	13.5	13.3	14.8	12.0	12.4	12.9	13.1	12.6	12.9	14.0	13.8
3.6	15.5	14.6	16.1	15.6	15.1	15.1	14.6	14.6	13.6	15.7	15.3	13.8	14.9	13.8	13.1	13.1	13.4	13.0	13.3	14.7	13.7
4.6	13.1	12.6	12.7	12.6	11.9	13.5	12.5	12.1	12.4	12.6	12.5	12.8	11.7	11.9	13.1	11.8	9.3	12.7	12.6	12.6	13.1
5.6	10.7	11.4	11.0	10.2	10.6	9.3	11.1	10.2	10.1	10.3	9.6	8.6	9.8	8.9	24.5	10.2	7.6	9.4	9.3	10.9	10.4
6.6	10.8	10.4	11.6	10.4	11.3	9.2	10.8	10.4	11.1	10.6	10.2	9.8	12.1	10.3	10.5	10.5	9.4	10.5	11.2	10.2	10.4
7.6	7.6	7.7	8.0	8.5	6.8	7.6	7.5	6.7	6.8	6.6	7.8	6.8	8.0	7.9	6.5	6.9	10.2	7.8	8.0	7.4	7.4
8.6	12.3	13.3	14.0	13.2	14.6	12.5	12.4	13.6	15.2	12.9		12.2	11.6	11.5	13.9	12.8	12.8	12.7	12.2	13.2	11.0
9.6	9.2	9.8	9.9	10.3	10.3	9.8	10.6	10.6	9.6	9.6		8.8	10.0	10.5	10.6	8.8	9.5	10.3	9.0	10.9	9.1
10.6	9.2	10.3	9.3	8.7	10.4	9.4	10.8	9.5	9.9	9.4		10.1	9.7	10.4	10.2	9.9	9.5	9.2	9.2	9.7	9.6
11.6	5.4	5.5			4.8		5.9			6.4		6.2	5.4		6.3		5.7		5.9		6.2
12.2	6.9	7.4			16.6		6.6			8.0		6.4	7.7		7.3		7.3		6.8		8.0
13.1	27.6	29.5			28.5		28.6			29.0		28.1	27.9		28.0		28.4		27.8		28.4
14.1	31.1	32.2			30.8		31.0			32.1		30.8	31.9		31.8		32.5		31.6		31.5
15.1	34.3	35.3			33.1		33.0			34.0		34.6	33.3		33.7		34.1		32.3		33.2
16.1	29.9	31.7			32.0		31.4			31.7		31.3	30.2		32.0		33.2		31.6		32.5
17.1	31.3	33.5			32.4		32.9			33.2		32.0	32.9		32.7		33.2		34.1		32.6
18.1	28.7	30.4			28.8		28.0			28.3		27.9	28.7		27.8		27.7		29.3		28.2
19.1	29.7	27.8			30.9		27.8			32.4		31.4	30.6		30.9		31.9		30.3		31.0
20.2	27.4	25.9			27.6		26.9			26.8		26.9	28.1		27.4		26.7		26.0		29.1
21.2	24.6	23.7			25.2		25.0			27.1		24.9	24.7		25.3		26.1		26.5		26.4
22.2	20.9	22.7			23.2		24.2			23.3		22.6	22.9		23.4		23.6		23.3		23.7
23.2	22.7	24.5			22.7		22.9			23.5		22.6	22.7		22.7		22.4		21.7		24.0
24.2	26.7	26.7			25.9		26.9			26.2		25.9	26.7		25.1		28.0		26.0		26.2
25.2	23.6	24.3			25.5		23.9			24.5		23.8	25.7		23.6		25.7		26.0		25.6
26.2	16.7	18.2			17.1		17.8			16.9		17.8	17.5		17.5		17.4		15.5		18.0
27.2	31.9	32.0			31.6		30.8			30.8		29.6	29.0		29.5		29.5		30.1		30.4
28.2	41.5	41.9			43.8		41.3			40.5		40.7	39.0		38.6		38.7		37.9		37.6
29.2	51.0	51.9			48.5		47.4			45.5		45.0	45.9		43.8		44.6		43.5		40.7

TABLE 13

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 02893

Borehole 02893

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	2.8	2.0	8.9	9.5	10.0	9.3	8.3	7.8	7.5	8.3	7.1	7.6	11.2	11.5	9.2	7.6	8.1	8.0	8.4	11.3	9.1
1.1	7.5	7.8	10.2	9.7	9.6	10.0	9.7	9.7	10.5	8.2	8.6	9.5	9.3	14.0	12.9	13.1	11.0	17.0	12.0	13.2	12.4
1.6	7.5	8.0	8.6	8.1	8.1	7.2	8.0	9.4	9.0	8.0	8.0	8.7	9.0	15.3	13.2	15.7	16.1	16.5	15.0	14.3	14.5
2.2	8.1	7.9	7.2	8.5	7.2	7.9	8.6	7.1	7.9	7.5	7.5	7.1	8.4	17.6	16.3	18.5	18.4	18.5	16.4	15.3	16.4
2.6	7.1	8.1	8.4	8.7		9.7	9.9	10.5	9.5	8.3	9.8	8.4	10.4	16.7	15.0	18.6	18.8	14.0	17.7	17.5	17.2
3.2	8.2	7.4	8.9	8.7	9.4	9.3	8.4	9.1	8.7	8.9	8.7	7.5	8.7	14.5	13.4	14.6	13.4	10.2	14.6	13.6	12.4
3.6	8.9	6.7	8.1	8.0	7.9	7.0	8.1	7.6	6.9	8.0	18.5	7.5	7.4	25.1	8.5	10.2	10.5	7.8	9.6	10.1	9.6
4.6	9.1	8.8	7.3	8.7	9.0	9.5	8.9	9.1	8.0	8.0	7.9	8.9	8.6	23.6	8.7	9.2	8.4	11.2	9.4	9.0	10.0
5.6	9.8	11.4	10.4	9.0	10.1	10.1	10.9	10.3	9.7	10.1	8.0	9.8	10.3	10.9	10.2	11.0	10.3	12.9	10.9	10.9	10.6
6.6	14.1	13.0	14.0	12.7	13.7	12.7	13.5	12.3	14.2	12.9	10.0	12.9	13.0	12.9	12.5	13.6	12.0	13.8	12.6	11.7	13.4
7.6	14.5	14.8	15.7	15.9	15.3	16.2	15.4	15.2	16.0	14.4	14.3	15.3	15.5	16.0	15.7	14.4	15.5	16.2	15.8	16.3	17.3
8.6	17.3	19.3	17.8	17.4	18.3	20.0	21.0	20.6	19.4	20.8		21.0	19.9	19.2	17.8	21.3	19.8	19.9	19.4	20.0	17.3
9.6	9.3	8.6	9.4	9.7	10.1	10.2	9.7	10.8	9.0	8.2		8.2	9.5	19.2	8.5	8.3	8.5	8.6	-4.0	8.6	8.5
10.6	8.0	8.7	8.5	9.3	8.5	9.0	8.7	8.6	8.9	8.1		6.5	9.1	8.3	9.6	7.9	8.1	8.0	8.6	8.7	9.5
11.6	7.2	10.2			8.5		6.8			9.1		8.7	9.6		8.7		9.4		7.5		9.0
12.2	6.0	7.6			7.1		7.6			7.3		7.5	7.8		9.1		7.7		8.2		9.5
13.1	24.4	22.8			10.1		23.6			23.4		23.6	23.2		24.6		25.0		25.6		25.1
14.1	23.4	24.3			23.2		23.8			23.8		24.3	23.0		23.6		26.6		26.3		25.8
15.1	35.9	35.4			23.8		35.0			35.5		35.3	37.8		37.2		39.2		37.6		37.2
16.1	30.3	30.7			34.2		30.1			31.2		30.7	31.1		32.0		34.5		32.9		34.5
17.1	32.7	31.3			30.6		31.2			30.9		30.5	33.2		32.7		33.5		32.6		35.1
18.1	29.3	29.1			29.3		28.8			29.3		29.2	29.1		29.7		29.9		30.4		30.1
19.1	23.6	24.1			24.0		23.6			23.2		23.2	23.6		23.9		22.9		24.3		24.0
20.2	21.2	22.1			20.9		20.7			20.4		22.4	21.1		20.4		21.4		22.3		22.9
21.2	28.0	28.5			28.0		26.4			28.2		26.4	28.4		28.9		30.1		29.5		28.3
22.2	30.1	32.1			32.1		32.0			32.0		33.2	30.4		33.4		37.2		37.1		36.8

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TABLE 14

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 02993

Borehole 02993

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/26	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	16.6	17.3	27.1	25.6	27.4	27.3	22.7	23.7	23.6	23.3	22.4	23.2	23.6	30.9	30.9	31.2	31.3	30.9	28.2	34.6	32.8
1.1	31.1	29.9	29.5	32.1	31.8	29.5	29.9	28.1	28.0	29.6	27.8	28.3	27.2	26.7	26.7	30.4	30.2	28.9	29.1	30.2	29.5
1.6	24.8	24.7	24.6	23.8	22.7	23.2	24.3	22.8	22.9	22.9	22.1	23.4	22.3	13.8	13.8	24.3	23.1	23.3	23.8	22.7	23.6
2.2	28.9	26.8	27.4	27.7	26.2	26.2	27.4	26.3	25.0	27.4	25.6	26.2	24.8	24.3	24.3	25.2	25.0	23.7	24.1	26.2	25.7
2.6	19.6	20.0	17.8	17.8	17.9	18.2	19.2	17.8	16.0	17.8	16.9	16.6	15.0	15.3	15.3	14.5	16.2	15.3	16.6	16.4	17.0
3.2		13.9	13.5	13.5	13.1	13.1	13.4	13.1	13.0	12.6	12.2	13.0	11.6	12.7	12.7	10.6	11.9	12.1	10.8	12.4	11.5
3.6	11.1	11.5	10.7	10.3	10.6	11.4	9.3	10.5	9.8	9.8	10.4	9.4	10.1	9.3	9.3	10.4	8.9	9.5	10.1	10.4	22.0
4.6	15.6	16.5	17.5	15.6	17.3	17.6	16.4	16.7	16.5	16.4	17.5	16.3	16.8	15.6	15.6	16.3	15.2	17.6	15.8	16.5	14.6
5.6	10.2	10.5	11.1	11.2	10.1	10.8	10.8	11.0	10.9	11.6	9.9	9.6	10.4	10.5	10.5	10.9	10.2	9.5	10.1	9.9	9.5
6.6	11.3	11.4	11.6	12.7	10.9	11.4	11.5	12.1	10.2	11.8	11.8	12.3	12.5	11.0	11.0	11.1	11.4	11.5	12.8	12.0	11.0
7.6	12.4	12.6	12.6	12.7	12.4	10.9	12.2	12.4	12.1	11.0	12.2	12.1	11.5	10.4	10.4	12.4	11.0	10.1	11.0	11.9	10.4
8.6	9.7	10.3	12.0	10.7	11.0	10.0	11.0	10.6	9.9	8.7		9.4	10.2	11.0	11.0	10.7	11.0	9.8	10.3	9.3	10.6
9.6	7.8	8.5	9.4	7.7	7.4	7.3	8.7	8.3	7.7	8.3		8.9	8.3	10.2	10.2	9.9	7.5	9.4	8.9	9.5	10.4
10.6	12.4	11.1	11.4	12.4	11.2	10.8	13.5	11.3	11.9	10.7		12.4	11.7	13.4	13.4	12.0	12.7	12.1	12.0	12.9	12.3
11.6	10.4	10.0			10.5		10.8					11.0	9.0				9.8		10.6		10.4
12.2	10.5	11.3			10.8		10.8					11.2	11.1				10.9		10.7		11.4
13.1	10.0	9.9			11.0		9.6					10.4	8.7				9.7		8.0		10.2
14.1	26.6	25.9			26.2		27.5					26.3	26.2				26.4		25.6		27.7
15.1	30.1	31.2					30.8					31.9	31.9				31.9		31.1		31.0
16.1	37.7	37.2			36.0		38.1					37.5	36.5				37.0		37.0		38.1
17.1	30.6	31.2			32.9		31.2					31.9	18.7				35.2		31.0		31.5
18.1	31.5	31.1			30.4		29.7					31.6	31.7				32.1		31.3		33.0
19.1	31.0	32.7			32.2		30.5					33.0	31.7				31.3		31.0		33.2
20.2	32.1	31.4			32.7		32.2					31.4	31.5				32.3		31.3		32.4
21.2	31.9	32.8			30.6		31.4					31.5	32.3				32.0		31.3		31.1
22.2	34.3	34.6			33.4		34.4					35.5	36.2				34.4		35.4		34.5
23.2	34.4	32.5			34.7		34.2					34.6	34.9				33.2		35.5		35.0
24.2	34.2	34.5			35.9		35.3					35.9	34.0				34.4		34.7		35.7
25.2	15.1	15.2			15.4		13.7					13.5	13.0				11.1		12.3		11.7
26.2	4.4	4.1			4.2		4.7					3.7	2.2				3.8		3.1		3.6
27.2	5.1	5.7			5.0		4.9					5.6	5.6				4.1		4.1		4.5
28.2	7.7	7.2			7.3		6.4					6.4	5.9				6.3		5.1		7.0

TABLE 15

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 03093

Borehole 03093

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/27	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	7.0	6.9	16.0	17.1	19.8	20.4	19.7	19.1	18.9	19.3	20.0	19.4	23.5	31.9	31.9	36.4	35.2	34.3	35.3	38.5	38.5
1.1	14.1	15.1	17.0	15.5	17.7	17.0	18.3	18.3	16.6	17.0	18.6	17.9	16.5	22.9	23.1	22.6	22.7	22.7	22.7	25.6	24.7
1.6	22.5	23.6	24.1	23.3	23.4	23.8	23.5	22.4	22.9	22.5	22.3	23.6	21.1	26.1	24.4	25.3	26.0	25.1	25.6	27.1	25.8
2.2	21.8	22.2	22.7	23.0	22.3	22.1	21.6	22.0	21.2	19.9	20.3	21.0	20.1	21.2	20.5	22.7	21.7	23.0	22.3	21.4	22.3
2.6	18.5	17.5	18.5	18.1	18.5	17.2	17.7	18.1	16.6	17.9	17.3	16.8	17.2	16.6	16.8	18.0	17.7	18.2	18.8	17.9	17.4
3.2	14.4	13.4	15.4	14.6	14.9	15.6	13.6	14.3	15.2	12.9	14.6	14.1	13.6	13.9	13.8	15.5	13.8	26.4	14.8	13.6	15.0
3.6	14.0	16.5	16.0	16.0	16.5	16.4	15.4	15.8	14.6	16.2	15.9	15.3	15.2	16.5	15.5	16.5	15.8	15.3	16.0	15.9	17.3
4.6	17.2	12.3	13.1	12.4	12.8	12.3	12.0	11.6	11.6	12.4	12.8	12.2	11.8	13.0	12.0	12.4	11.0	11.8	13.1	12.4	13.4
5.6	15.8	15.1	14.1	14.1	14.4	14.6	14.7	14.9	12.9	13.9	14.2	13.5	15.0	14.3	13.5	13.9	14.6	14.0	12.8	14.1	15.1
6.6	12.9	13.3	13.1	15.1	13.4	12.0	13.9	14.4	13.4	12.2	13.2	13.2	14.1	12.4	13.7	12.7	12.5	12.4	12.9	13.8	12.5
7.6	10.2	9.4	11.5	11.5	10.9	11.9	8.9	10.3	11.1	10.9	10.8	9.5	9.8	12.4	10.0	11.4	11.1	11.3	11.2	9.8	11.2
8.6	17.2	17.6	16.8	16.6	17.6	17.3	17.8	18.6	17.2	17.9		18.4	20.1	19.1	19.3	20.4	19.5	18.9	19.5	19.8	20.8
9.6	11.7	12.8	13.2	13.5	14.1	13.0	12.6	13.5	11.4	13.0		12.8	13.0	11.9	12.2	12.3	13.1	13.7	12.6	12.3	12.1
10.6	12.4	11.9	11.0	11.9	13.3	12.0	12.5	12.3	11.5	11.5		13.0	12.7	11.1	12.1	12.7	13.2	11.7	12.7	13.1	13.5
11.6	21.7	21.4			21.2		20.8					22.0	20.3		20.9			20.9	21.6		20.3
12.2	33.2	32.2			31.4		31.1					32.7	31.8		30.6			32.6	32.3		31.3
13.1	38.6	40.2			39.3		39.5					41.0	40.6		40.6			40.0	41.9		40.6
14.1	39.6	40.4			38.8		39.6					38.3	0.5		40.6			40.8	39.3		40.3
15.1	41.8	41.6			41.5		40.9					41.6	2.8		42.5			41.4	42.5		43.2
16.1	38.7	38.3			39.0		39.8					39.1	38.5		37.4			39.1	38.4		38.6
17.1	37.8	39.0			37.9		38.2					39.7	38.2		38.4			37.2	39.7		39.0
18.1	35.1	34.1			34.4		33.9					34.3	34.7		33.7			33.0	34.7		33.2
19.1	37.9	37.5			37.3		37.5					36.9	38.4		36.1			36.9	36.3		36.8
20.2	37.2	37.1			38.0		36.9					38.9	35.9		35.9			37.5	37.8		37.6
21.2	39.8	39.3			39.8		38.9					38.9	39.9		39.6			38.4	40.7		39.1
22.2	36.2	35.5			34.6		35.3					36.1	36.1		34.4			35.5	34.4		37.1
23.2	34.5	35.0			33.8		33.6					32.6	34.8		33.7			35.0	34.8		33.7
24.2	39.4	40.4			40.9		40.5					39.9	40.8		40.3			39.3	39.0		39.5
25.2	31.7	32.1			31.0		30.2					29.4	26.6		28.5			38.6	27.7		27.9
26.2	19.7	19.6			20.0		20.9					20.2	21.4		20.2			19.1	20.9		20.2
27.2	24.5	23.7			24.6		23.6					23.4	23.9		21.8			22.5	21.8		21.3
28.2	40.7	34.3			33.1		31.6					27.0	25.3		24.7			25.0	23.3		23.7

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TABLE 16

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 03193

Borehole 03193

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/27	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
0.6	4.8	4.7	10.5	11.7	12.0	9.9	11.0	10.1	9.6	8.5	7.8	7.2	10.2	11.5	12.5	18.0	17.3	17.6	15.9	20.6	19.5
1.1	19.4	18.1	17.9	19.9	18.6	19.7	20.2	17.7	19.0	16.9	17.3	16.7	16.0	17.4	16.4	22.2	22.8	22.7	22.2	23.3	24.5
1.6	22.2	21.2	20.2	21.1	20.9	20.8	19.8	21.7	19.7	20.7	19.4	19.6	18.6	19.0	17.9	21.8	22.7	21.6	21.3	24.1	24.3
2.2	20.5	19.7	20.0	20.7	20.0	20.1	19.0	20.5	19.1	18.5	18.8	19.6	18.9	17.7	18.2	18.5	19.3	19.8	18.8	19.6	20.6
2.6	23.8	24.5	23.5	25.3	23.3	26.0	23.2	24.4	23.6	24.2	22.8	23.7	22.7	22.7	22.8	23.8	23.4	23.7	24.6	23.6	24.6
3.2	24.9	24.7	25.2	25.7	25.0	25.2	26.0	24.4	26.3	25.1	26.3	24.9	25.2	27.1	25.0	24.6	25.5	26.0	26.2	25.4	26.7
3.6	25.2	26.3	27.2	25.8	26.3	25.9	27.1	27.6	25.9	27.0	26.4	25.6	26.8	25.0	26.5	24.3	17.1	25.9	23.6	24.9	24.2
4.6	16.4	16.5	16.7	17.5	17.5	17.6	16.3	17.7	16.8	16.1	15.9	16.9	17.3	16.8	14.8	17.3	14.0	29.4	16.6	16.5	16.2
5.6	14.0	14.9	15.1	15.9	13.9	15.4	15.3	14.9	17.2	14.0	13.7	15.5	14.6	15.0	14.3	14.4	16.1	15.1	14.5	14.2	14.5
6.6	15.7	16.6	17.5	17.8	17.0	16.7	15.8	16.4	17.1	16.3	16.2	17.0	16.9	16.8	16.9	16.8	12.3	15.1	16.0	15.3	16.2
7.6	11.1	12.0	12.2	11.3	11.8	11.0	12.3	11.9	10.9	11.1	10.8	11.3	12.3	11.4	11.6	11.9	14.3	17.0	10.8	25.2	25.3
8.6	13.1	15.1	12.6	13.9	13.5	15.2	14.2	15.9	14.6	15.5		15.8	15.1	15.3	15.5	15.2	8.1	10.3	15.3	15.8	15.8
9.6	8.2	9.7	9.6	7.9	8.3	8.5	9.5	9.6	9.2	8.7		9.1	10.8	8.7	21.3	9.5	9.4	16.2	8.2	8.3	8.8
10.6	9.5	8.4	9.6	9.0	10.1	8.7	9.4	9.5	9.8	9.4		8.7	9.9	-4.7	8.5	8.7	18.1	9.4	8.6	9.6	8.6
11.6	19.0	19.1			18.7		18.5					19.4	19.0		19.8		33.7		20.3		17.6
12.2	32.4	32.4			33.0		32.4					32.8	32.7		32.6		32.6		33.2		33.6
13.1	29.8	28.5			30.2		30.4					30.2	29.2		30.1		28.5		29.7		30.5
14.1	26.0	26.1			26.4		26.0					26.6	24.1		24.7		24.9		24.9		25.6
15.1	35.6	36.3			37.2		36.7					37.1	37.2		36.8		36.8		37.1		37.4
16.1	30.9	32.4			30.8		32.3					31.9	32.5		32.5		33.1		32.4		32.9
17.1	30.4	29.6			30.2		29.9					30.9	31.4		30.4		28.3		30.8		30.7
18.1	30.4	29.9			31.1		29.8					30.3	31.1		29.6		32.6		30.7		31.6
19.1	26.7	26.9			26.3		26.4					26.2	28.1		27.5		26.8		27.2		27.7
20.2	27.3	27.8			27.2		26.7					25.6	26.4		25.6		26.6		25.7		38.7
21.2	25.7	25.4			25.2		26.1					26.7	26.7		24.9		25.2		25.9		25.2
22.2	27.8	27.3			27.4		28.7					27.6	28.5		27.9		27.5		29.2		29.0
23.2	28.8	26.1			28.6		28.9					28.1	28.6		28.4		28.4		29.1		28.7
24.2	29.0	28.3			27.7		26.6					28.7	28.8		25.6		27.6		28.2		28.0
25.2	31.3	32.3			32.6		29.7					28.1	26.7		27.3		28.8		25.8		26.4
26.2	27.0	25.4			27.5		26.2					26.1	28.2		27.0		26.9		28.2		27.3
27.2	26.4	26.2			24.6		25.5					27.0	26.4		26.5		26.7		26.2		25.8
28.2	29.9	29.7			29.9		32.1					29.1	28.7		29.6		26.9		30.0		15.3
29.2		87.9			38.9		32.5					32.0	37.2		34.3		35.3		36.6		33.5

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TABLE 17

SUMMARY OF SITE 2 SOIL-MOISTURE MEASUREMENTS

BOREHOLE 03293

Borehole 03293

Vertical Depth Below Ground Surf. (Feet)	Volumetric Moisture Content % Volume																				
	7/27	8/3	* 8/4	8/5	8/6	8/7	8/11	8/13	8/16	8/18	8/23	8/25	** 9/8	** 9/15	9/17	** 9/27	9/29	10/1	10/8	10/20	10/22
1.1	14.2	14.8	12.1	13.5	14.6	14.1	13.8	14.9	12.1	13.0	12.1	14.3	7.5	6.9	6.4	7.9	9.1	9.4	8.2	10.3	9.4
1.6	14.8	15.0	14.5	14.2	14.7	15.4	14.3	15.1	13.8	14.6	12.2	13.7	15.1	16.4	17.1	18.4	18.3	18.3	17.8	19.6	18.6
2.2	15.8	15.8	15.0	17.1	14.9	15.5	14.1	15.8	12.8	14.0	14.7	13.5	13.6	13.6	14.0	16.7	16.0	16.5	14.3	17.7	17.7
2.6	15.3	14.9	13.3	13.8	13.8	13.6	13.5	13.5	13.6	12.7	14.0	12.0	12.9	12.2	13.0	13.9	14.2	14.4	14.2	14.3	13.3
3.2	12.3	12.0	12.6	13.7	12.4	11.4	12.5	11.5	10.0	11.8	11.0	11.3	13.6	13.0	12.3	12.4	13.6	12.4	12.8	13.2	12.7
3.6	7.7	9.3	10.0	8.9	8.2	8.7	9.3	8.3	7.3	7.8	7.0	6.5	11.0	12.0	11.0	9.6	9.8	10.9	10.2	9.4	9.6
4.6	10.0	9.1	10.2	10.1	9.6	9.6	9.1	8.8	10.6	9.5	9.1	8.3	8.3	6.7	7.7	7.2	6.6	6.8	7.3	7.1	7.3
5.6	7.8	9.1	6.4	9.6	7.8	8.3	8.3	7.4	7.9	8.3	8.6	9.2	9.5	8.1	8.6	8.9	8.8	8.9	8.4	9.4	9.2
6.6	5.7	6.1	6.6	7.3	5.3	7.4	7.6	7.3	6.6	7.1	5.8	6.7	8.0	9.4	8.2	8.4	6.1	8.9	9.9	8.9	8.6
7.6	9.9	10.1	9.6	10.1	10.5	9.7	10.5	10.0	10.0	12.2	10.8	11.6	7.6	7.9	7.8	8.0	8.0	7.5	6.7	7.2	8.4
8.6	9.8	10.6	8.1	8.9	8.7	8.0	8.7	7.9	9.3	8.8		8.6	10.5	10.4	11.4	10.4	11.1	11.5	11.0	9.7	10.2
9.6	7.3	7.5	7.3	8.6	7.5	9.4	8.9	7.4	7.9	7.2		7.1	5.9	7.5	6.3	7.7	7.3	7.2	18.9	6.2	6.8
10.6	8.2	8.7	9.5	8.7	8.9	8.1	9.7	9.4	9.9	10.6		9.4	7.5	7.3	6.8	7.9	8.3	7.3	8.0	9.0	9.2
11.6	9.4	8.7			9.6		9.9					8.4	10.2	10.5	10.3	8.7	10.4	8.3	10.2	9.8	9.4
12.2	6.9	6.9			7.1		7.6					6.6	10.8		9.4			10.4	10.0		11.1
13.1	8.8	9.6			7.7		9.1					10.2	7.9		7.6			7.6	6.7		6.5
14.1	24.8	25.9			25.8		13.2					24.0	8.8		8.1			8.7	9.3		8.7
15.1	20.7	19.6			22.7		21.7					19.4	24.7		25.2			25.7	25.5		24.9
16.1	29.1	30.0			30.9		17.4					29.9	20.7		20.2			21.2	21.2		20.6
17.1	29.7	30.1			28.9		29.4					30.1	30.2		31.0			30.4	30.3		30.6
18.1	28.8	29.9			31.0		30.0					29.7	31.0		29.3			29.6	29.4		29.8
19.1	28.6	27.5			27.1		28.5					28.1	30.0		29.5			30.4	29.6		29.9
20.2	24.3	25.0			23.8		37.9					25.3	28.8		27.3			28.9	26.8		28.5
21.2	24.2	22.9			22.3		23.2					23.7	25.0		25.5			25.1	25.7		24.9
22.2	17.8	18.3			18.1		18.1					16.9	22.7		23.0			21.8	23.7		23.4
23.2	14.2	14.2			14.2		13.4					14.7	17.5		17.1			17.1	17.8		17.2
24.2	26.3	27.2			27.0		28.2					27.9	14.8		14.1			26.5	14.2		13.6
25.2	29.2	28.8			27.4		28.8					28.5	27.2		28.7			26.4	26.5		26.8
26.2	30.7	32.0			29.5		30.7					30.6	29.9		29.5			28.5	28.8		30.2
27.2	30.4	30.3			29.9		30.6					29.9	29.6		30.6			30.4	29.4		31.0
28.2	20.2	20.1			20.5		19.7					18.7	30.0		29.7			29.3	30.0		30.9
													18.6		18.3			18.0	18.7		17.5

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soil-moisture profiles for Boreholes 02793, 02993, 03093, and 03293 show a decrease in soil moisture at this depth, revealing the effects of this change in lithology. The water table, noted during drilling at a depth of approximately 27 ft below ground surface, can be discerned from the soil-moisture profiles of Boreholes 02793, 03093, and 03193 by a sharp increase in soil-moisture contents at between 25 and 27.5 ft below ground surface.

Surveys at Site 2, like those of Site 1, were generally consistent below 1.0 ft for the monitoring period of July 26 to August 25 represented on Figures 18 through 23 (a and b series). A range of soil-moisture contents can be seen above 1.0 ft below ground surface. The same drying trend as noted at Site 1 can be seen at 0.5 ft for all boreholes, except Boreholes 03093 and 03293. Again, a wetting front is not distinguishable below 0.5 ft with the exception of Borehole 03293. The soil-moisture content at 1.0 ft on August 5 was slightly elevated, indicating that a wetting front may have progressed this far downward. No pulses were noted past 1.0 ft on subsequent days' surveys, indicating a greater evapotranspiration than percolation rate.

Soil-moisture surveys for the time period encompassing and following the precipitation events in September are included on Figures 18 through 23 (c and d series). The expected response of soil-moisture to these precipitation events can be distinguished on Figures 18c, and 20c through 22c (Boreholes 02793, 02993, and 03093, respectively), with the greatest soil-moisture immediately following the artificial precipitation event of September 20 through 24, 1993. Unfortunately, no distinguishable pulse could be traced below 1.0 ft following these natural and artificial precipitation events.

Figures 30 through 35, show soil-moisture content versus time (soil-moisture time series) at 0.5, 1.0, 5.5, 10.5, and 15.0 ft below ground surface for Site 2. Boreholes 02793 through 03193 show remarkable increases in soil-moisture content at 0.5 ft from August 3 to August 4, 1993 resulting from the artificial precipitation of August 4, 1993. Boreholes 02793, 02993, and 03193 show

diminishing soil-moisture contents with time until the beginning of September when they increase again as a result of the precipitation events in September. Time series measurements at 0.5 ft all show a response to the September precipitation events, with the exception of Boreholes 02893 and 03293 (Figures 31 and 35). These time series show an unexplained decrease in soil-moisture at this depth. The cause of this is decrease is unknown but may result from neutron loss to the atmosphere, as discussed previously in Section 3.4.2.2.1. Hence, time series measurements at the 1.0-ft depth may be more reliable. All six boreholes' measurements responded as expected, with increasing moisture content resulting from precipitation events in August and September, 1993.

3.4.3 Meteorological

Tables 18a and 18b present summaries of precipitation for Sites 1 and 2, respectively, for the period August 3 through October 22, 1993 collected from on-site storing rain gages and the RFP meteorological station. Also included on Tables 18a and 18b are daily precipitation data from the RFP Meteorological Station. Precipitation data for August 4 and 5 and September 20 through 24 represent artificial precipitation. The rain gauges were not emptied at Site 1 following the August 4 simulation or at either site during the September 20 through 24 simulation.

4.0 DATA INTERPRETATION AND ANALYSIS

4.1 UNSATURATED SOIL HYDRAULIC PROPERTIES

Unsaturated soil hydraulic properties for this Interim Report were determined for the limited number of samples having data. Five soil samples [ATT-1 (Borehole 02393, 2.0-4.0 ft), ATT-2 (Borehole 02393, 4.4-5.4 ft), ATT-4 (Borehole 02993, 7.9-9.9 ft), ATT-5 (Borehole 02993, 19.4-

TABLE 18a

SUMMARY OF SITE-1 PRECIPITATION

	Precipitation (inches) Measured by Rain Gages at Location								
Date	02093	02293	Hole	02393	NW Post	02593	02693	3687BR	RFP Met. Station
8/3/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/4/93	0.50	0.80	0.50	0.10	0.85	0.85	0.60	0.55	0.05
8/5/93	0.50	0.90	0.50	0.10	0.80	0.80	0.70	0.50	0.14
8/6/93	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.10
8/7/93	0.10	0.00	0.20	0.10	0.00	0.20	0.00	0.20	
8/9/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/11/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/12/93									0.02
8/13/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/17/93									0.03
8/18/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/20/93									0.01
8/21/93									0.01
8/23/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/25/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
9/2/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
9/5/93									0.17
9/6/93									0.02
9/7/93									0.32
9/8/93	0.30	0.50	0.60	0.30	0.30	0.50		0.70	0.01
9/13/93									0.57
9/15/93	0.20	0.50	0.90	0.70		0.50		2.60	
9/16/93									0.01
9/17/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
9/18/93									0.20
9/20/93	0.00	0.40	0.30	0.30		0.40		0.40	
	Artificial Precipitation								
	0.80	0.40	0.90	0.40		1.00		0.40	
	Artificial Precipitation								
	1.10	0.40		0.50		1.30		0.50	
	Artificial Precipitation								
	1.00	0.40	0.30	0.50		1.30		0.50	
9/22/93	1.40	0.40	0.00	0.60	0.00	1.30		0.60	0.03
	Artificial Precipitation								
	2.30	0.80	0.70	1.00	0.10	1.90		1.90	
9/23/93									0.01
9/24/93	2.40	0.70	0.50	1.00	dry	1.90		1.80	
	Artificial Precipitation								
		1.00	0.30	1.40	dry	2.30			
	Emptied Gages								
9/27/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/1/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/8/93	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
10/15/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/20/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/22/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

TABLE 18b

SUMMARY OF SITE-2 PRECIPITATION

Date	Precipitation (inches) Measured by Rain Gages at Location							RFP Met. Station
	02793	02893	02993	03093	03193	03293	12491	
8/4/93	0.65	0.30	1.10	0.40	1.10	1.10	0.50	0.05
8/5/93	1.80	<0.1	1.20	1.00	1.20	1.00	1.20	0.14
8/5/93	<0.1	<0.1	0.15	0.10	<0.1	0.10	<0.1	
8/6/93	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
8/7/93	0.10	<0.1	0.30	0.10	0.10	<0.1	0.20	
8/9/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/11/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/12/93								0.02
8/13/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/17/93								0.03
8/18/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/20/93								0.01
8/21/93								0.01
8/23/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8/25/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
8/26/93								0.01
9/2/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
9/5/93								0.17
9/6/93								0.02
9/7/93								0.32
9/8/93	0.40	0.50	0.80	0.50	0.70	0.50	0.30	0.01
9/13/93								0.57
9/15/93	0.70	0.50	0.30	0.50	0.30		0.40	
9/16/93								0.01
9/17/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
9/18/93								0.20
9/20/93	0.30	0.00	0.40	0.30	0.30		0.40	
	Artificial Precipitation							
	1.30	1.10	1.10	1.00	0.50		1.40	
9/21/93	1.20	0.70	1.00	1.00	0.50		1.30	
	Artificial Precipitation							
	1.50	>1.00	1.50	1.30	0.70		1.50	
	Artificial Precipitation							
	1.50	1.00	1.50	1.20	0.40		1.50	
9/22/93	1.70	0.00	1.70	1.10	0.70		1.60	0.03
	Artificial Precipitation							
	2.30	0.50	2.10	1.30	1.00		1.90	
	Artificial Precipitation							
	2.70	0.70	2.20	1.40	1.20		2.10	
9/23/93								0.01
9/24/93	2.70	0.60	2.30	1.40	1.20	0.00	2.10	
	Artificial Precipitation							
	3.30	0.50	2.50	1.60	1.40	0.00	2.50	
	Emptied Gages							
9/27/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/1/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/8/93	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
10/15/93	0.20	0.00	0.10	0.00	0.00	0.00	0.00	
10/20/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10/22/93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

21.5 ft), and ATT-6 (Borehole 02993, 17.0-18.0 ft) shown in Table 7] were submitted to ATT, Inc. for selected laboratory tests including natural moisture content, moisture-characteristic curve determinations, and Bruce-Klute diffusivity tests. The methods used for the analyses of these test results were described in Sections 2.2.1, 2.2.2, and 2.2.3. Additionally, preliminary results for two soil samples [CSM Test (Borehole 02793, 14.4-14.9 ft) and CSM 1-2 (Borehole 02293, 2.9-3.4 ft) shown in Table 7] were available from the USGS/CSM laboratory which determined moisture-characteristic and unsaturated hydraulic-conductivity curves for those two samples using a new procedure (Appendix C-1). Results of these laboratory tests were analyzed and compared, to the extent possible, given the preliminary nature of the USGS/CSM laboratory tests and the limited amount of data received to date.

One of the goals of the unsaturated soil hydraulic-properties data analysis was to compare these properties as obtained from different laboratory test procedures and theoretical analyses. Moisture-characteristic curves obtained from ATT, Inc. using ASTM Procedure D2325 were corrected for the coarse fraction (greater than 2-mm diameter) in the total sample and the laboratory data fitted to a van Genuchten function (van Genuchten and others, 1991), as described in Section 2.2.2. Results of this analysis, along with the laboratory results of the Bruce-Klute diffusivity tests, were used to calculate the unsaturated hydraulic conductivity versus saturation curves using the analysis procedures discussed in Section 2.2.3. Moisture-characteristic curve data obtained from the USGS/CSM laboratory analyses also were fitted to a van Genuchten function as described in Section 2.2.2. These results are compared to similar samples analyzed by ATT, Inc. to assess the applicability of results using the two laboratory methods. Future Interim Reports for this study will more fully analyze and compare moisture-characteristic curves using the two laboratory methods (ASTM D2325 versus USGS/CSM flow-pump method). Because not all the USGS/CSM samples have been tested in the laboratory, direct comparison of similar soil samples from the same location in the same borehole is not possible in this Interim Report.

Additionally, resulting unsaturated hydraulic-conductivity curves from the Bruce-Klute diffusivity tests and the USGS/CSM flow-pump tests are compared to the extent possible. Direct comparison of laboratory results for similar soil samples in the same borehole are not possible at this time because not all USGS/CSM laboratory tests are completed. Unsaturated hydraulic conductivity curves from laboratory tests also are compared to theoretical curves calculated using van Genuchten functions as described in Section 2.2.3.

4.1.1 Moisture-Characteristic Curves

Moisture-characteristic data for the five soil samples tested by ATT, Inc. are presented in Appendix C-3. Soil-moisture contents were determined for matric potential values of 0, -0.3, -0.5, -1.0, -2.0, and -4.0 bars using the minus 2-mm fraction of the samples for both a primary and replicate sample. Table C-3 in Appendix C-3 is a summary of the results of the ATT, Inc. laboratory tests for both the primary and replicate samples. Because the pressure-plate moisture content of the samples appeared to be high at saturation (matric potential of 0 bars), the moisture-characteristic data for the five ATT, Inc. samples and their replicates were adjusted as shown in Table C-3 to coincide with the Bruce-Klute moisture data (Appendix C). As indicated in Section 2.2.2, the moisture-characteristic curves were also adjusted to reflect the presence of coarse fragments (greater than 2-mm in diameter) using the data shown in Table 3). For all three data sets for each sample (original pressure-plate data, Bruce-Klute test adjustment, and coarse fraction adjustment), van Genuchten functions were fit. Figures 36 through 40 show plots of the original data and van Genuchten fits for the moisture-characteristic curves for the five soil samples and five replicates tested by ATT, Inc. Analysis of these figures indicates that the adjustments made to the moisture-characteristic curves still preserved the general shape of the curves, but with reduced volumetric moisture content for a given value of matric potential. In this way, the use of these curves in calculating unsaturated hydraulic conductivity using the Bruce-Klute diffusivity data would be valid. For samples ATT-1, ATT-2, and ATT-4, the adjustment for coarse

fragments was relatively large because these samples contained over 50 percent coarse fragments (greater than 2-mm as indicated in Table 3). The corrections for samples ATT-5 and ATT-6 were smaller, because over 95 percent of the weight of these two samples were less than 2-mm diameter material (Table 3). The fitted values of the van Genuchten parameters (α, n, and m), along with the goodness of fit, represented by the coefficient of determination (R^2), are also shown on Figures 36 through 40.

The moisture-characteristic data for the two soil samples tested by the USGS/CSM laboratory (CSM Test and CSM 1-2) are summarized in Tables C-4 and C-5 (Appendix C-4). These data were not adjusted for the coarse fraction, because this fraction was not removed prior to running the laboratory tests. van Genuchten functions were fit to the data for these two samples as shown on Figures 41 and 42. The CSM Test sample (Borehole 02793, 14.4-14.9 ft) fit was easily done using the available data (Figure 41). The van Genuchten fit to sample CSM 1-2 (Figure 42) was more difficult, because the moisture-characteristic curve data decreased to a matric potential of approximately -300 cm of water and then increased with decreasing volumetric moisture content. One fit to the complete data set (Figure 42) resulted in poor values of the van Genuchten parameters (solid line on Figure 42). A second fit using only the decreasing data resulted in an acceptable fit (dashed line on Figure 42) to the moisture-characteristic curve data. However, because the moisture-characteristic curve data from this sample may be incomplete (H. W. Olsen, USGS/CSM, Pers. Comm., October 25, 1993), the van Genuchten fit to these data should be used with extreme caution.

Because neither the CSM Test nor CSM 1-2 samples tested using the USGS/CSM procedure are exactly comparable to samples tested by ATT, Inc. using a standard pressure-plate test (ASTM D2325), it is difficult to compare the two laboratory methods directly. Future USGS/CSM tests will be comparable to the ATT, Inc. tests already completed. A preliminary comparison of the

results of the two methods are possible using both visual criteria and the parameter values from the van Genuchten fits to the data.

Sample CSM 1-2 (Borehole 02293, 2.9-3.4 ft) is most closely associated with similar soils in sample ATT-1 (Borehole 02393, 2.0-4.0 ft) (Figures 10a and 10b). Until more USGS/CSM data are available, this preliminary comparison will be made. Comparison of the shape of the van Genuchten fit to these two samples is shown on Figure 43 along with the van Genuchten parameters (α, n, and m). From Figure 43, it appears that the USGS/CSM data have not yet reached a moisture content which will lower the matric potential to less than -300 cm of water. Therefore, any conclusions about the comparability of the CSM 1-2 sample results to the ATT-1 sample results cannot be made at this time. It appears, however, that the two test methods may ultimately give similar results, if the USGS/CSM test is continued at smaller matric potentials.

Sample CSM Test (Borehole 02793, 14.4-14.9 ft) is most closely associated with similar soils in sample ATT-6 Borehole 02993, 17.0-18.0 ft) (Figure 11a). For preliminary comparison purposes, this comparison will be used until more USGS/CSM data are available. Comparison of the shape of the van Genuchten fit to these two samples is shown on Figure 44, along with the van Genuchten parameters (α, n, and m). From Figure 44, it appears that the two laboratory methods are capable of producing similar moisture-characteristic curves of acceptable accuracy. Because of the preliminary nature of the USGS/CSM laboratory procedure and the variability of the soil samples compared, the two van Genuchten fits are judged to be acceptable over the range of laboratory data. At the drier end of the matric potential values (less than approximately -4,000 cm of water), the fit is not as good, which would be expected.

4.1.2 Unsaturated Hydraulic Conductivity

Unsaturated hydraulic conductivity was calculated from the ATT, Inc. test data by combining the slope of the moisture-characteristic curves with the diffusivity data using the equations given in Section 2.2.3. The same five samples used to calculate the moisture-characteristic curves (ATT-1, ATT-2, ATT-4, ATT-5, and ATT-6) were also analyzed to obtain the unsaturated hydraulic conductivity versus volumetric moisture content. The diffusivity (Bruce-Klute) and unsaturated hydraulic conductivity calculations are given in Tables C-6 through C-10 (Appendix C-4) for the five samples. Results of the calculations are plotted versus van Genuchten functions on Figures 45 through 49. For comparison purposes, the unsaturated hydraulic conductivity is plotted as "relative" hydraulic conductivity, which is the ratio of unsaturated hydraulic conductivity to saturated hydraulic conductivity. The unsaturated hydraulic-conductivity values, based upon the Bruce-Klute diffusivity, agree well (within an order of magnitude) with the theoretical (van Genuchten) values near the wettest segments of the curves. After two and four log cycles, the calculated values diverge from the theoretical values by more than an order of magnitude (Figures 45 through 49). The reasons for this are twofold: the diffusivity analogy for calculation of moisture movement does not truly represent the mass transfer of water; and large errors exist in the diffusivity analogy on the dry end (lower left) of the curves. It is noted from Figures 45 through 49 that the departure of the calculated values from the van Genuchten fit values is always toward higher hydraulic conductivities on the dry end of the curves. In all five tests, the volumetric moisture contents for both the laboratory data and the van Genuchten fit results were corrected for the coarse fraction of the soil that was removed prior to analysis before plotting.

USGS/CSM unsaturated hydraulic conductivity data for the two available soil samples (CSM Test and CSM 1-2) are summarized in Tables C-4 and C-5 (Appendix C-4) and plotted versus van Genuchten functions on Figures 50 and 51. The preliminary USGS/CSM conductivity data

appear to match the theoretical (van Genuchten) fit about as well as the Bruce-Klute calculated conductivity data, that is, within one order of magnitude over the first log cycle.

A comparison of the unsaturated hydraulic conductivity versus saturation for the CSM 1-2 sample (Borehole 02293, 2.9-3.4 ft) with the ATT-1 sample (Borehole 02293, 2.0-4.0 ft), along with the van Genuchten fit, is shown on Figure 52. Analysis of the results shown on Figure 52 indicates that, because only preliminary data are available from the USGS/CSM laboratory for this sample, the comparison is generally poor.

A comparison of the unsaturated hydraulic conductivity versus saturation for the CSM Test sample (Borehole 02793, 14.4-14.9 ft) with ATT-6 (Borehole 02993, 17.0-18.0 ft) along with the van Genuchten fit, is shown on Figure 53. Analysis of the results shown on Figure 53 indicates that there is good agreement between calculation of unsaturated hydraulic conductivity using Bruce-Klute data and the USGS/CSM flow-pump method. Because the USGS/CSM data are preliminary, final analysis and comparison of more samples must await further USGS/CSM laboratory tests.

4.2 STEADY-STATE FLOW ANALYSIS

Laboratory geotechnical data were not received in time to perform the Steady-State Flow Analysis. This analysis will be performed for the laboratory results received to date, and any additional analyses results received, beginning with the next Interim Report.

5.0 CONCLUSIONS

Based upon the limited data available at the time of this Interim Report, the following conclusions are made regarding RFP recharge:

- Soil-moisture profiles were generally static below 1.0 ft from July to October, 1993 (Figures 12 through 23). Although these Figures suggest slight changes in moisture content below 1.0 ft, these variations are within the range of variation expected due to the random radioactive decay of the neutron source. Consequently, it is not possible to determine if slight changes in moisture content are occurring.

- Increased moisture contents from the surface to 1.0 ft indicate water did infiltrate and percolate short vertical distances during this period. However, it was apparently used to meet evapotranspiration demands since there was no increase in moisture content below 1.0 ft.

- Continued monitoring of the soil moisture is needed to obtain a better assessment of the potential for movement. Initial results indicate that no significant water movement has taken place at the two study sites.

6.0 ACKNOWLEDGMENTS

Studies leading to this Interim Report were conducted under the general supervision of Mr. Michael G. Waltermire, P.E., Project Manager, Advanced Sciences, Inc. (ASI). The Task Manager for these studies was Ms. Rose M. Zeiler, ASI Senior Hydrogeologist. Technical direction for the study was provided by Dr. James R. Kunkel, P.E., P.H., ASI Senior Principal Engineer. Field investigations were conducted by Ms. Laurie A. Host, ASI Hydrogeologist and Ms. Theresa Santangelo-Dreiling, ASI Senior Hydrogeologist. Field measurements were conducted by ASI Field Technicians under the direction of Ms. Host and Dr. Kunkel. This Interim Report was written by Ms. Host under the guidance of Dr. Kunkel. This Interim Report has been reviewed by Mr. Waltermire, Ms. Zeiler, Ms. M. Deanna Kaskie, ASI Technical Editor,

and Dr. Timothy D. Steele, P.H., Manager of ASI's Water-Resources/Physical-Sciences Department.

EG&G Environmental Management/Earth Resources Division (EM/ERD) responsive reviewers of this report included:

Constance J. Dodge
Timothy Loveseth
Barry Roberts
Robert G. Smith

This report was prepared and submitted in partial fulfillment of the Revised Statement of Work, Stratigraphic and Ground-Water Recharge Evaluation, Rocky Flats Plant, dated February 8, 1993 and the associated Modification No. 2 to Subcontract BA106133-088-93 dated April 13, 1993. EG&G's Project Manager for this study was Mr. Robert G. Smith.

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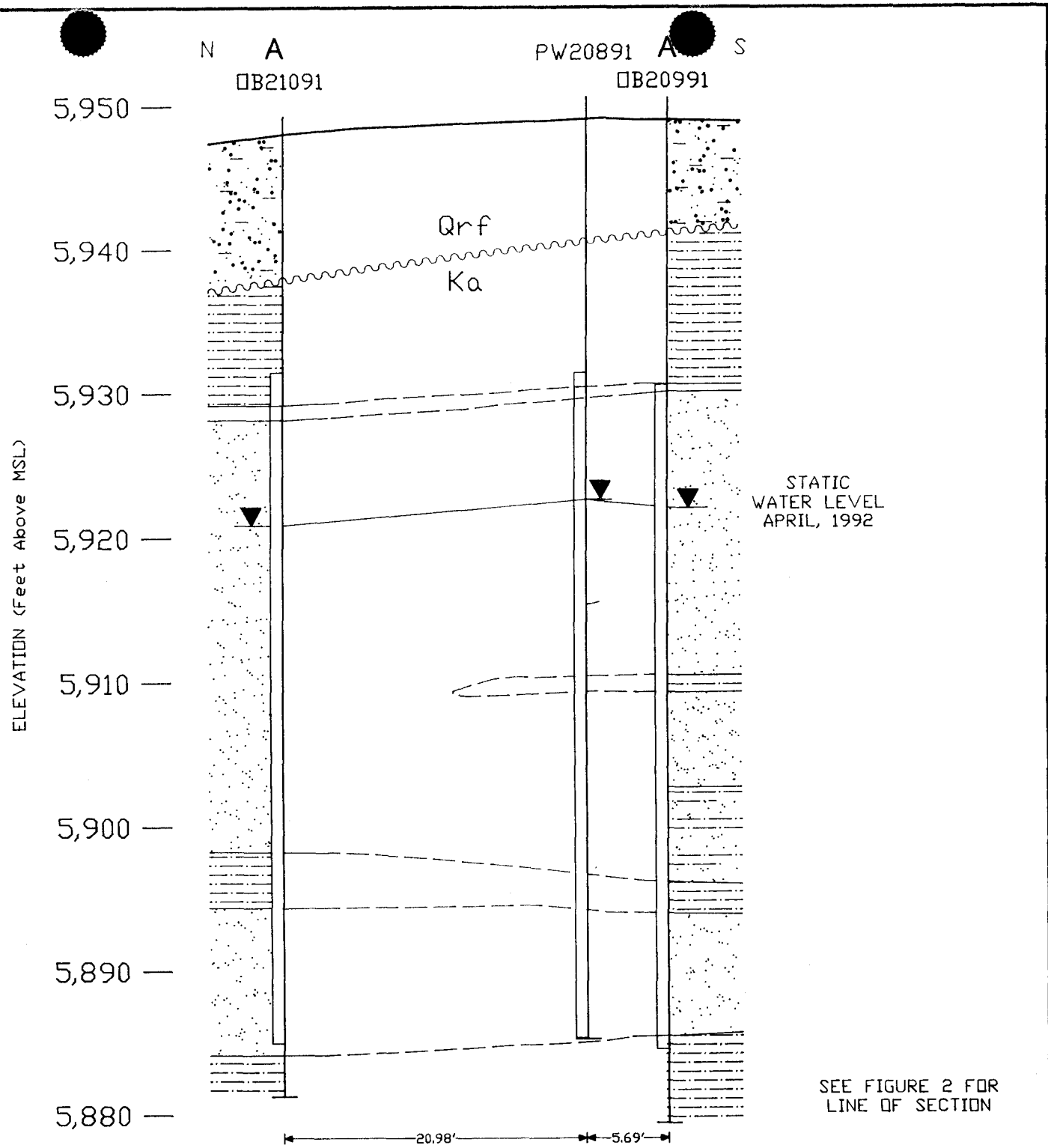
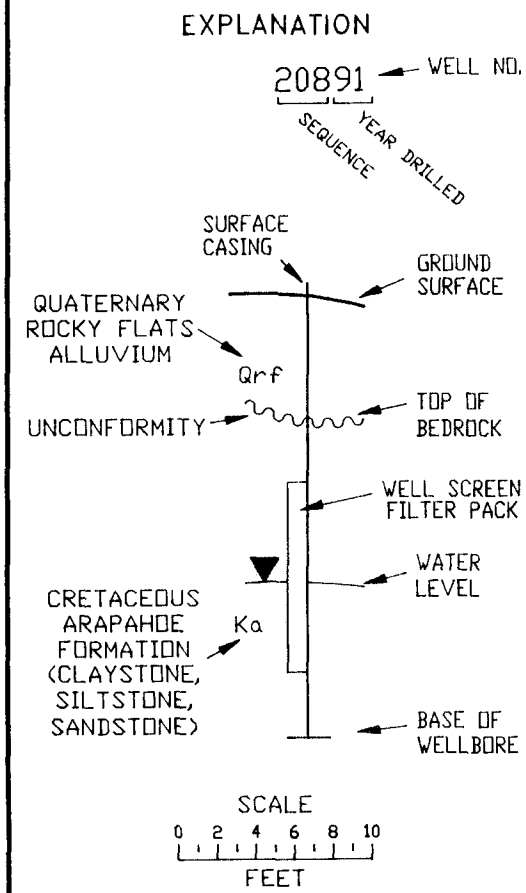


SEE FIGURE 2 FOR
LINE OF SECTION



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Rocky Flats Plant, Golden, Colorado

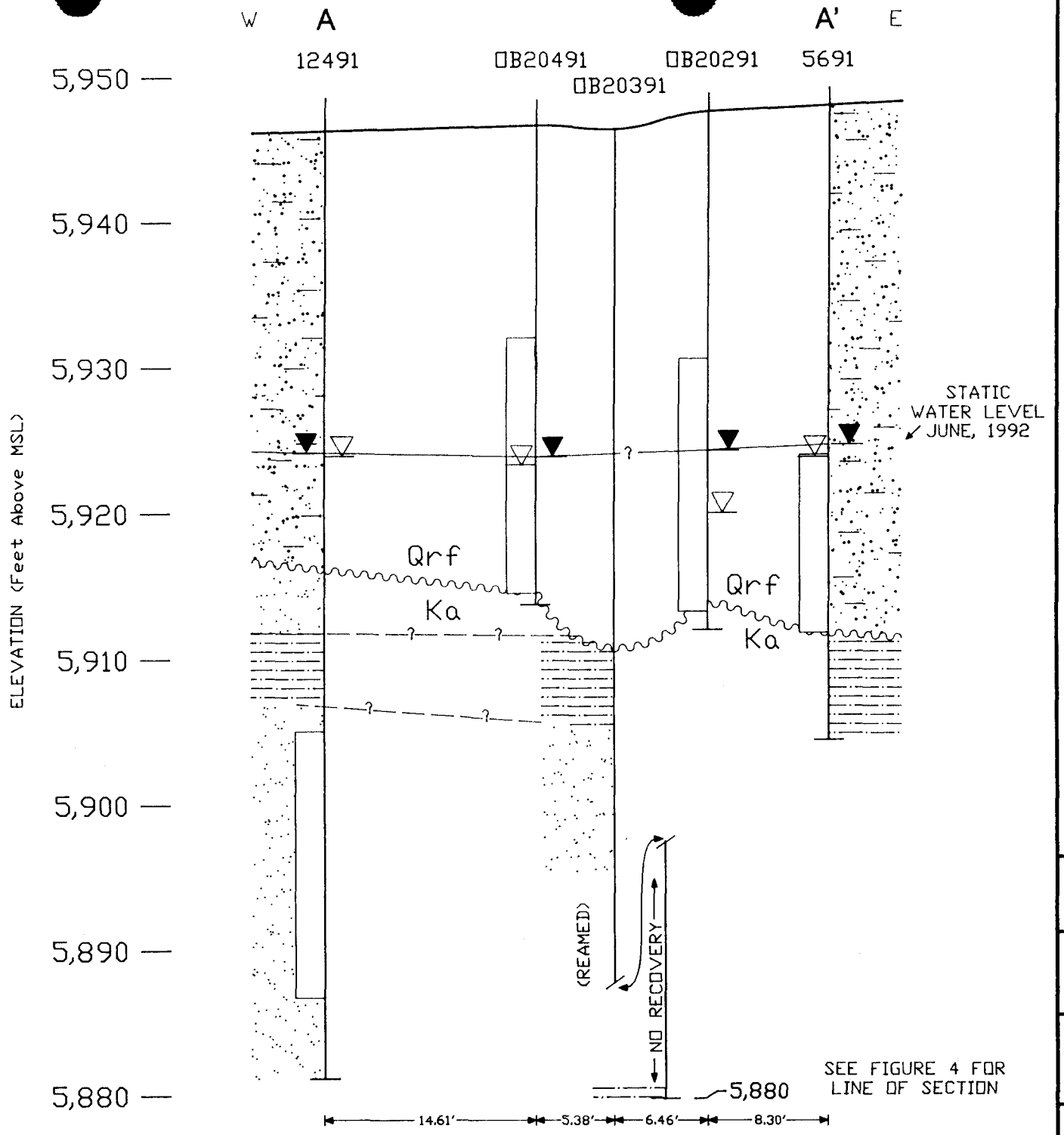
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

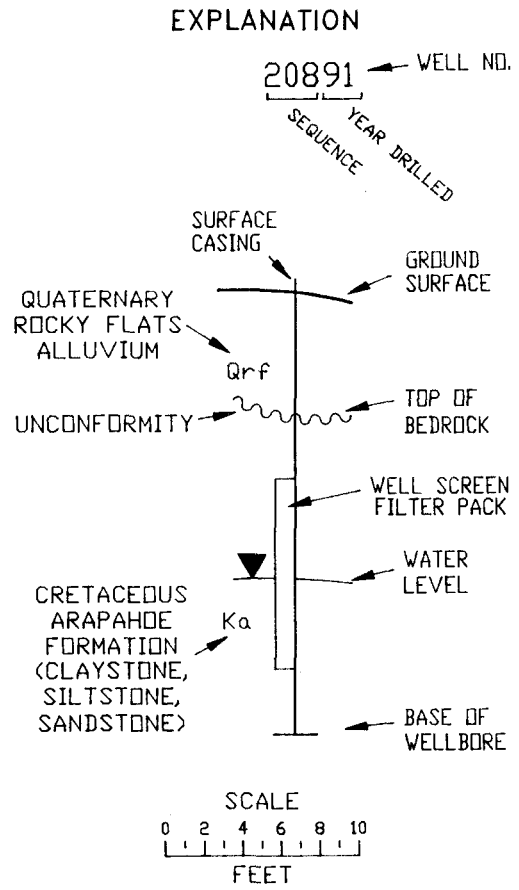
Cross Section of Site 1

FIGURE 3 **OCTOBER 1993**

GRS-3.DWG

Status: 10/28/93





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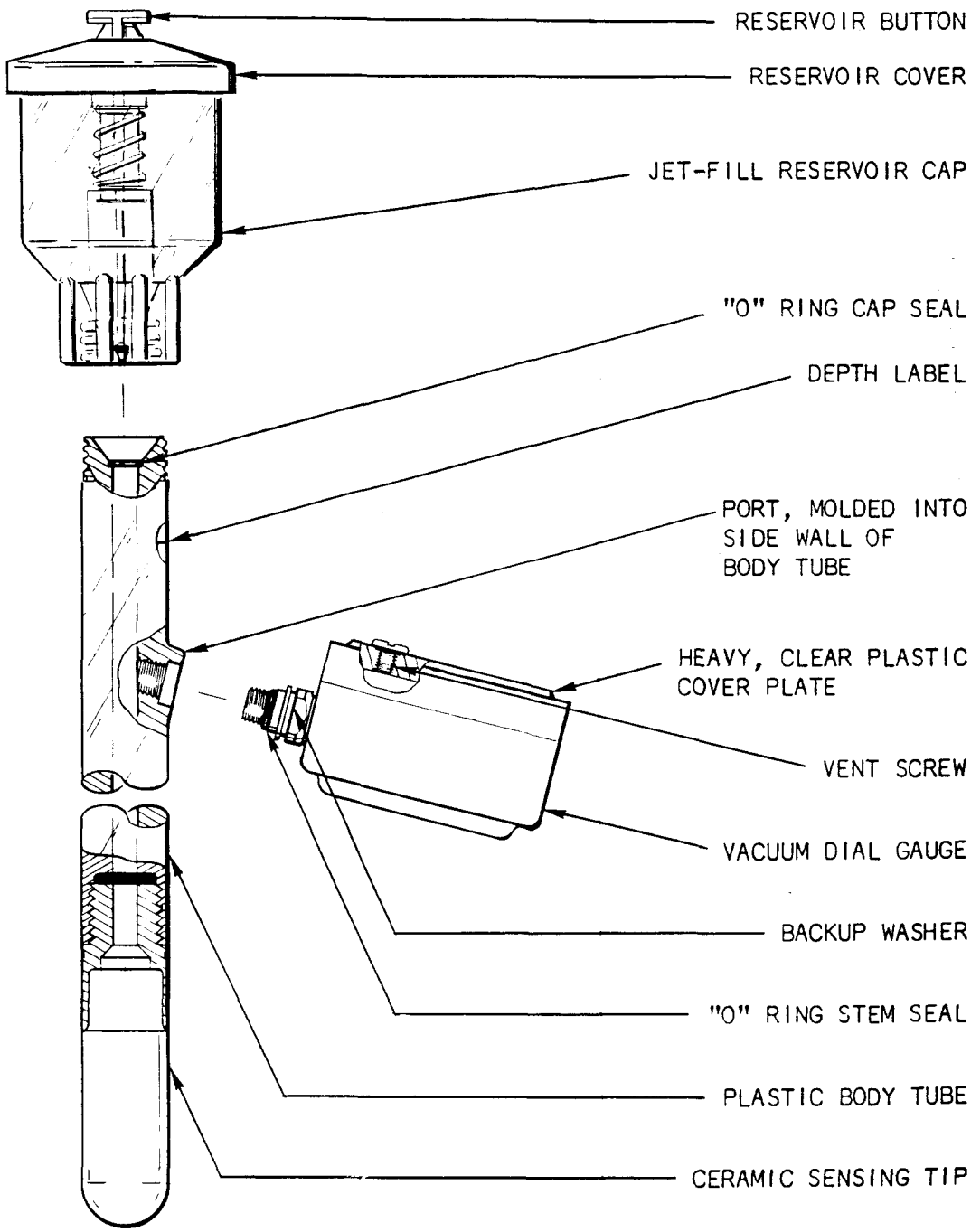
GROUNDWATER RECHARGE STUDY INTERIM REPORT

Cross Section of Site 2

FIGURE 5 **OCTOBER 1993**

GRS-5.DWG

Status: 10/28/93



Source: Soilmoisture Equipment Corp., 1986

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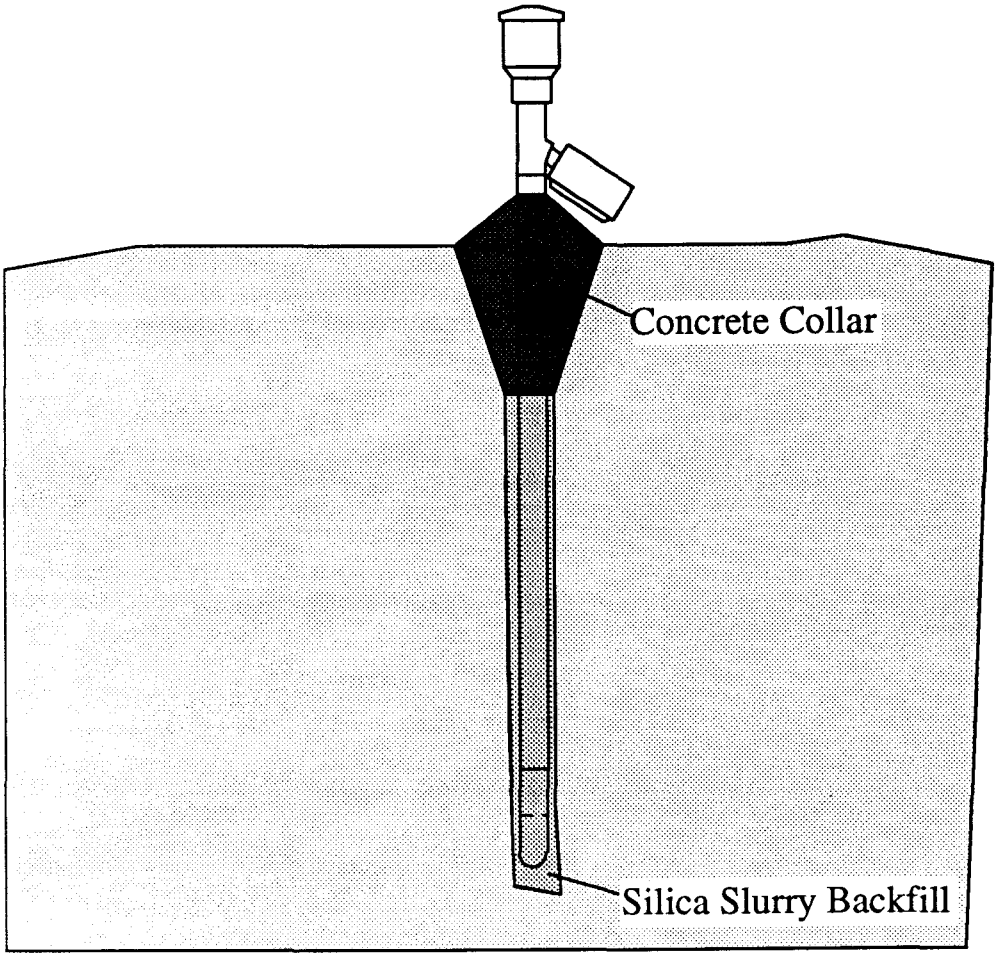
GROUNDWATER RECHARGE STUDY INTERIM REPORT
Detail of Jet Fill Tensiometer Model 2725A
FIGURE 6 OCTOBER 1993

File: TENSASMB.DRW

Status: 10/27/93



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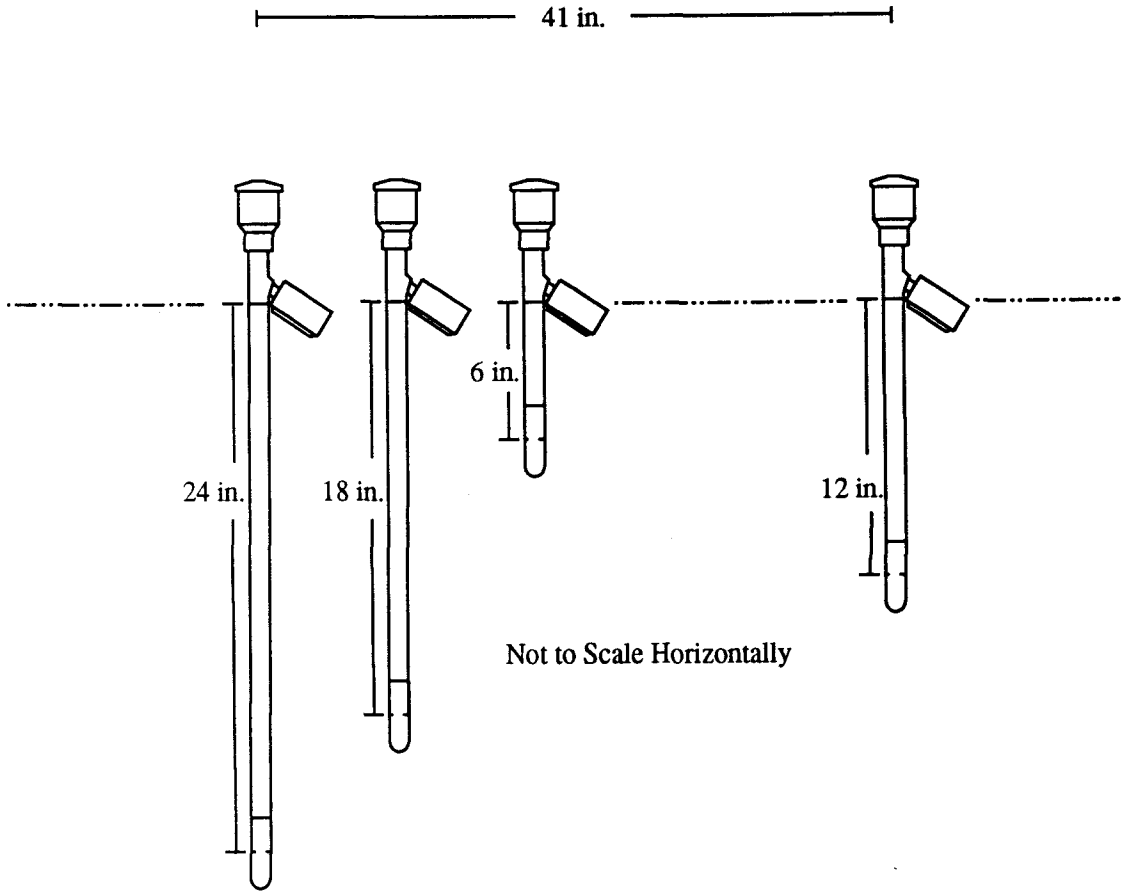
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Generalized Completion Diagram for Tensiometers

FIGURE 7 OCTOBER 1993

File: TENCOMP.DRW

Status: 10/27/93



(See Figure 2 for Plan View)

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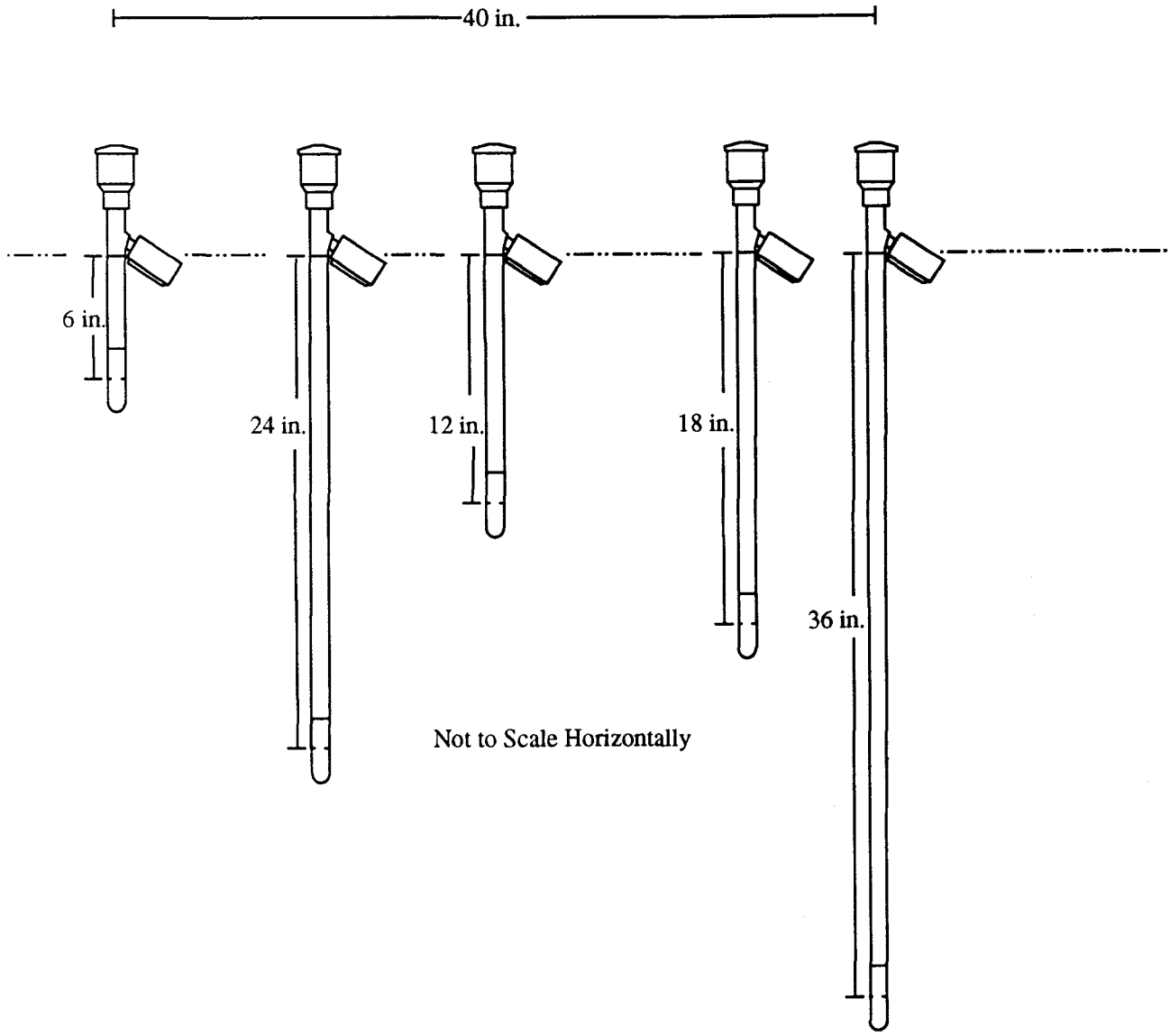
GROUNDWATER RECHARGE STUDY INTERIM REPORT
Cross Section of Tensiometer Installation Geometry Site 1
FIGURE 8 OCTOBER 1993

File: TENCOMP1.DRW

Status: 10/27/93



(See Figure 4 for Plan View)

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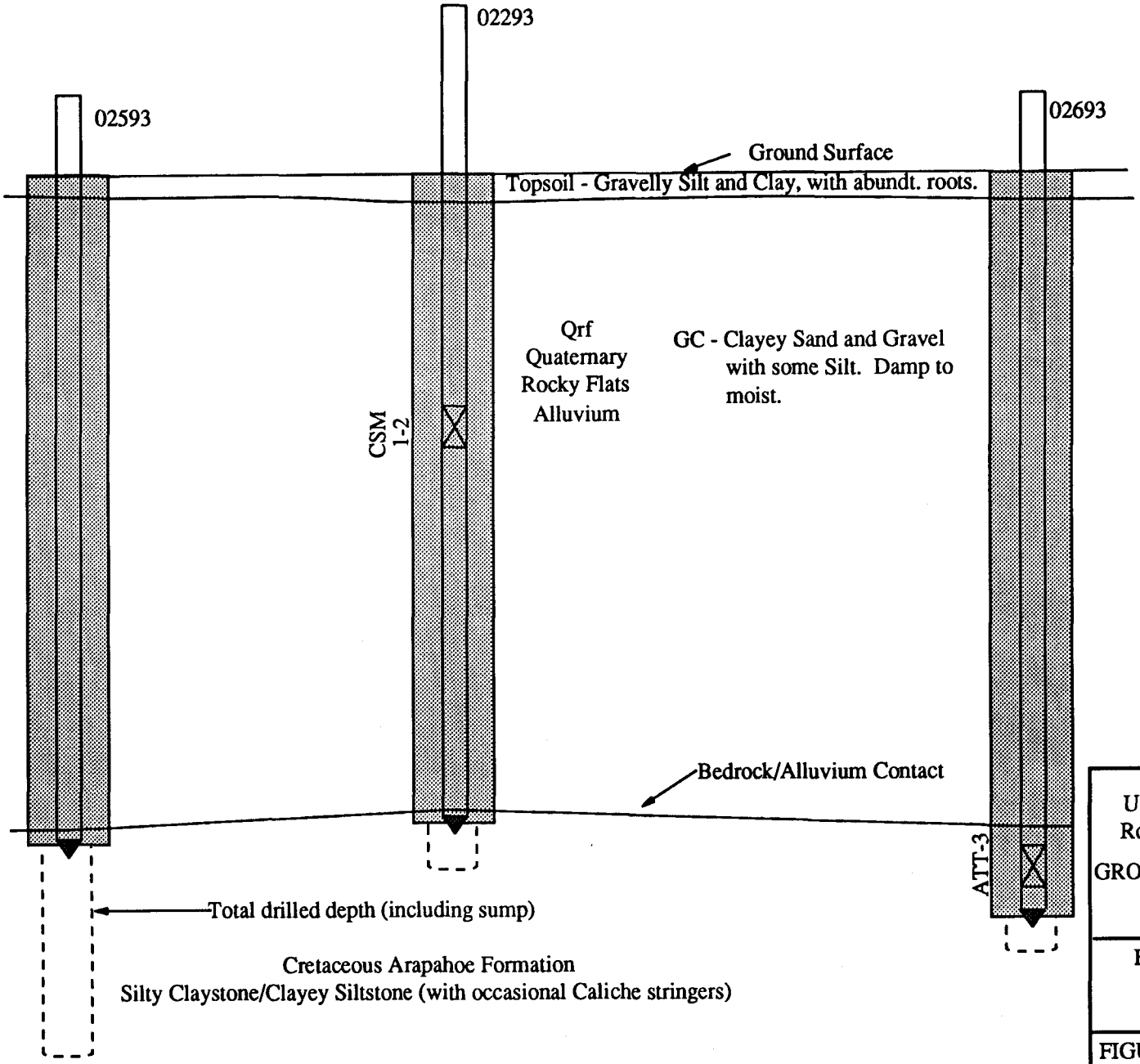
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Cross Section of Tensiometer
Installation Geometry
Site 2

FIGURE 9 OCTOBER 1993

File: TENCOMP2.DRW

Status: 10/27/93



LEGEND

Hydroprobe's Zone of Thermalization (Approximate)

Sample Location

CSM 1-2 — CSM Sample

ATT-2 — Advanced Terra-Testing Sample

SCALE: 1" = 2'

0 — 2 FEET

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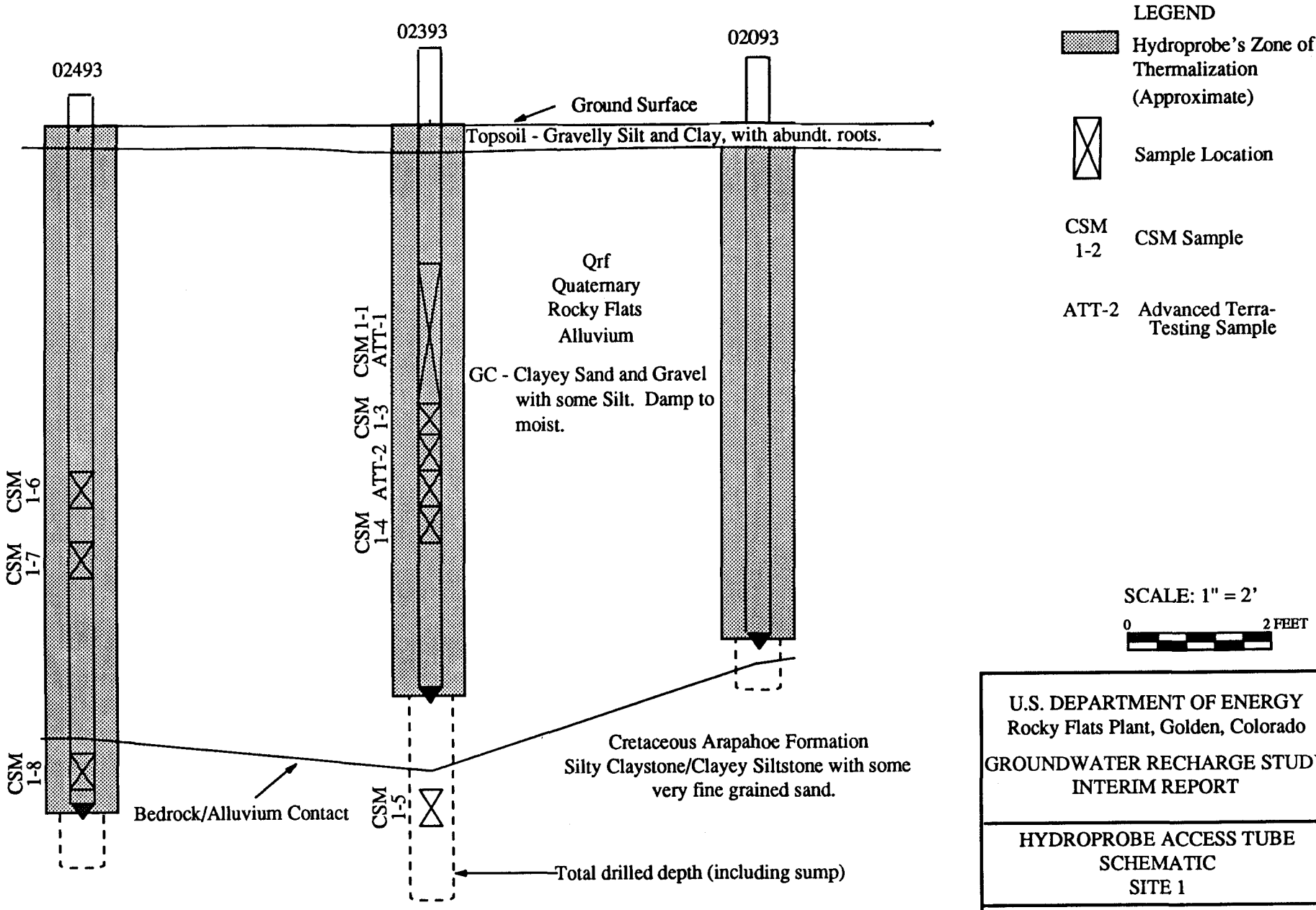
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

HYDROPROBE ACCESS TUBE
SCHEMATIC
SITE 1

FIGURE 10a — OCTOBER 1993

File: FTITUBE1.DRW

Status: 10/27/93



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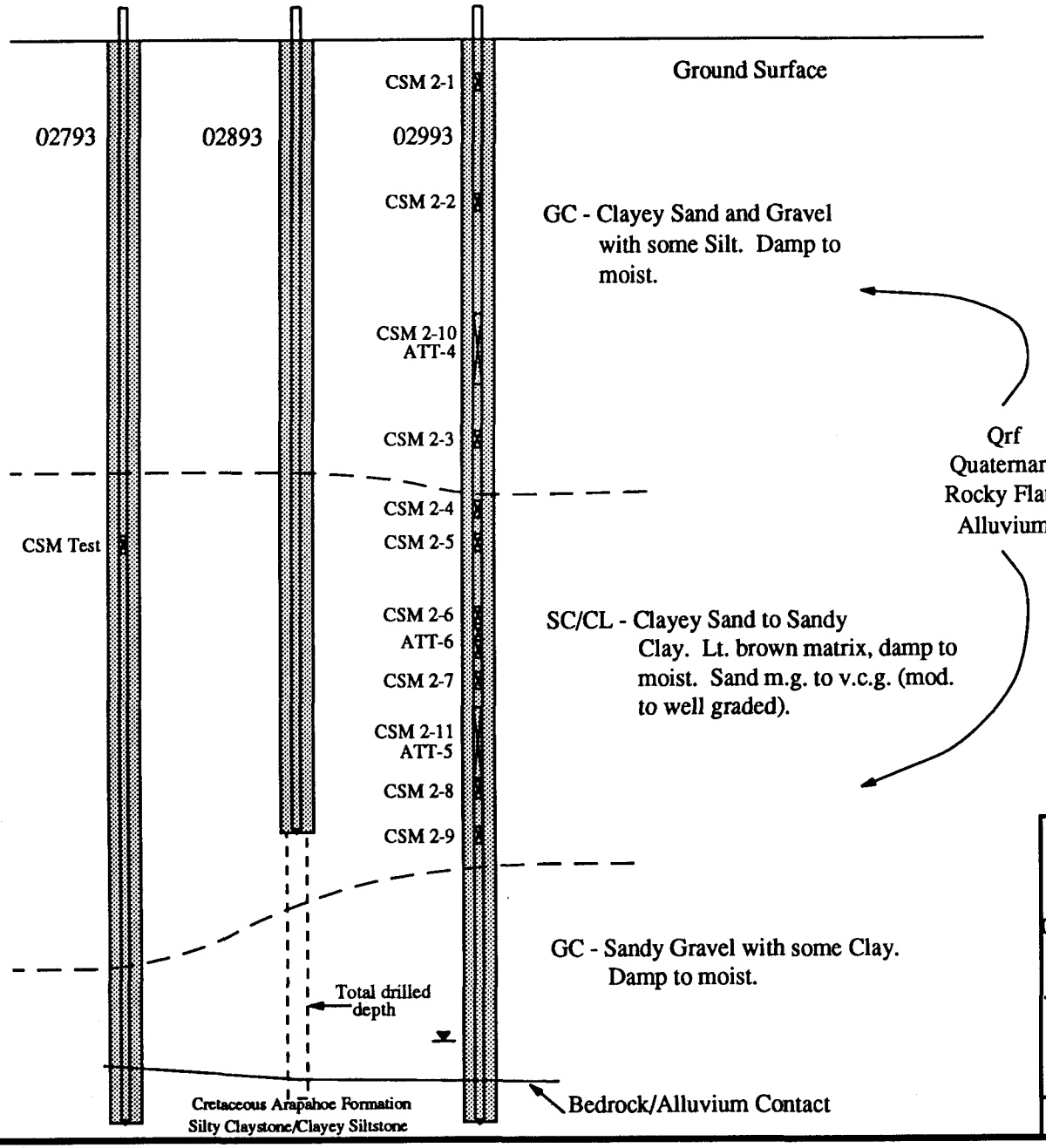
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

HYDROPROBE ACCESS TUBE
SCHEMATIC
SITE 1

FIGURE 10b OCTOBER 1993

File: ST1TUBE2.DRW

Status: 10/27/93



LEGEND

Hydroprobe's Zone of Thermalization (Approximate)

Sample Location

CSM 1-2 CSM Sample

ATT-2 Advanced Terra-Testing Sample

SCALE: 1" = 5'

0 5 FEET

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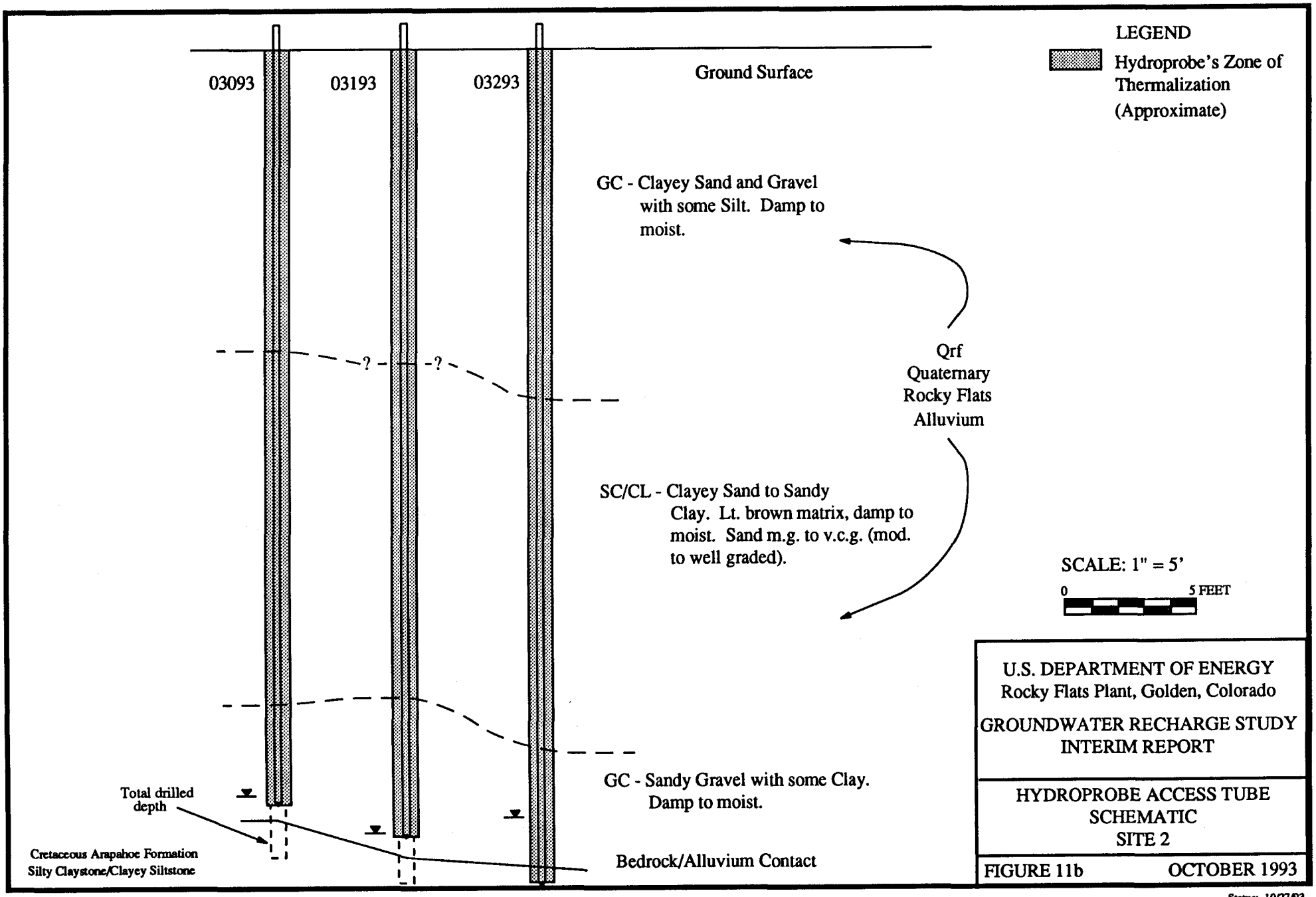
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

HYDROPROBE ACCESS TUBE
SCHEMATIC
SITE 2

FIGURE 11a OCTOBER 1993

File: ST2TUBS1.DRW

Status: 10/27/93


03093
03193
03293
Ground Surface
LEGEND
Hydroprobe's Zone of Thermalization (Approximate)
GC - Clayey Sand and Gravel with some Silt. Damp to moist.
Qrf Quaternary Rocky Flats Alluvium
SC/CL - Clayey Sand to Sandy Clay. Lt. brown matrix, damp to moist. Sand m.g. to v.c.g. (mod. to well graded).
SCALE: 1" = 5'
0
5 FEET
GC - Sandy Gravel with some Clay. Damp to moist.
Total drilled depth
Cretaceous Arapahoe Formation Silty Claystone/Clayey Siltstone
Bedrock/Alluvium Contact
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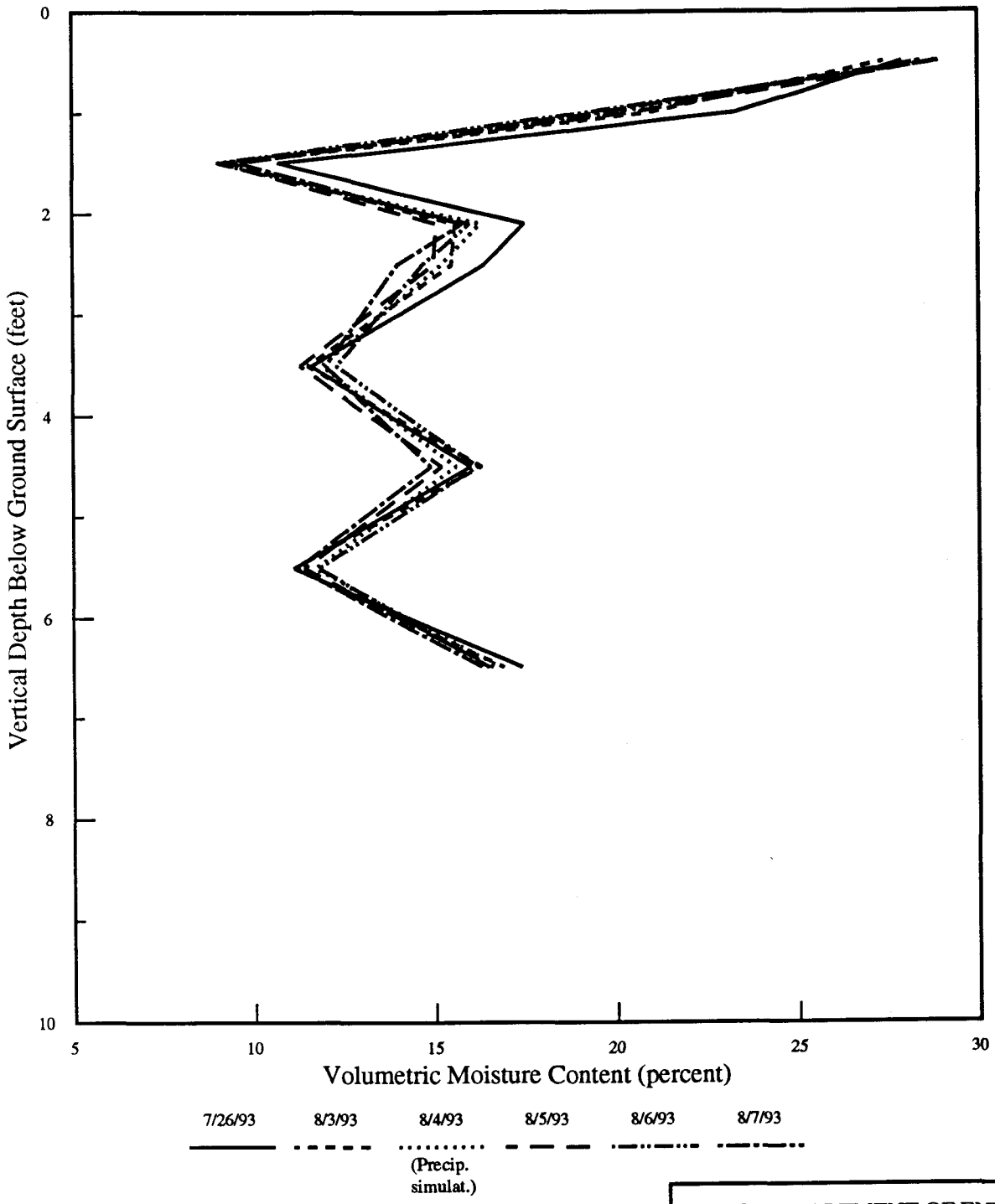
Rocky Flats Plant, Golden, Colorado
GROUNDWATER RECHARGE STUDY
INTERIM REPORT
HYDROPROBE ACCESS TUBE
SCHEMATIC
SITE 2
FIGURE 11b
OCTOBER 1993
Status: 10/27/93



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Rocky Flats Plant, Golden, Colorado

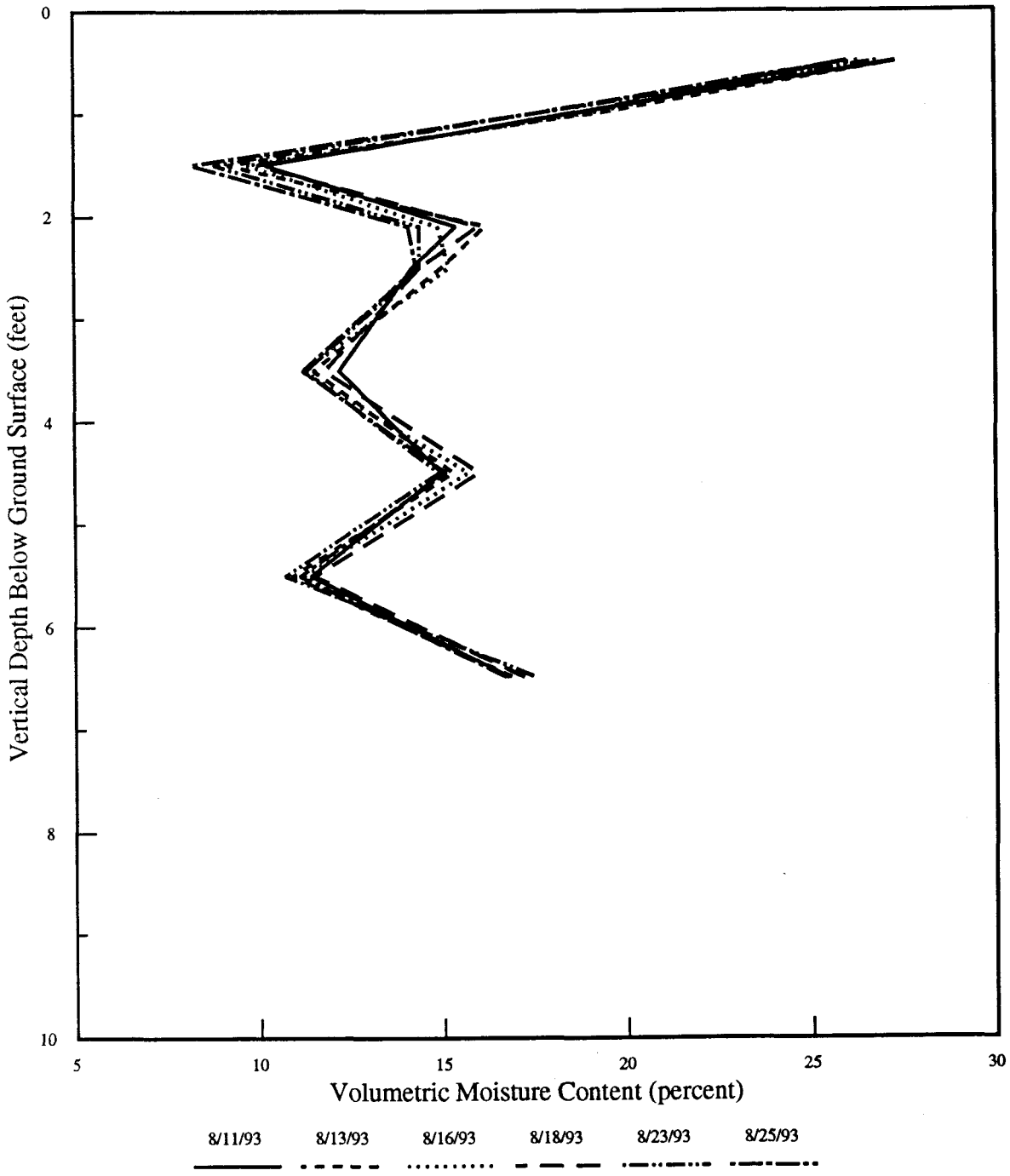
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02093

FIGURE 12a OCTOBER 1993

File: 020CHART.DRW

Status: 10/27/93



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Rocky Flats Plant, Golden, Colorado

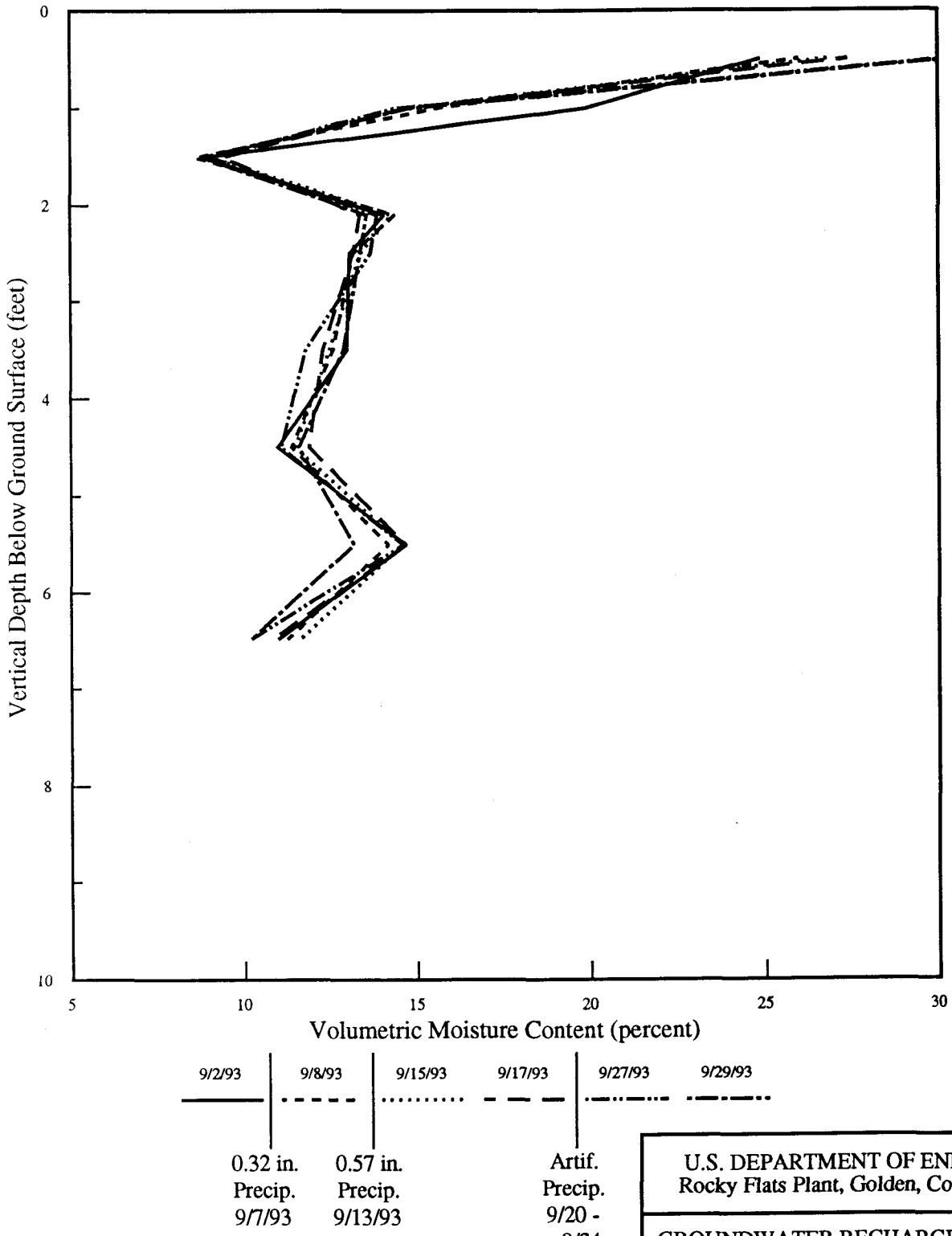
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02093

FIGURE 12b OCTOBER 1993

File: B20CHART.DRW

Status: 10/27/93



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Rocky Flats Plant, Golden, Colorado

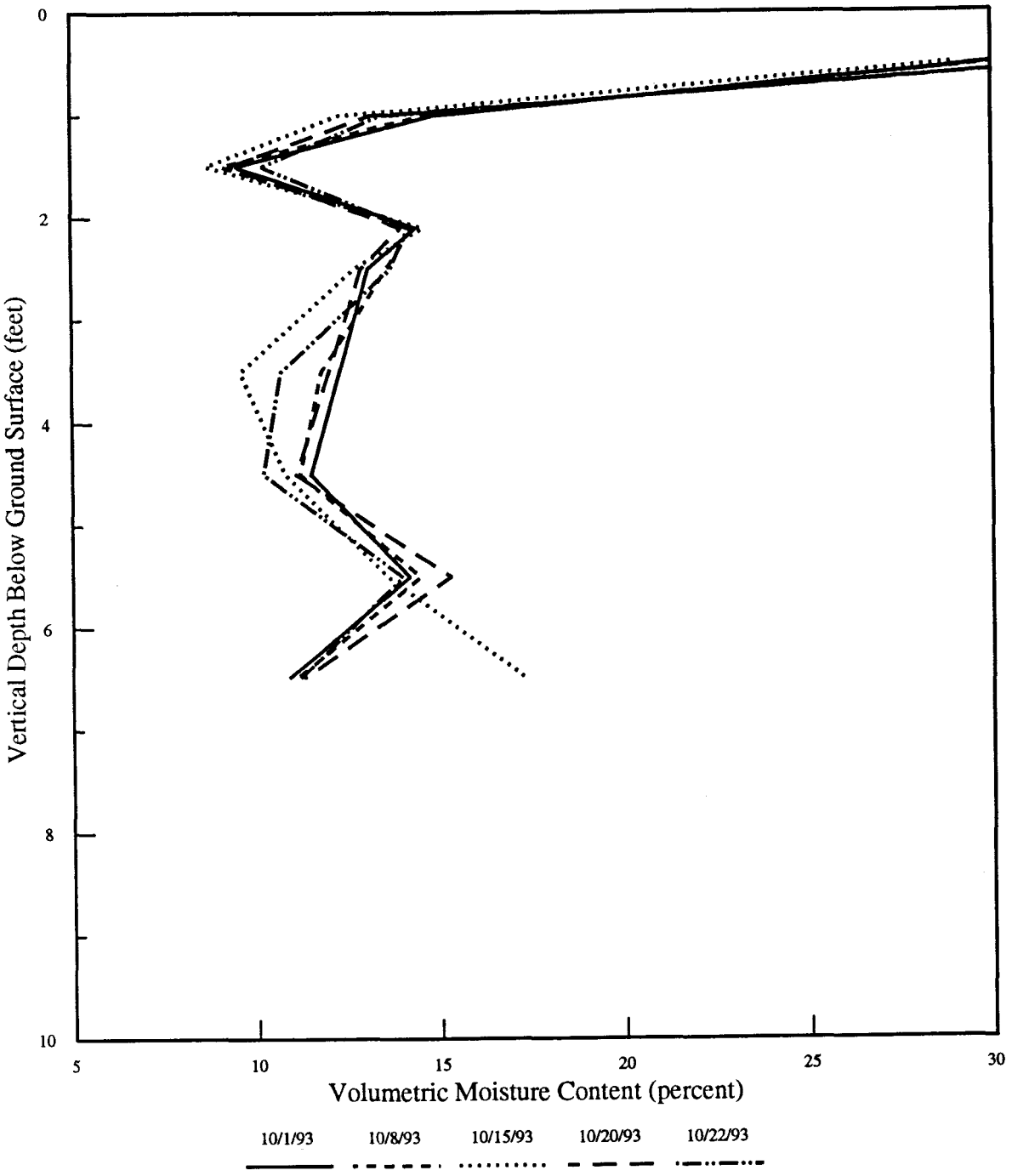
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02093

FIGURE 12c OCTOBER 1993

File: C20CHART.DRW

Status: 10/27/93



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Rocky Flats Plant, Golden, Colorado

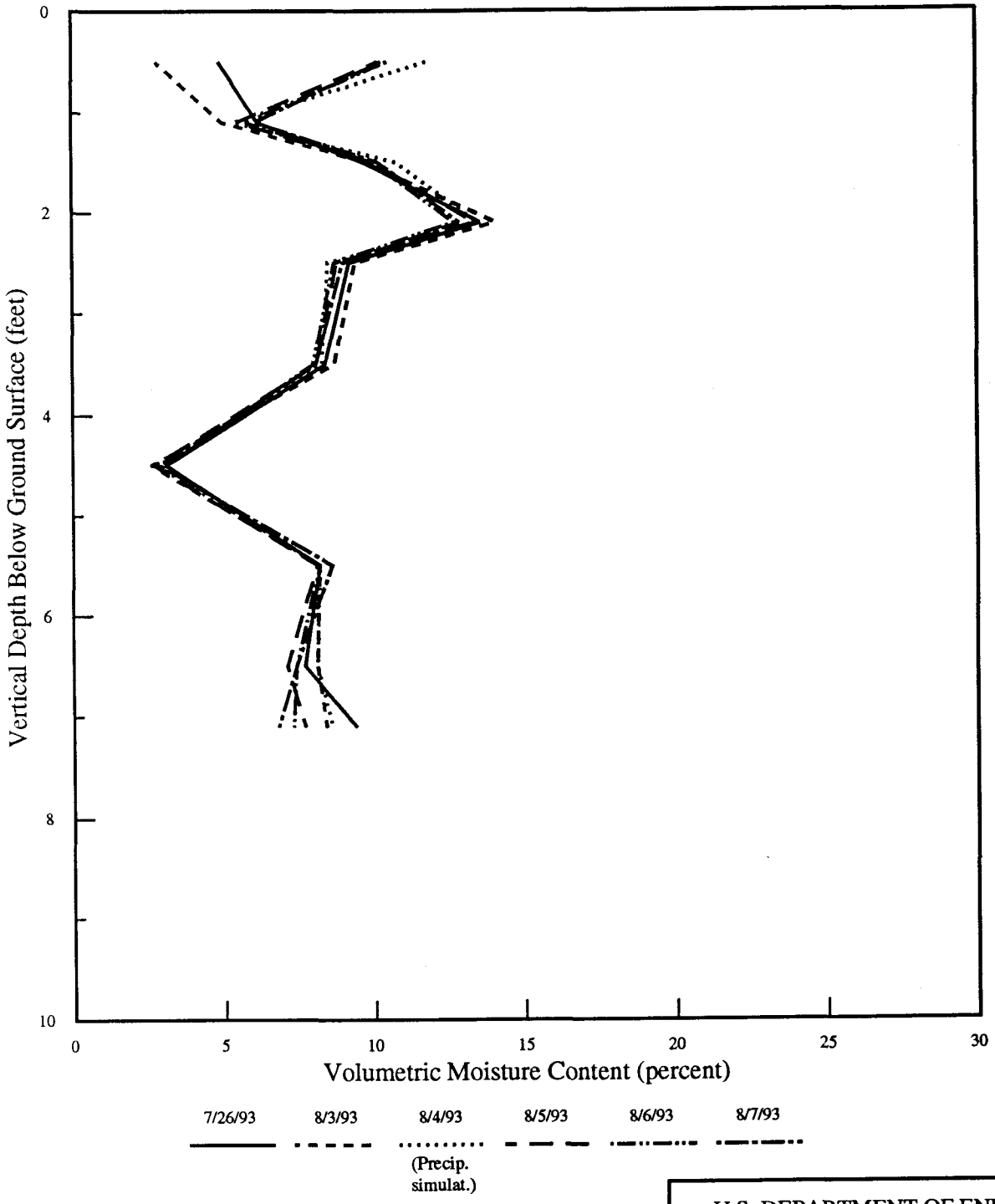
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02093

FIGURE 12d OCTOBER 1993

File: D20CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

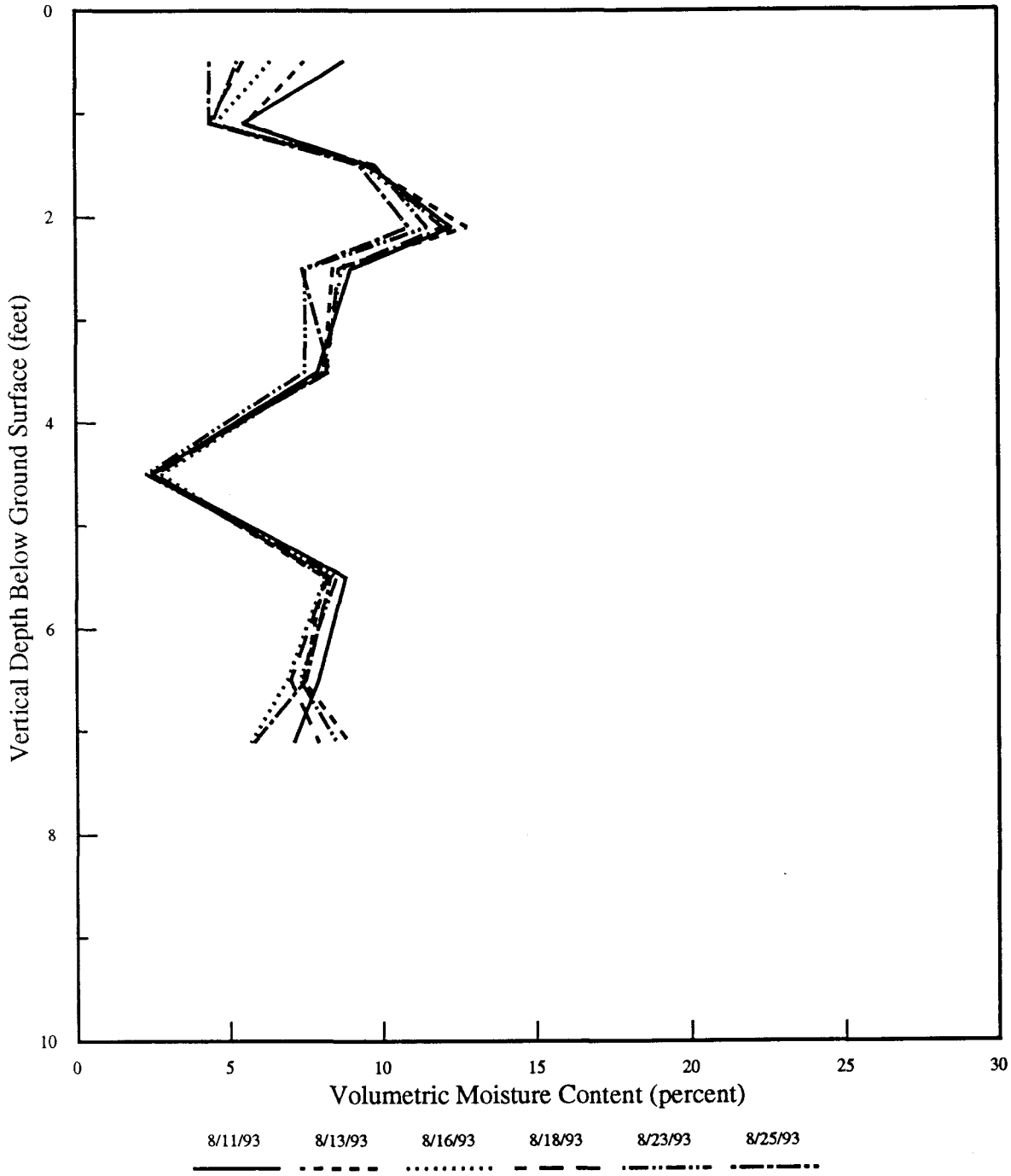
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02293

FIGURE 13a OCTOBER 1993

File: 022CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

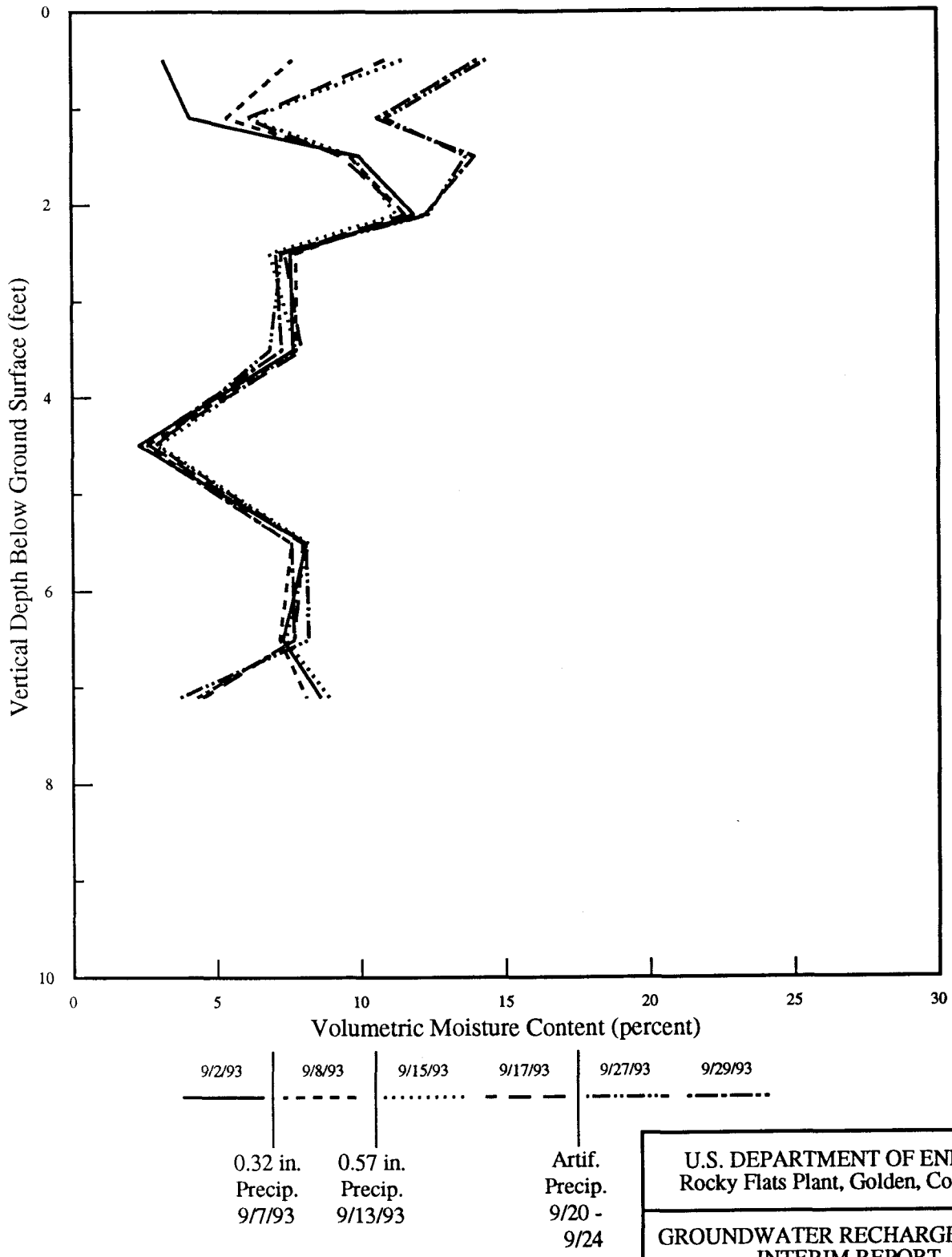
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02293

FIGURE 13b OCTOBER 1993

File: B22CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

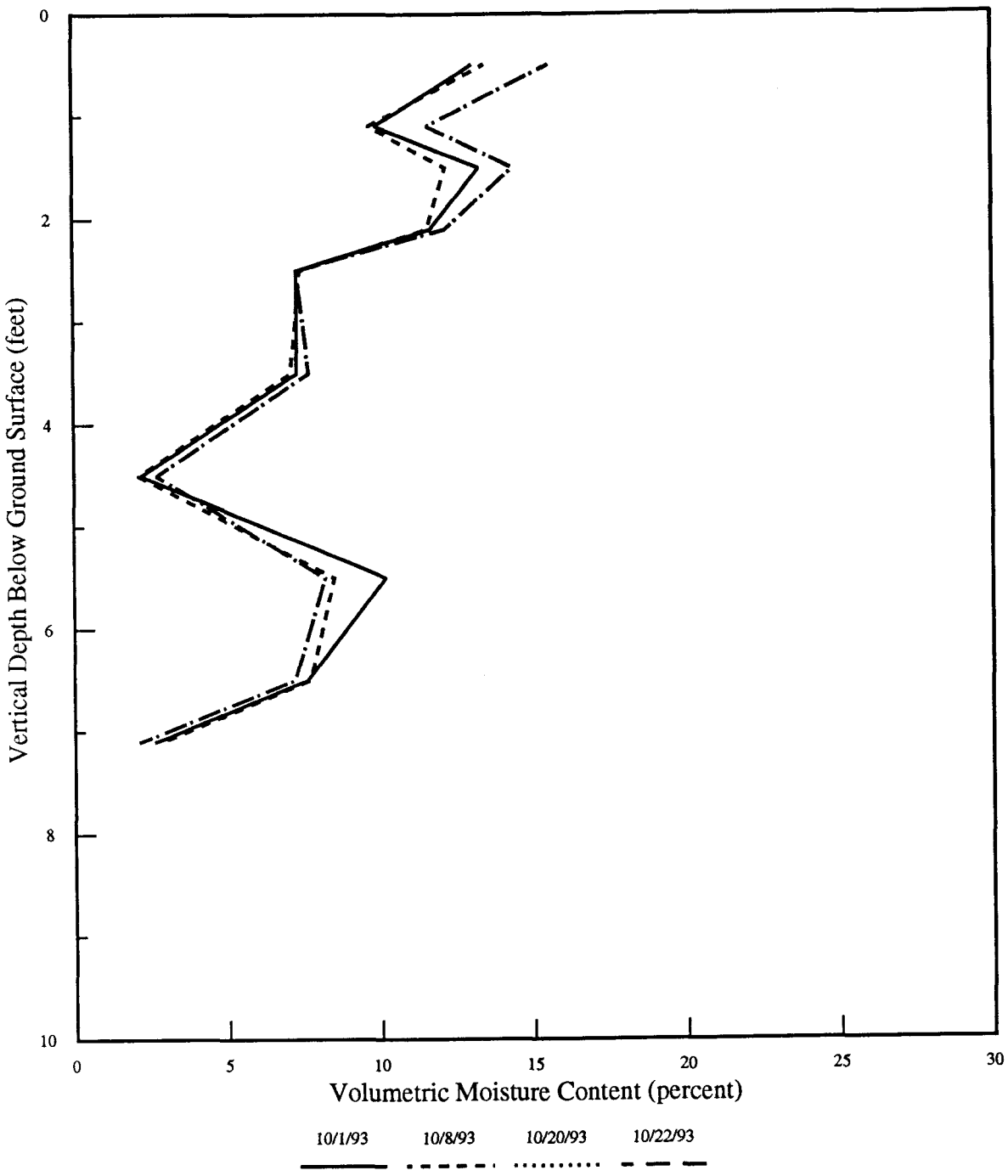
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02293

FIGURE 13c OCTOBER 1993

File: C22CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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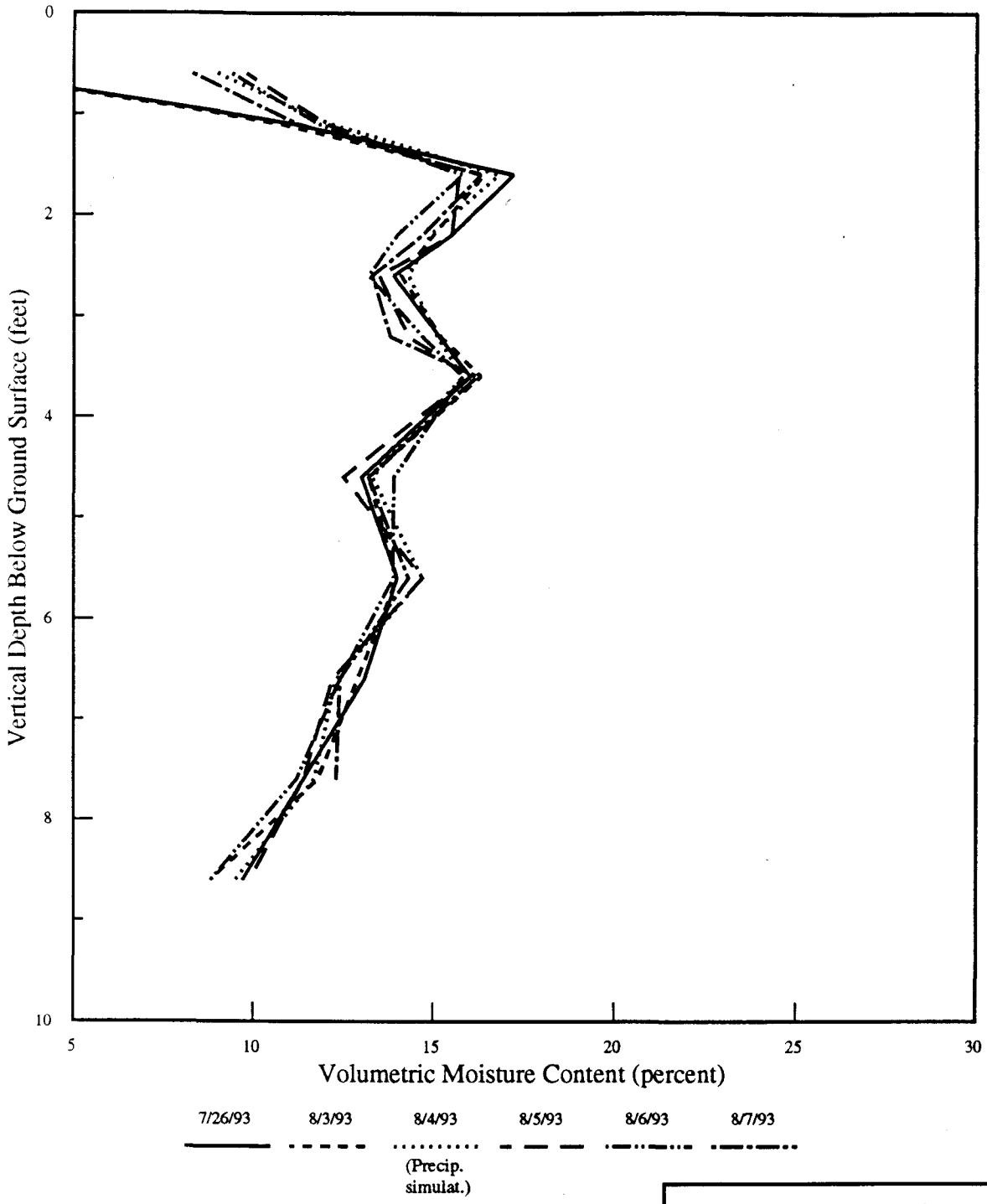
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02293

FIGURE 13d OCTOBER 1993

File: D22CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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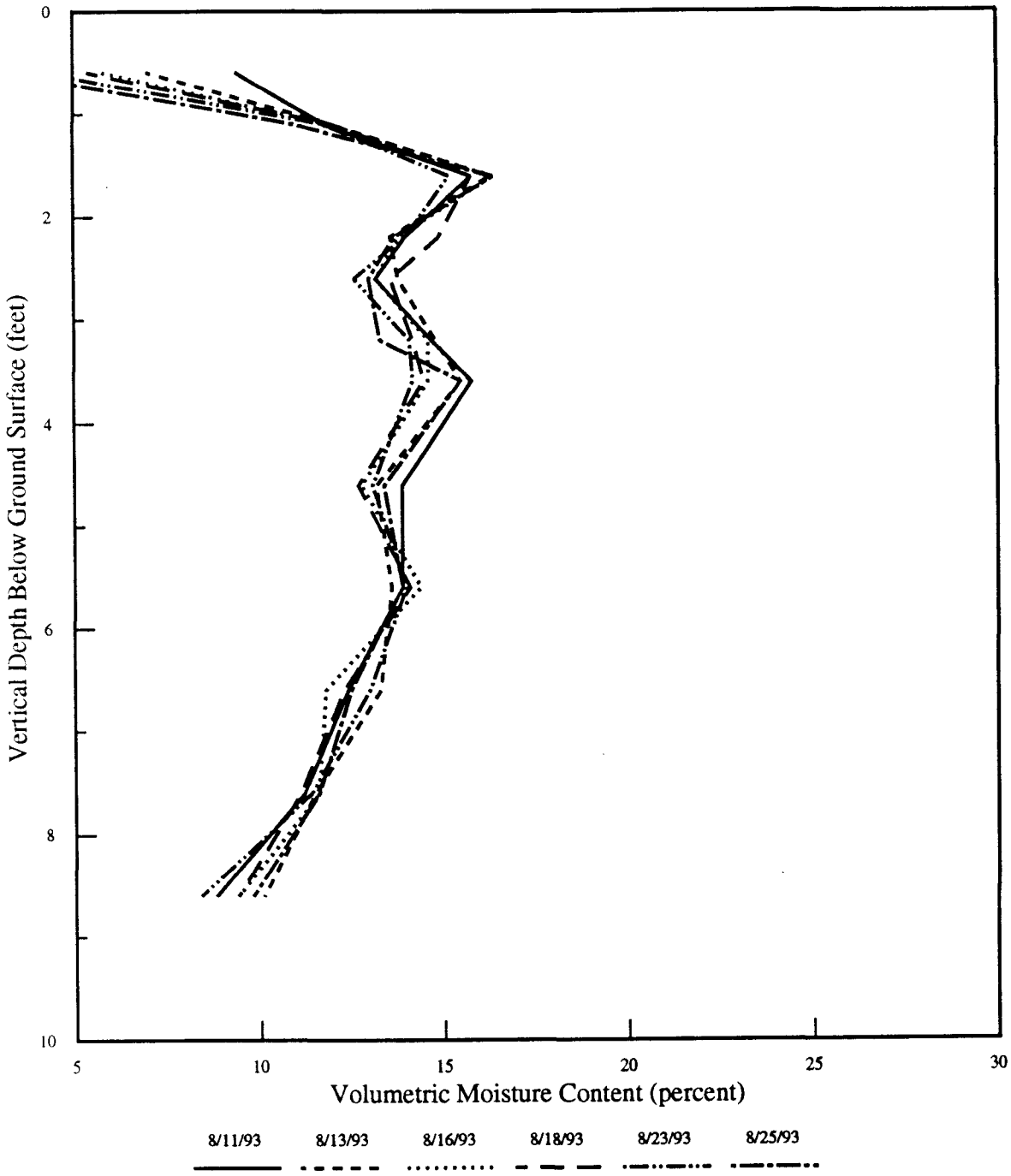
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02393

FIGURE 14a OCTOBER 1993

File: 023CHART.DRW

Status: 10/26/93



U.S. DEPARTMENT OF ENERGY
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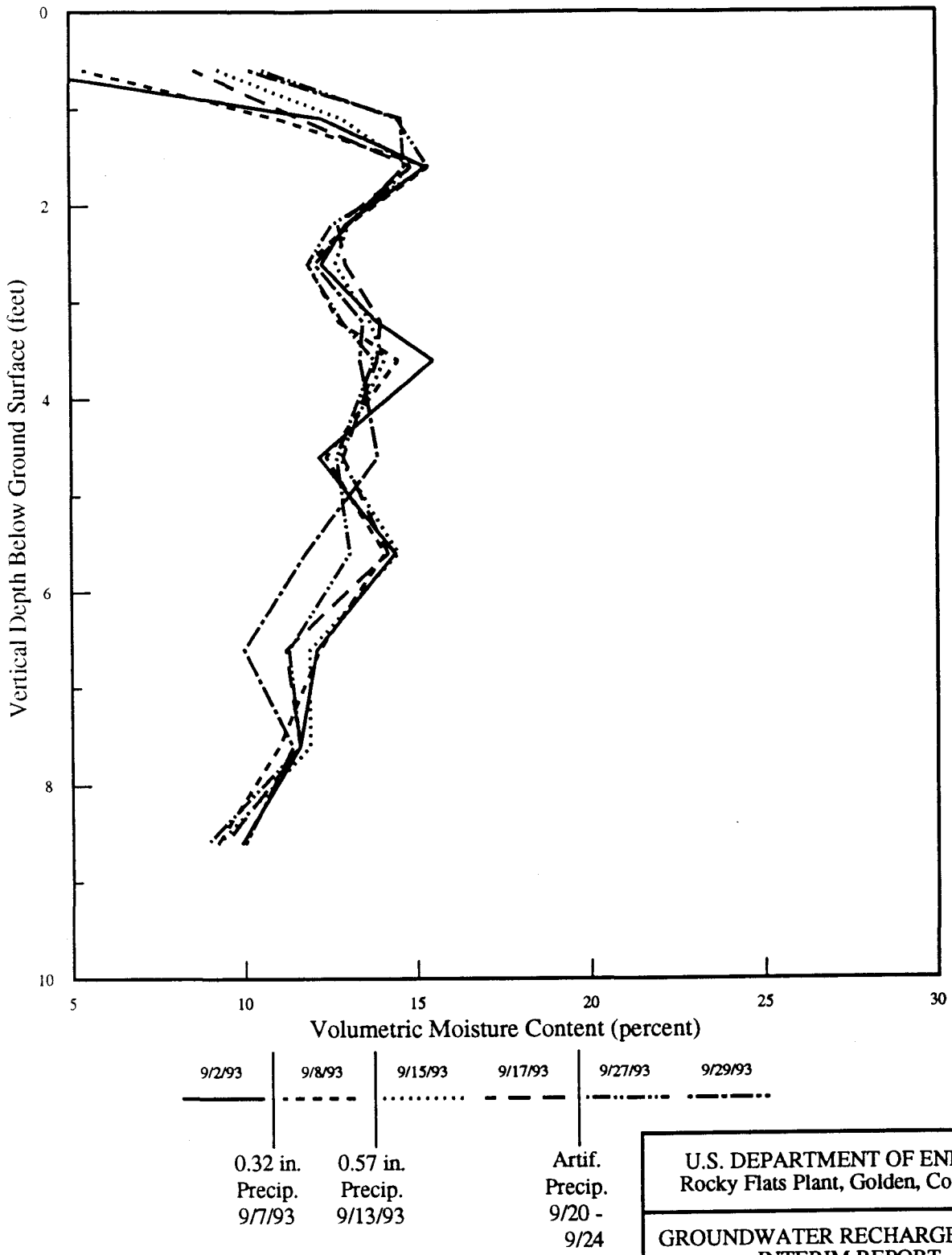
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02393

FIGURE 14b OCTOBER 1993

File: B23CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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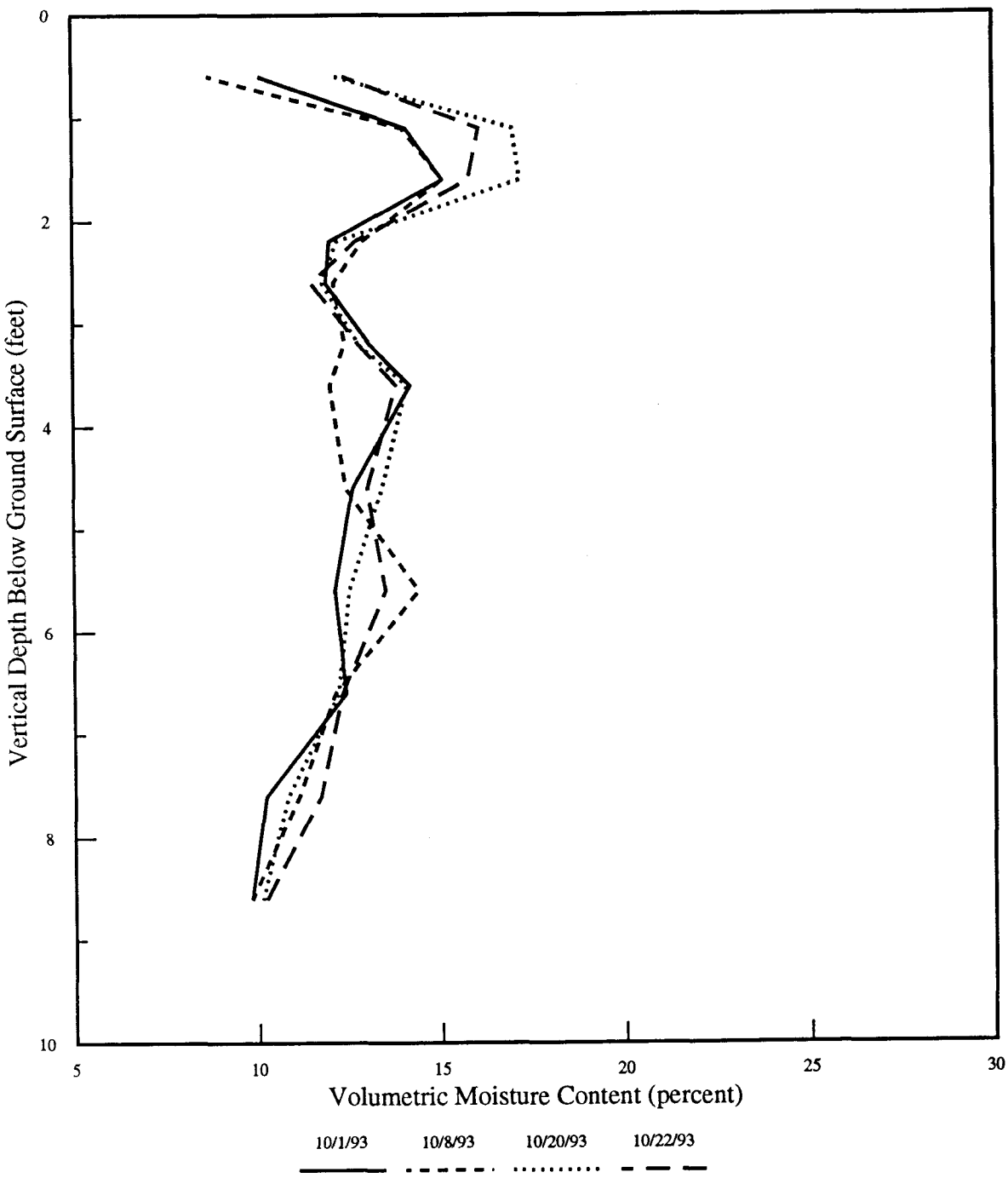
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02393

FIGURE 14c OCTOBER 1993

File: C23CHART.DRW

Status: 10/27/93



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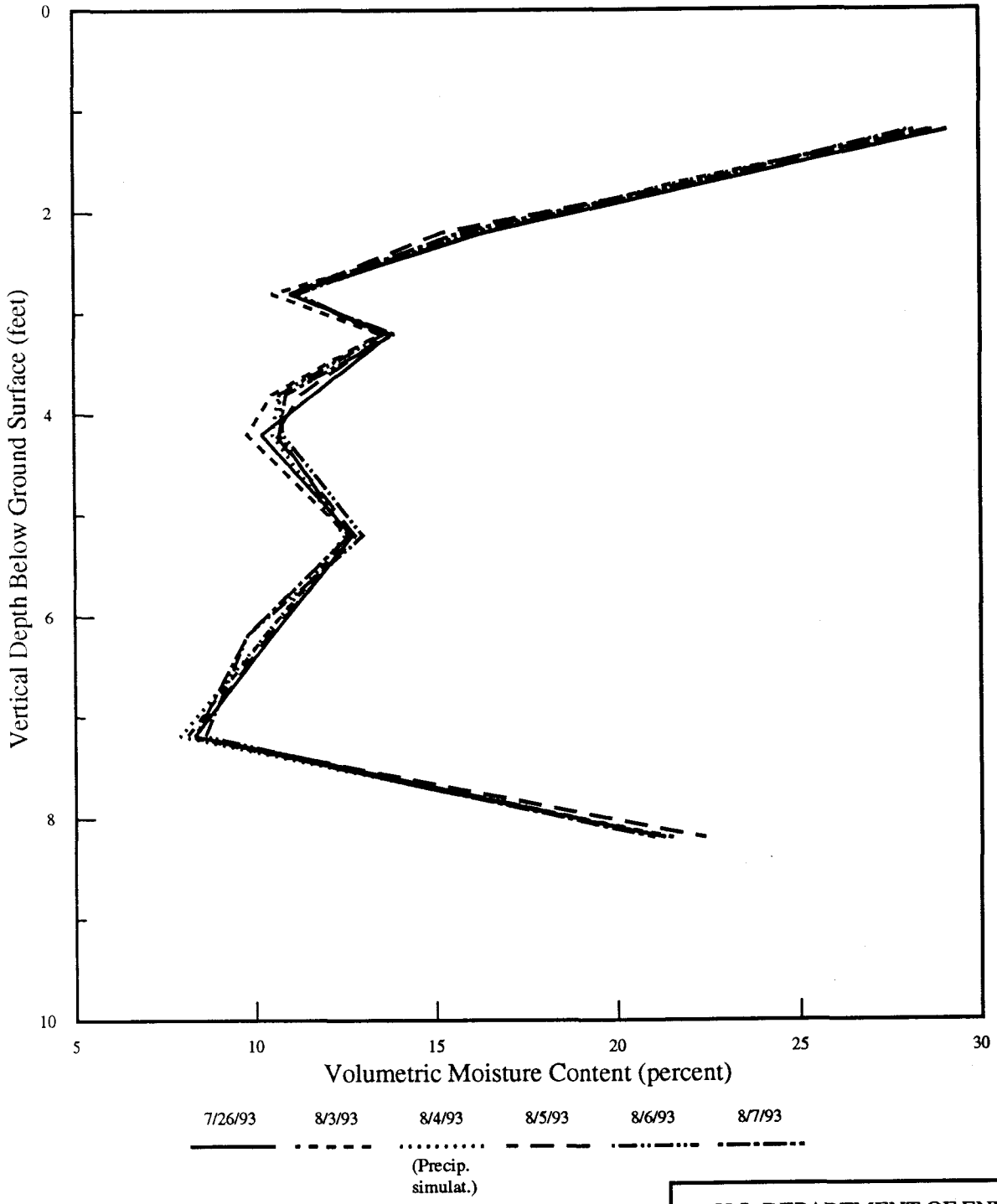
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02393

FIGURE 14d OCTOBER 1993

File: D23CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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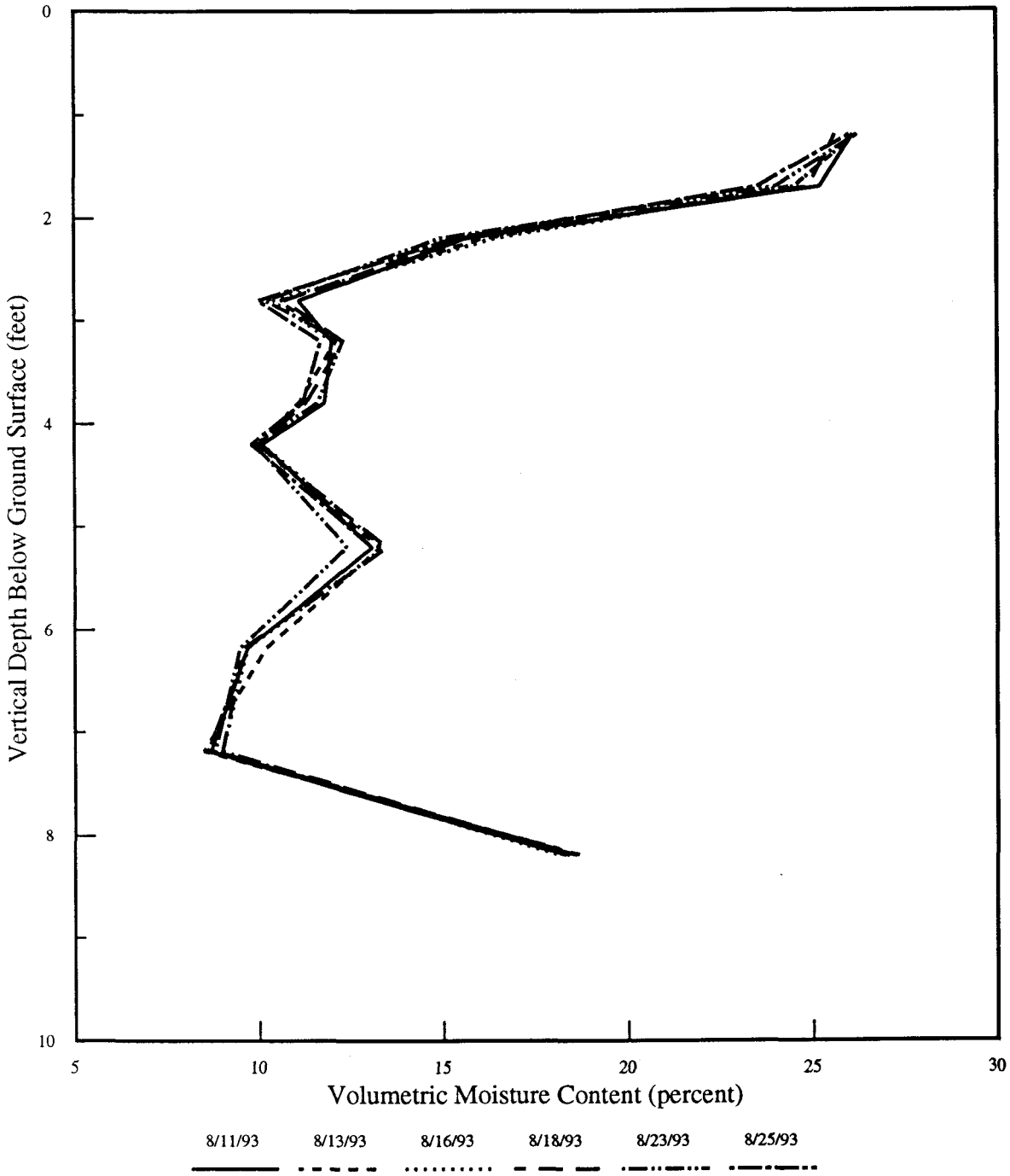
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02493

FIGURE 15a OCTOBER 1993

File: 024CHART.DRW

Status: 10/27/93



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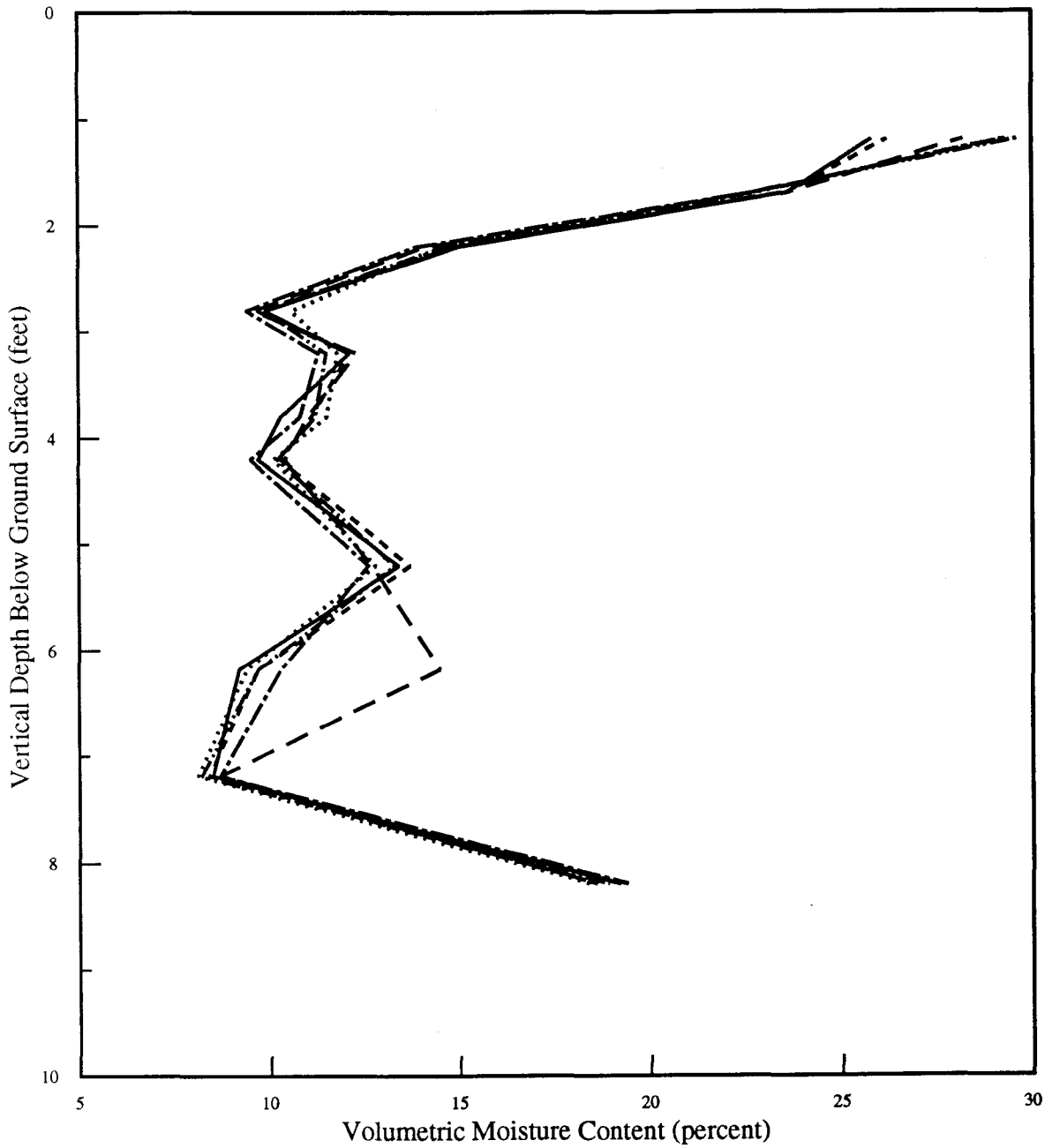
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02493

FIGURE 15b OCTOBER 1993

File: B24CHART.DRW

Status: 10/27/93



9/2/93 | 9/8/93 | 9/15/93 | 9/17/93 | 9/27/93 | 9/29/93

0.32 in. Precip. 9/7/93

0.57 in. Precip. 9/13/93

Artif. Precip. 9/20 - 9/24

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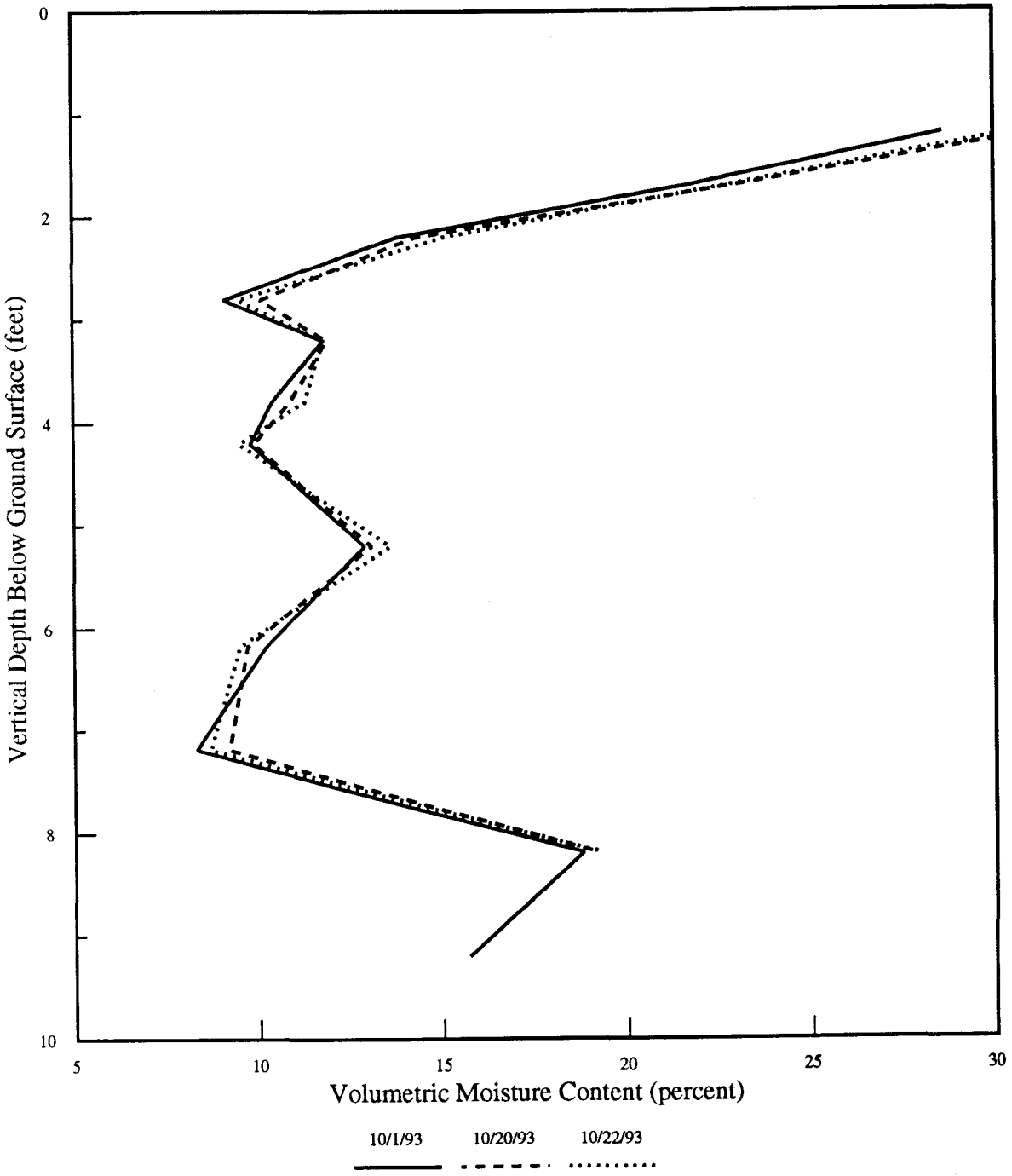
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02493

FIGURE 15c OCTOBER 1993

File: C24CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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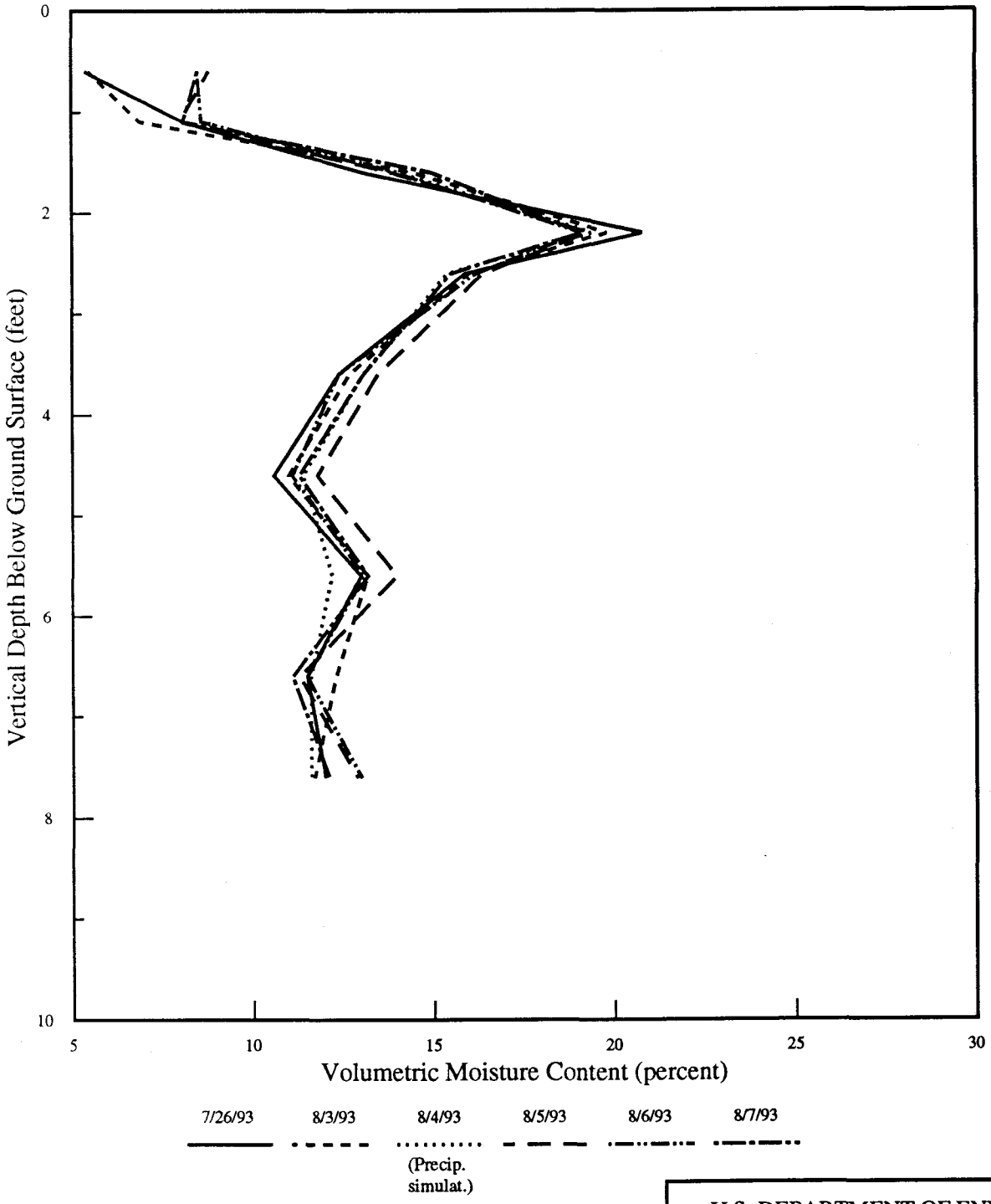
GROUNDWATER RECHARGE STUDY
DRAFT INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02493

FIGURE 15d OCTOBER 1993

File: D24CHART.DRW

Status: 10/27/93



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Rocky Flats Plant, Golden, Colorado

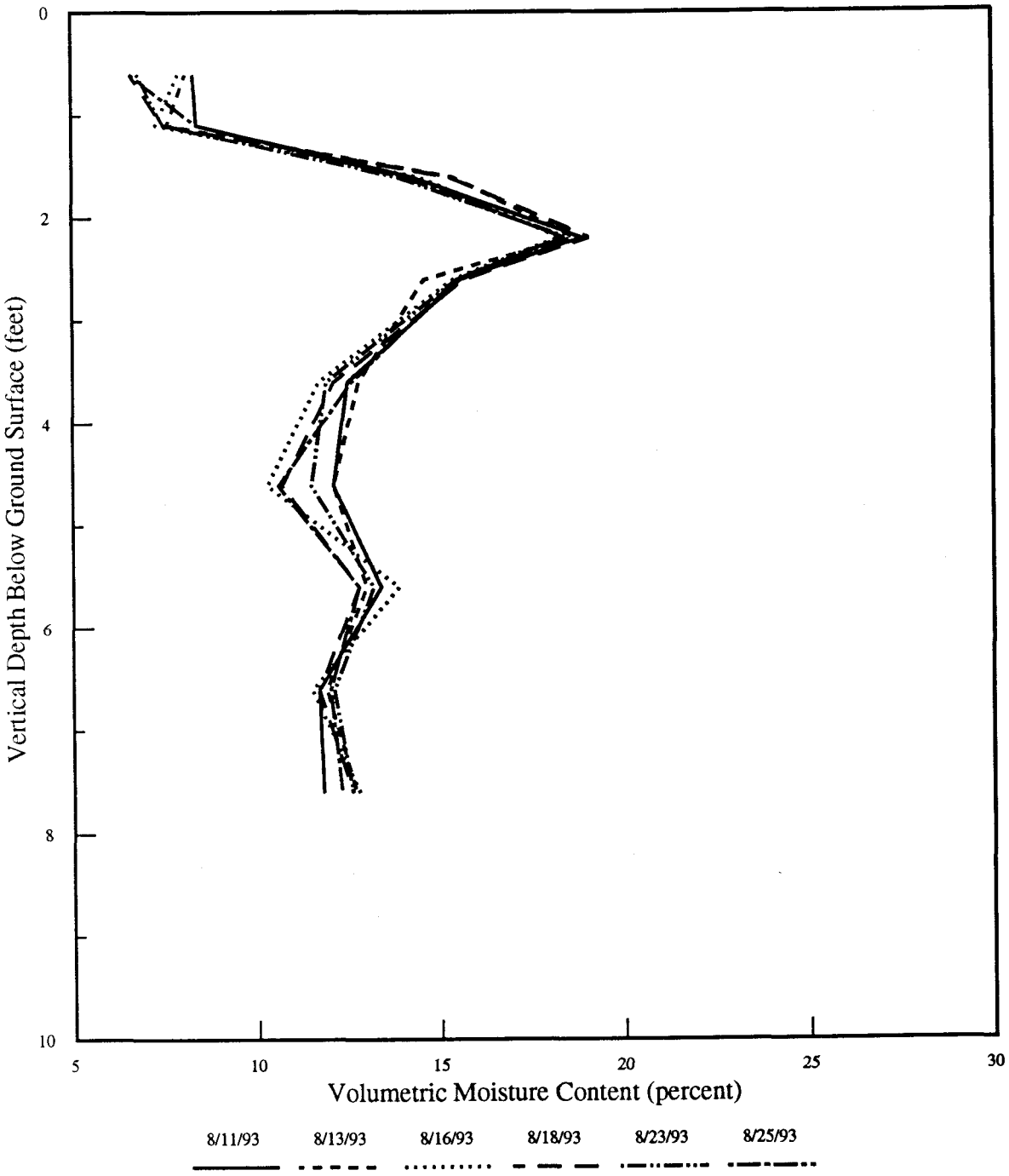
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02593

FIGURE 16a OCTOBER 1993

File: 025CHART.DRW

Status: 10/27/93



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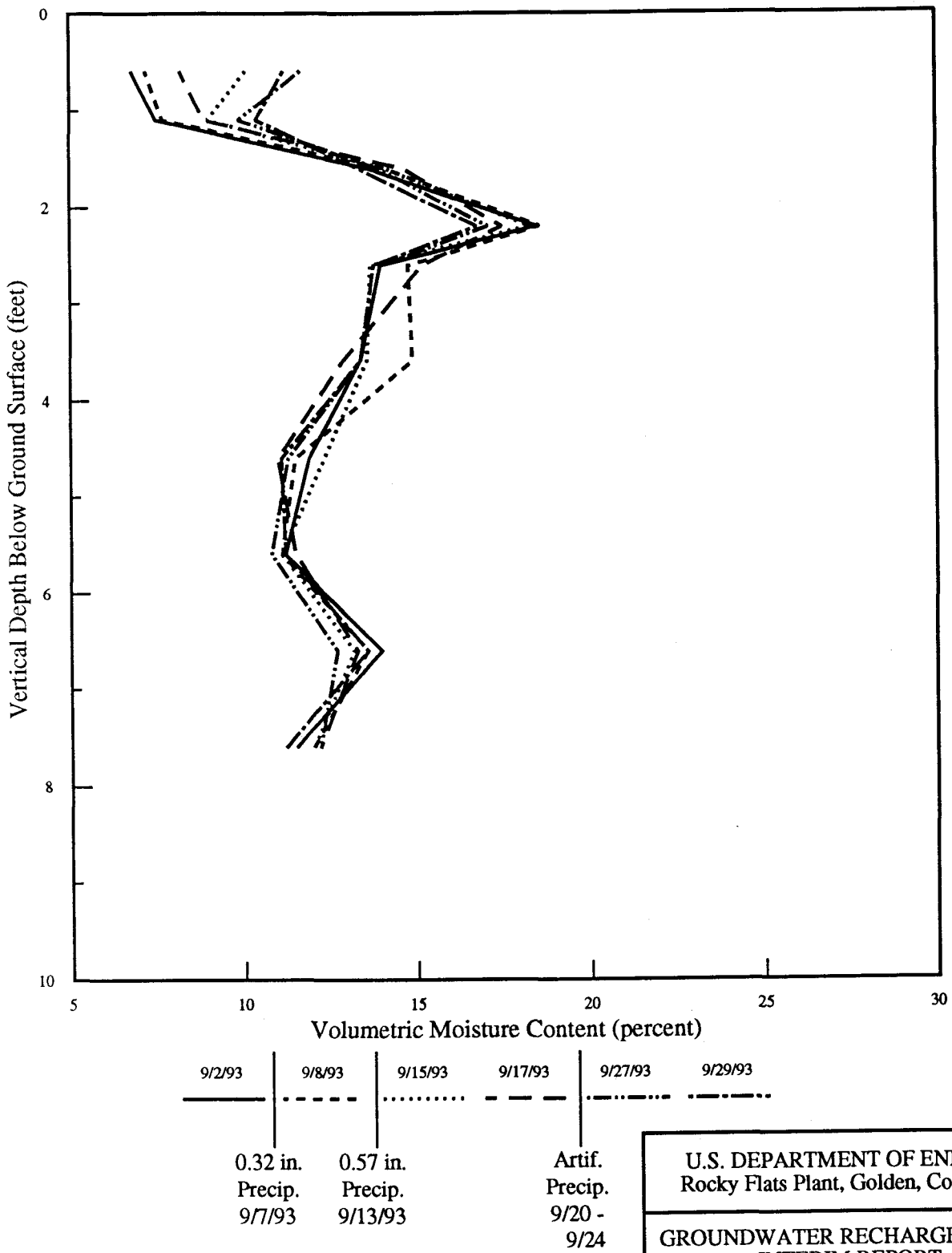
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02593

FIGURE 16b OCTOBER 1993

File: B25CHART.DRW

Status: 10/27/93



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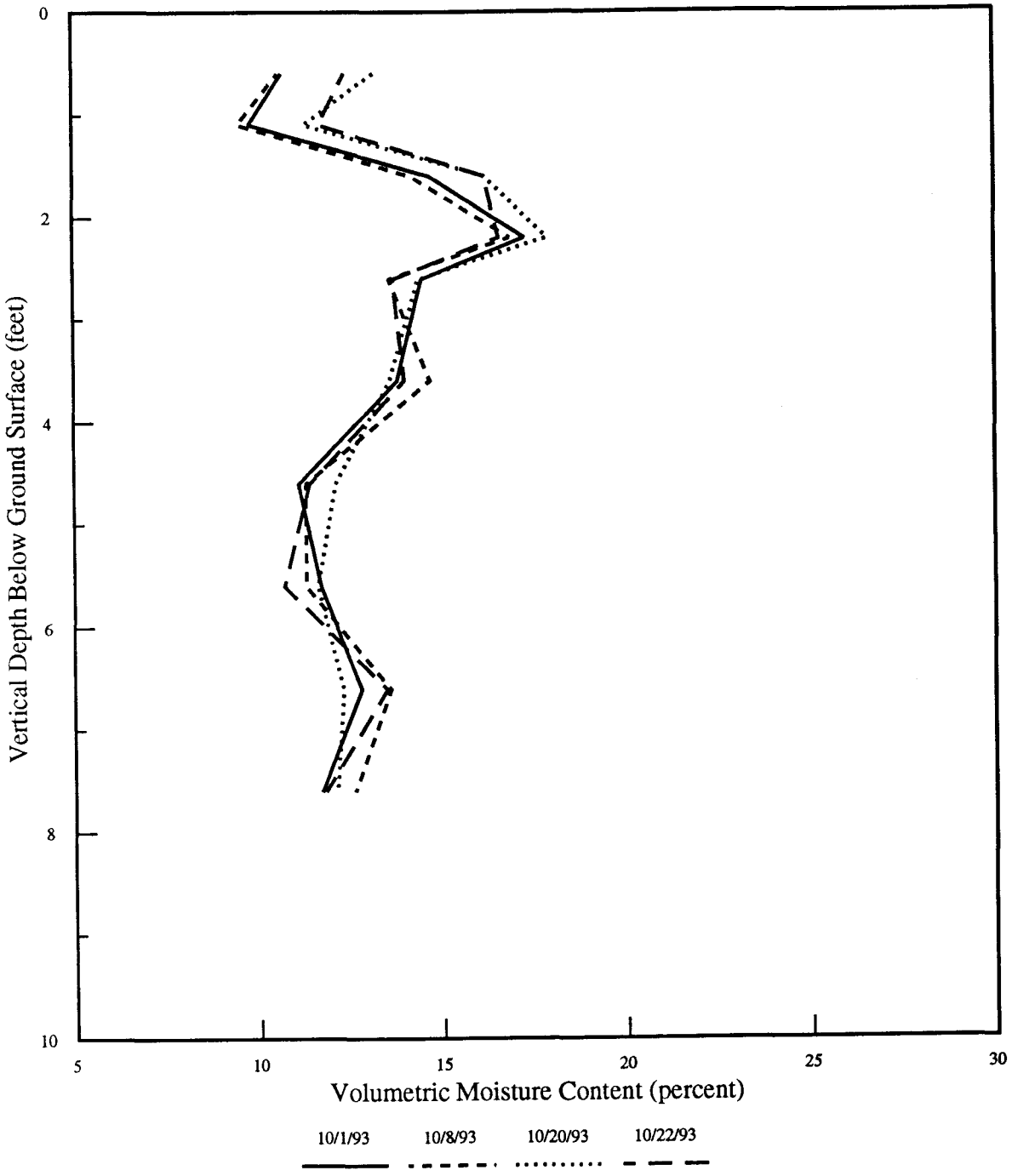
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02593

FIGURE 16c OCTOBER 1993

File: C25CHART.DRW

Status: 10/27/93



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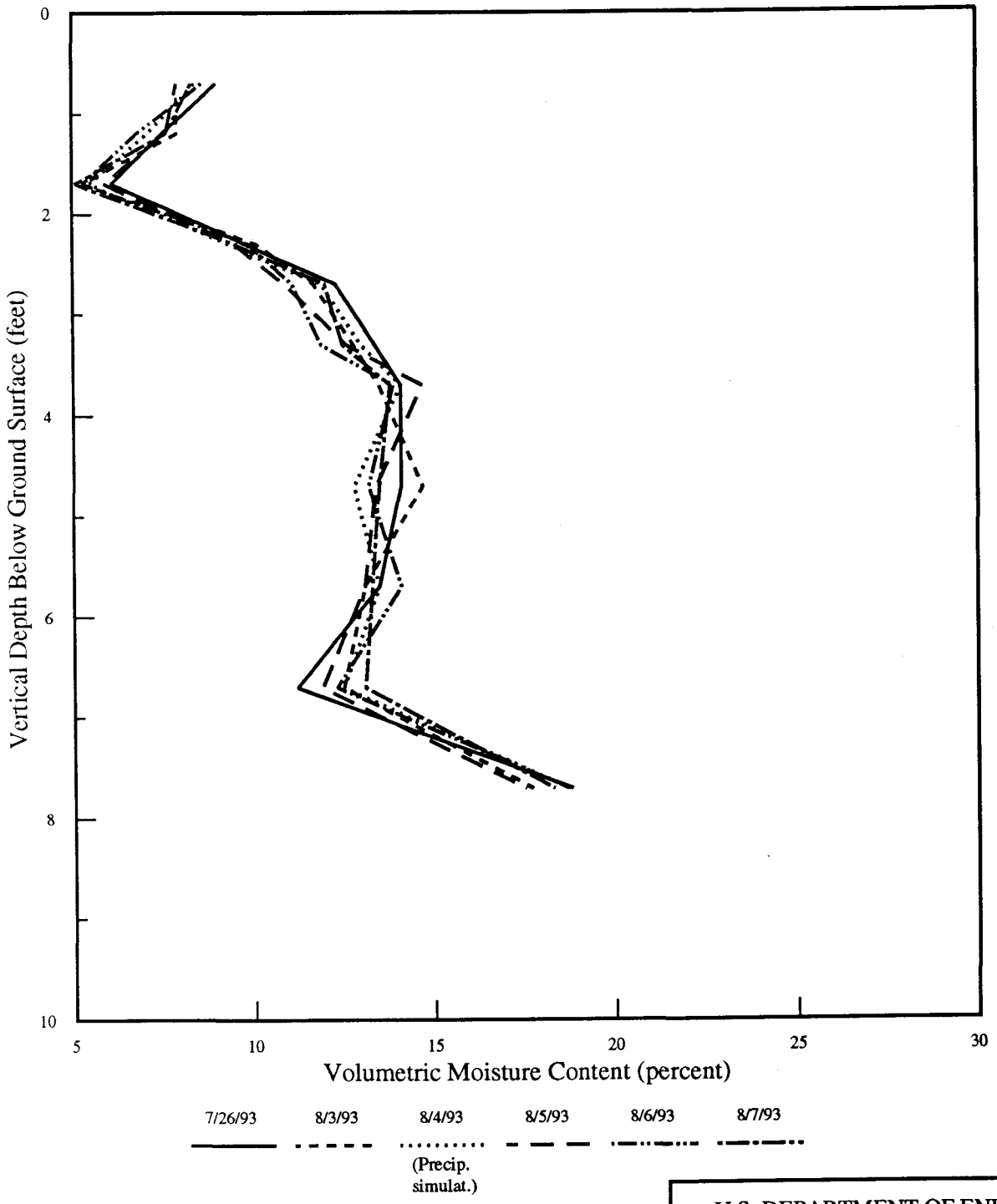
GROUNDWATER RECHARGE STUDY
DRAFT INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02593

FIGURE 16d OCTOBER 1993

File: D25CHART.DRW

Status: 10/27/93



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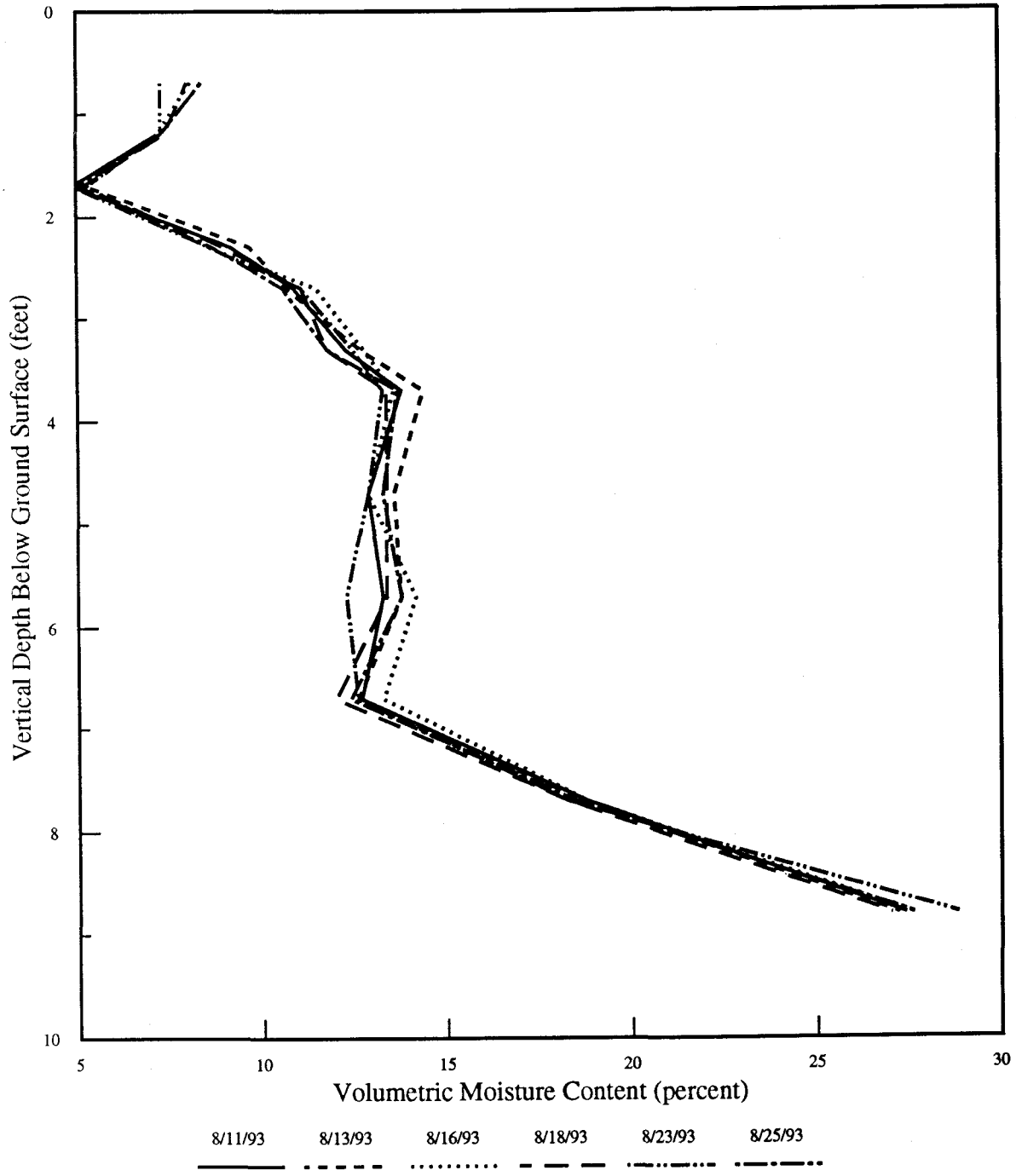
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02693

FIGURE 17a OCTOBER 1993

File: 026CHART.DRW

Status: 10/27/93



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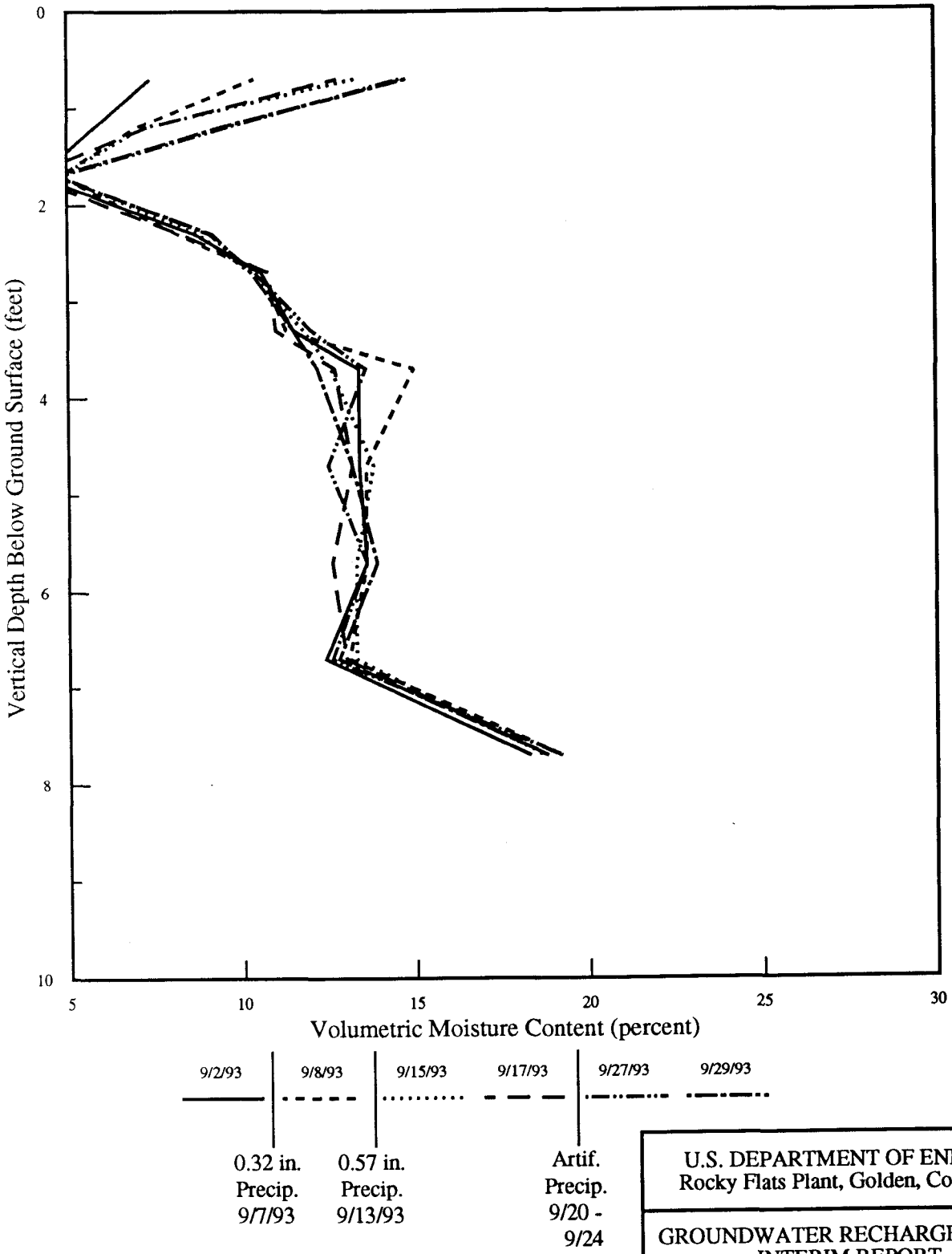
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02693

FIGURE 17b OCTOBER 1993

File: B26CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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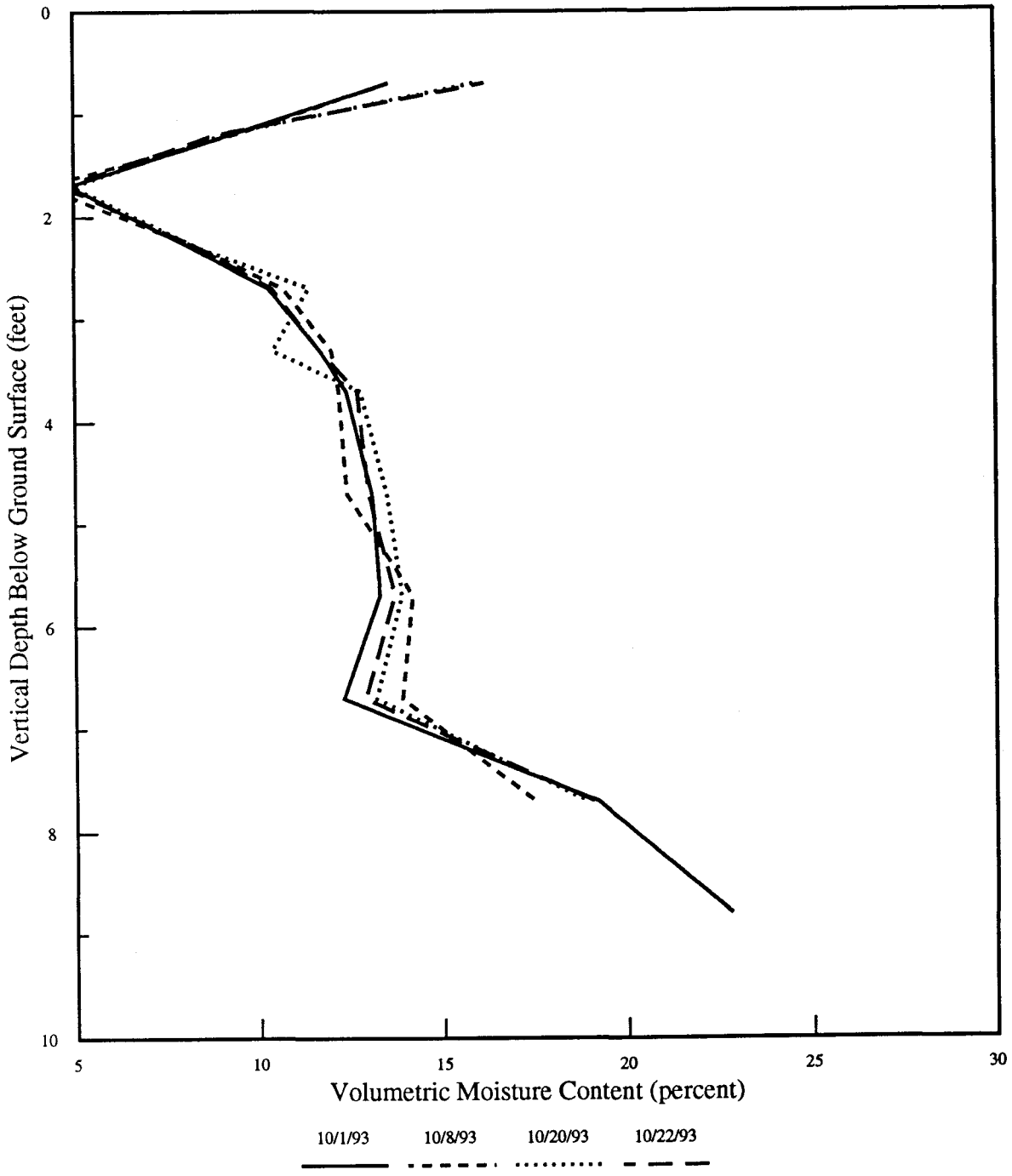
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02693

FIGURE 17c OCTOBER 1993

File: C26CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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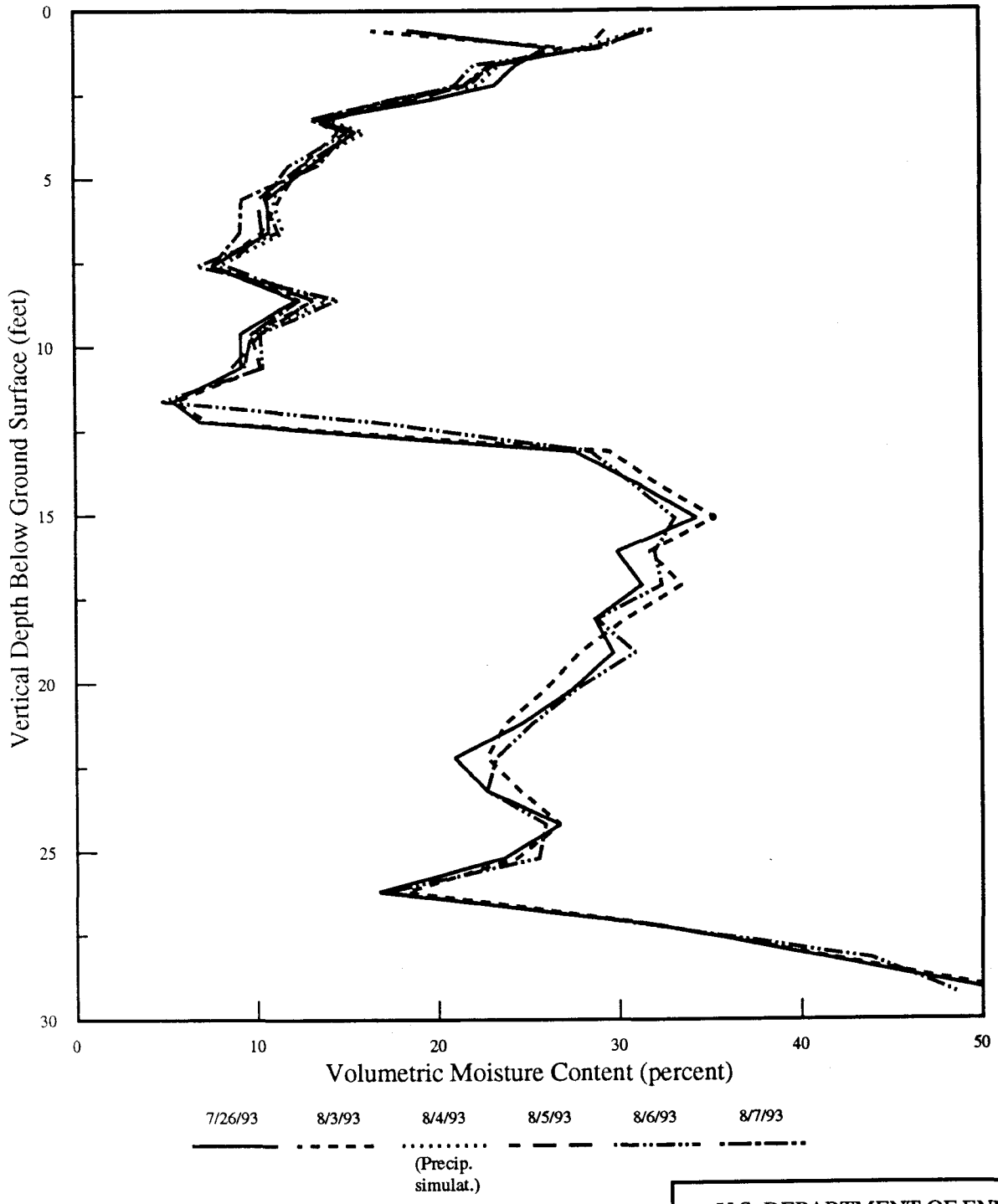
GROUNDWATER RECHARGE STUDY
DRAFT INTERIM REPORT

SITE 1
Soil Moisture Profiles
Hydroprobe Access Tube 02693

FIGURE 17d OCTOBER 1993

File: D26CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

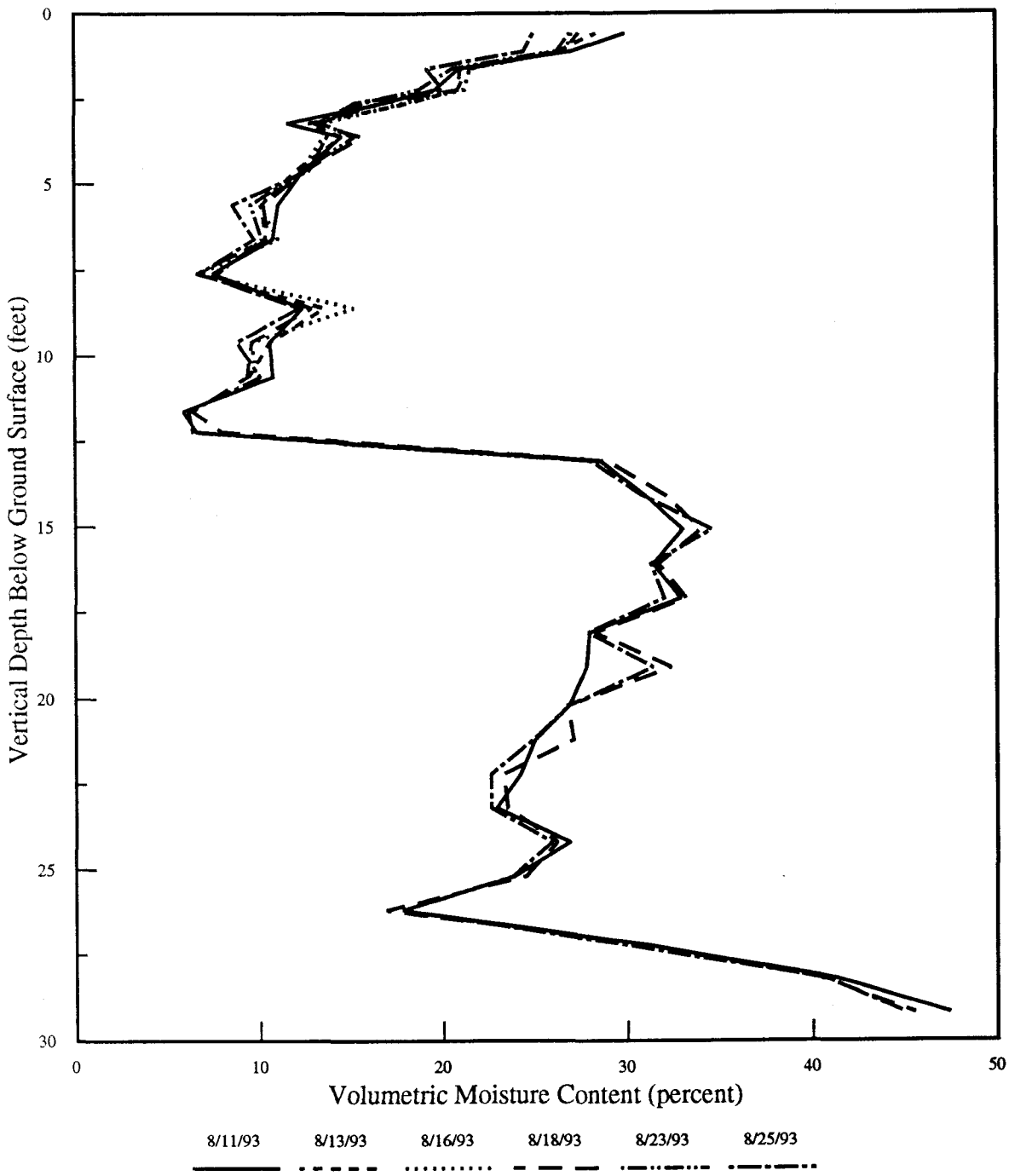
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02793

FIGURE 18a OCTOBER 1993

File: 027CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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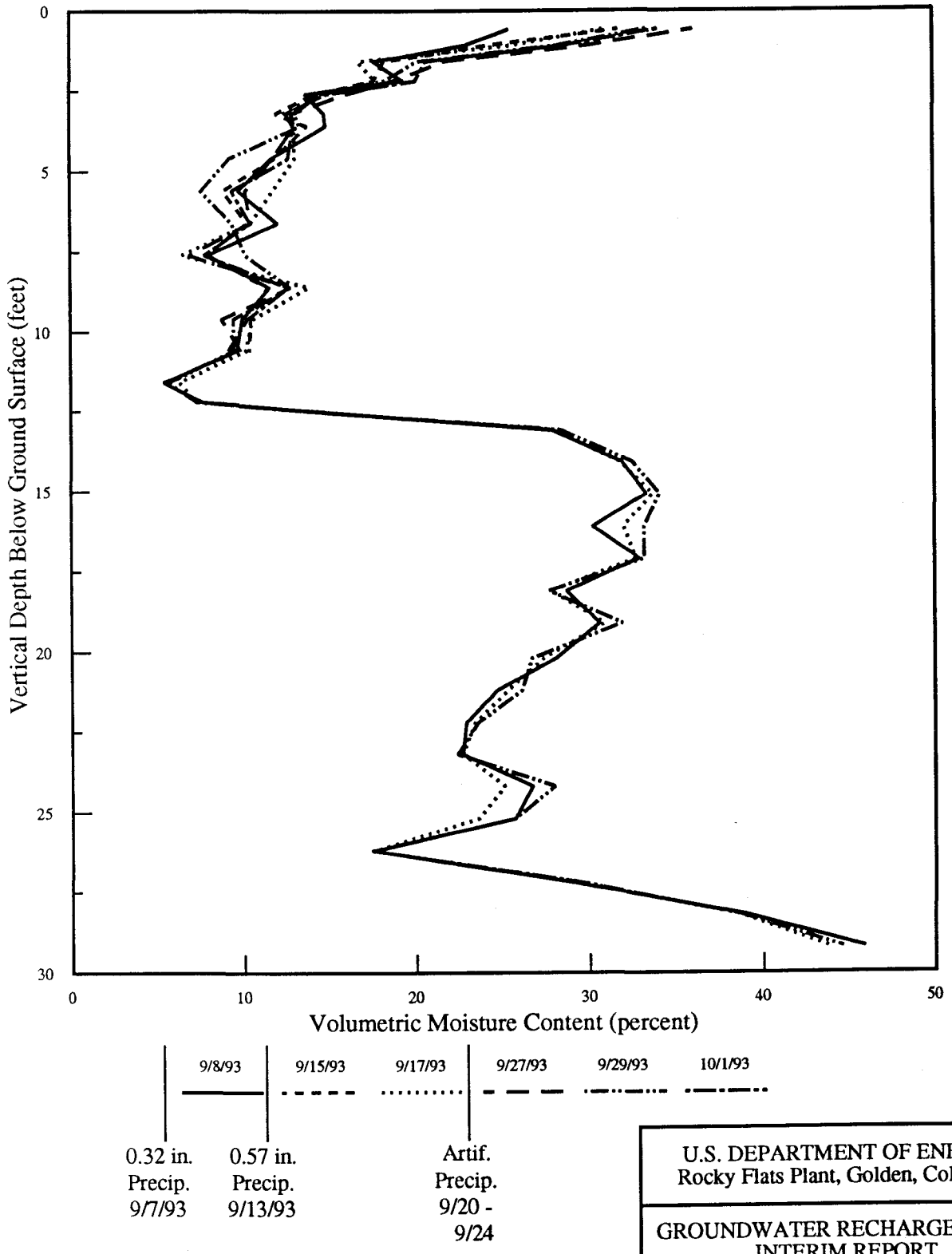
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02793

FIGURE 18b OCTOBER 1993

File: B27CHART.DRW

Status: 10/27/93



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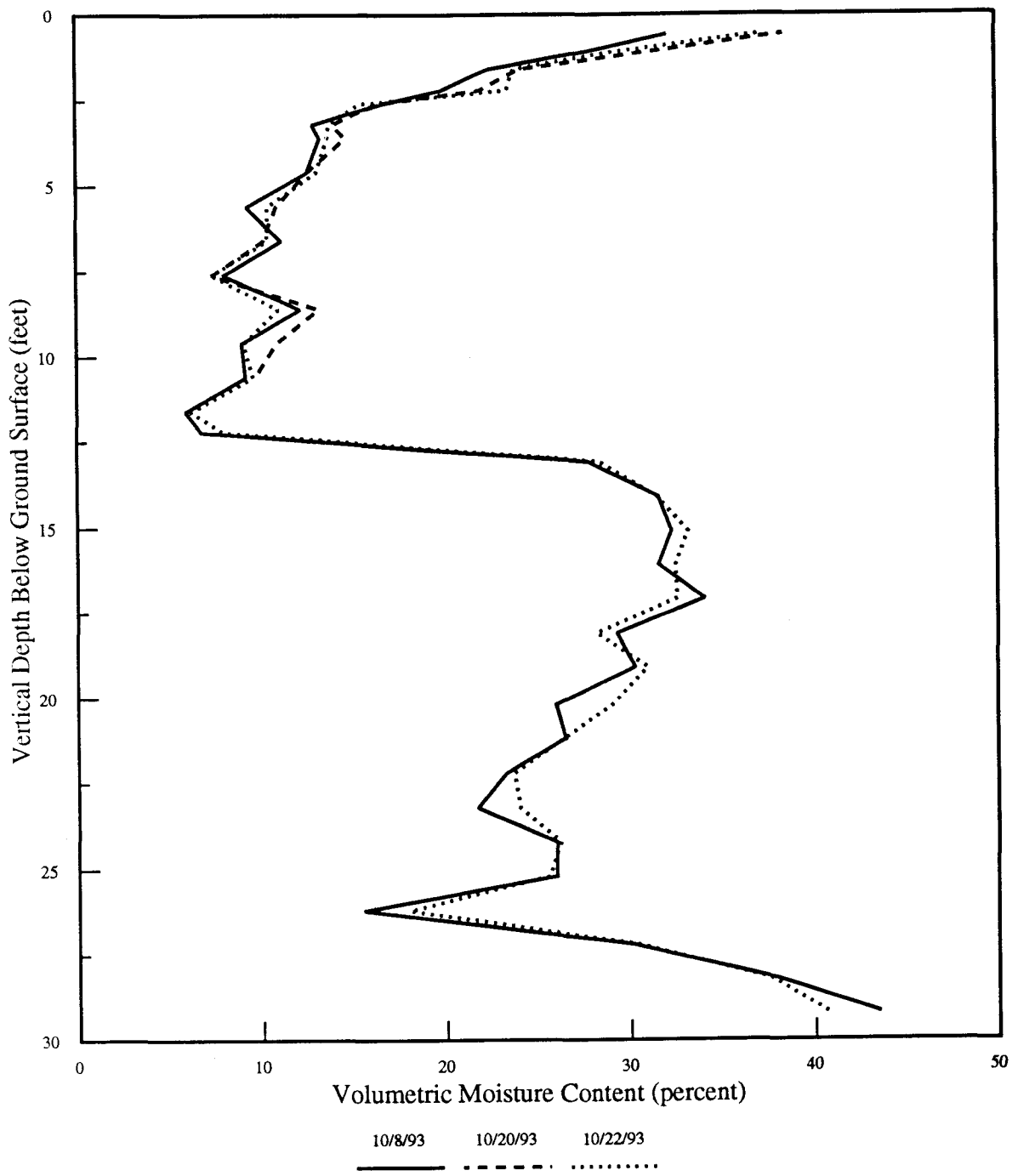
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02793

FIGURE 18c OCTOBER 1993

File: C27CHART.DRW

Status: 10/27/93



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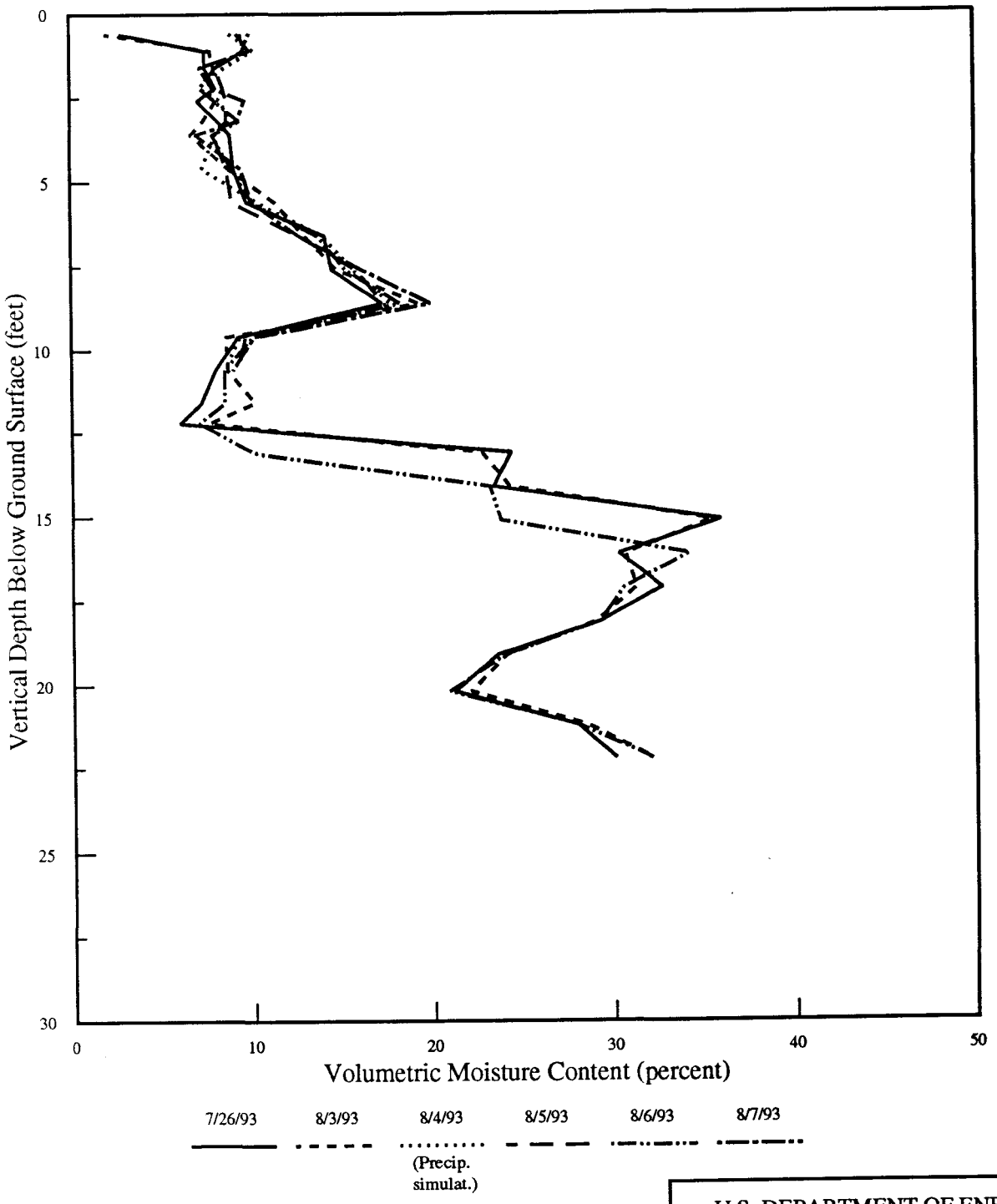
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02793

FIGURE 18d OCTOBER 1993

File: D27CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
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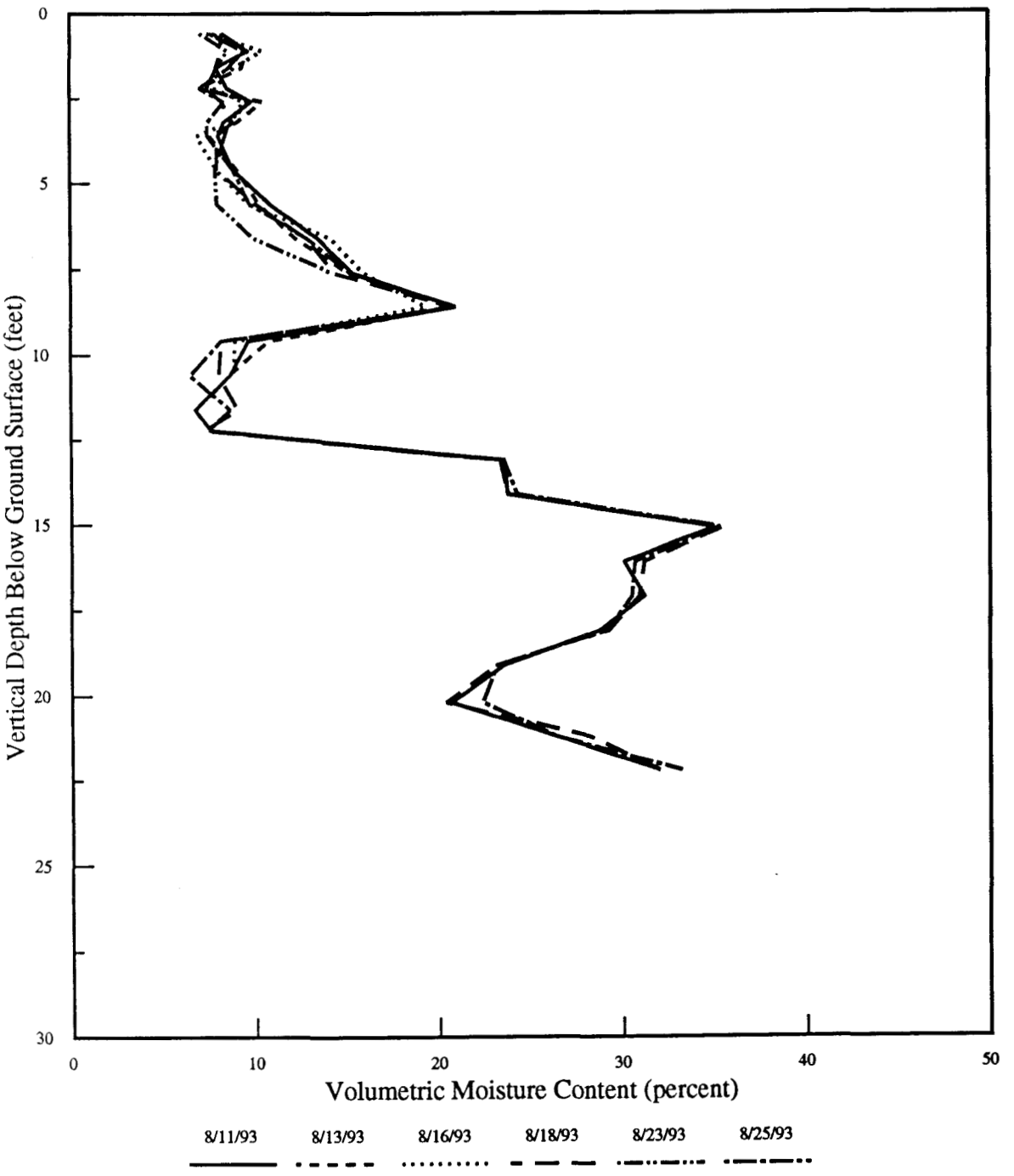
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02893

FIGURE 19a OCTOBER 1993

File: 028CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

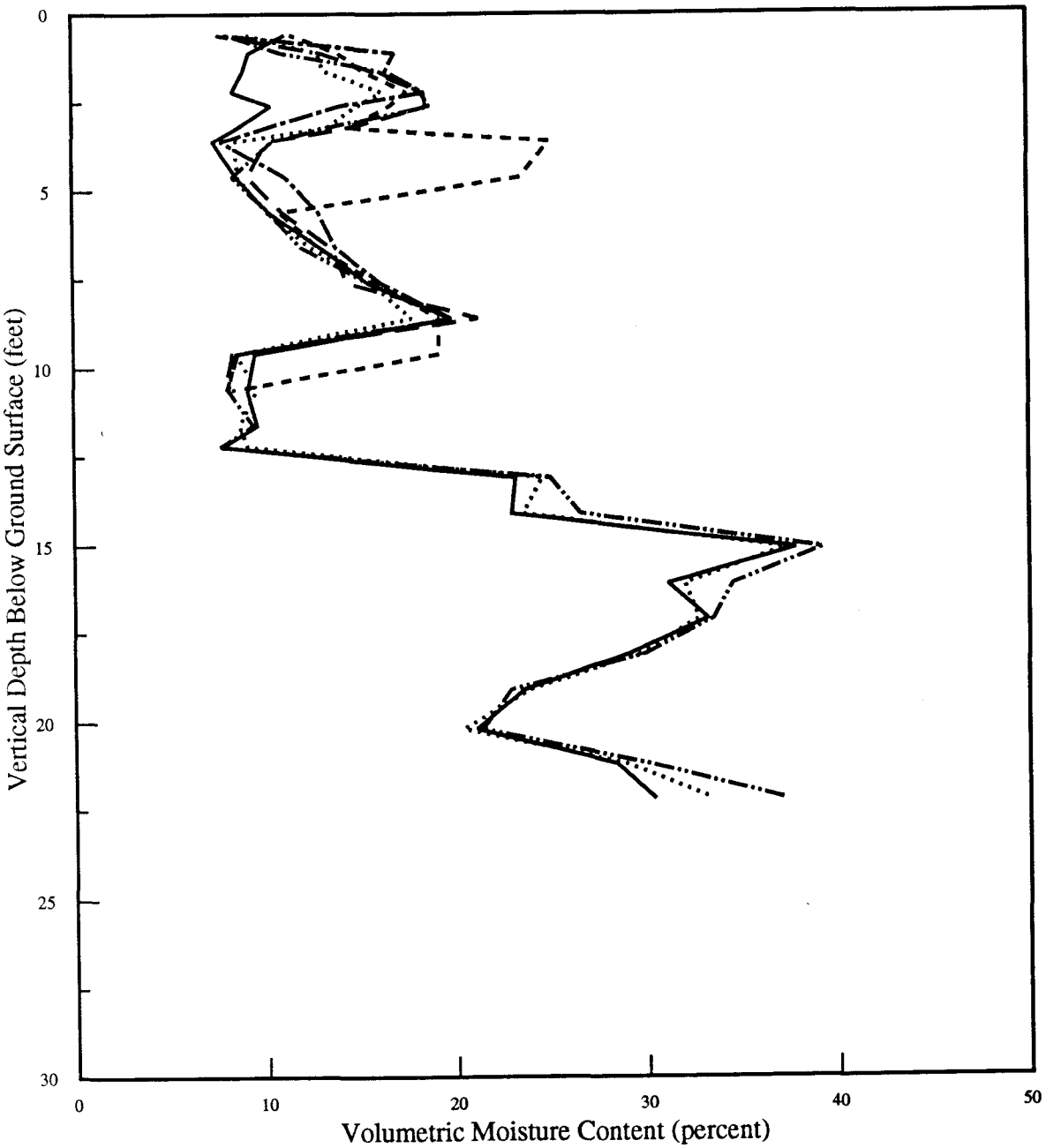
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02893

FIGURE 19b OCTOBER 1993

File: B28CHART.DRW

Status: 10/27/93



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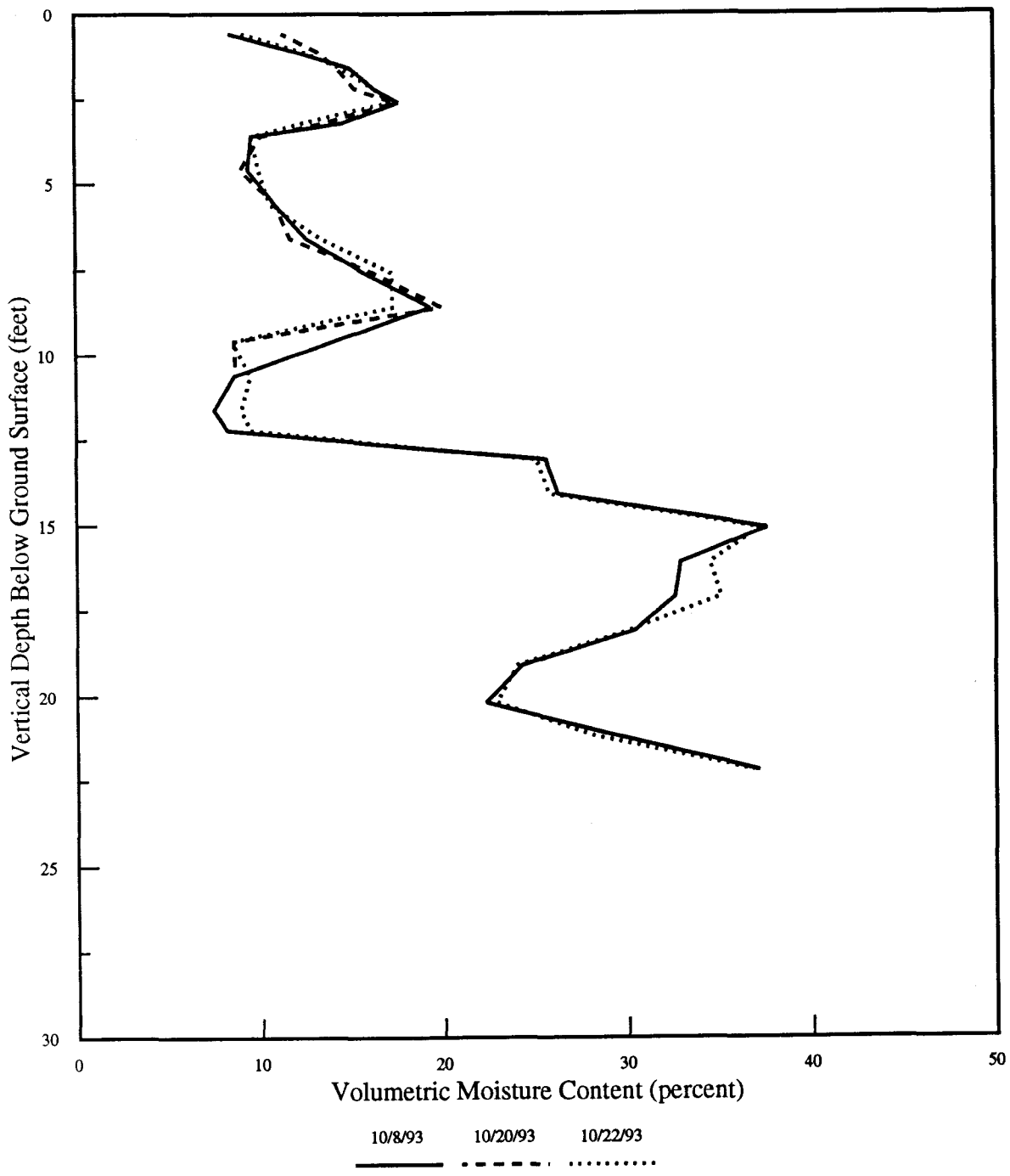
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02893

FIGURE 19c OCTOBER 1993

File: C2SCHART.DRW

Status: 10/27/93



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GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
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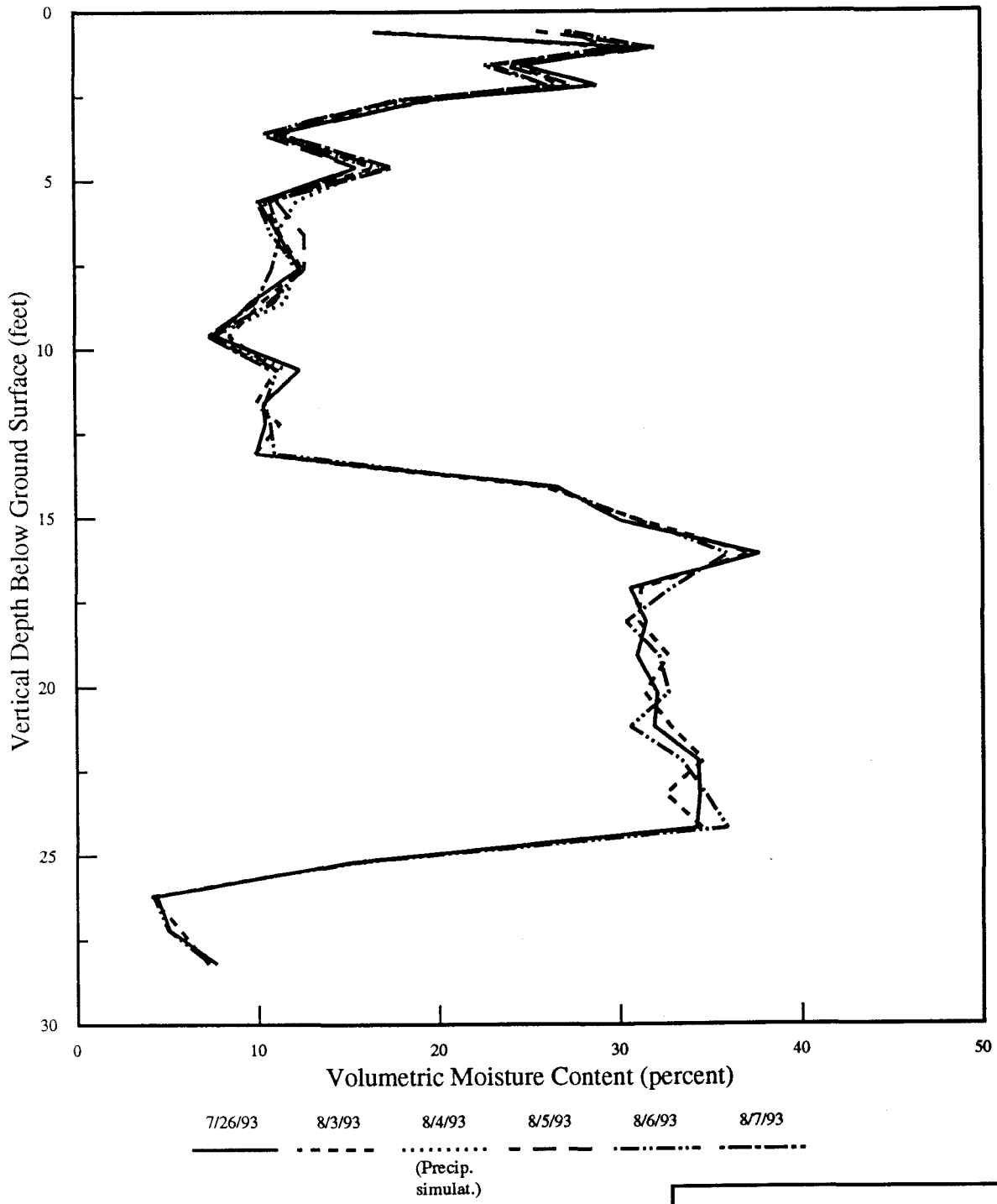
Hydroprobe Access Tube 02893

FIGURE 19d OCTOBER 1993

File: D28CHART.DRW

Status: 10/27/93



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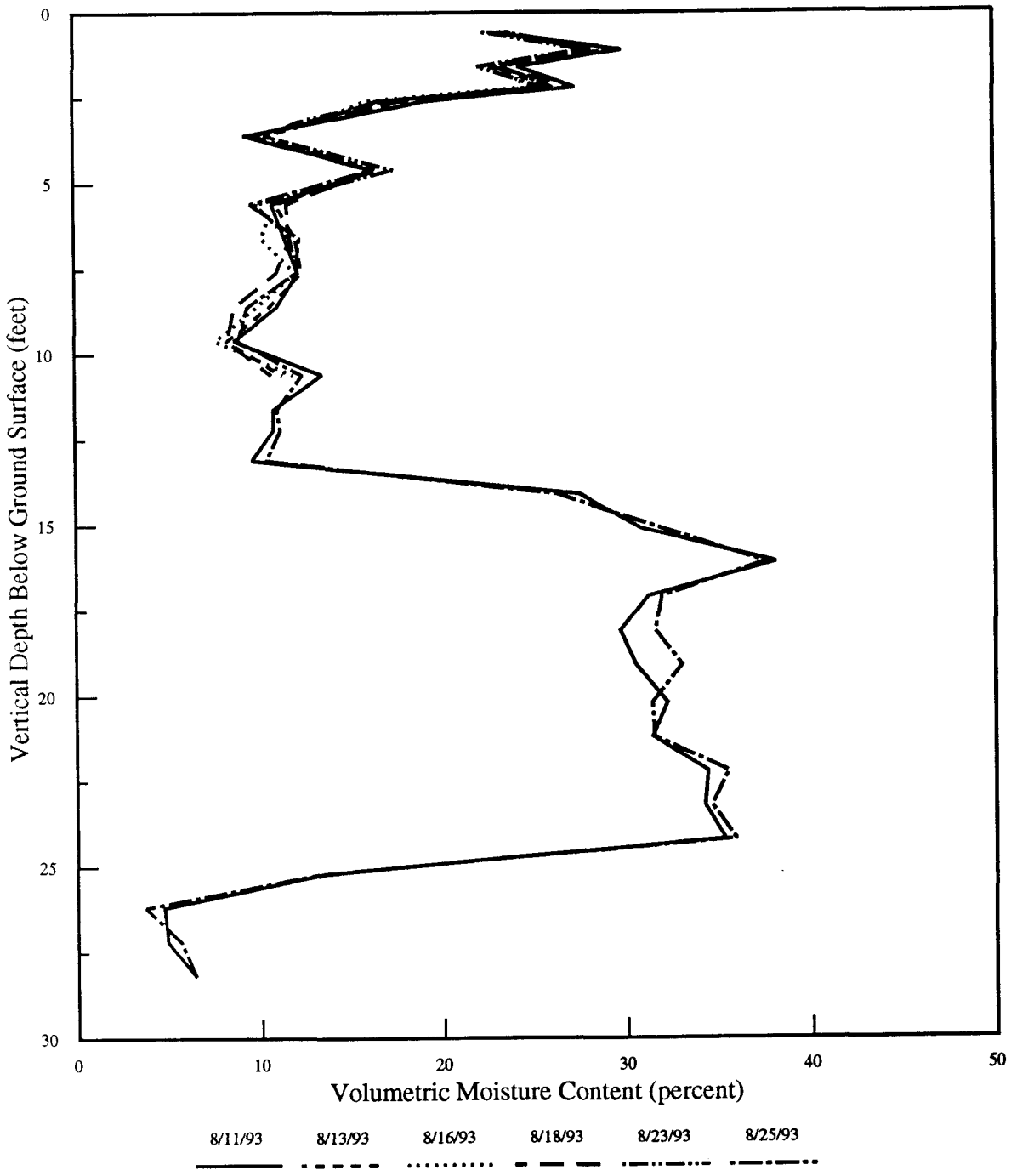
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02993

FIGURE 20a OCTOBER 1993

File: 029CHART.DRW

Status: 10/27/93



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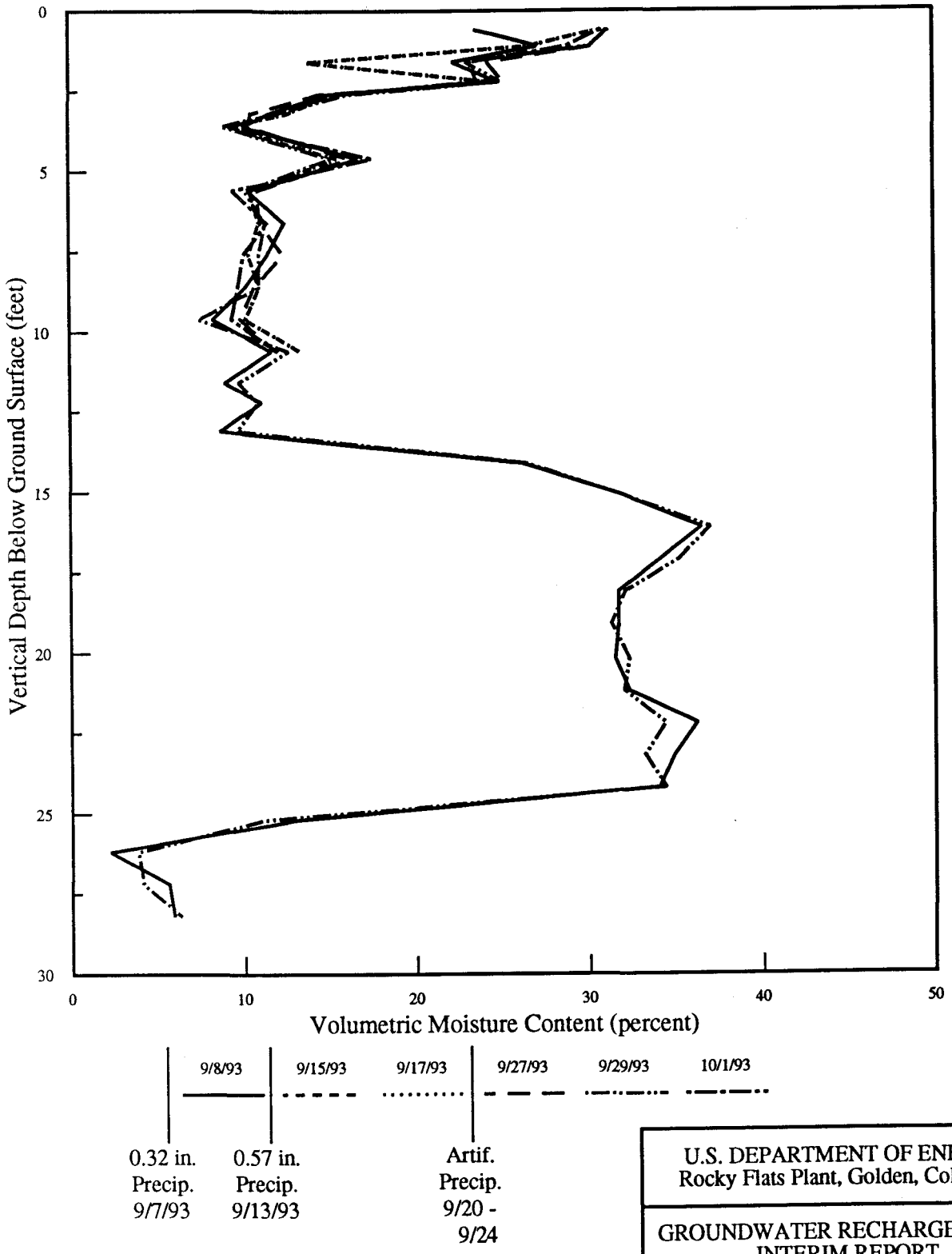
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02993

FIGURE 20b OCTOBER 1993

File: B29CHART.DRW

Status: 10/27/93



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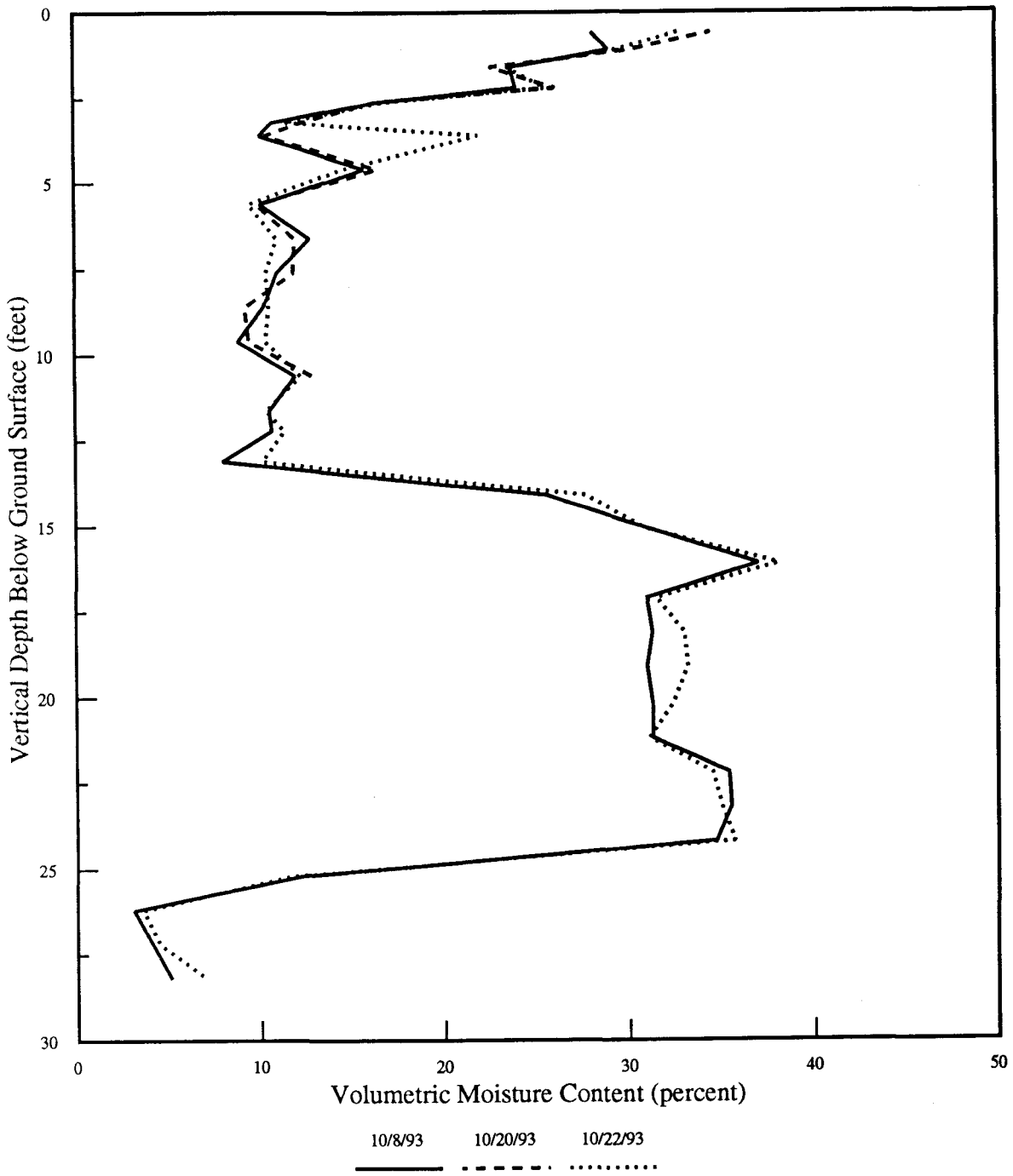
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02993

FIGURE 20c OCTOBER 1993

File: C29CHART.DRW

Status: 10/27/93



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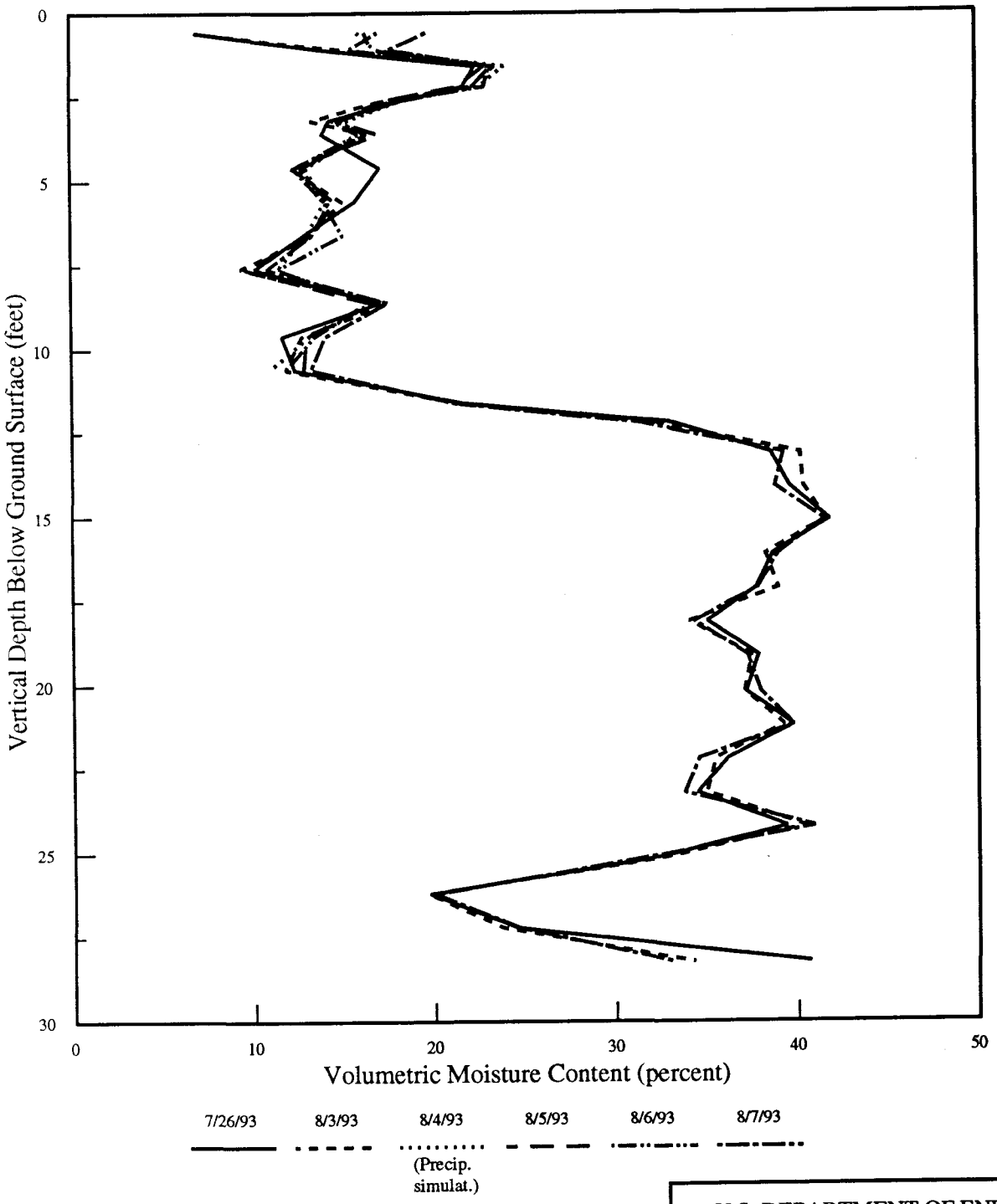
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 02993

FIGURE 20d OCTOBER 1993

File: D29CHART.DRW

Status: 10/27/93



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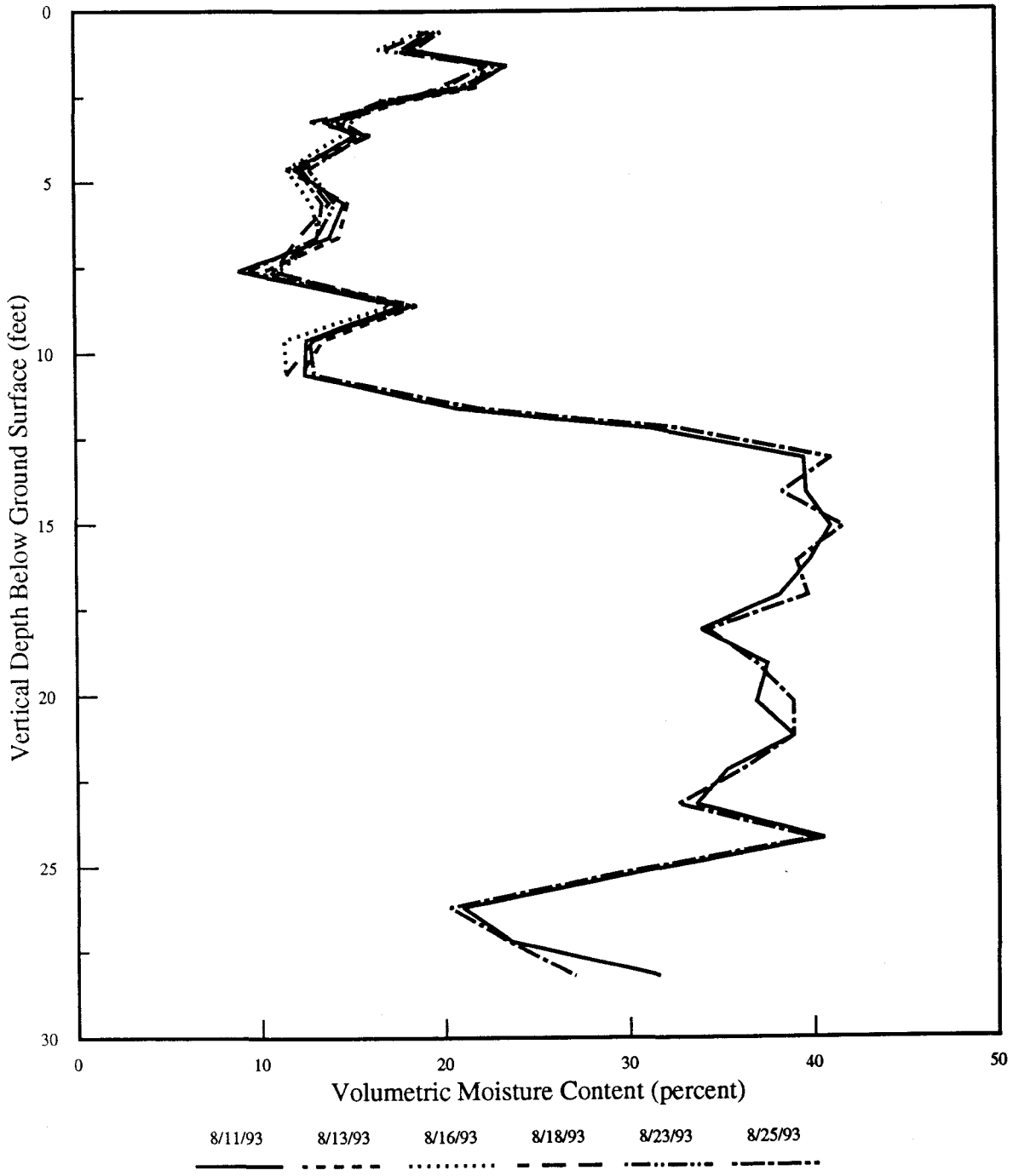
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03093

FIGURE 21a OCTOBER 1993

File: 030CHART.DRW

Status: 10/27/93



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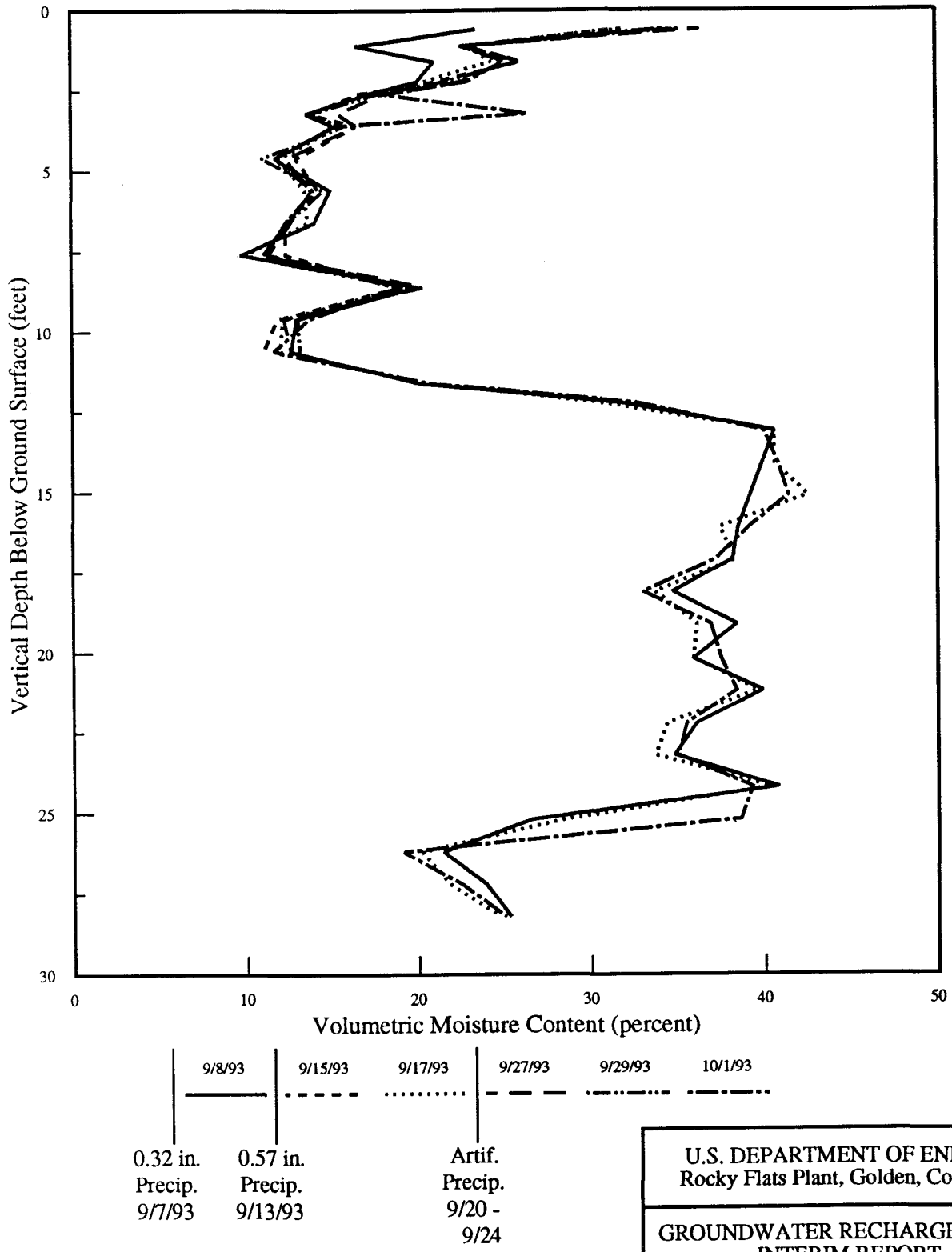
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03093

FIGURE 21b OCTOBER 1993

File: B30CHART.DRW

Status: 10/27/93



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GROUNDWATER RECHARGE STUDY
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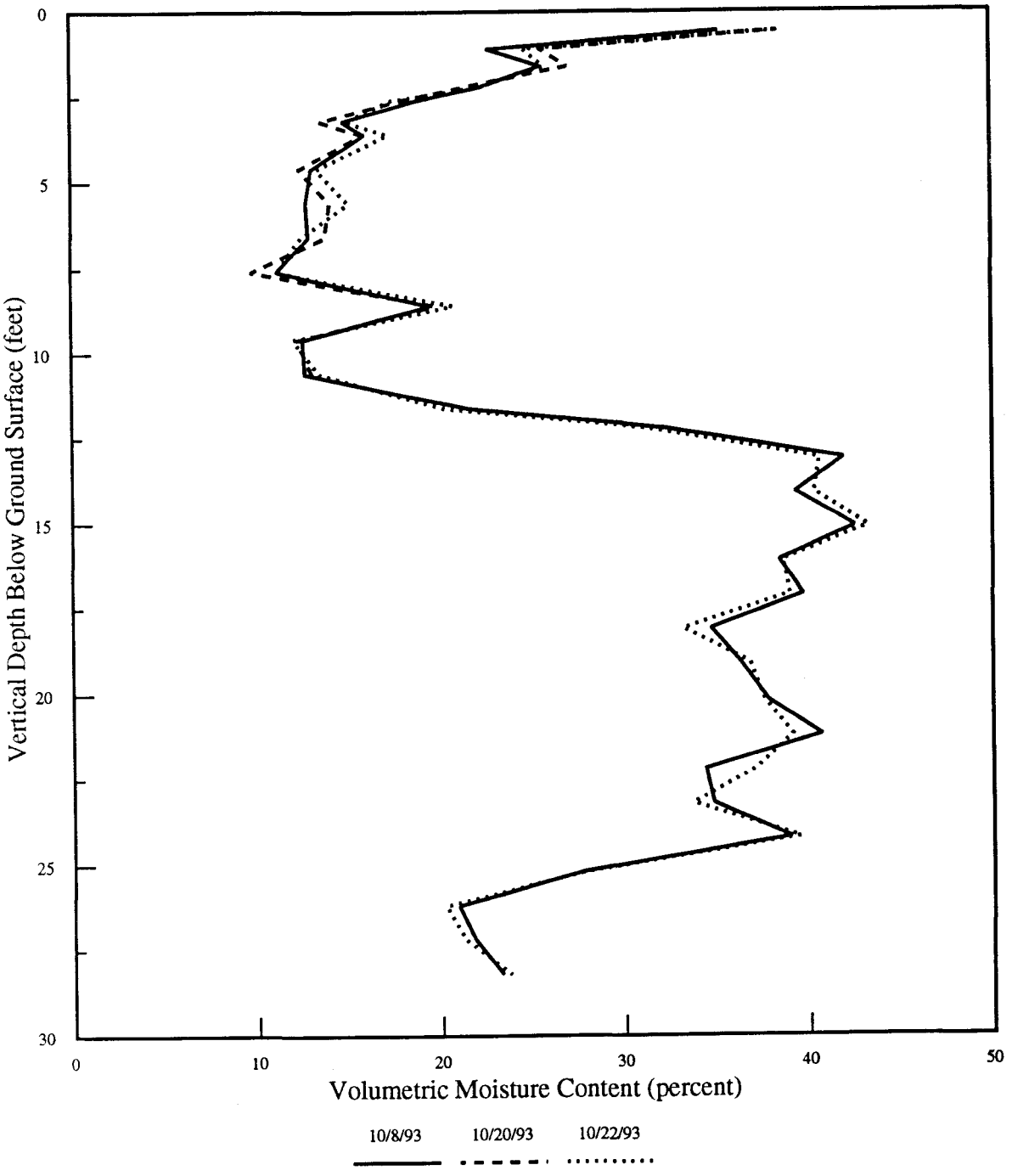
SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03093

FIGURE 21c OCTOBER 1993

File: C30CHART.DRW

Status: 10/27/93



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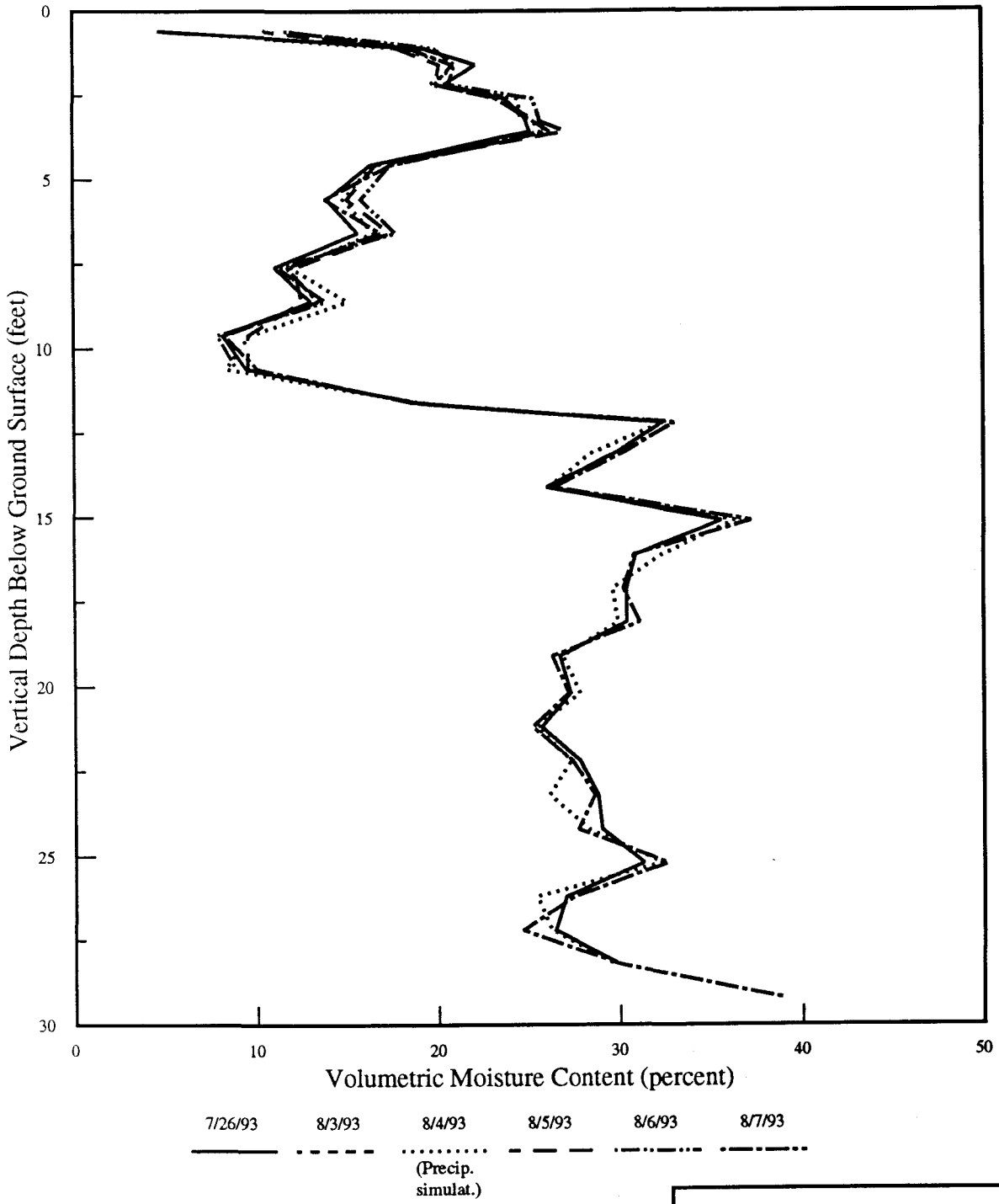
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03093

FIGURE 21d OCTOBER 1993

File: D30CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

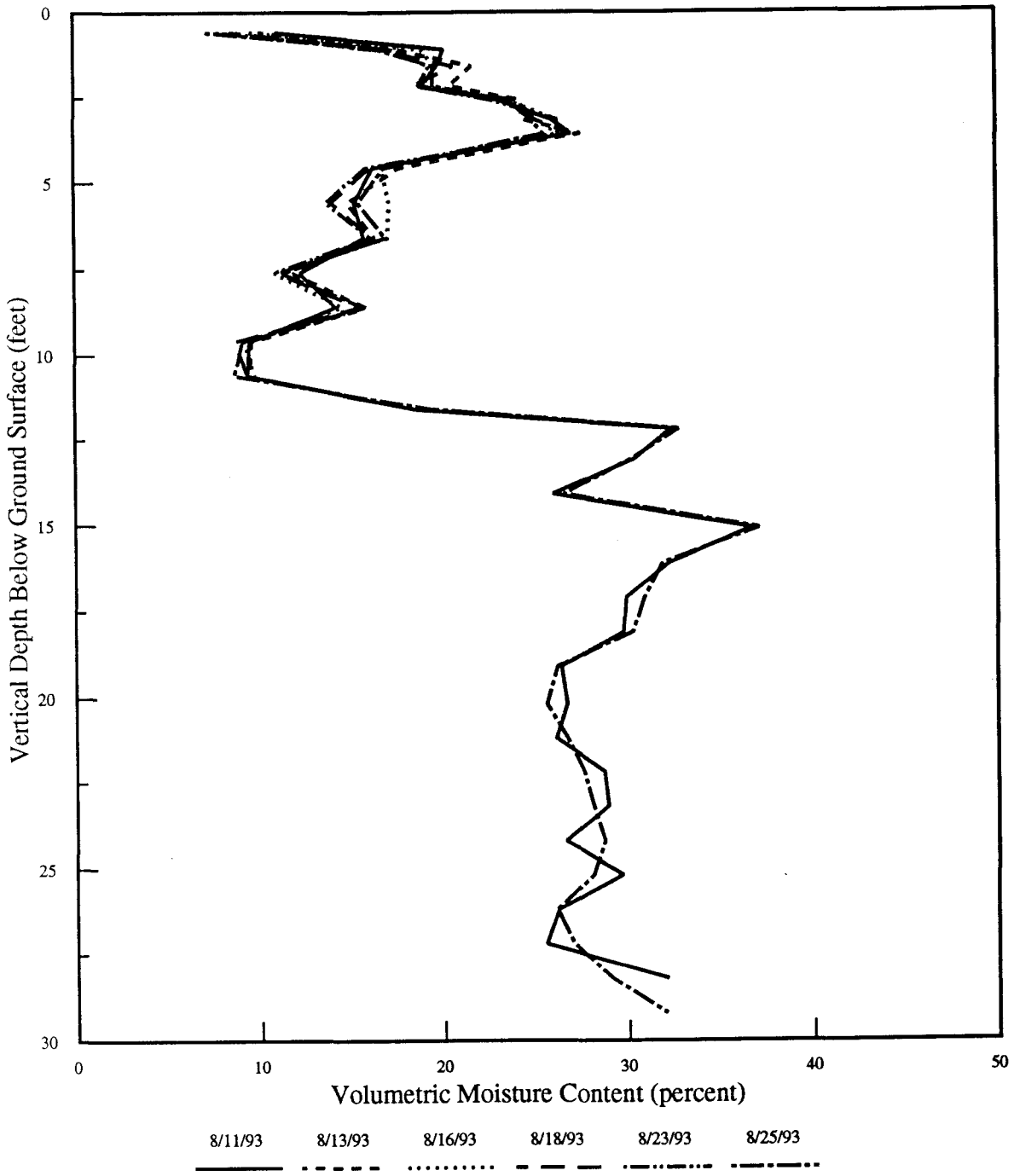
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03193

FIGURE 22a OCTOBER 1993

File: 031CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

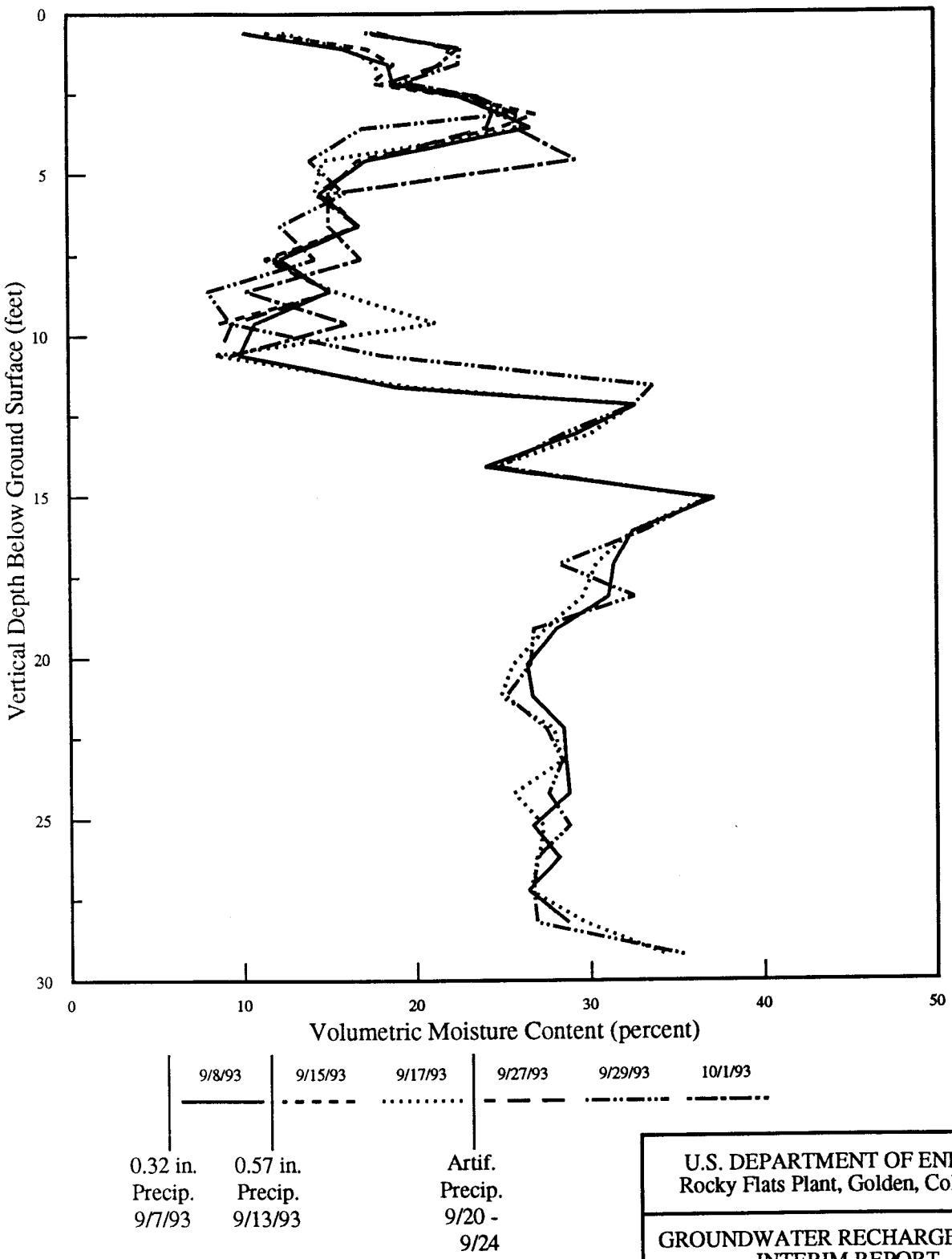
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03193

FIGURE 22b OCTOBER 1993

File: B31CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

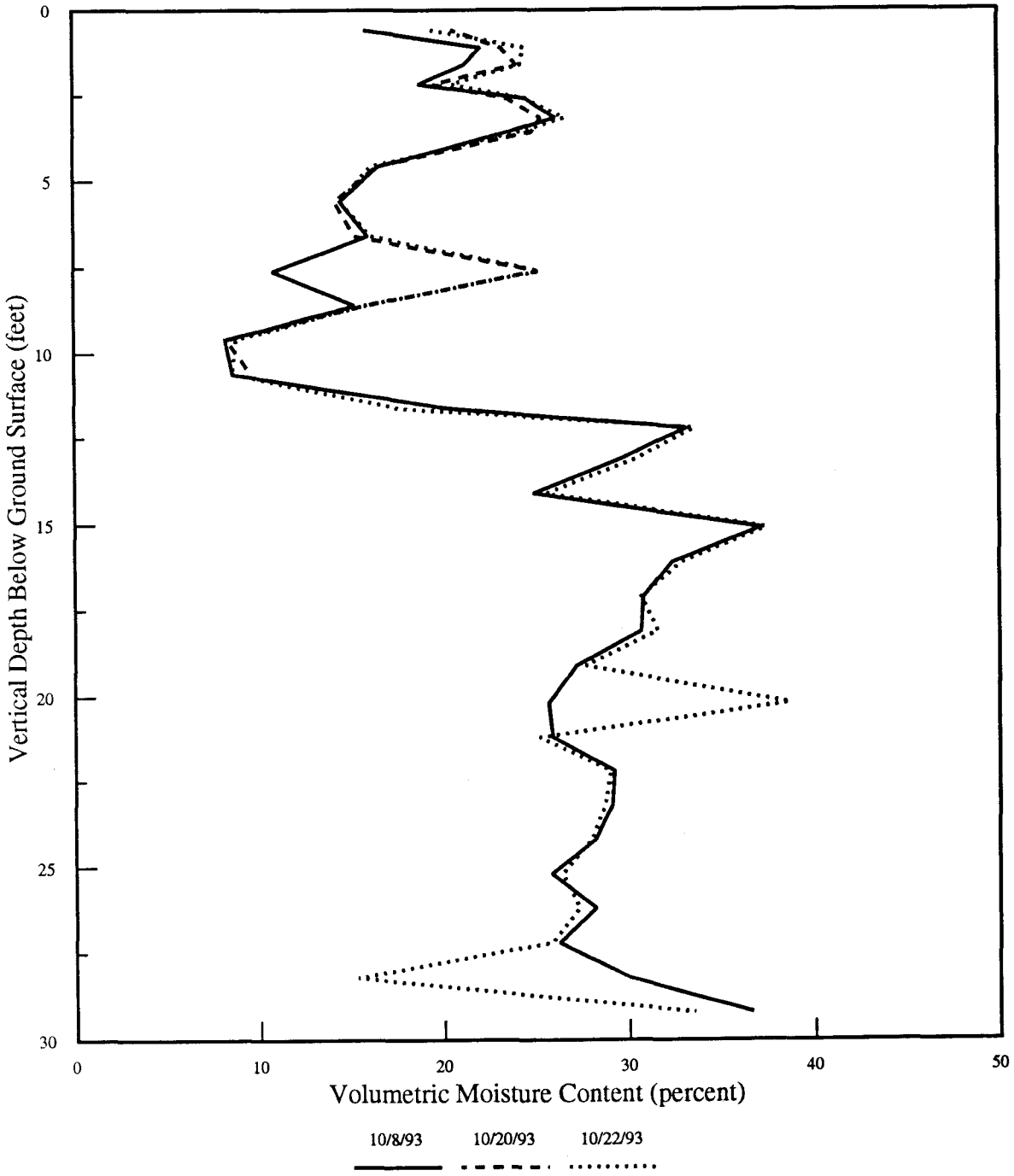
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03193

FIGURE 22c OCTOBER 1993

File: C31CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

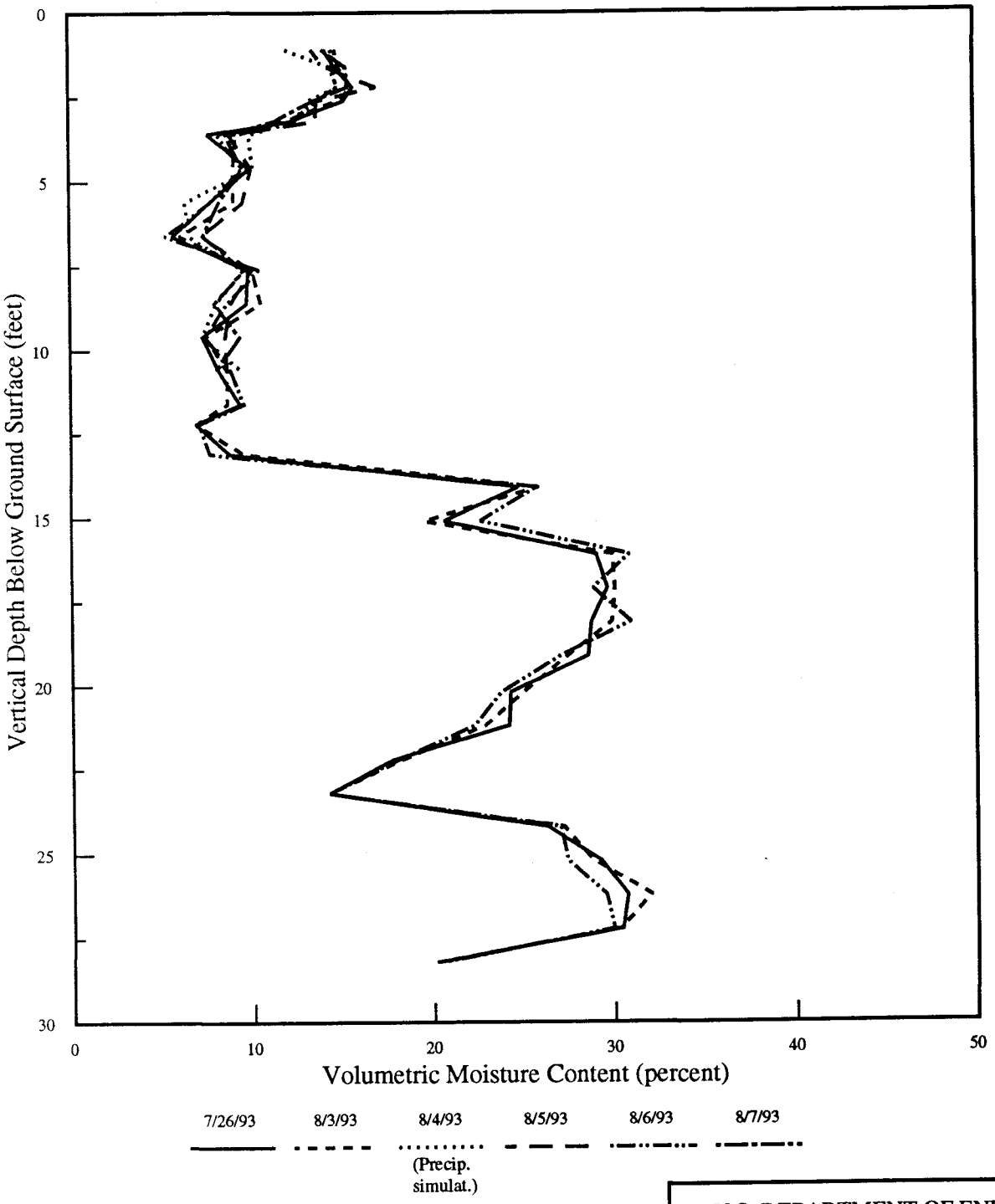
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03193

FIGURE 22d OCTOBER 1993

File: D31CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

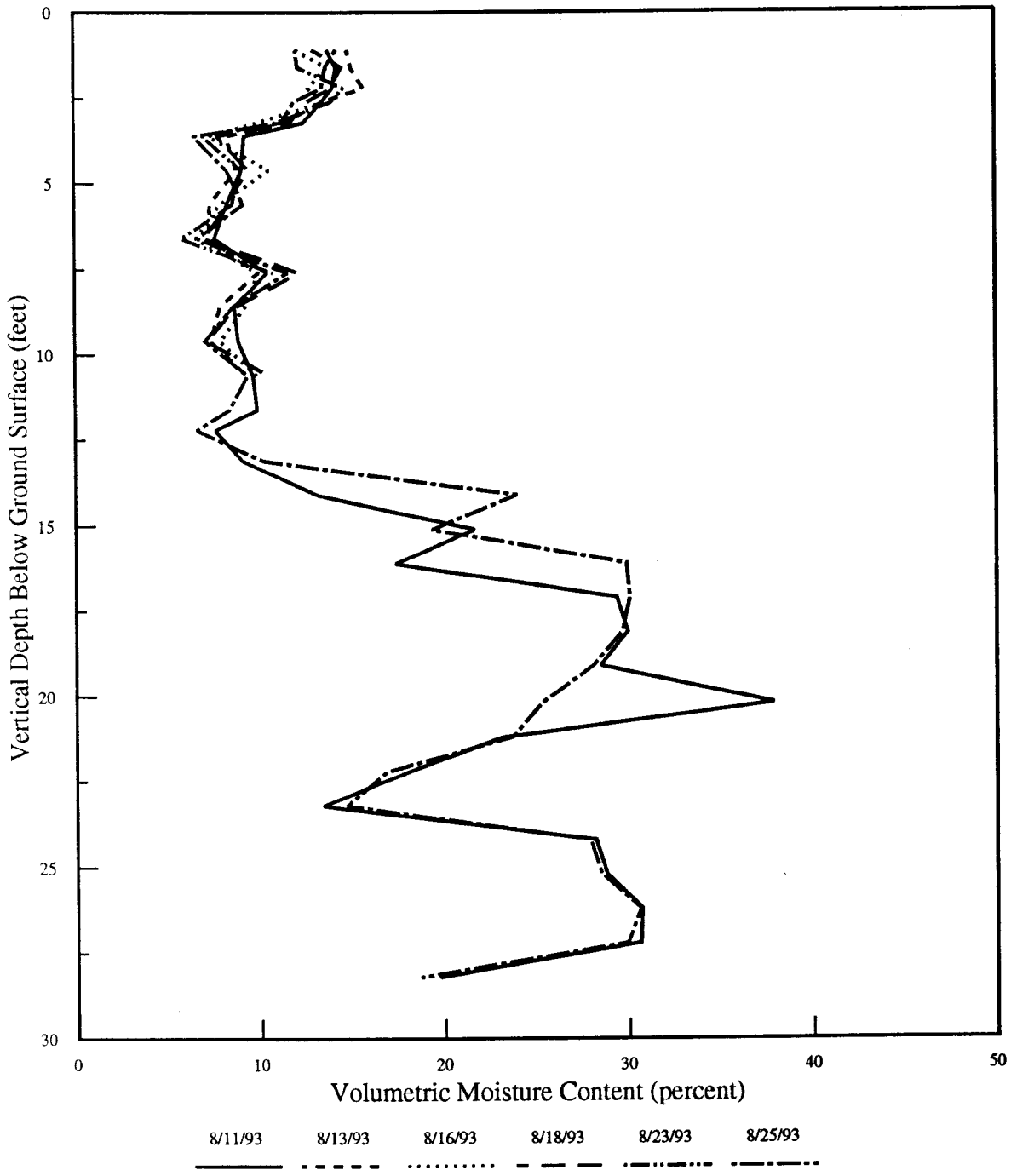
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03293

FIGURE 23a OCTOBER 1993

File: 032CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

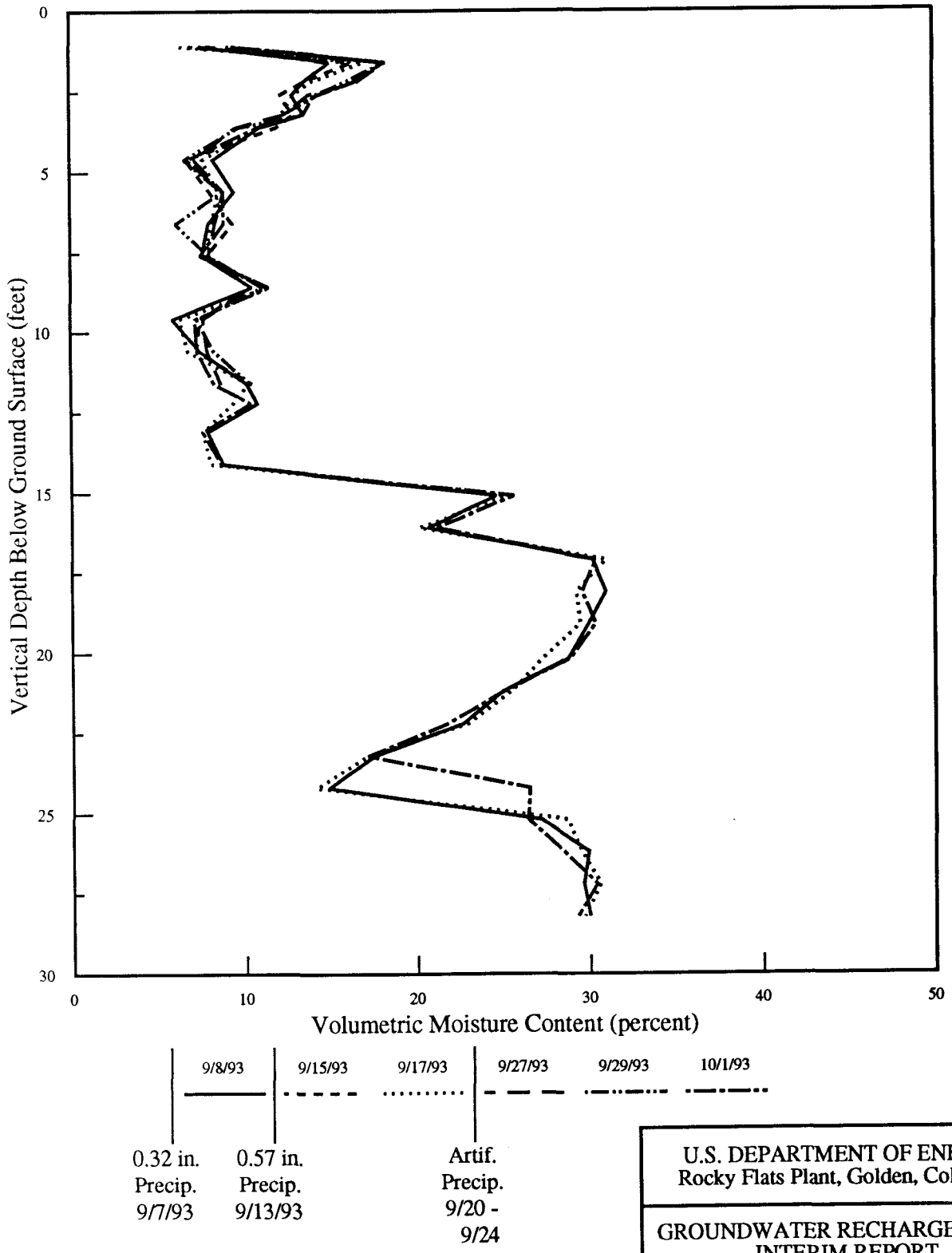
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03293

FIGURE 23b OCTOBER 1993

File: B32CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

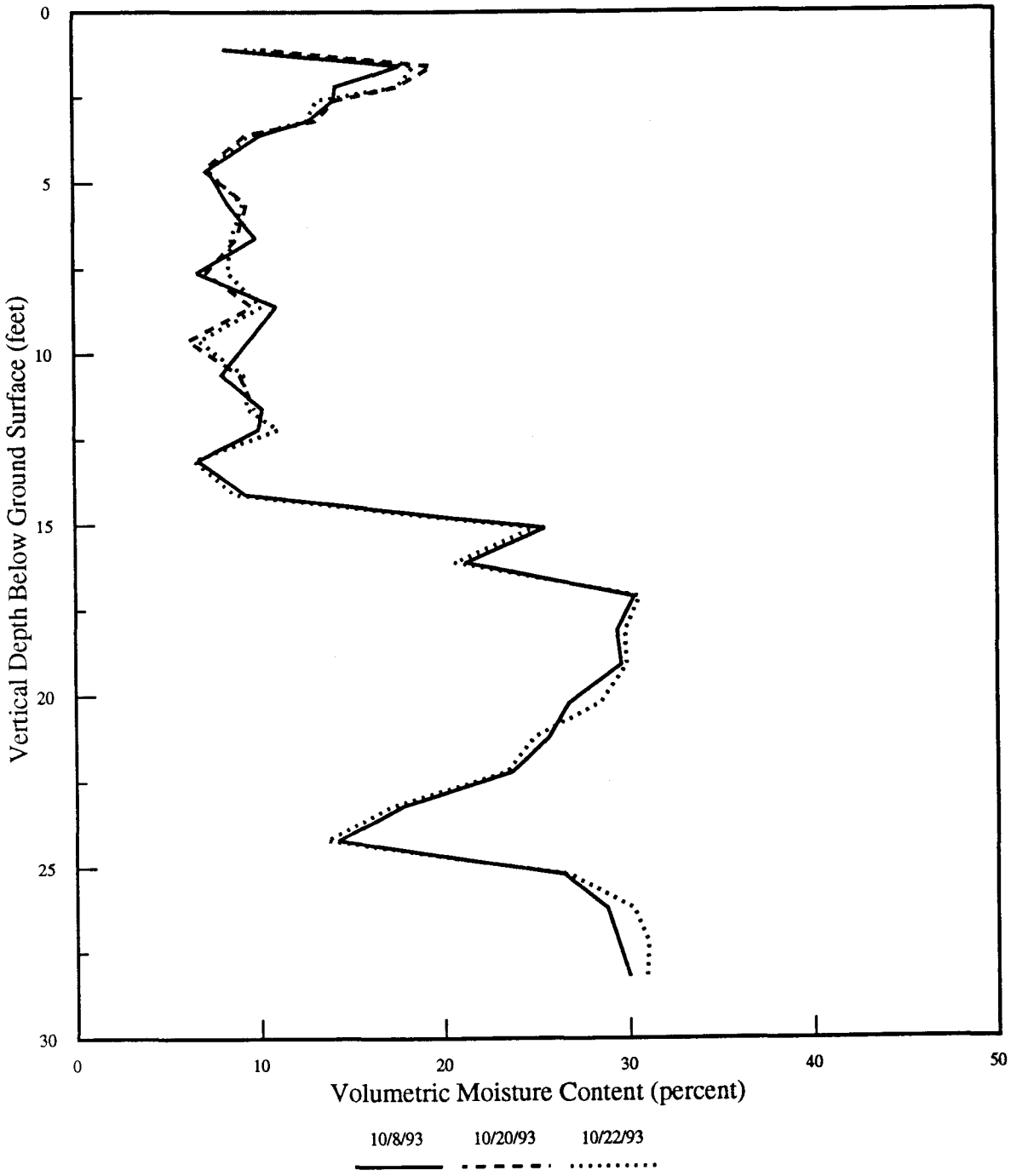
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03293

FIGURE 23c OCTOBER 1993

File: C32CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

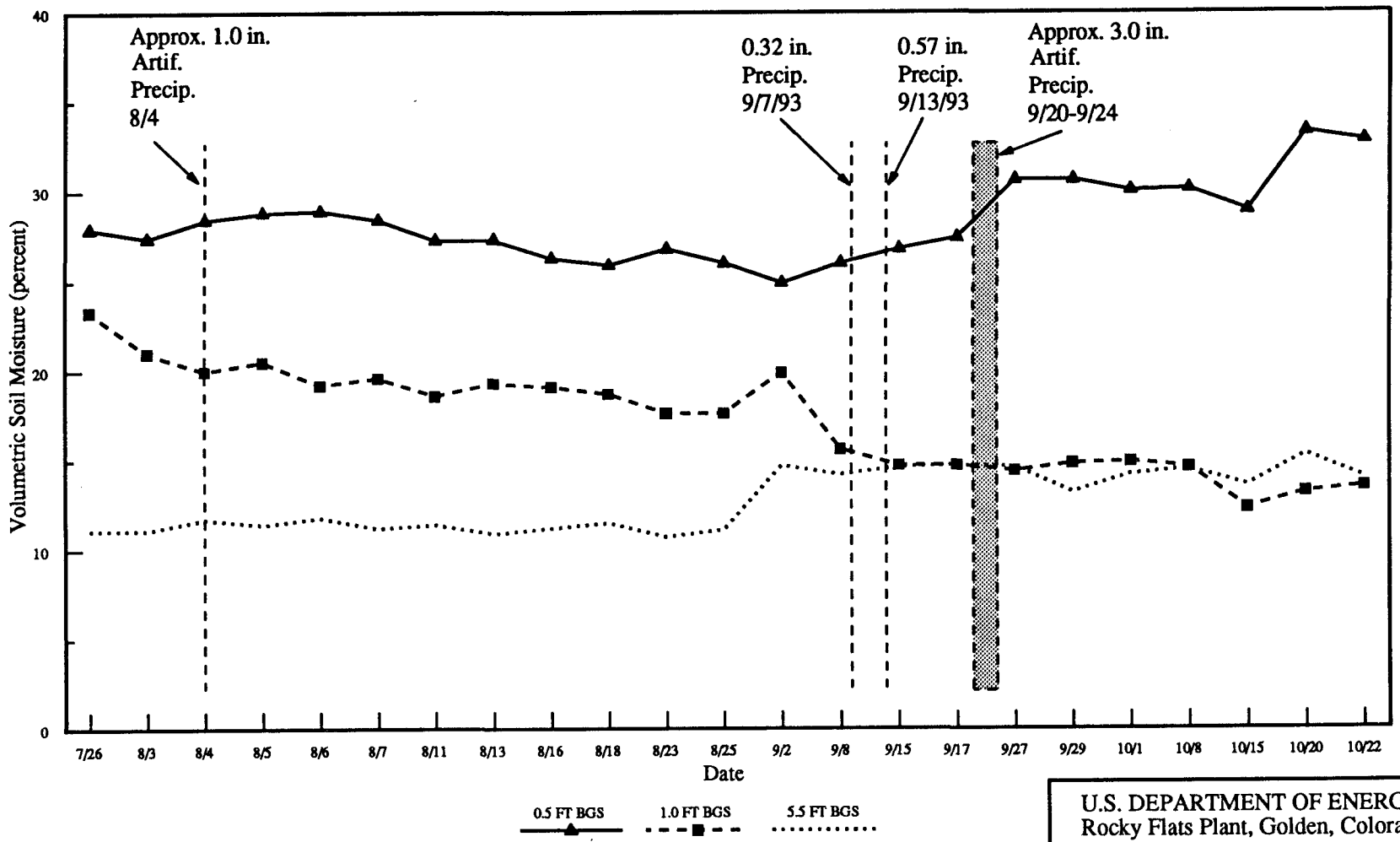
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Profiles
Hydroprobe Access Tube 03293

FIGURE 23d OCTOBER 1993

File: D32CHART.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

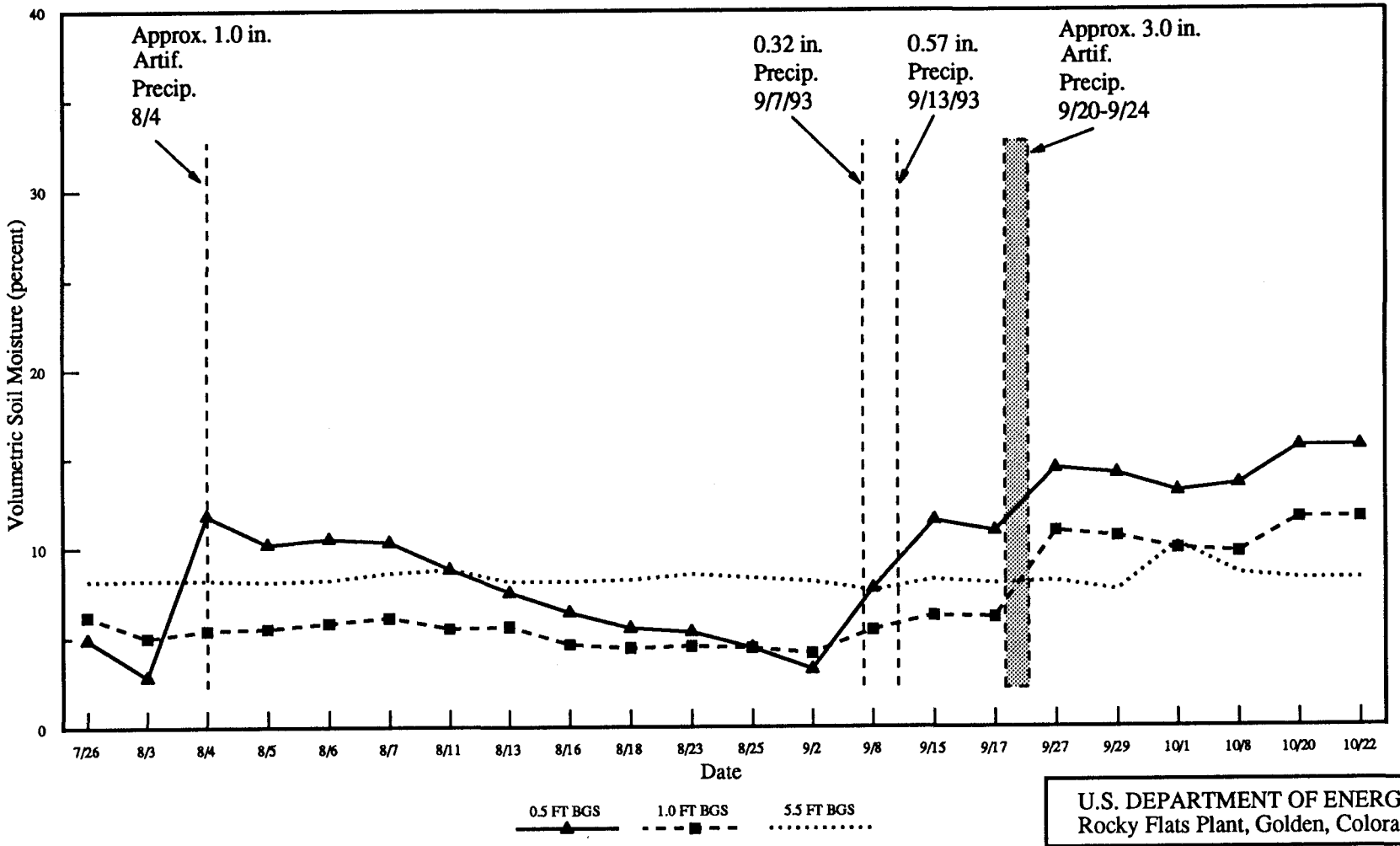
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02093

FIGURE 24 OCTOBER 1993

File: 020TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

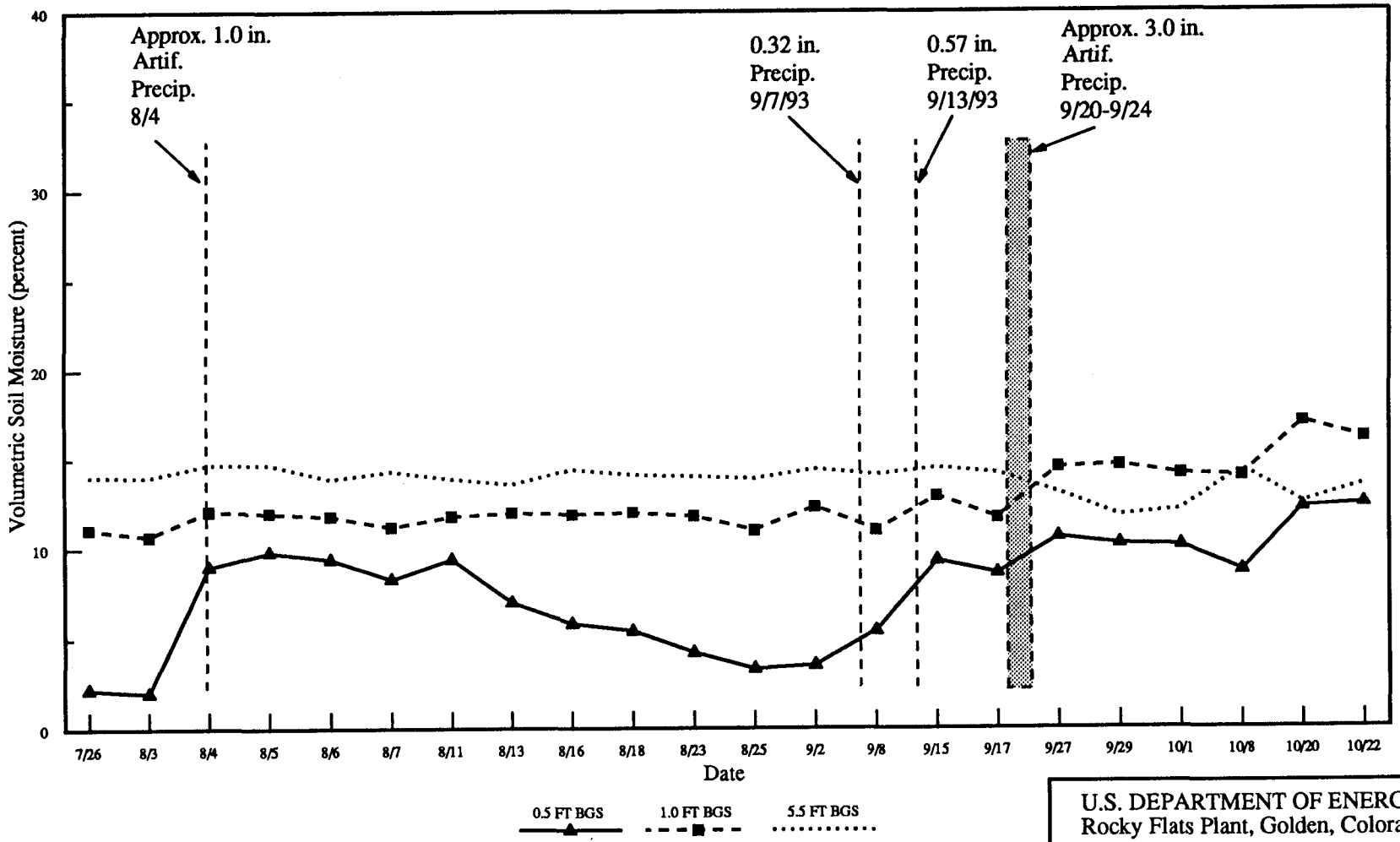
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02293

FIGURE 25 OCTOBER 1993

File: 022TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

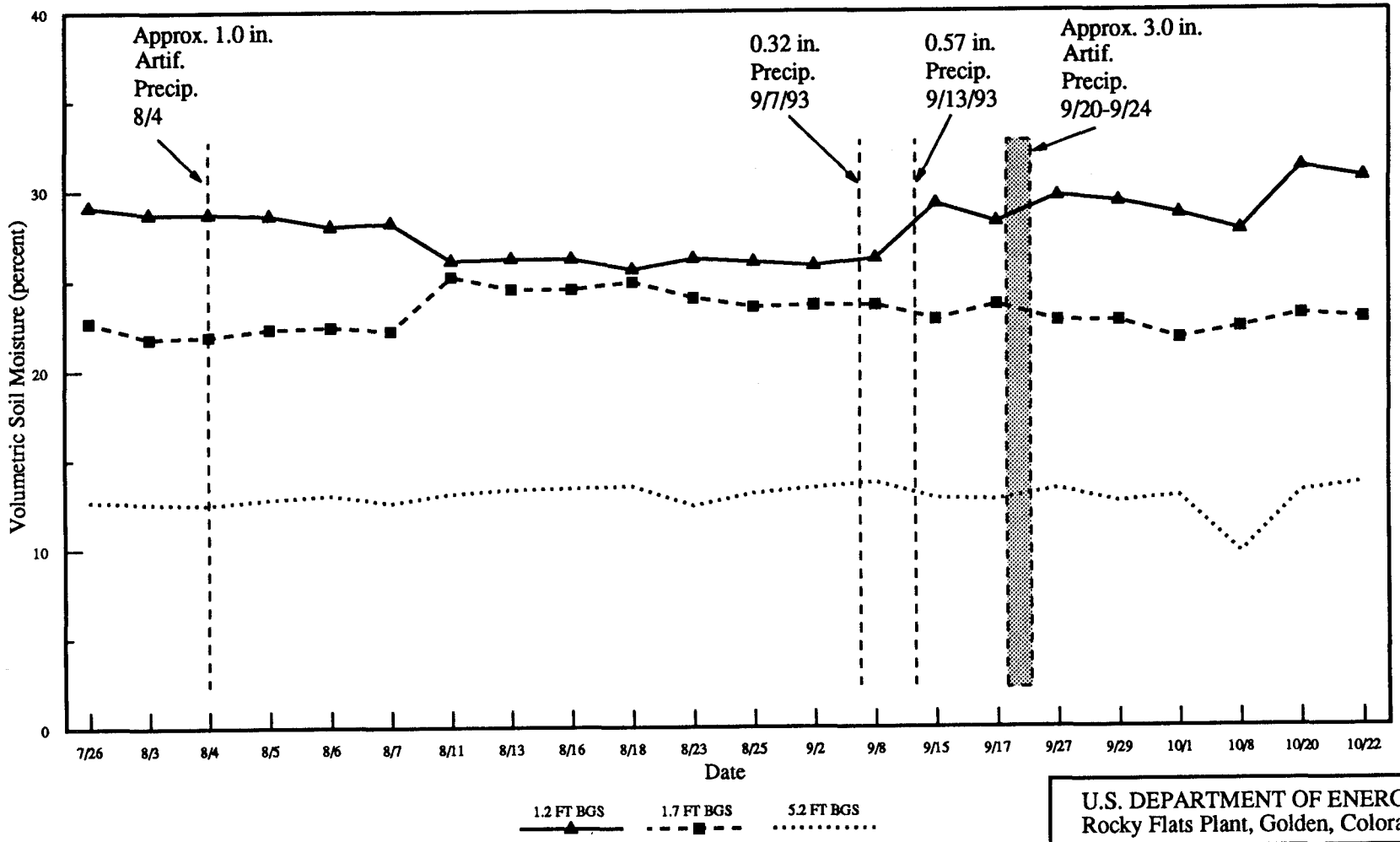
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02393

FIGURE 26 OCTOBER 1993

File: 023TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

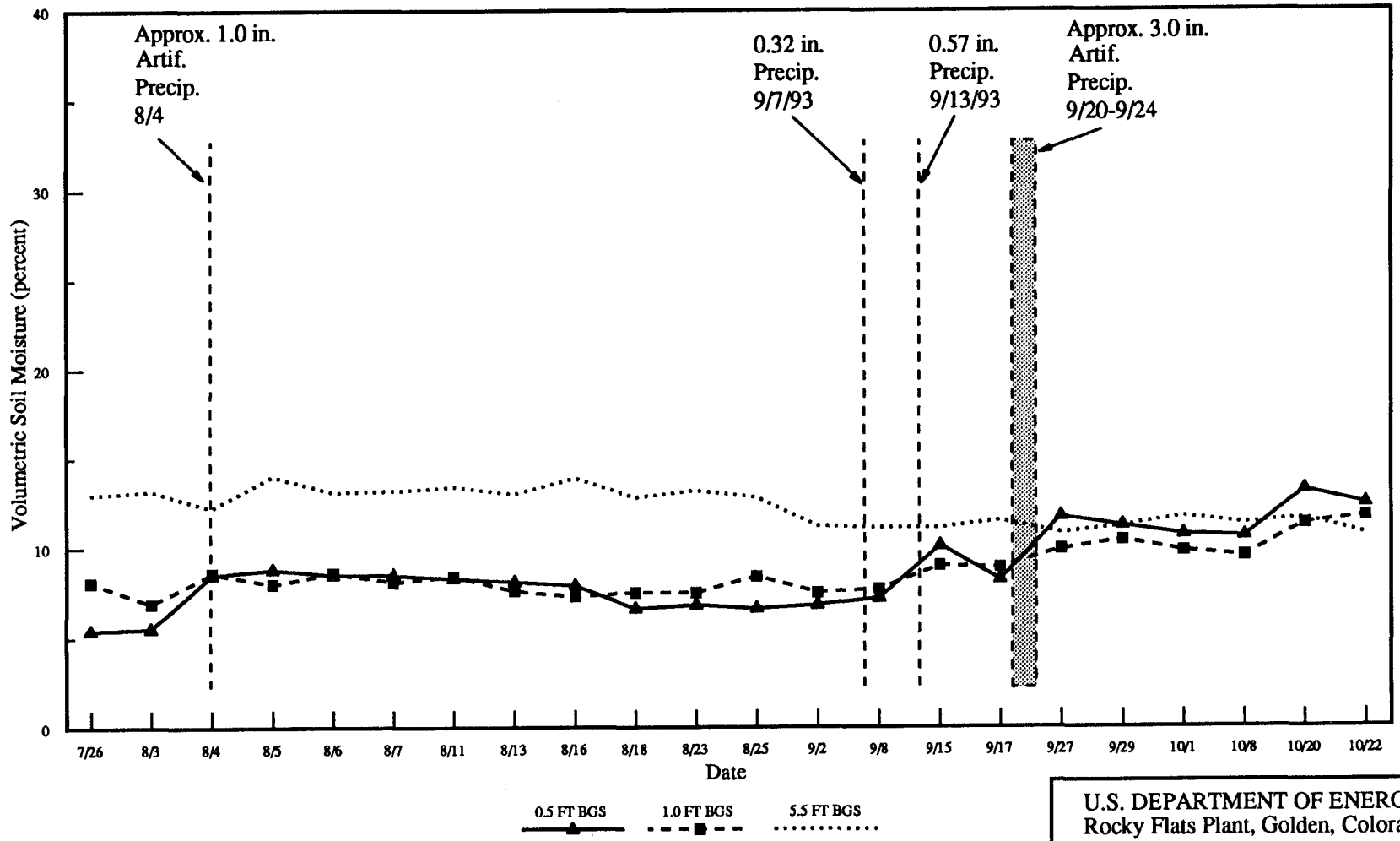
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02493

FIGURE 27 OCTOBER 1993

File: 024TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

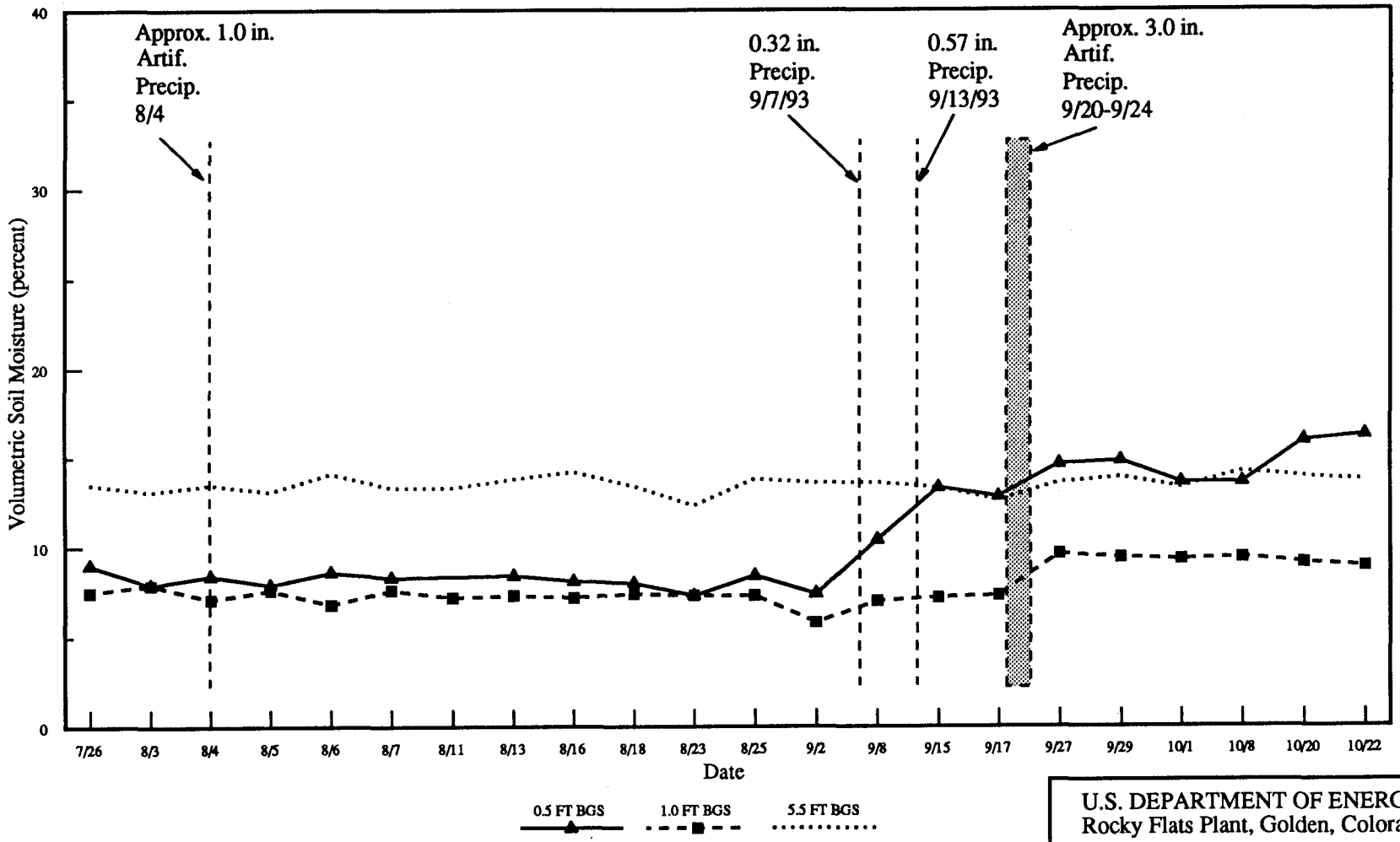
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02593

FIGURE 28 OCTOBER 1993

File: 025TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

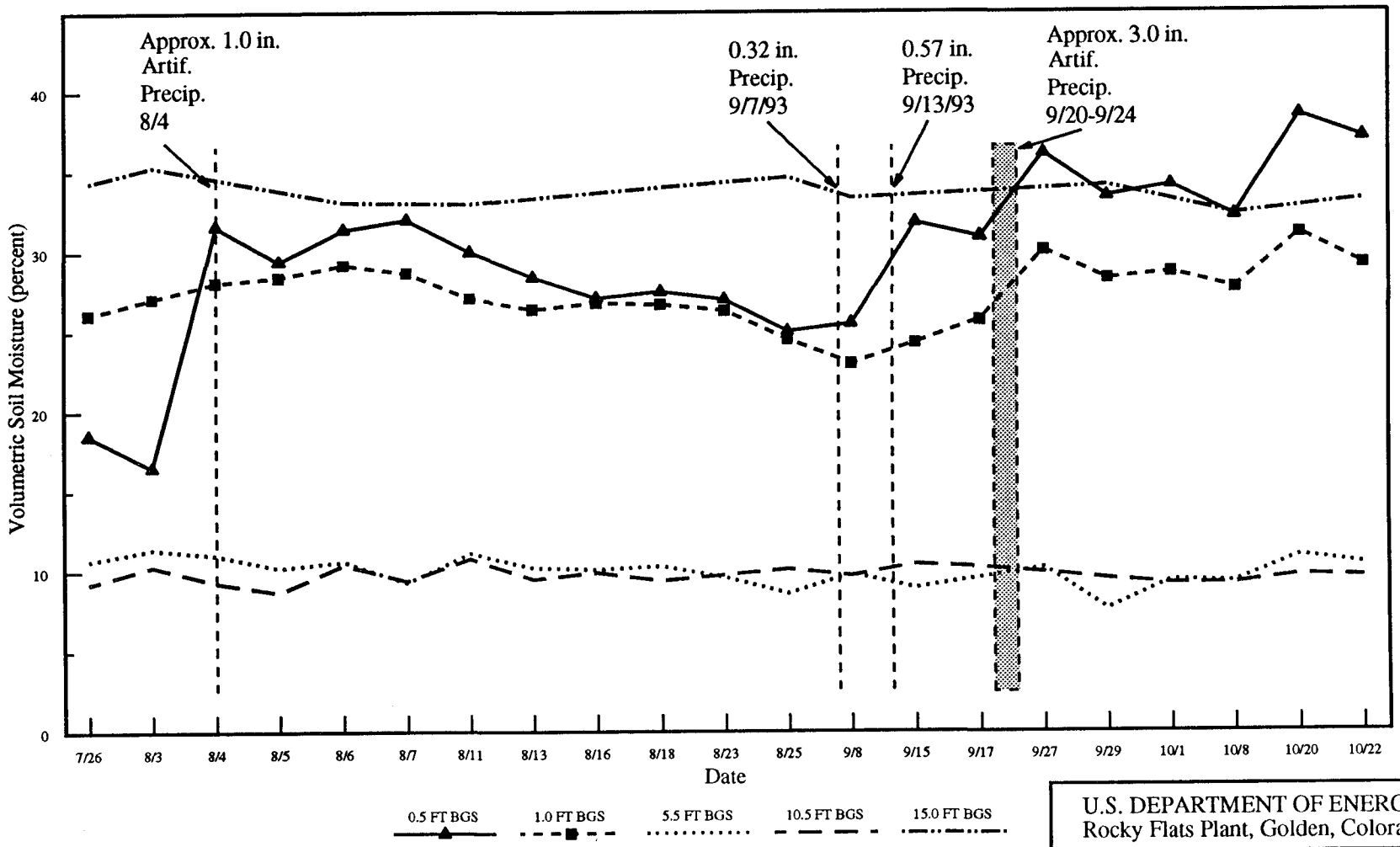
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 1
Soil Moisture Time Series
Hydroprobe Access Tube 02693

FIGURE 29 OCTOBER 1993

File: 026TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

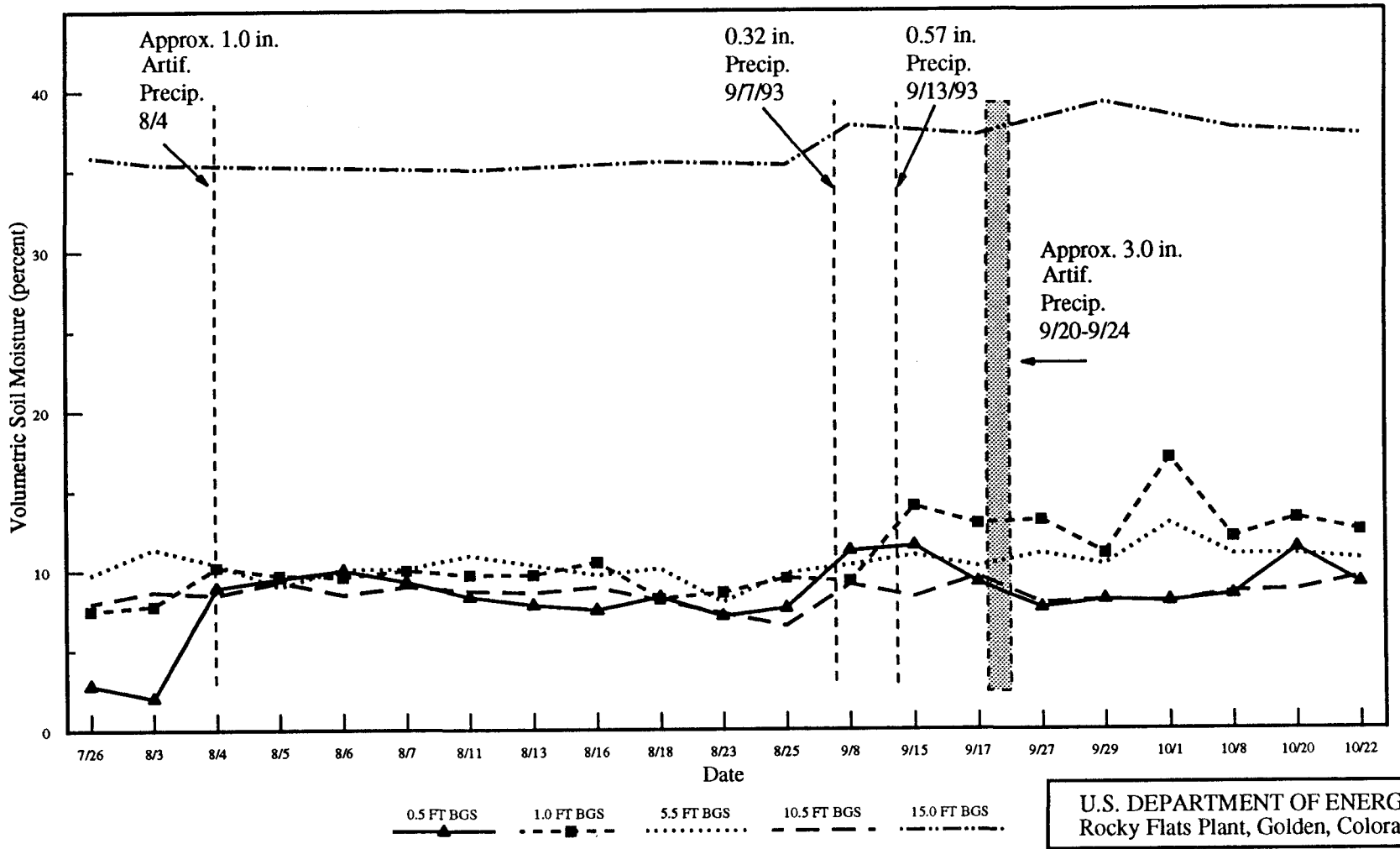
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 02793

FIGURE 30 OCTOBER 1993

File: 027TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

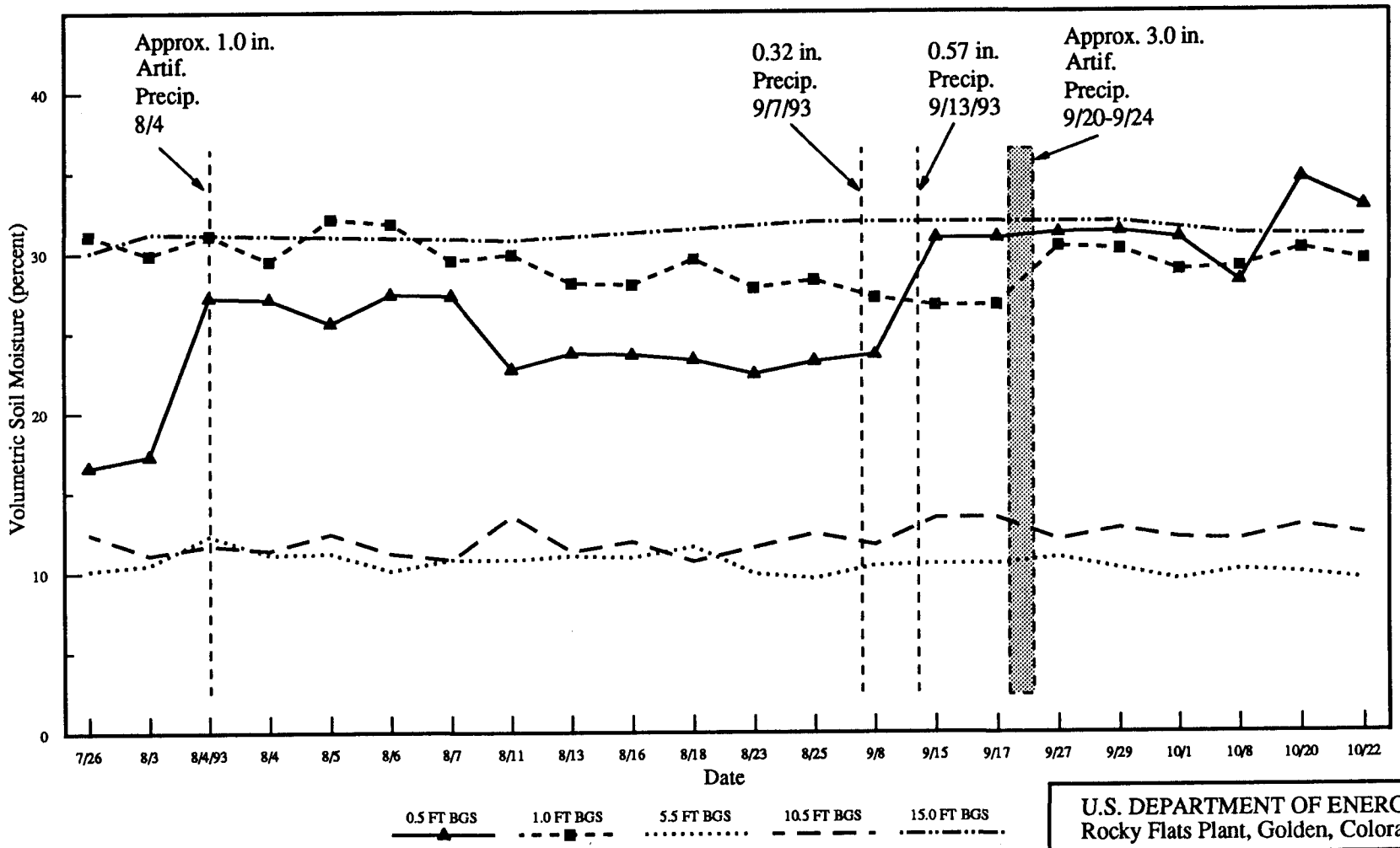
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 02893

FIGURE 31 OCTOBER 1993

File: 028TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

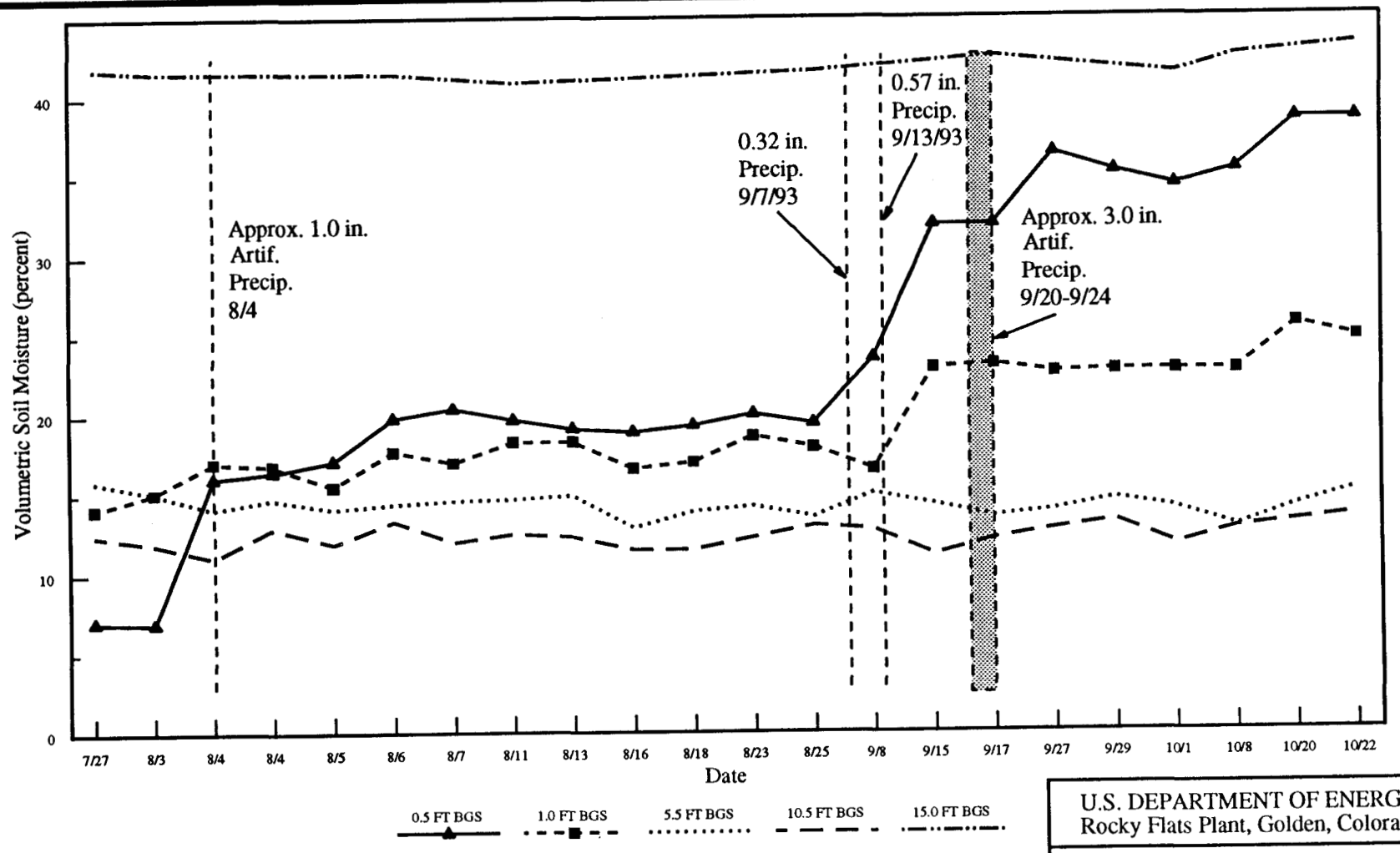
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 02993

FIGURE 32 OCTOBER 1993

File: 029TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

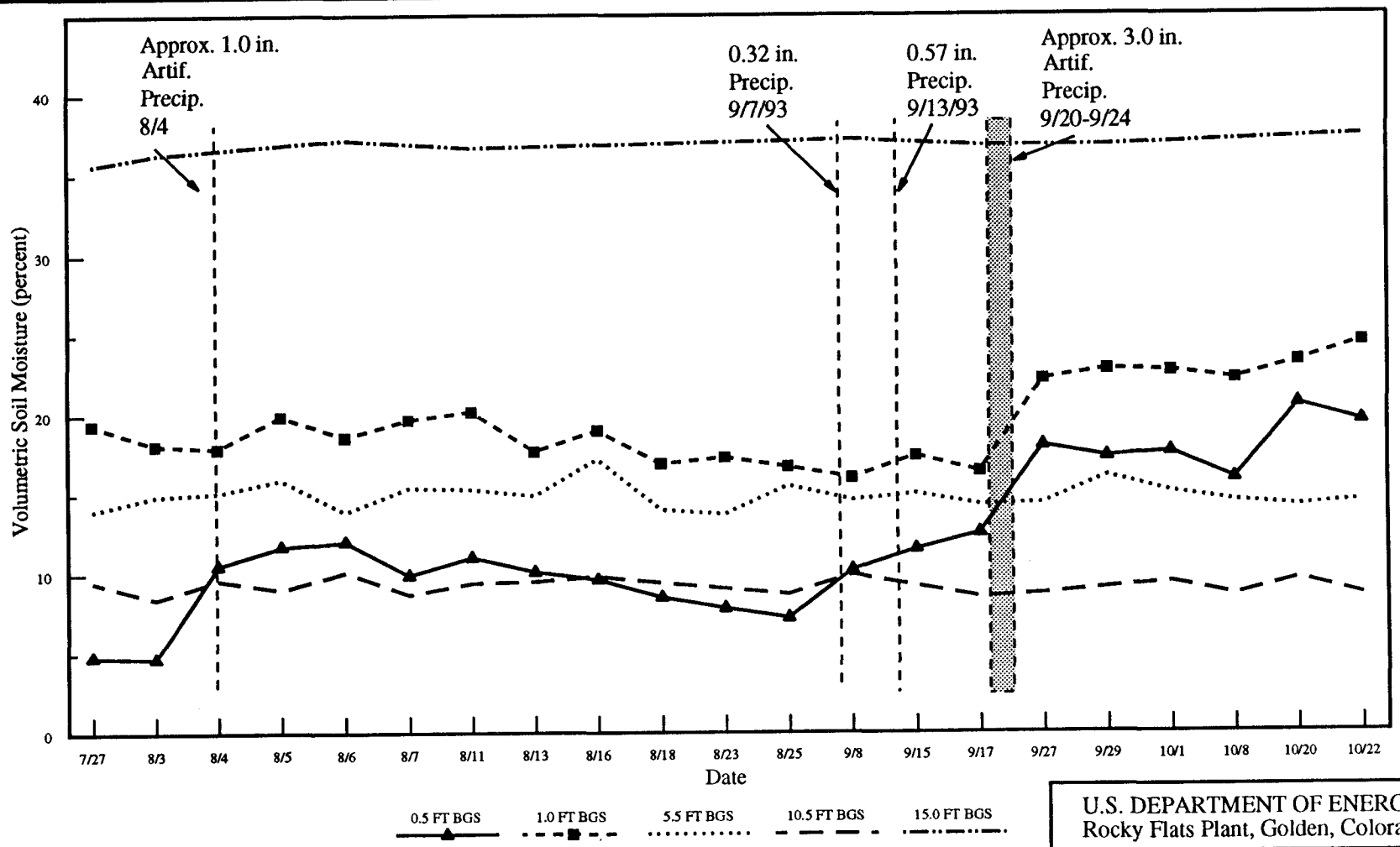
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 03093

FIGURE 33 OCTOBER 1993

File: 030TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

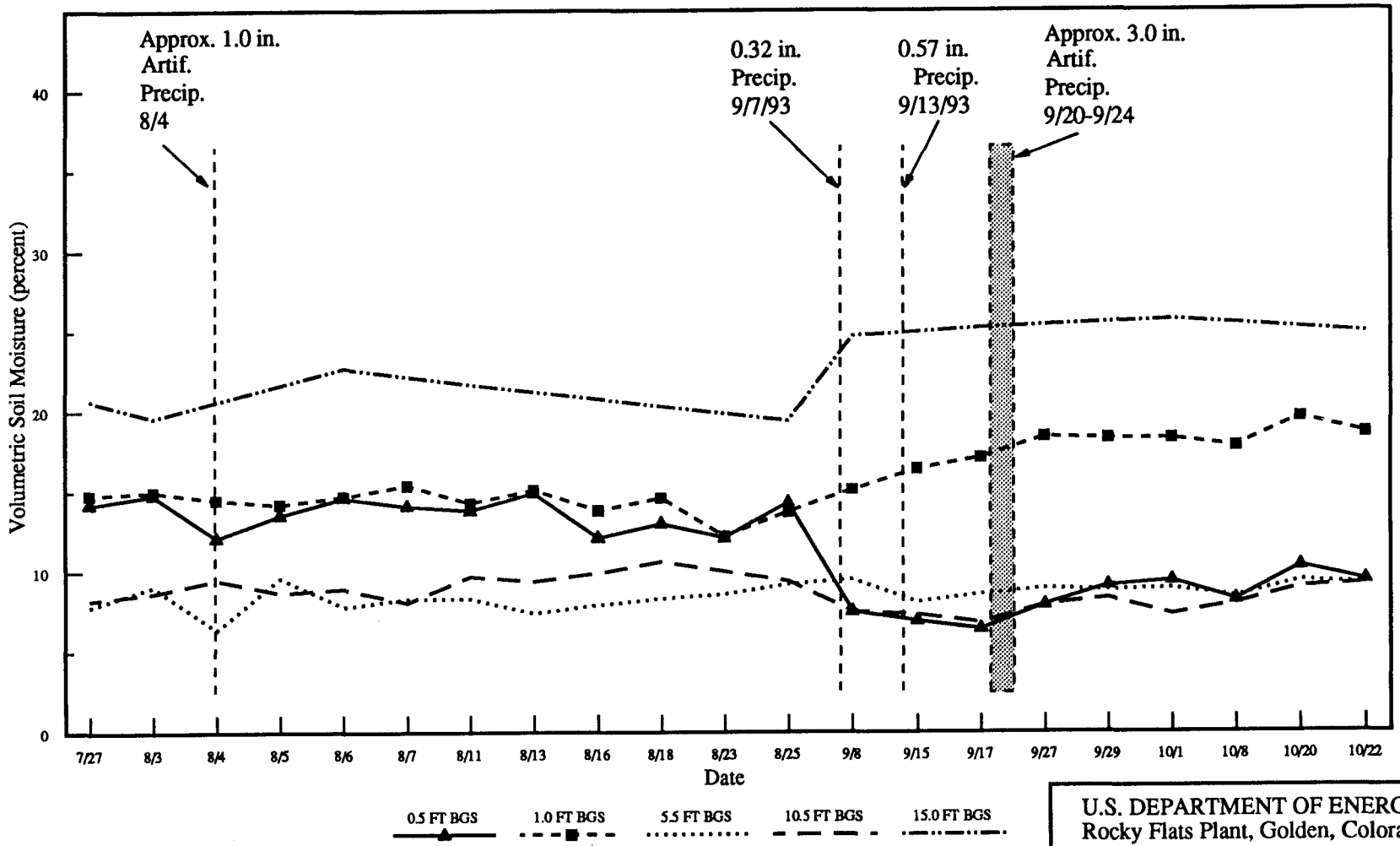
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 03193

FIGURE 34 OCTOBER 1993

File: 031TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

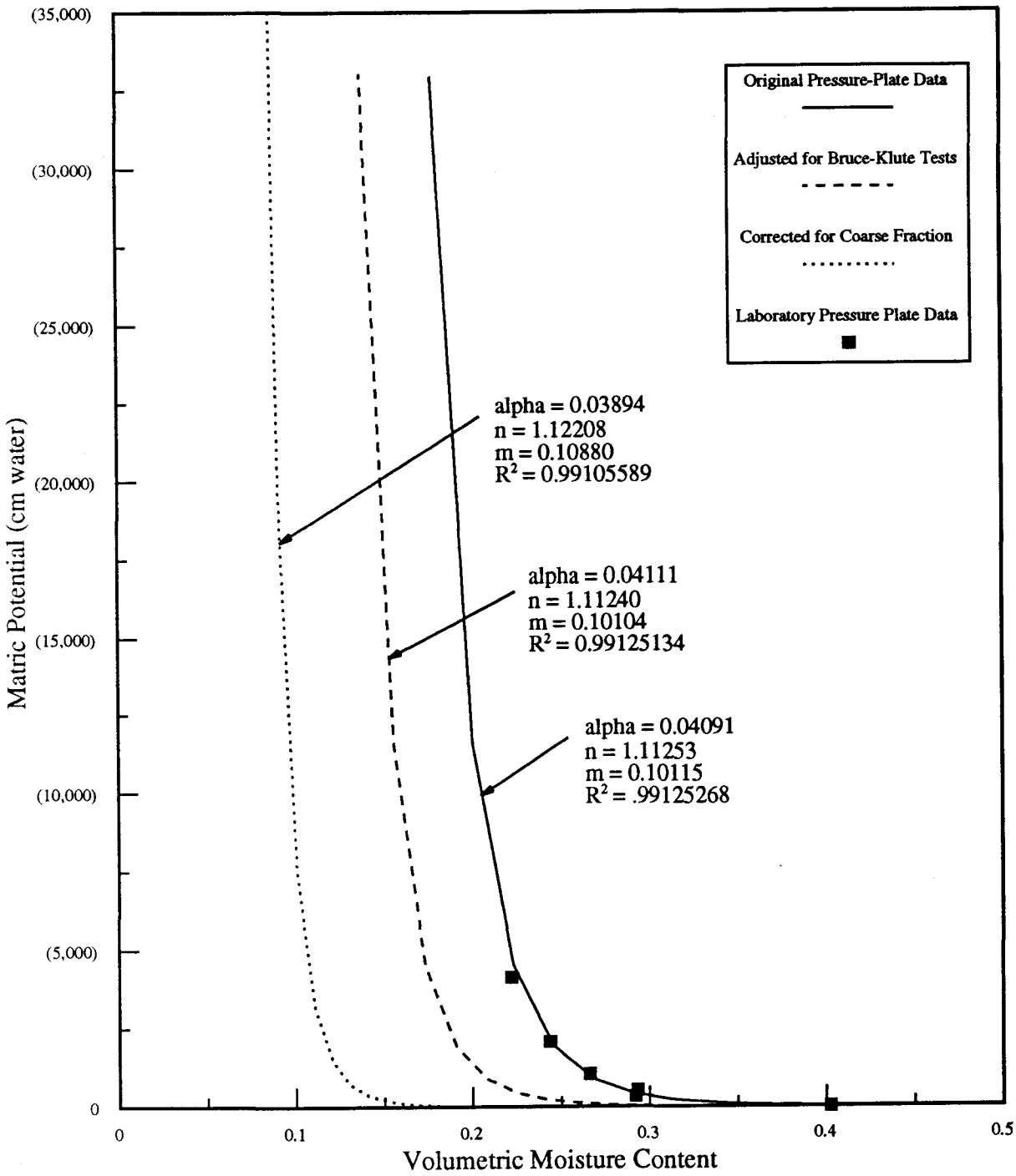
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

SITE 2
Soil Moisture Time Series
Hydroprobe Access Tube 03293

FIGURE 35 OCTOBER 1993

File: 032TIMES.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

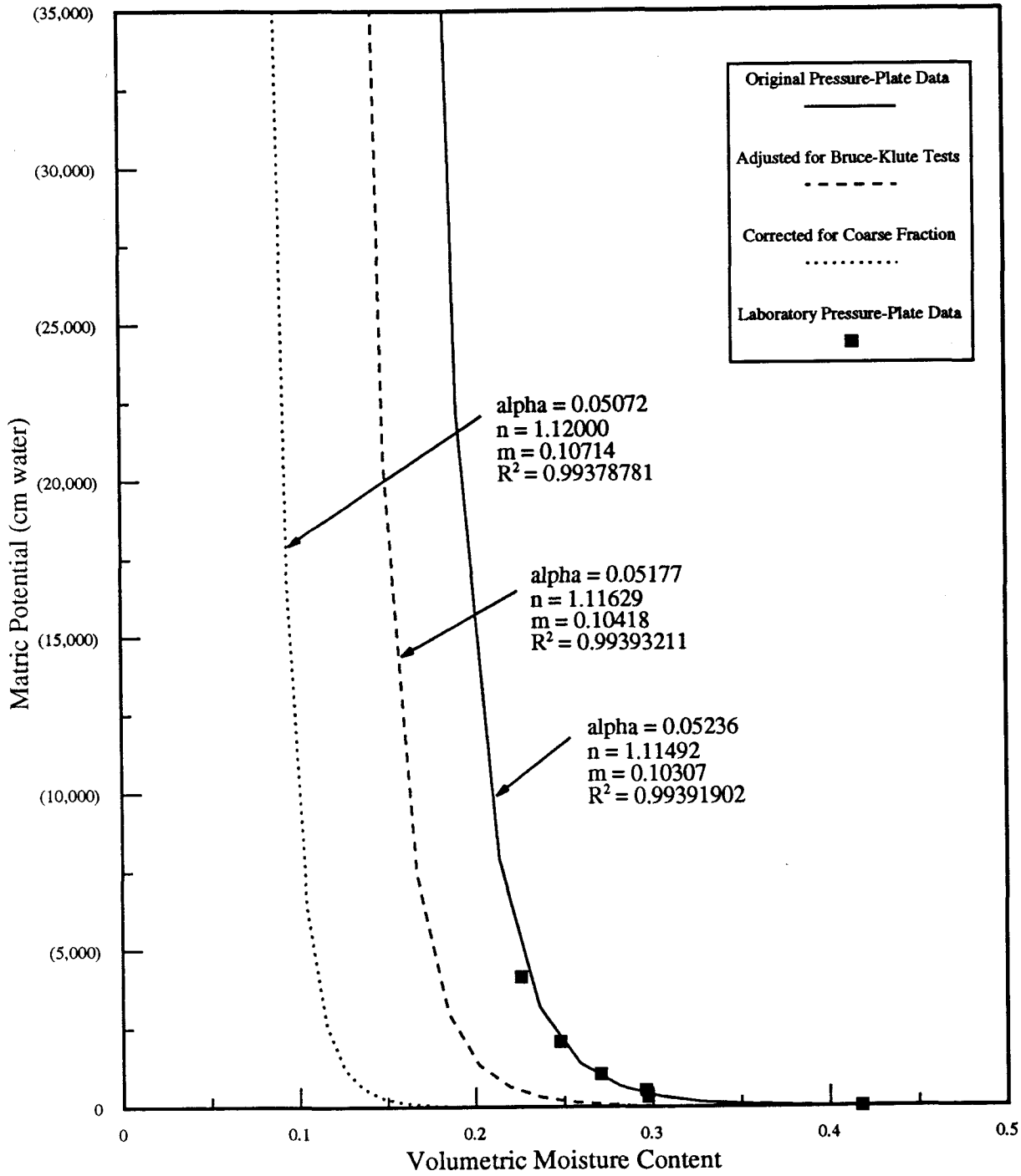
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02393, 2.0-4.0 ft.

FIGURE 36a OCTOBER 1993

File: ATT1GEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

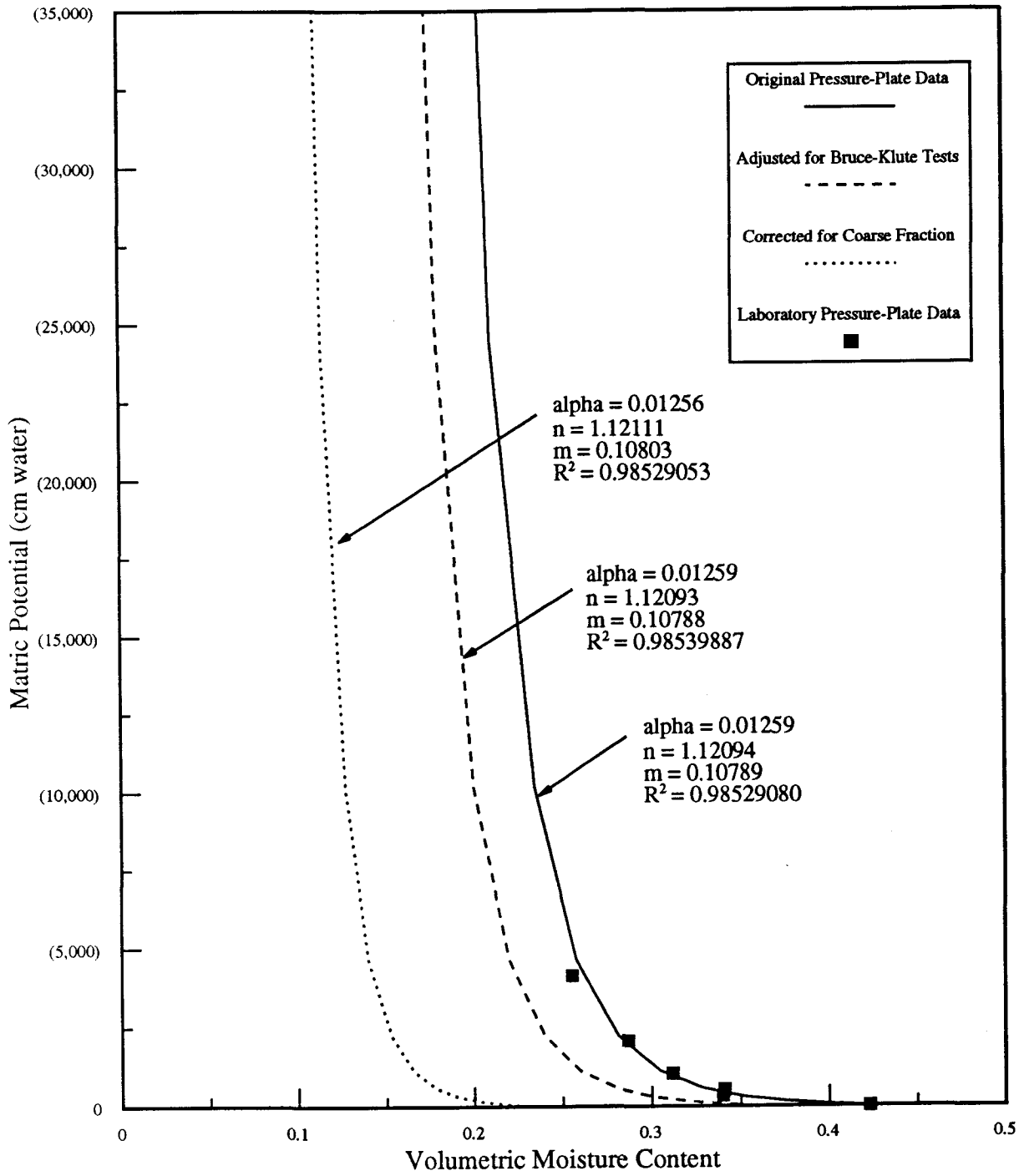
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02393, 2.0-4.0 ft. Replicate

FIGURE 36b OCTOBER 1993

File: ATT1RGEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

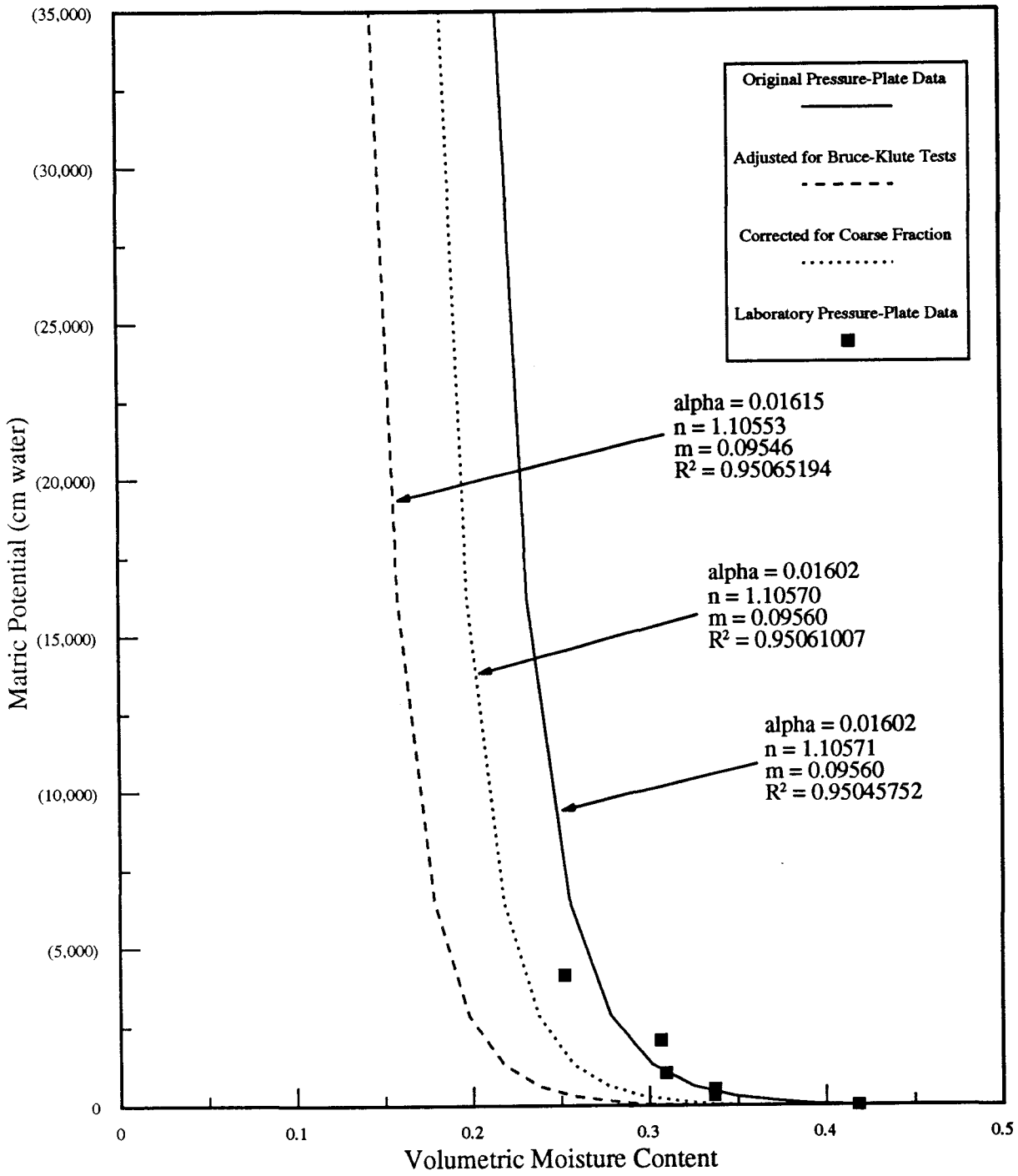
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02393, 4.4-5.4 ft.

FIGURE 37a OCTOBER 1993

File: ATT2GEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

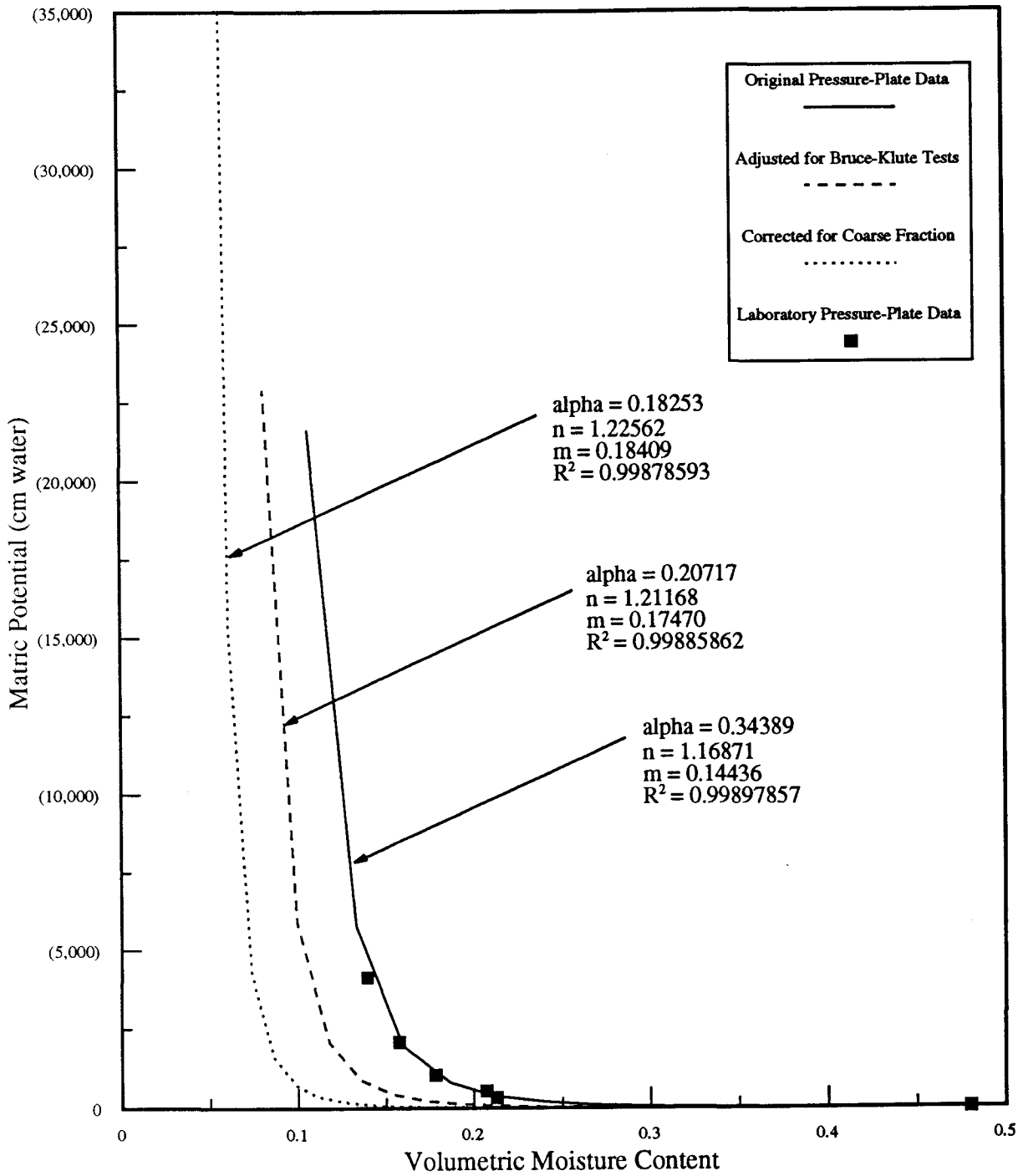
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02393, 4.4-5.4 ft., Replicate

FIGURE 37b OCTOBER 1993

File: ATT2RGEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

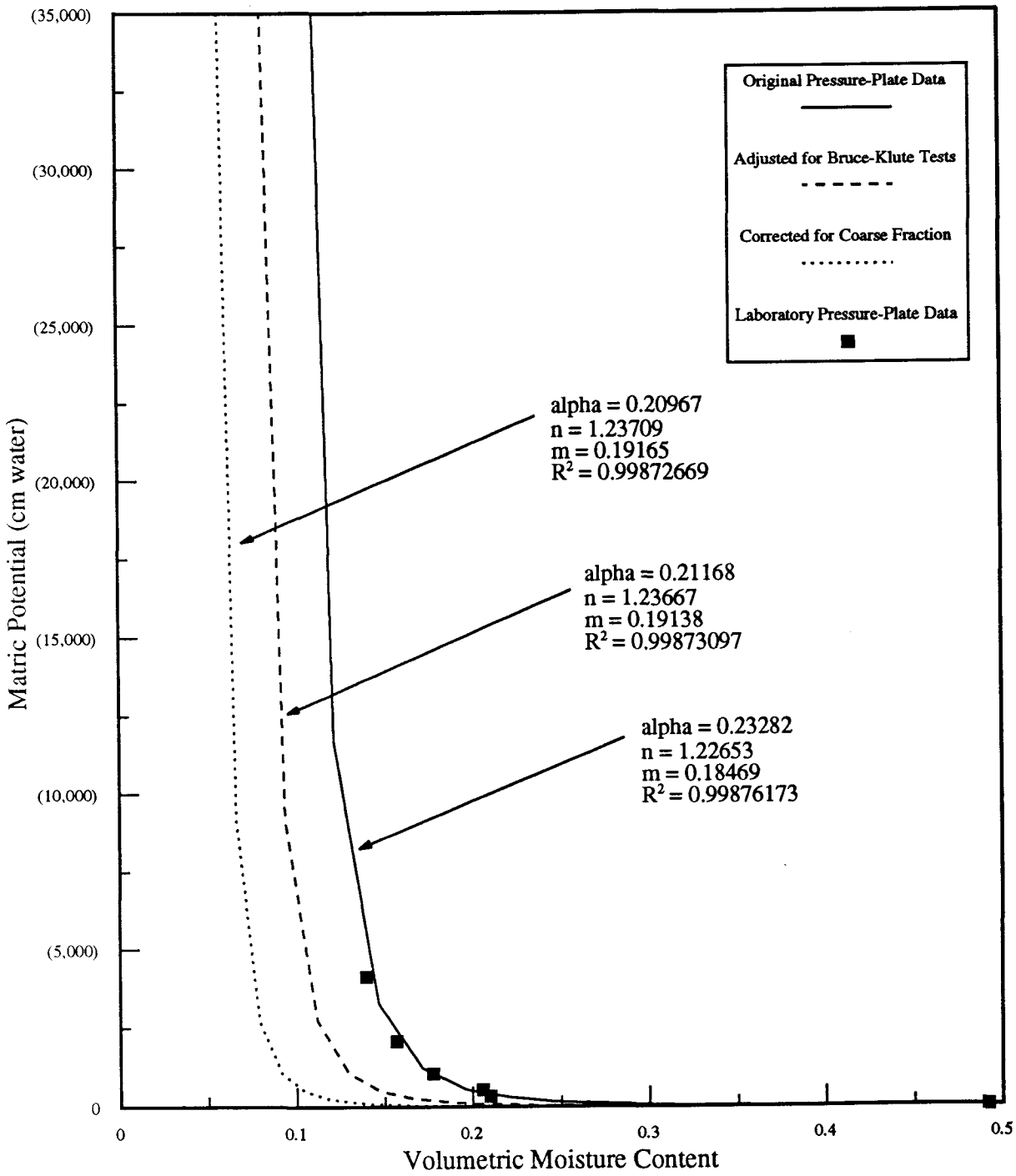
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 7.9-9.9 ft.

FIGURE 38a OCTOBER 1993

File: ATT4GEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

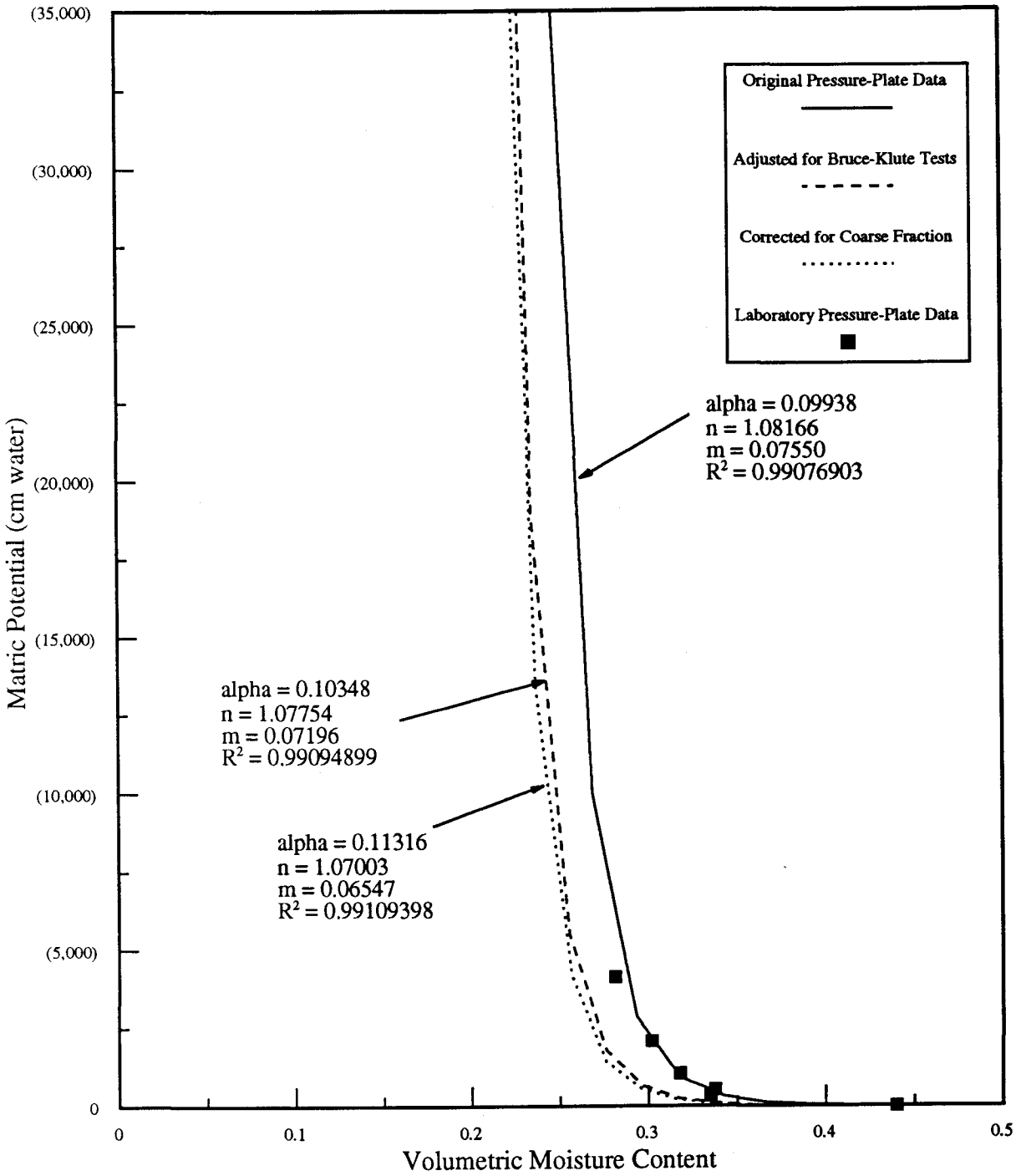
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 7.9-9.9 ft., Replicate

FIGURE 38b OCTOBER 1993

File: ATT4RGEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

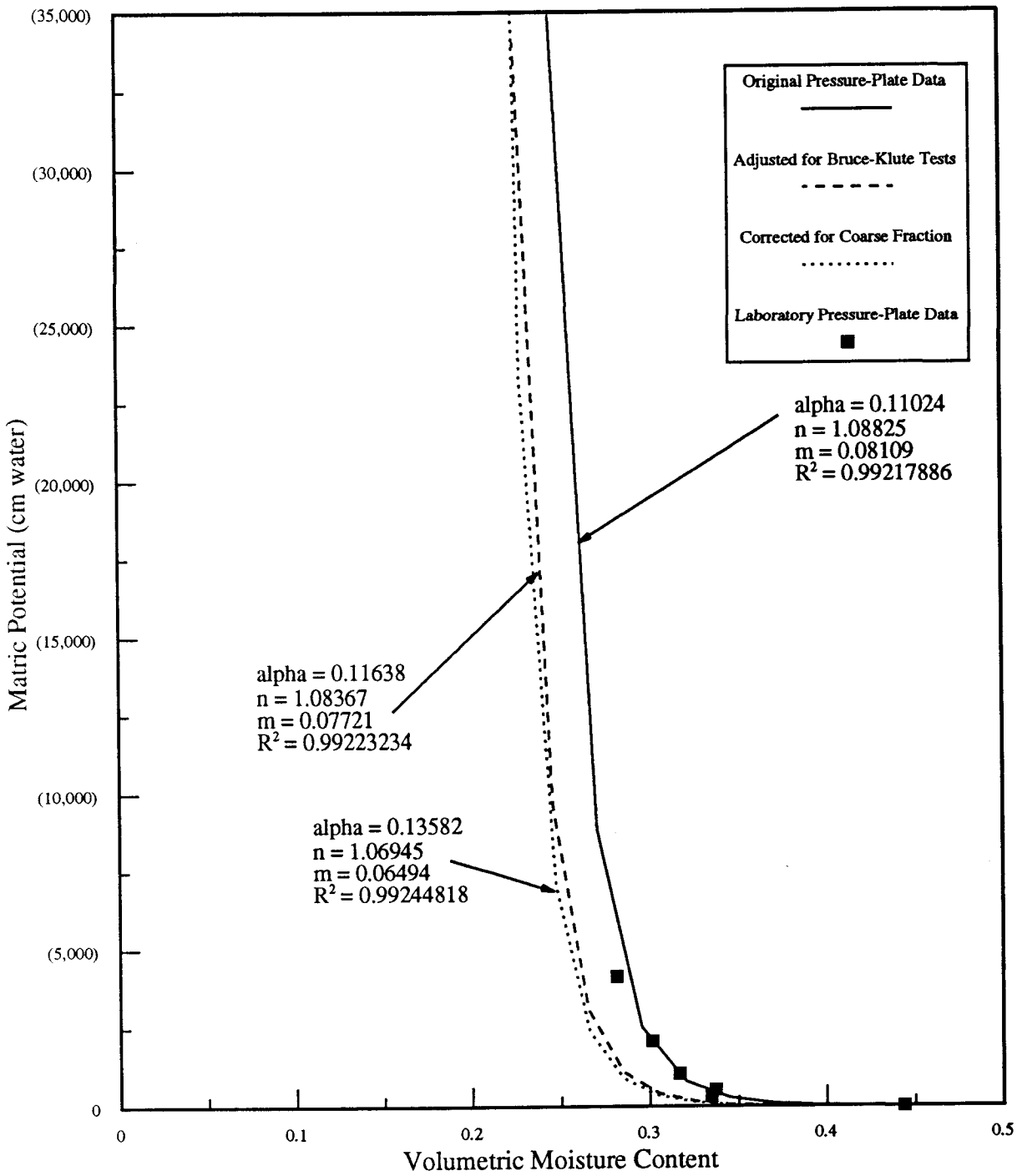
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 19.4-21.5 ft.

FIGURE 39a OCTOBER 1993

File: ATT5GEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

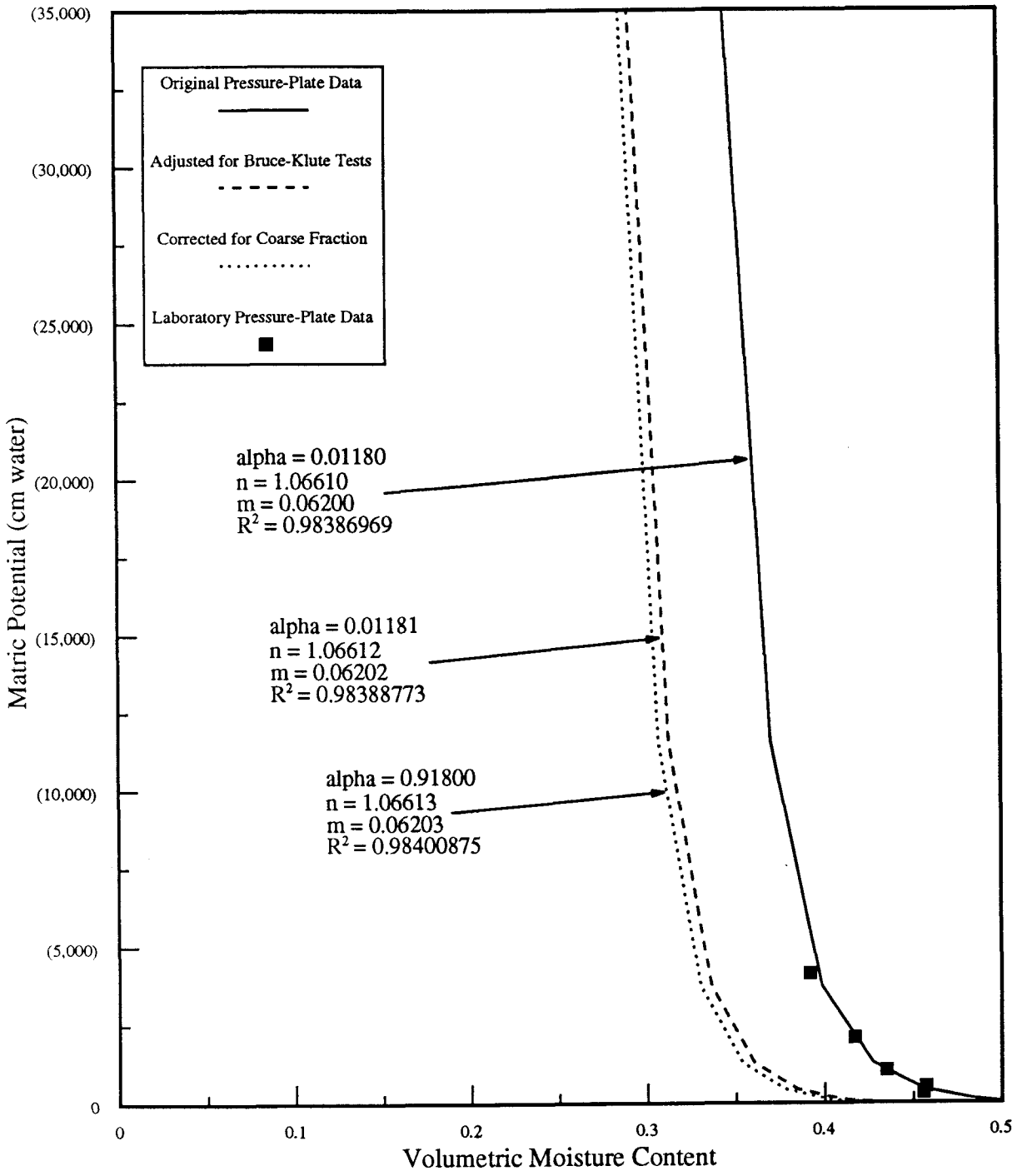
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 19.4-21.5 ft., Replicate

FIGURE 39b OCTOBER 1993

File: ATT5RGEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

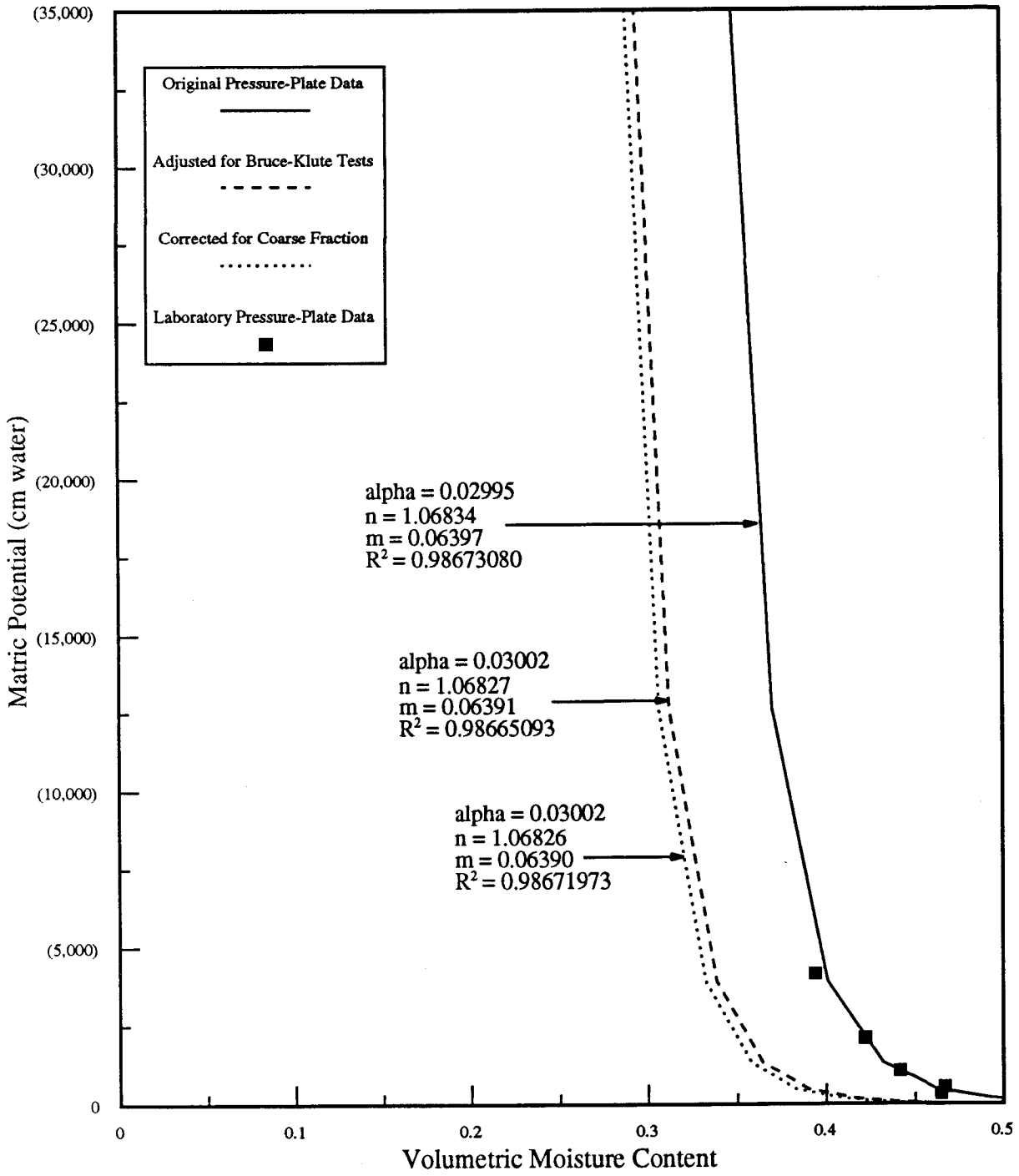
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 17.0-18.0 ft.

FIGURE 40a OCTOBER 1993

ATT6GEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

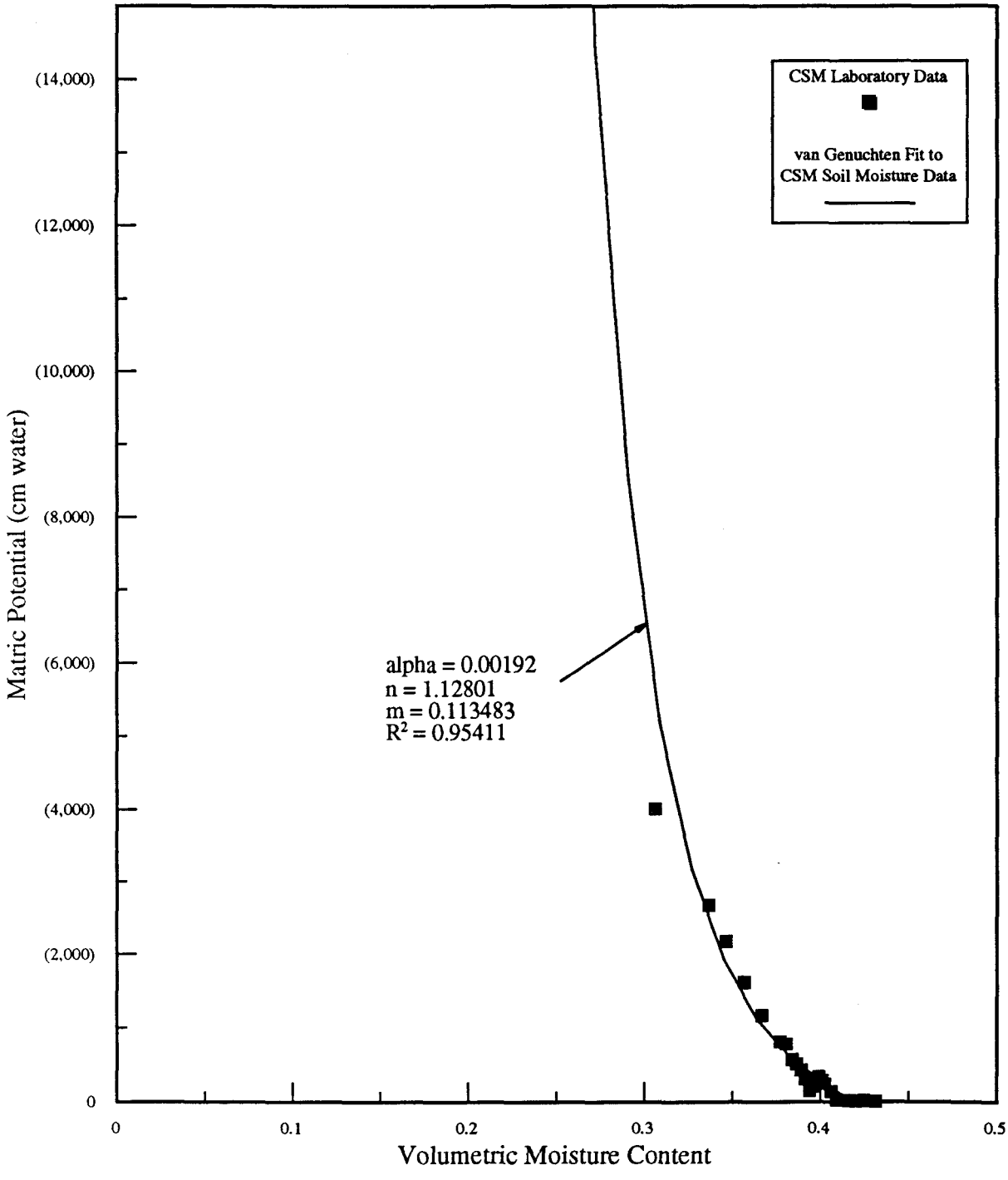
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
Moisture Characteristic Curve Data
Borehole 02993, 17.0-18.0 ft., Replicate

FIGURE 40b OCTOBER 1993

File: ATT6RGEN.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

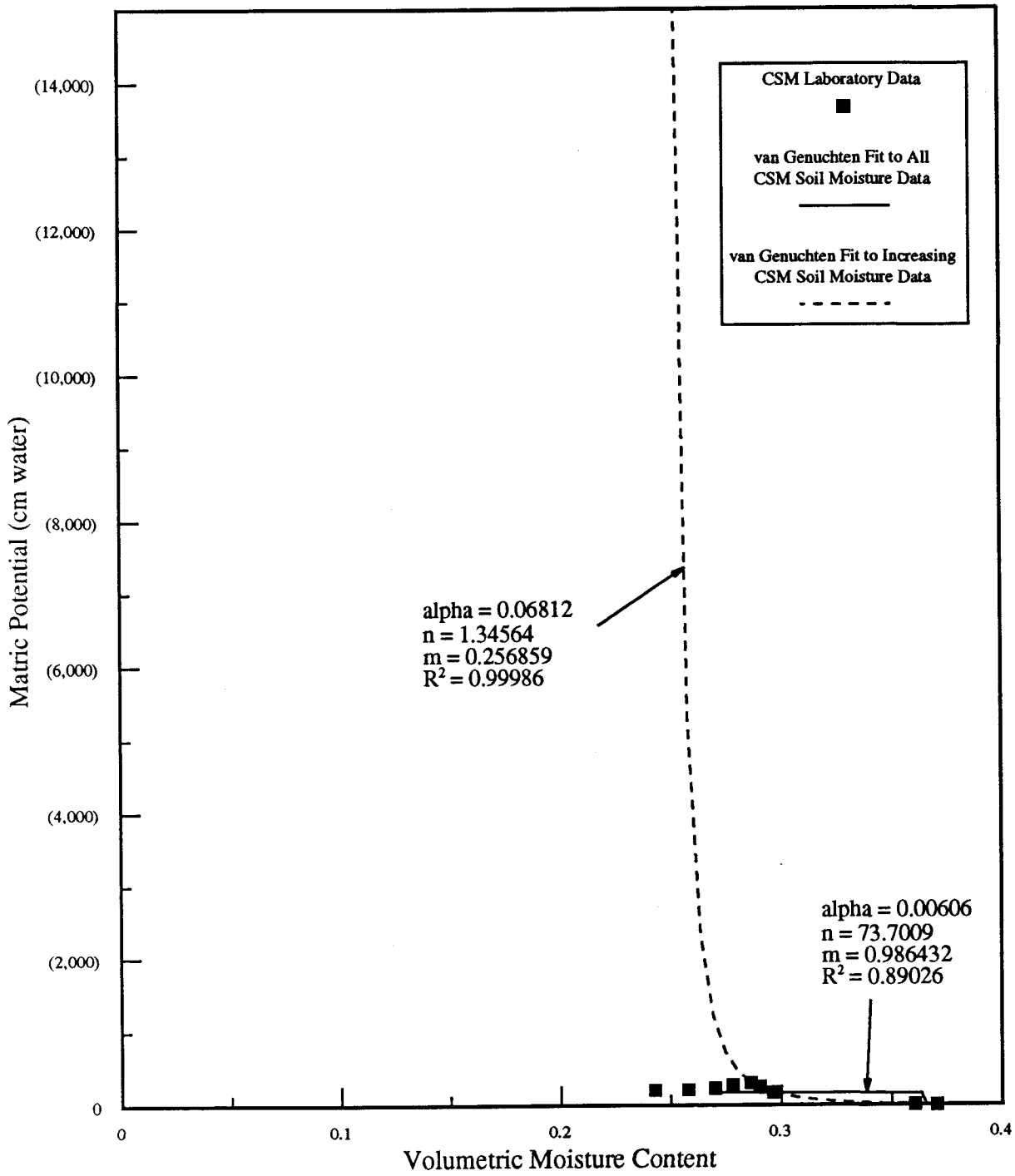
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
CSM Moisture-Characteristic Curve Data
Borehole 02793, 14.4-14.9 ft.

FIGURE 41 OCTOBER 1993

File: M02793.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

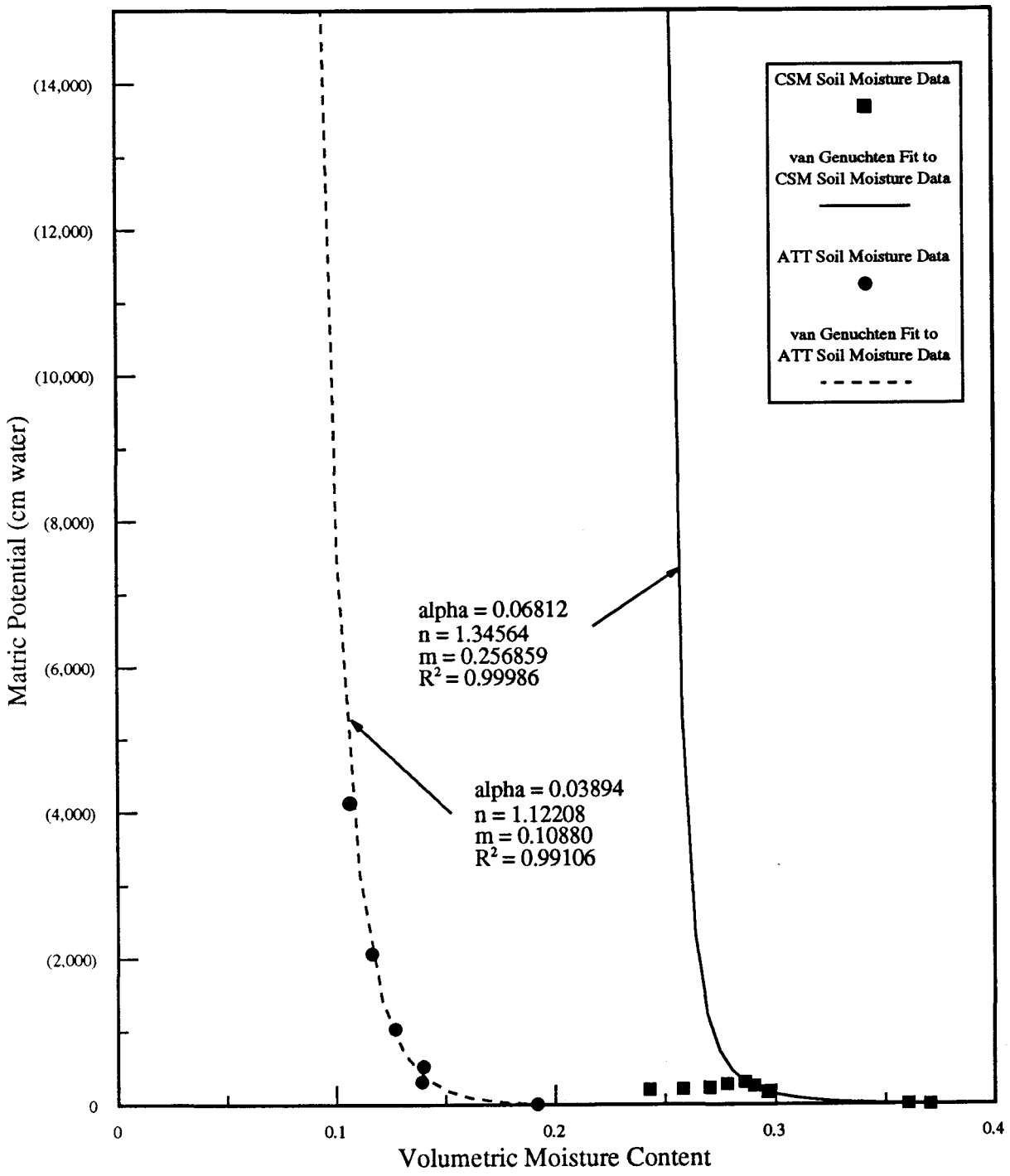
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

van Genuchten Fit to
CSM Moisture-Characteristic Curve Data
Borehole 02293, 2.9-3.4 ft.

FIGURE 42 OCTOBER 1993

File: M02293.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

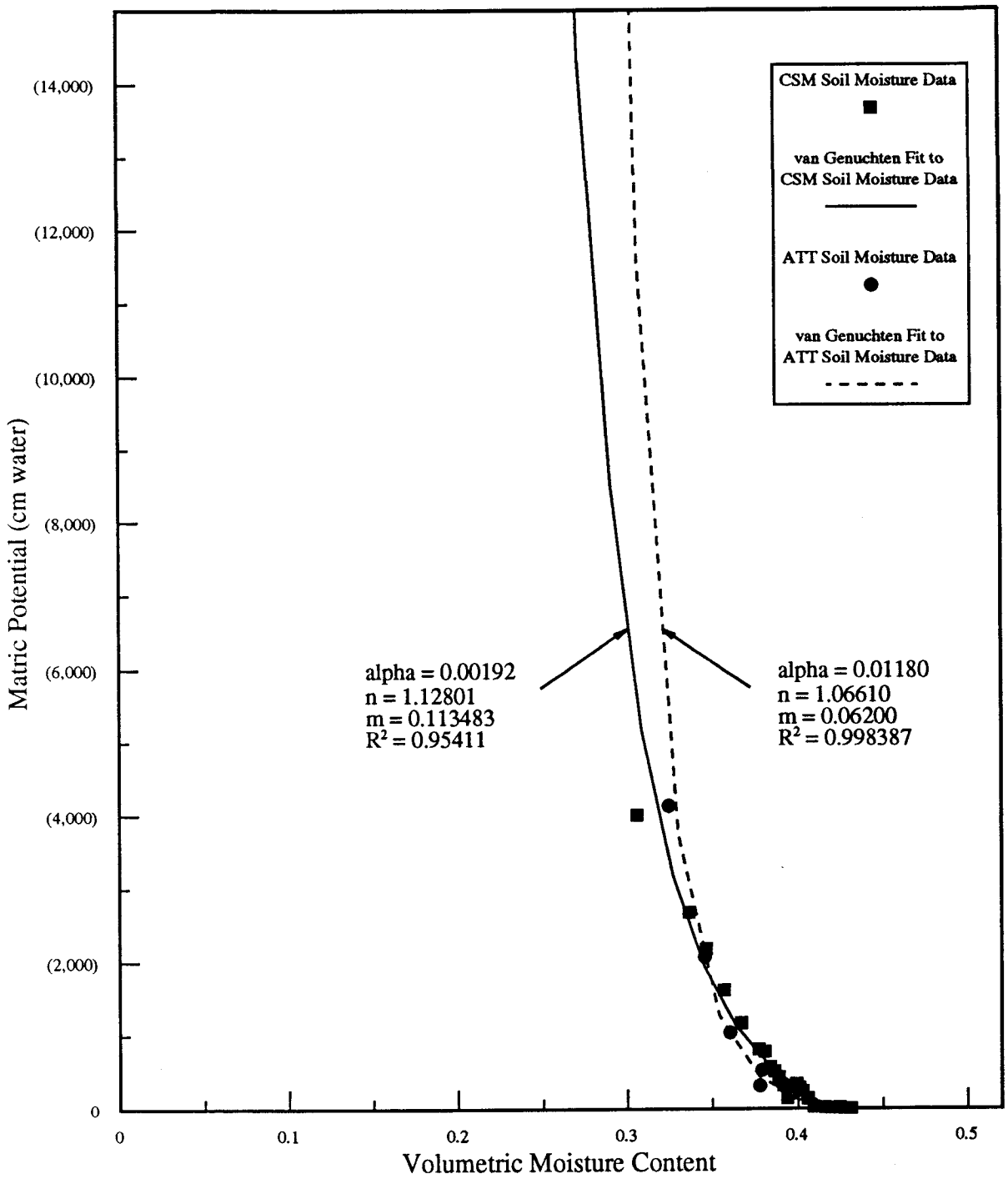
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Comparison of ATT, Inc. to
CSM Moisture-Characteristic Curve Data
Borehole 02293, 2.9-3.4 ft.

FIGURE 43 OCTOBER 1993

File: COM1-2.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

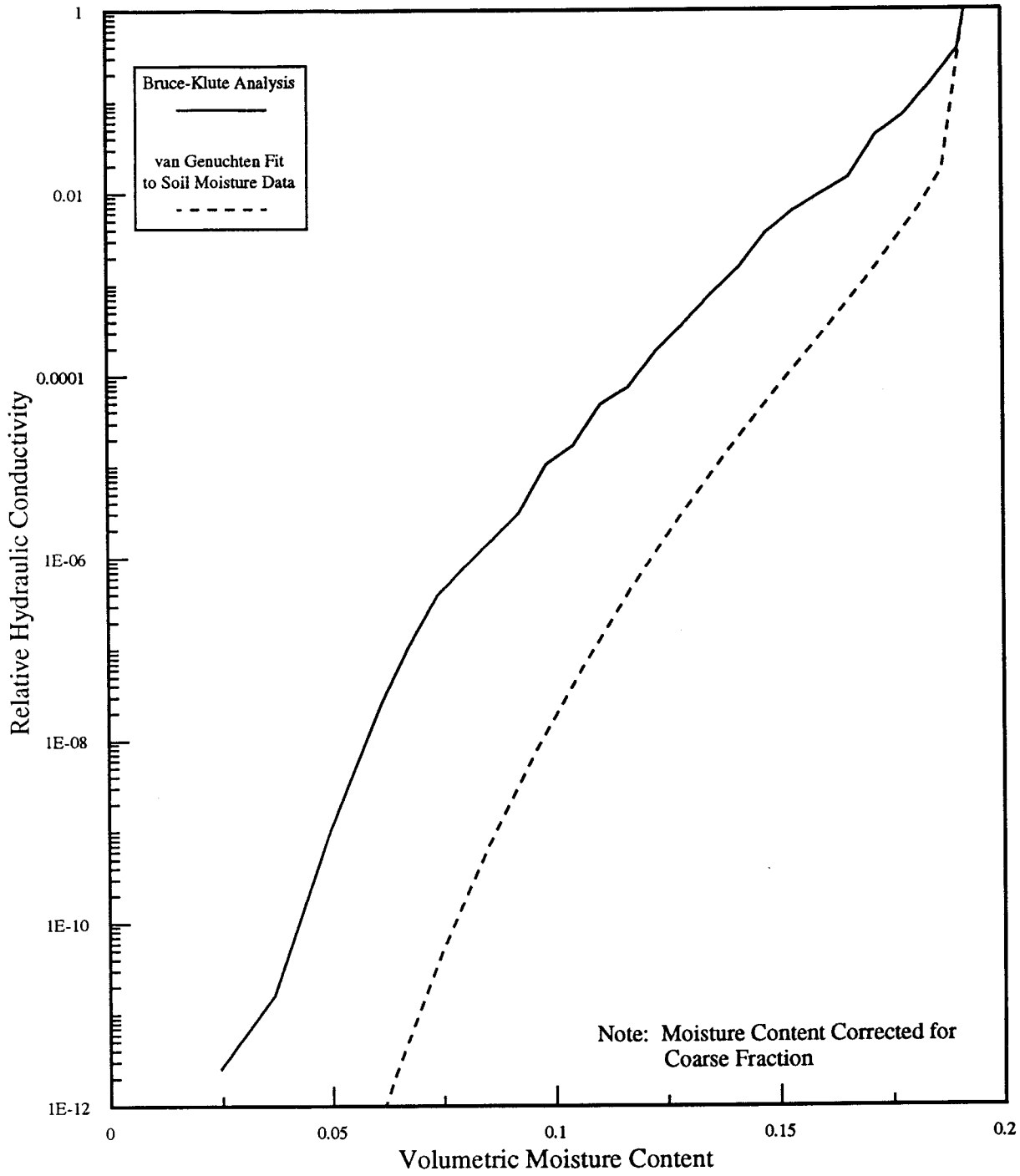
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Comparison of ATT, Inc. to
CSM Moisture-Characteristic Curve Data
Borehole 02793, 14.4-14.9 ft.

FIGURE 44 OCTOBER 1993

File: COMTEST.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

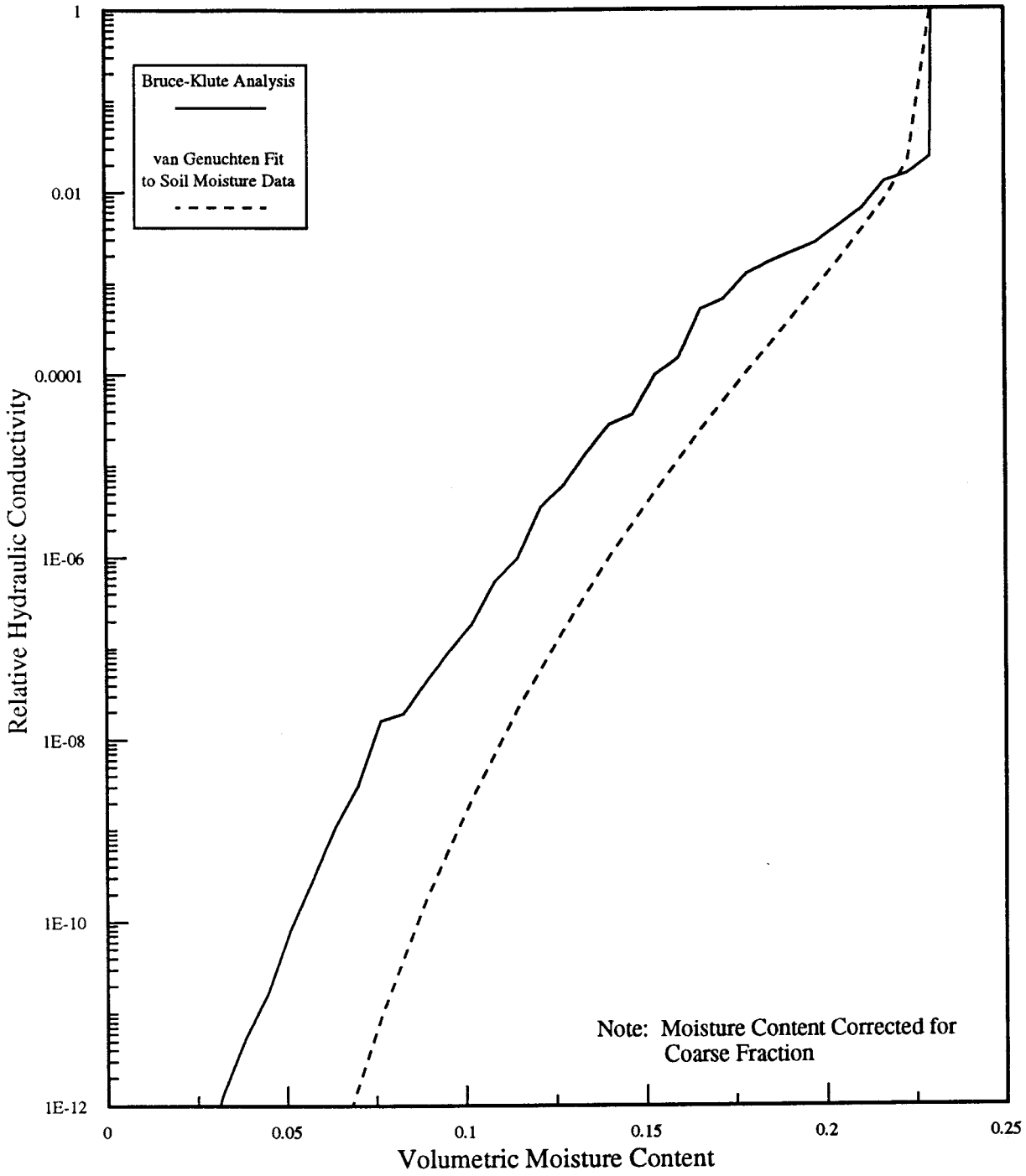
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Bruce-Klute Analysis Vs. van Genuchten Fit
Borehole 02393, 2.0-4.0 ft.

FIGURE 45 OCTOBER 1993

File: ATT-1B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

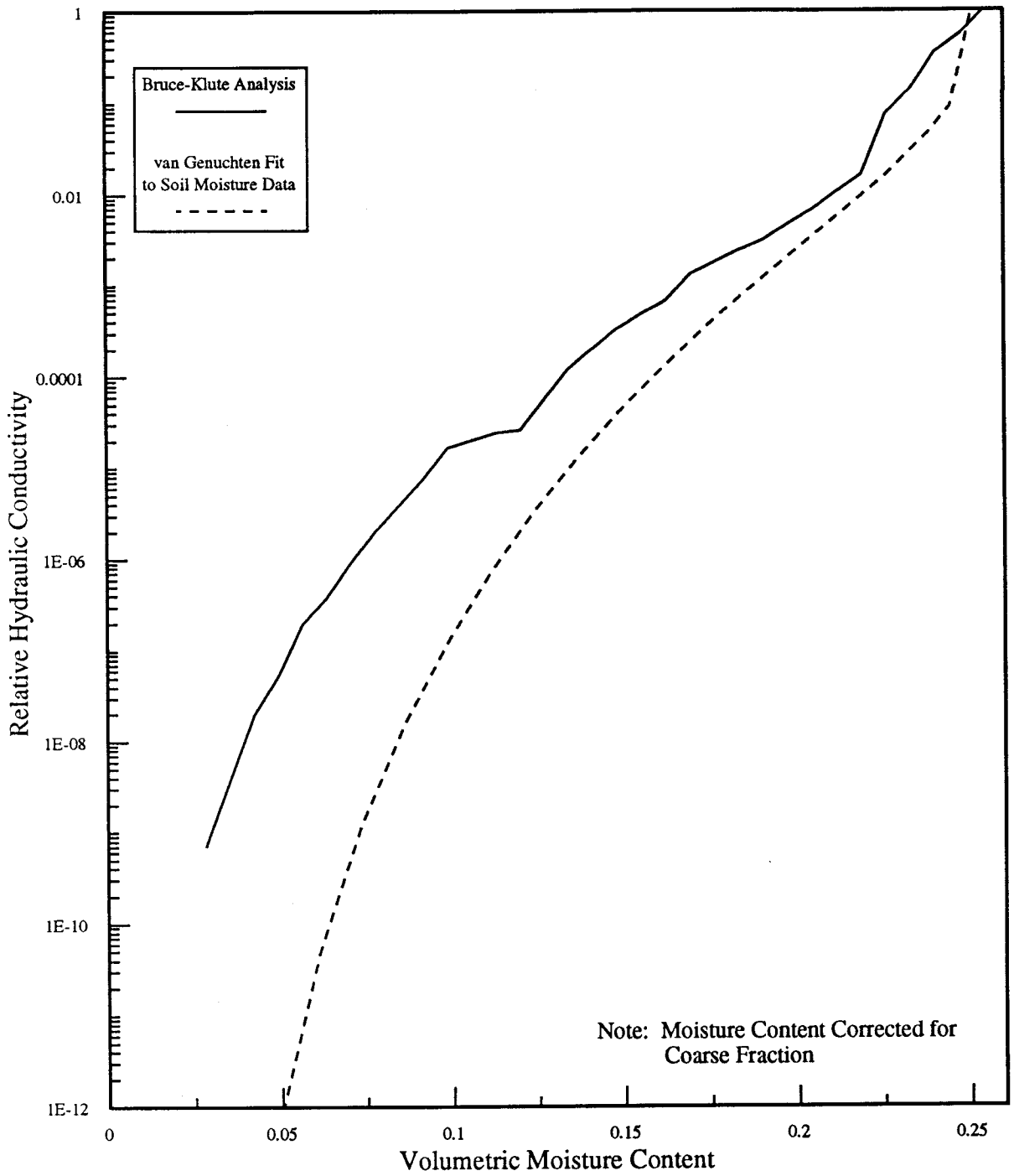
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Bruce-Klute Analysis Vs. van Genuchten Fit
Borehole 02393, 4.4-5.4 ft.

FIGURE 46 OCTOBER 1993

File: ATT-2B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

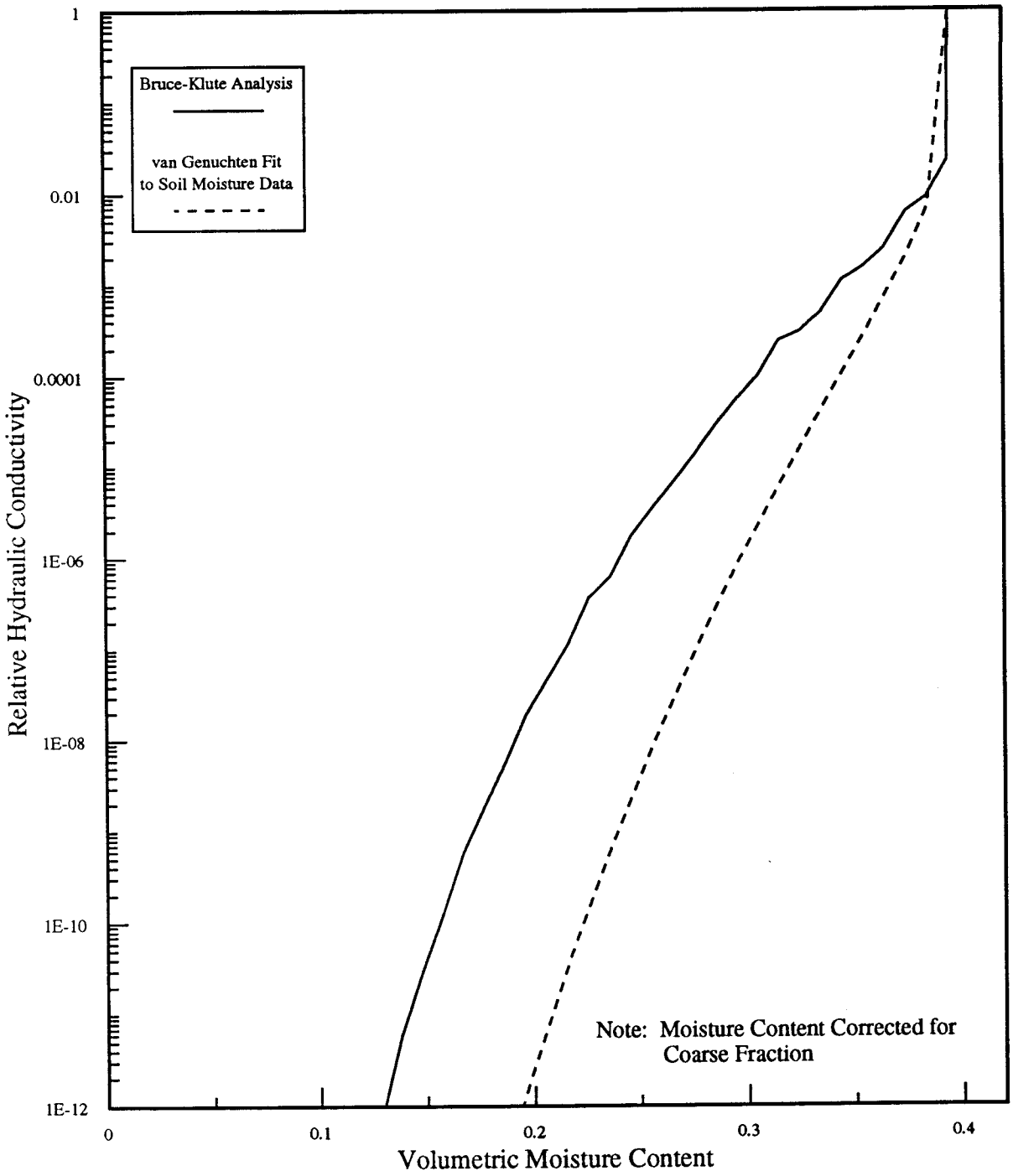
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Bruce-Klute Analysis Vs. van Genuchten Fit
Borehole 02993, 7.9-9.9 ft.

FIGURE 47 OCTOBER 1993

File: ATT-4B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

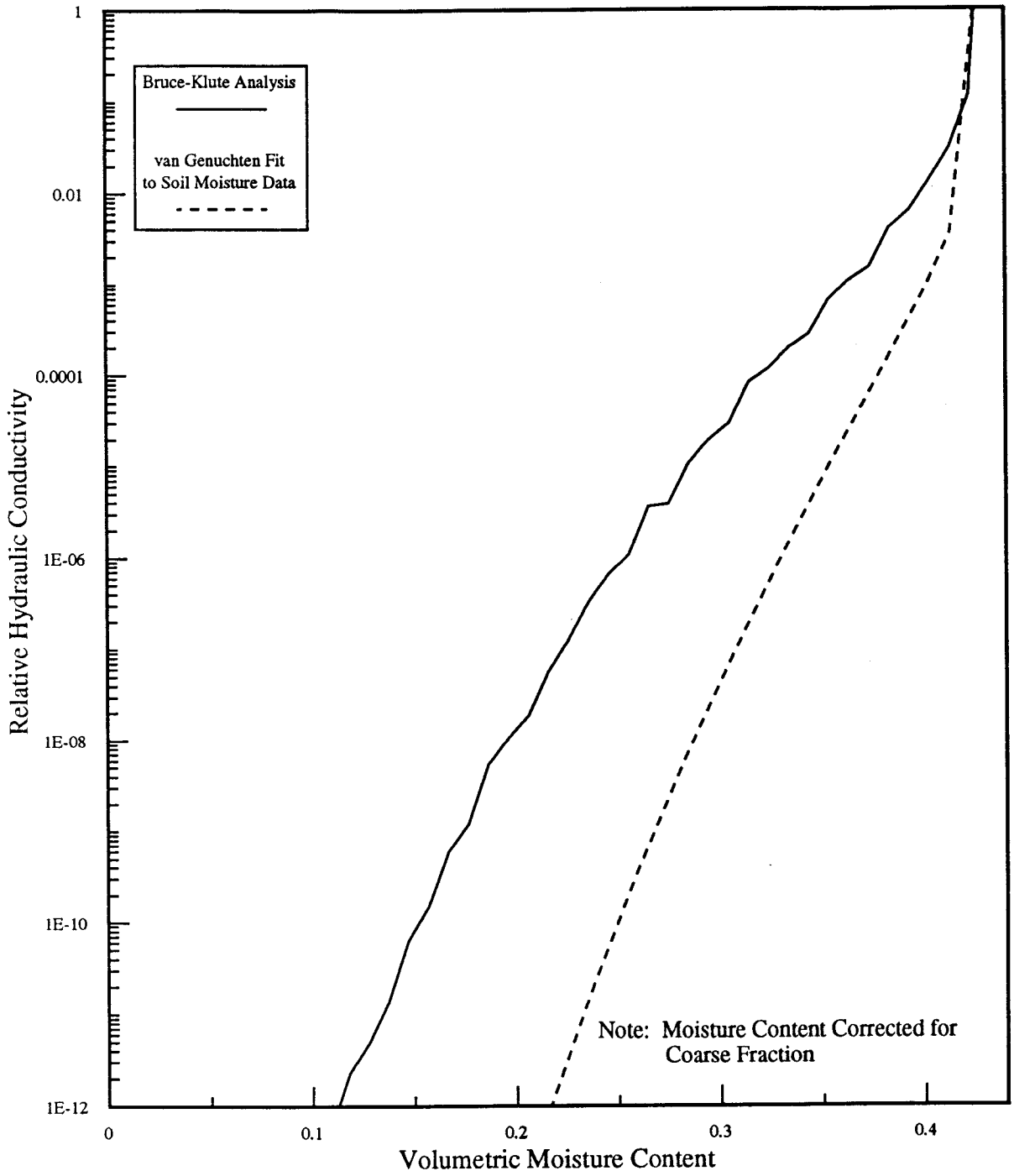
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Bruce-Klute Analysis Vs. van Genuchten Fit
Borehole 02993, 19.4-21.5 ft.

FIGURE 48 OCTOBER 1993

File: ATT-5B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

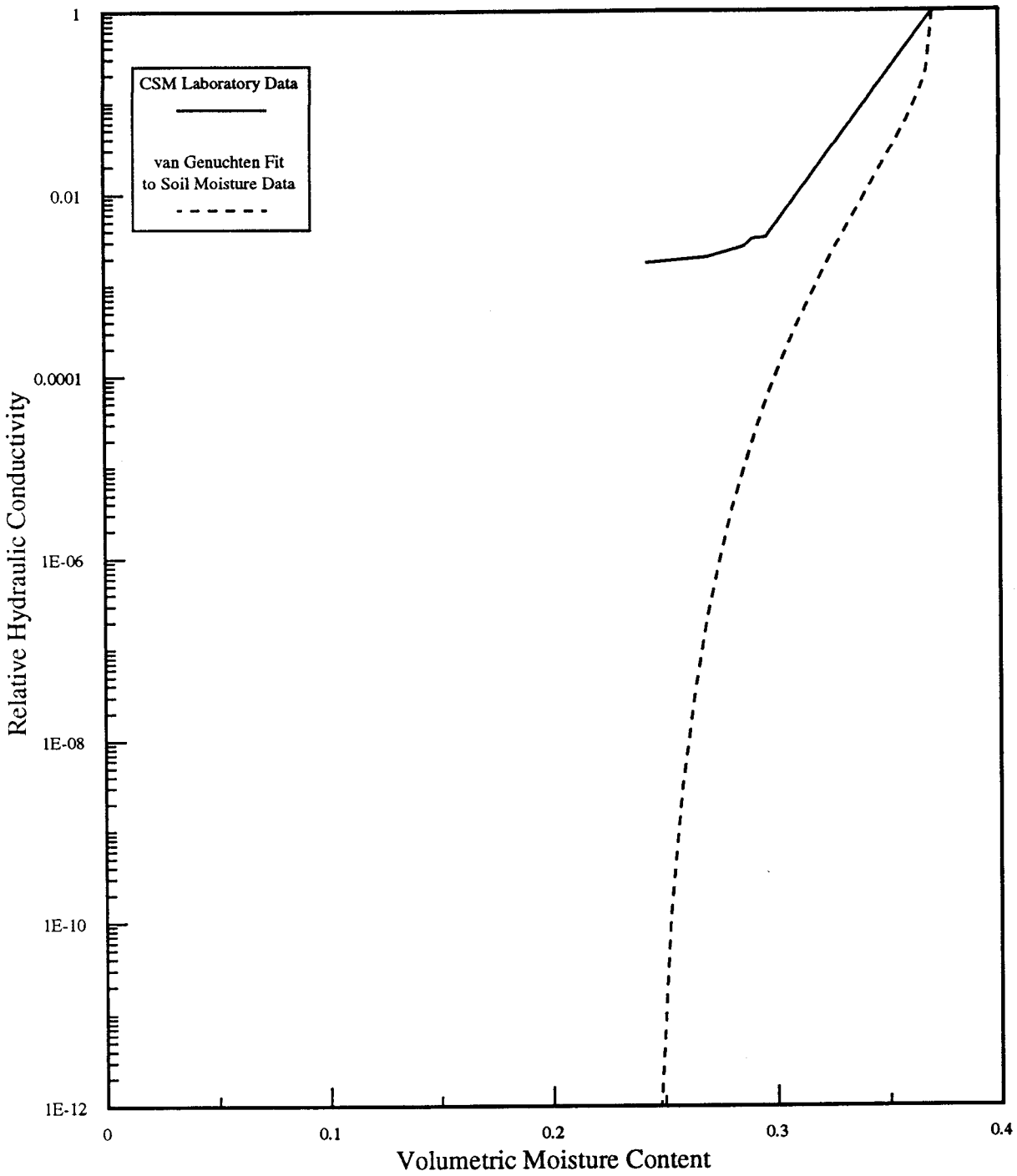
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Bruce-Klute Analysis Vs. van Genuchten Fit
Borehole 02993, 17.0-18.0 ft.

FIGURE 49 OCTOBER 1993

File: ATT-6B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

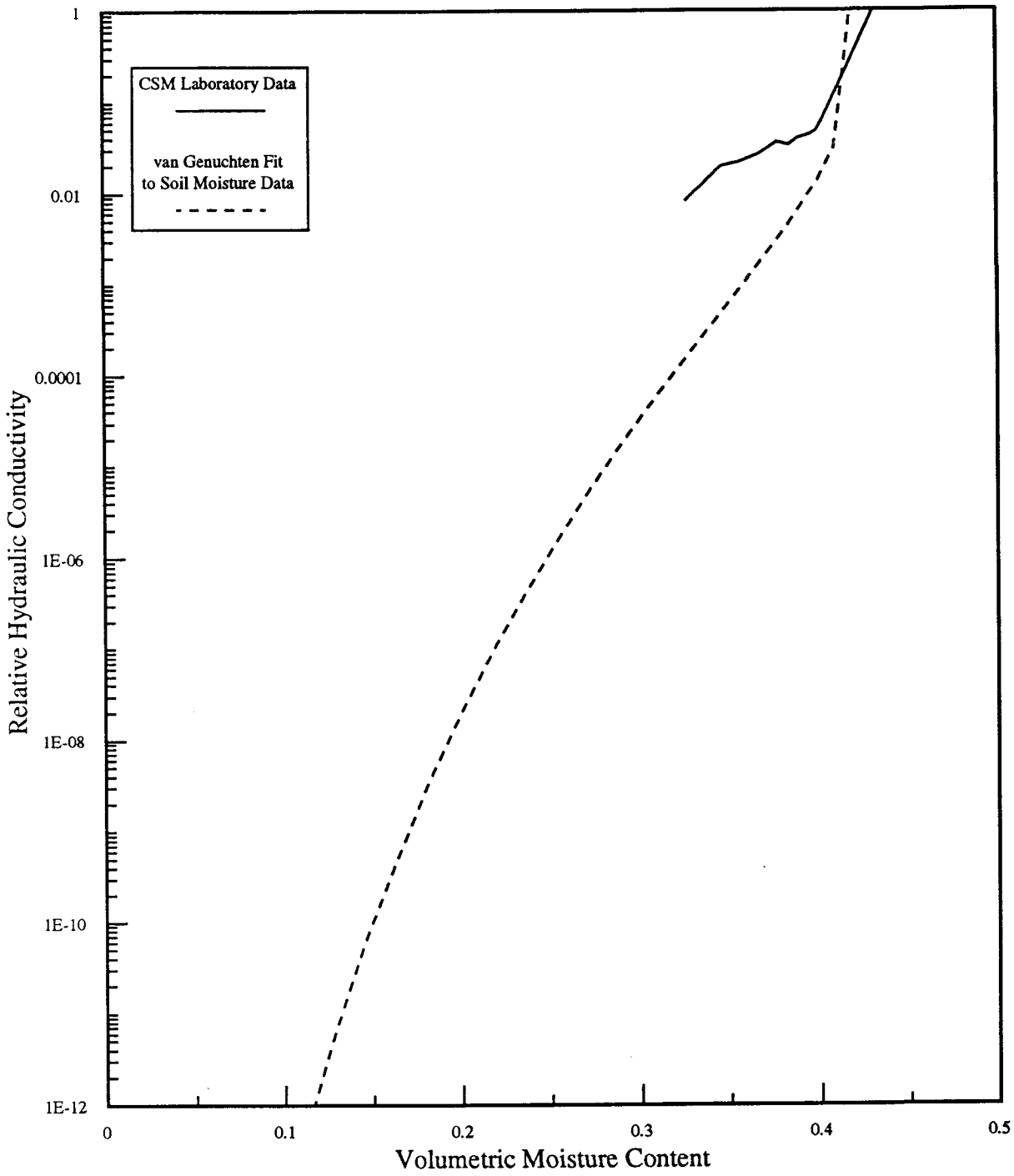
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
CSM Laboratory Data Vs. van Genuchten Fit
Borehole 02293, 2.9-3.4 ft.

FIGURE 50 OCTOBER 1993

File: CSMRF12.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

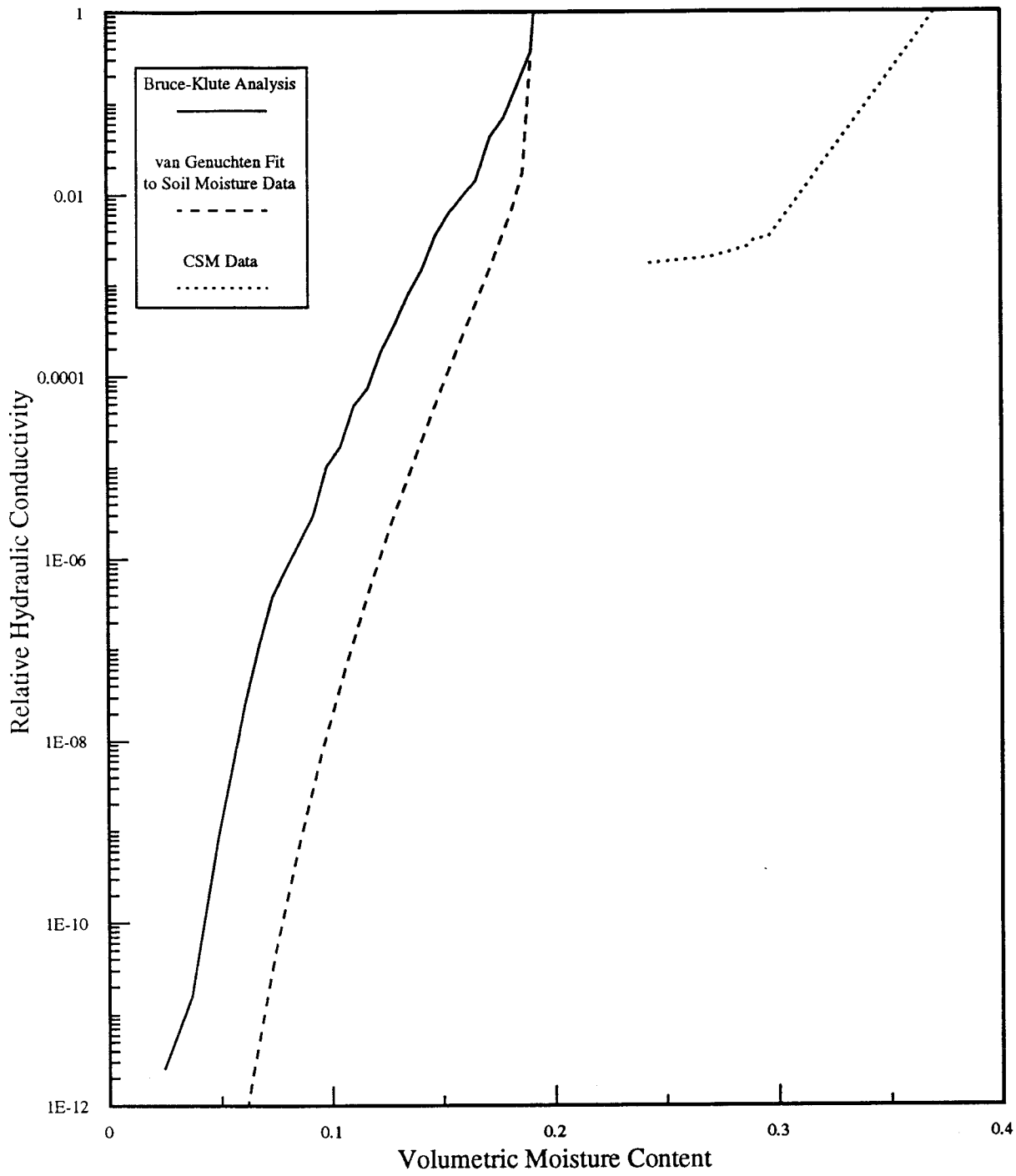
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
CSM Laboratory Data Vs. van Genuchten Fit
Borehole 02793, 14.4-14.9 ft.

FIGURE 51 OCTOBER 1993

File: CSMRF31.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

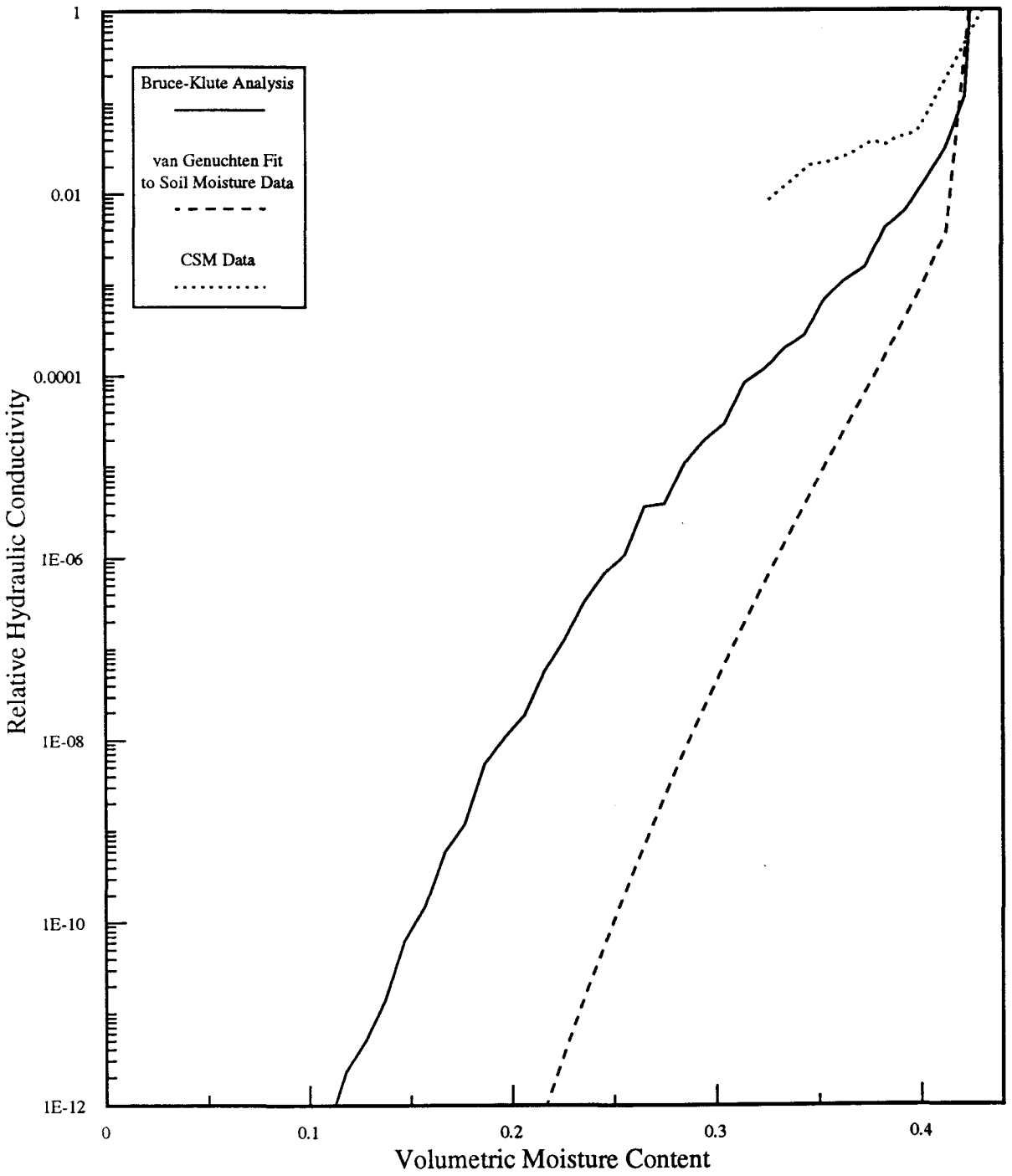
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Comparison of B-K and CSM Analysis
Borehole 02293, 2.9-3.4 ft.

FIGURE 52 OCTOBER 1993

COMATT1B.DRW

Status: 10/27/93



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Unsaturated Hydraulic Conductivity
Comparison of B-K and CSM Analysis
Borehole 02993, 17.0-18.0 ft.

FIGURE 53 OCTOBER 1993

File: COMATT6B.DRW

Status: 10/27/93

APPENDIX A

FIELD DOCUMENTATION

Appendix A-1

Site 1 Preliminary Well-Site Logs

PRELIMINARY WELL-SITE FIELD LOG

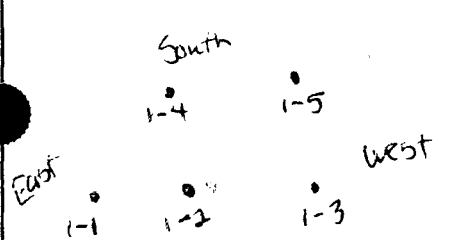
Date: 6/16/93 Borehole Number: Site 1-1 02093

Rig Geologist: LAHost Company: HSI

Recharge Study

			FEET
1	Dry - Gravelly Silt to Silty Gravel with some Sand and roots liner 1/2 full.	1-1	
2	Damp-Dry Silty Clay with some gravel, liner full	1-2	1
3	Same as above Dk. yellowish brown (10yr 4/2) Slightly more gravel.	1-3	
4	Clayey sand, may be calcareous sand. Very Pale orange m.g. Sand. Some gravel. Appears fine. Sample dry.	1-4	2
Note:	Hole Sluffed, had to Drill out 1 ft of Sluff. from 3 to 4 after 2nd Sample taken (2-4 ft sample).	1-5	
5	Appears to be topsoil sluff. See discript of (1) above. 1/2 full liner.	1-6	3
		1-7	
6	Sand + Gravel with possible calcareous matrix, damp to dry very pale orange. m.g. to c.g. sand. Full liner.	1-8	4
7	Same as above. Gravel is to approx. 1.0 in.	1-9	
8	Same as above. More gravel.		
Note:	Sluff fell back in hole off augers. Using Sample rod (3.0") to try + get Sluff. - Successful (measured to 4.0 ft.	1-10	5
9	Gravelly Sand + Clay no color change, as above (calcareous?) damp.	1-11	
10	Sandy Clay with some coarse gravel (~1.5 in.) may be reworked claystone.	1-12	6
11	Sandy to gravelly clay. Damp. As above	1-13	
12	Clayey Sand to sandy clay. Color change of matrix to lt. brown 5yr 5/6. measured depth 6.0 ft.	1-14	7
13	Same as above - damp	1-15	
14	Same as above - damp fine gravel also present.	1-16	8
15	Same as above - damp. Fine gravel.	1-17	
16	Bedrock at bottom of liner. Silty Claystone. Lt Olive gray (5y 6/1) to Clayey Siltstone. Some streaks of whitish silt.	1-18	9
		1-19	
		1-20	10

NOTES: Configuration of Boreholes:



Descriptions from ends of Brass liners. (btm end)

* Drilled with 3¼" auger.

TD = 8.0 ft.

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/17/93

Borehole Number: 02193 Site 1

Rig Geologist: LA Host

Company: ASI

FEET

1 No Sample

2 Gravelly silt + clay, brown with roots (topsoil) dry at 0.5. top is ground surf horizon. Sample must have slipped 0.5' down.

3 Same as above. full recovery

4 Same as above. " " Gravel to ~1.0 in, has some m.g. sand.

5 Liners left out of sampler. Bagged sample

6

7

8

2.0-3.0' ~~3.0-4.0'~~ Same as above.

LAH ~~4.0~~ 3.0-4.0 Sandy Gravel with some silt. Color change to grayish orange 10 yr 7/4. gravel to cobble sized. Damp/dry. sand m.g. to c.g.

9 - 1/2 full with sluff at top.

10 Clayey sand and Gravel - Damp to dry. Wellgrade sand, v.f.g to v.c.g. Gravel - fine to cobbles.

11

12

13 Abandoned at 6.0 ft. Couldnt

14 get thru rock.

15

16

NOTES: Using 4.0 in auger.

* Descriptions from bottom of liners.

02193 02293

02093

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/17/93 Borehole Number: 02293 Site 1

Rig Geologist: LAH Company: HSI

FEET

1 Empty
2 Gravelly Silt + Clay., Topsoil with roots Matrix dk. brown, dry.
3 Silty Sand + gravel, gravel crushed by sampler. Dry. Matrix dk brown
4 Gravelly Clay with abundt. Silt + Sand. v. pale orange (10yr 8/2) to pale yellowish brown (10yr 6/2). Damp/dry.
5 Clayey gravel with abundt Silt + some Sand. matrix moisty v. pale orange. Damp.
6 Same as above
7 Same as above
8 Same as above

9 empty hit rock at 4.3 ft. trying to drill through.
10 empty
11 Stuff from above at top, sand and gravel at btm. Color change to gray on btm. side. Gravelly Sand at btm. fine gravel.
12 Clayey Sand + Gravel - Matrix lt. brown - (10yr 6/6) Damp. gravel to ~~1.5~~ 0.5 in. (broken).
13 ½ full.
14 Clayey Sand + Gravel as above
15
16
17 Clayey Sand and Gravel as above.
18
19 Bedrock in b' n of liner
20 Bedrock weathered Silty Claystone with caliche. lt Olive gray.

NOTES:

E 02293 S 02293 W 02093

Descriptions from btm. of liners.

*Drilled with 4.0 in. auger

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/21/93 Borehole Number: 02393 Site i

Rig Geologist: LAHost Company: ASI

FEET

1 – empty
2 – Grayish Clay with trace sand. Dark brown Clay. Dry.
3 – Same as above.
4 – Clayey Sand, very pale orange. May be Calcareous

0–2

5, 6, 7, 8 – Driller helper forgot liner bagged in ziplock. Full recovery.
2.0–3.0 Same as above with abundt. gravel. Has some sluff from above. Pale orange.
3.0–4.0 ~~Gravel~~ Same as above. Gravel large + broken.

2–4.0

9, 10, 11, 12 – All are Clayey Sand + gravel. matrix dark yellowish ~~orange~~ to lt. brown (10yr 6/6 to 5yr 5/6). Damp. Gravel fine to coarse, broken by sampling.

4.0–6.0

13, 14 – Probably* sluff
15, 16 – Clayey sand as liners and gravel 9–12. Damp

* when driller went back into hole to sample from 6.0–8.0, rod only went down to 5.0 (sluffed in from 6.0 to 5.0). Drove to 6.7' so only bottom 0.7 ft is real, in place sample (liner # 16.).

LAH 6.0–8.0

17 – Silty Gravel, dry, grayish orange. Doesn't really look like sluff but must be.
18 – Empty!

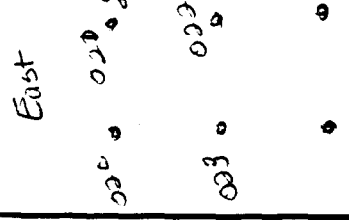
LAH 8.0–10.0

19, 20 – Clayey sand and gravel as in liners 9–12.

21, 22 – Clayey sand + gravel. (Bagged contents of liner to conserve liners.
23 – Top is alluvium, bottom is bedrock.
24 – ~~Clayp~~ Sandy Claystone. to Clayey Sandstone. Damp. Sand is f.g. to v.f.g. weathered, friable. Lt. olive gray to yellowish gray (5y 6/1 to to 5y 8/1).

NOTES:

- TD = 10.0 ft (sampled).
  = 11.0 ft drilled. Will allow to sluff up in to 10.0 ft.



PRELIMINARY WELL-SITE FIELD LOG

Date: 6/21/93 Borehole Number: 02493 Site 1

Rig Geologist: LAHost Company: ASI

FEET

1 Empty
2 Empty
3 1/2 Full - bagged topsoil damp.
4 Full - topsoil + gravel
2nd Spoon measured to 3.9'
5 Bagged - 3/4 full.
6 Gravel and Sandy clay, to clayey Sand. Damp.
7 Same
8 Same
9 Gravel at top. Clayey Sand + gravel at btm. Gravel fine to ~1/2 in. Clay damp. Lt. brown 5yr 5/6. Sand is f.g. to v.c.g.
10 Clayey Sand + gravel as above. More gravel, less Clay. Fine to med. gravel (granules to ~ 0.5 in.)
11 Clay matrix color change to mottled lt. olive gray and lt. brown, damp. Gravel larger pieces. As above.
12 Gravel + Sand.
13, 14 Sluff? Bagged this to conserve liners
15, 16 Clayey sand + gravel. Damp. Lt. brown matrix.
17, 18 Clayey Sand + Gravel.
Top of bedrock estimated at 8.5 ft.
19, 20 Sandy Claystone to Clayey Sandstone.

Last Sample 9.5' Will drill out to 10.5 ft.

NOTES:

E

02493

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/22/93 Borehole Number: 02593 Site 1

Rig Geologist: Theresa Santangelo Company: ASI

FEET

1 empty
2 top soil dark brown dry
3 sand + gravel trace clay light orangish brown; Dry
4 sand + gravel pale orangish brown, abundant clay; Dry
5 sand + gravel, moderate orange pink (5YR 8/4) some clay; Damp. #5 is 3/4 full
6 AS ABOVE
7 AS ABOVE
8 AS ABOVE
9 top appeared to be sluff, looked like topsoil, Bottom sand + gravel, some to abundant clay, light brown (5YR 5/6) damp
10 AS ABOVE
AS ABOVE
12 AS ABOVE
13 top looks like sluff, bottom is as above ~~but~~ ~~abundant~~ 2SR
14 AS ABOVE
15 AS ABOVE
16 AS ABOVE
17 TOP AS ABOVE, BOTTOM Clayey siltstone, some F.G. sand ~~et~~ trace calcarious material; Damp.
18 AS ABOVE
19 AS ABOVE
20 AS ABOVE

1 2 3 4 5 6 7 8 9 10

NOTES:

TD = 10'

Reemed OUT TO

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/22/93 Borehole Number: 02693 Site 1

Rig Geologist: Theresa Santangelo Company: ASI

FEET

1 empty
2 3/4 full - topsoil
3 full - clayey sand + gravel mod. brown (5YR 4/4) abundant roots dry
4 3/4 full - gravel, mod. brown (5YR 4/4) abundant clay + sand; Damp
5 AS ABOVE
6 TOP AS ABOVE, Bottom silty sandy + gravel, very pale orange (10YR 8/2) calcarious? DRY Trace clay.
7 AS ABOVE
8 AS ABOVE
9 - 3/4 full appears to be sluff
10 TOP appears to be sluff, BOTTOM silty sand + gravel, very pale orange (10YR 8/2) calcarious? trace clay; DRY
11 Clayey sand + gravel light brown (5YR 5/4) moist
12 AS ABOVE
13 Sluff - bagged
14 Sand + gravel - Some silt. Matrix mod. brown (5yr 3/4)
15 dry sluff (?).
16 - Sand + gravel, some silt + clay. Damp to moist. Lt. brown to dark yellowish brown matrix (5yr 5/6 to 10yr 4/2).
17 - Empty
18 Gravelly sand + clay, damp
19 Bottom - Bedrock, top gravelly sand + clay damp
20 Bedrock Silty Claystone - Damp.
TD = 9.0ft (sampled)

NOTES:

Appendix A-2

Site 2 Preliminary Well-Site Logs

PRELIMINARY WELL-SITE FIELD LOG

Date: 06/23/93

Borehole Number: 02793 Site 2

Rig Geologist: Theresa Santangelo LAHost.

Company: ~~02793~~ 2HB ASI

FEET

Drove 0'-2'

1 empty

2 clayey sandy Topsoil ~~mod~~ 2YR dark yellowish brown (10YR 4/2) abundant roots; Damp.

3 as above w/ some gravel

4 silty sandy gravel grayish orange (10YR 7/4); Damp.

Drove 2.0-4.0

5 topsoil/Sluff

6 Clayey sand + gravel, damp. to Silty Sand + gravel.

7

8

Drove Sampler 3.0-5.0 to clean out cave-in from 3.0 to 4.0.

Drove 5

9 Sluff

10 Sluff

11 top is Sluff Bottom Clayey sand + gravel with lt. brown (5yr 5/6) matrix Gravel well graded, angular, damp.

12 Same as above

Drove to 7.0

13 - Bagged Clayey sand + gravel as above, damp. Some sluff at top.

14, 15, 16. Clayey Sand + gravel, as above, damp.

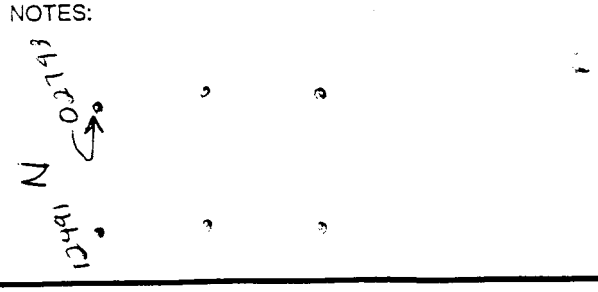
Drove to 9.0

17, 18, 19, 20 Clayey Sand + Gravel, as above

AH 6/23/93

~~20~~ ~~21~~ ~~22~~ ~~23~~ 9.0-11.0 No liners in sampler. Bagged recovery (100% recovery). Clayey sand + gravel. Damp to dry As above.

NOTES:



PRELIMINARY WELL-SITE FIELD LOG

Date: 6/22/93 Borehole Number: 02793

Rig Geologist: LAHost Company: ASI

Liner No.		FEET
	See previous page for 9.0-11.0 ft. interval discription	
9.0-12.0 21, 22, 23, 24	Bagged. Driller did not put liners in tubes. Clayey Sand + gravel.	11
11.0-11.5 ~~25~~, ~~26~~, ~~27~~	Sluff (put in drum)	12
~~28~~	(Btm at 11.5 (11.25?) ft.	
25	Clayey Sand + gravel, damp, as above	13
12.5-14.0 26	Clayey Sand + Gravel with some silt. Lt. Brown matrix as above but gravel is finer.	14
27	Sandy Clay with some gravel (?). Sand is fine to coarse, core is damp. Clay is lt. brown, (5yr 5/6) Trace carb. material	
28	Sandy Clay, no gravel visible in end of liner. Carb. material visible. Sand is f.g. to m.g., lt. brown, damp	15
29	Same as above.	
30	Same as below (Sandy clay).	
14.0-16.0 31, 32, 33	Sandy Clay. lt. brown (5yr 5/6). Damp. Sand is pred. m.g. Soil is cohesive, damp.	16, 17
16-18.0 34, 35, 36	Sluff (no recovery in 34 + 35 found drill rod pin between 36 + 37.	18
37	Sandy Clay. Lt. brown (5yr 5/6) Damp (As above) mottled with a little lt. olive gray clay.	19
17-19 (Sluff 17-18) 38 (18.0-18.5), 39 (18.5-19.0)	Sandy Clay as above.	

NOTES:

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/23/93 Borehole Number: 02793

Rig Geologist: LA Host Company: AST

Liner No.		FEET
40	Sandy Clay to Clayey Sand. Matrix is	
41	Lt. brown as above, damp. Sand is m.g.	
42	Some v.c.g. sand to fine gravel at very bottom	21
43	on interval and in shoe.	
44	Clayey Sand. Matrix Lt. brown, damp. to	22
45	moist.	
46		23
47		
48	Sand with Some Silt or Clay. m.g. to c.g.	24
49	moist. Dark yellowish orange 10yr 6/6. Interval	
50	coarsens toward btm (from f.g. ~~to c.g.~~ to m.g. at 23'	
51	to m.g. to c.g. at 25'. Trace gravel.	25
52	½ stuff bagged.	
53	Sand with Some Silt or Clay. Dark yellowish orange	26
54	(10yr 6/6) m.g. at top with trace gravel to c.g. at	
55	bottom mod. to well graded.	
56	Clayey Sand + Gravel Lt. brown matrix. Damp. c.g. Sand.	27
57	rounded, claystone inclusions (fine gravel size).	
58	V.F.g. Clayey Sand stone (Top of bedrock?). Damp.	28
59	Pale yellowish brown (10yr 6/2).	
	Sandy Claystone. V.F.g. Sand. Gravel in liner is probably	
	stuff from above. Damp. Color as above.	29
60		
61	No Liners top foot appears to be stuff broken cobbles etc.	
62	~~Clayey~~ Sandstone. with Some Clay. V.F.g. Grayish orange	
63	10yr (7/4) to very pale orange (10yr 8/2). Damp	

21.0-21.0 ft
21.0-23.0'
23-25.0'
25-27.0'
27.0-29.0
29.0-31.0

NOTES: Sampled to 31.0 ft. Casing stuck in hole and broken.

2

PRELIMINARY WELL-SITE FIELD LOG

PAGE 1 OF ___

Date: 6/24/93

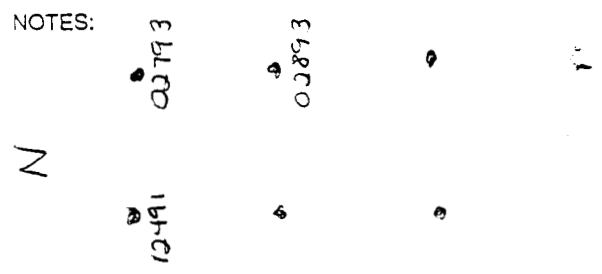
Borehole Number: 02893

Rig Geologist: ~~Theresa Sarangelo~~ LA HOST.

Company: ASI

Depth	Sample	Description	FEET
0.0-2.1	1	Clayey Gravel topsoil (½ full), damp and sand.	
	2	Gravelly Silt with some clay (typical topsoil) abundt. root material at btm of line. matrix dk brown to grayish brown 5yr 3/2.	
	3	Same as above. May have some calcareous material.	1
	4	Silty Clay with some sand trace fine gravel.	
2.1-4.0	5	½ full - emptied into a bag.	
	6	Coarse Gravel in a Clayey Sand matrix, dry	2
	7		
	8		3
4.0-6.0	9	Sandy Gravel with some Clay. matrix lt. brown (5yr 5/6). Damp Gravel coarse. (Typical QRF).	
	10		
	11		4
	12		
6.0-8.0	13		
	14	Clayey Sand + Gravel. Damp. Typical Qrf as above.	5
	15		
	16		6
7.5-9.5	17		
	18	Clayey sand + Gravel Damp. Sand fairly coarse.	
	19		7
	20		
9.5-11.5	21		
	22	Clayey sandy gravel, damp. As above.	8
	23		
	24		9

NOTES:



PRELIMINARY WELL-SITE FIELD LOG

Date: 062493 Borehole Number: 02893

Rig Geologist: Rose M. Zeller Company: ASI

		FEET
11.5-13.6	25 Mostly gravel, rock fragments ~~w/~~ some red clayey sand	
	26 As above	
	27 Red clayey sand at base, rock fragments at top.	
	28 Red clayey sand, no gravel, damp	
	Shoe Red Clayey sand	
13.6-15.6	29 Red ~~sandy clay at base~~ clayey sand	MOIST
	30 "	
	31 Red + gray sand clay at base, red clayey sand at top	
	32 Red + gray sandy clay	
15.3-17.1	33	
	34	
	35 As above, some to trace small gravel damp to moist.	
	36	
17.6-19.6	37	
	38	
	39 As above, some gravel fragments in 37 - sloughed from above? ~~Note~~ Note:	
	40 Sample not full diameter of liner	
19.0-21.0	41	
	42 As above, sample not full diameter of liner	
	43	
	44	
20.4-22.5	45 As above, moist, clayey sand, some fine gravel.	
	46	
	~~47~~ Note: pushed liners up. recovered 1.6' at top of this	
	~~48~~ interval. Shoe + ≈ .3' in core barrel same as above	

NOTES: ~~Begin Box #3 at 47.6 Sample #33~~ RMZ 6/25/93
Begin Box #3 at 15.3', Sample 33, end at 23.0', Sample # ~~36~~ 47

PRELIMINARY WELL-SITE FIELD LOG

Date: 063593 Borehole Number: 02893

Rig Geologist: Ralph Zeller Company: ASI

FEET

23.5-24.5
47 Red clayey sand w/ large gravel, moist.
48 Red clayey sand, some gravel (small), moist
49 As above
Shoe As above

24.5-26.0
50 Red clayey sand at top turning to gray green gravelly clay, damp.
51 Gray green gravelly clay changing to reddish clayey gravelly sand
52 Reddish clayey gravelly sand, moist - slightly?
53 As above

26.0-27.0
54 Gravelly clayey sand, reddish, moist. good sample No.
55 As above at top, gravel fragments at base. NO
56 Mostly gravel - ~~[illegible]~~ moist - very
57 Sandy gravelly clay - moist to wet - free water?

27.0-28.9
58 Sandy clayey gravel. moist to wet
59 As above but w/ rock fragments. *
60 fine gravelly clayey sand. moist to wet.
61 Bedrock at 30.3' weathered sandstone - clayey + fine gr.

TD at 30.8'

NOTES: Begin Box #4 at Sample # ~~53~~ 48 (23.0')
Augered through 26.0 - 27.0 - Cobbles in hole.
*/No means not a good sample
Broke auger in hole. Tried unsuccessfully to dig it out w/ 10" auger. Will try to fish it out. Augers down about 3.0'.

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/28/93 Borehole Number: 02993 - Site 2

Rig Geologist: Theresa Santangelo Company: ASI

		FEET
Drove 0'-2'	1 empty	
	2 Clayey gravel Topsoil Dk yellowish brown; Damp	
	3 Gravelly silt, abundant sand, trace clay; Dry	1
	4 AS ABOVE	
Drove 4.9'-6'	5 1/2 full - light gray sand & gravel; Dry (NOT saved in liner)	2
	6 Clayey sand & gravel, some silt, lt brown (5YR 5/6); Damp	
	7 Same AS Above but the color ranging to grayish orange (10 YR 7/4)	3
	8 AS ABOVE	
Drove 6'-8'	9 TOP Appears to be Sluff, bottom description same as # 10, 11, + 12.	4
	10 Sand & gravel, grayish orange (10YR 7/4), abundant silt some clay; Damp.	
	11 AS Above	5
	12 AS Above	
Drove 5.2'-8'	13 AS ABOVE	6
	14 AS ABOVE	
	15 AS ABOVE	7
	16 AS ABOVE	
Drove 7.1'-9'	17 - 3/4 full - Sluff	8
	18 - Sluff	
	19 - Clayey sand & gravel, lt. brown (5YR 5/6) some silt; Damp	
	20 - AS above	
Drove 9'-10'	21 - 1/4 full - sluff - did not save	9
	22 - Sluff	
	23 - Sand & gravel, lt. brown (5YR 5/6) abundant clay; Damp	
	24 - AS Above	

NOTES:

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/28/93 Borehole Number: 02993 - Site 2

Rig Geologist: Theresa Santangelo Company: AST

		FEET
Drove 10.1'-12'	25 clayey sand & gravel, lt brown (5YR 5/6); Damp	
	26 AS Above	– –
	27 AS Above	–11–
	28 AS Above	– –
Drove 11.8'-14'	29 AS Above	–12–
	30 AS Above	– –
	31 AS Above	–13–
	32 clayey sand, lt brown (5YR 5/6) some carbonaceous mat.; ~~Damp~~ MOIST	– –
Drove 14'-16'	33 AS ABOVE	–14–
	34 AS ABOVE	– –
	35 clayey sand/sandy clay, lt. brown (5YR 5/6) some carb. material moist.	–15–
	36 AS ABOVE	– –
16.0-18.1	37 Same as above.	–16–
	38* *Would make good sampler	– –
	39*	–17–
	40*	– –
18.1-20.0	41 Sandy Clay grading to clayey sand. Dark yellowish orange (10YR 6/6) moist.	–18–
	42*	– –
	43	–19–
	44	– –

NOTES:

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/28/93 Borehole Number: BH 02993 Site 2

Rig Geologist: LAH/TSD Company: ASI

Depth	Sample	Description	FEET
20.0-22.2	45*	Clayey Sand to Sandy Clay as above. Moist. Sand pred. well graded, trace c.g near btm. of interval.	
	46		21
	47		
	48		
22.2-24.0	49	~~S~~ Clayey Sand as above	22
	50		
	51		
	52	note: 0.15' extra recovery at top of sampler (above liner 44). Sluff? core slid in liners.	23
26.1-28.0	53	Clayey Sand and Gravel. Moist. Gravel to cobble sized.	24
	54		
	55		
	56	Driller noted bounce on rock at ≈ 25.5 ft.	25
Sluff to 27.4 26.1-28.0	57		
	58	Clayey Sand + Gravel as above. Moist.	26
	59		
	60		
27.4-29.0	61	Sluff (Rock fragments, discarded. Probably Sluff. discarded.	27
	62	Clayey sand with abundt. Gravel lt brown (5yr 5/6). Damp	
	63		
	64	Sand + gravel with abundt clay. Damp.	28
Drove 28.8-31	65	<1/4 full sluff	
	66	Appears to be sluff at the top. bottom is as above	29
	67	sandy clay/clayey sand, grayish orange pink (5YR 7/2) some gravel; moist	
	*68	Clayey Sand; grayish orange pink (5YR 7/2); ~~very~~ ISR moist	

NOTES:

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/29/93

Borehole Number: 03093-Site2

Rig Geologist: Theresa Sammarello

Company: ASI

FEET

Drove 0-2'

Top 0.9' - Slayey Sand, Dark yellowish brown (10YR 4/2) abundant gravel some roots; Dry

bottom 0.7' - Silty gravel, grayish orange (10YR 7/4) abundant sand some Clay Dry

Drove 1.5'-4'

As Above (recovery = 1.7')

TOP - 0.3' = Sloff

BOTTOM 1.7' = Silty gravel, very pale orange (10YR 8/2) abundant sand, some clay; Damp

Drove 4'-8'

As Above (Full recovery)

Drove 7.3'-10'

As Above

NOTES: SAMPLES from 0'-12' are collected in baggies.

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/29/93 Borehole Number: 03093-Site 2

Rig Geologist: Theresa Santangelo Company: ASI

FEET

Drove 8.3'-12.1'

TOP 1.3' - Sand & gravel, lt. brown (5YR5/6) some clay Damp.

BOTTOM 0.7' Sand, lt. brown (5YR5/6) some clay & carb. material Damp.

Drove 11.35'-14'

1 - TOP as above w/ trace gravel, bottom - sandy Clay & lt brown (5YR 5/6) some carb material; moist

2 AS Above

3 AS Above

4 - TOP as above, bottom becoming sandier

Drove 15'-16'

5 Sandy clay/Clayey Sand, lt. brown (5YR5/6), some carb. material; moist

6 As Above, trace gravel

7 As Above, No gravel

8 As Above, trace gravel

Drove 15.8'-18'

9 As Above, w/ gravel at top None at bottom

10 As Above, w/ no gravel

11 As Above

12 As Above w/ gravel on bottom

Drove 17.3'-19

13 - Sloff (NOT saved)

14 -

15 - clayey sand, lt. brown (5YR5/6) some carb mat., trace gravel

16 - As Above moist.

Drove 19.1'-21.2

17 As Above

18 As Above

NOTES: #'s 1, 2, 3, 4, Good for analysis

#'s 5, 6, 7, 8, Excellent for analysis

#9 Good

10, 11, 12 - excellent

#15, 16 - Good

#'s 17, 18, 19, 20 - excellent

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/29/93 Borehole Number: 03093

Rig Geologist: Theresa Santangelo Company: ASI

FEET

19 AS Above
20 AS Above
21 - Sandy clay/Clayey Sand, lt. brown (5YR 5/6) ~~some~~ trace carb material, trace gravel; moist
22 AS ABOVE
23 AS Above
24 AS above
25 - 1/2 - full - AS Above (in baggin)
26 AS Above
27 AS Above
28 AS Above
29 TOP - clay - bottom sand & gravel, lt. brown (5YR 6/4), Abundant clay; moist
30 AS Above
31 AS Above
32 AS Above
33 - 3/4 full Clayey sand & gravel, lt brown (5YR 5/6); moist.
34 Sand & gravel, lt. brown (5YR 5/6) Abundant clay; moist
35 Sand, lt. brown (5YR 5/6) Abundant Some Clay; wet
36 TOP - AS Above, bottom clayey sand & gravel
37 TOP - wet sand - bottom clayey gravel - wet
38 sandy claystone/clayey sandstone, Dark yellowish orange (10YR 6/6) wet
39 AS Above; moist (very)
40 AS Above > 3/4 full

Drove 21.2'-23'

Drove 23'-25'

Drove 24.9'-27'

Drove 26.7'-29'

Drove 28.9'-31'

NOTES: # 21, 22, 23, 24 - Good

TD = 31'

37, 38, 39 - excellent

40 - Good (Not full)

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/30/93 Borehole Number: 03193-SIT 2

Rig Geologist: Theresa Santangelo Company: ASI

FEET

1 - EMPTY
2 - TOP - TOP Soil, bottom - gravel, trace Clay Dry
3 AS Above. w/ some Clay
4 AS Above
5 - TOP appeared to be Sluff, bottom = Silty Sand + gravel, grayish orange (10 YR 7/4); some to trace clay; Dry
6 AS Above
7 As Above
8 As Above
9 - Sluff - discarded
10 - Sluff - discarded
11 - AS Above
12 - AS Above
13 - sand + gravel, lt brown (5YR 5/6) some clay; moist
14 - TOP - as above, - bottom gravel lt. gray; Dry
15 - Sand + gravel, lt. brown (5YR 5/6) some clay; moist
16 - AS Above
17 - Sluff
18 - Sluff
19 - Clayey Sand + gravel, lt brown (5YR 5/6); moist
20 - AS Above

DRILLED OUT - NO SAMPLES

Drove 0'-2'
Drove 1.9'-4'
Drove 2.9'-5'
Drove 4.7'-7'
Drove 6.3'-8.5'

NOTES: #2-8 - poor for analysis
#11 + 12 - poor " "
#19 + 20 - OK? " "

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/30/93

Borehole Number: ~~036~~ 03193-Site 2

Rig Geologist: Theresa Santangelo

Company: ASI

FEET

DRILLED OUT. NO SAMPLES

11

21 - Sandy Clay/Clayey sand, mottled lt brown (5YR 5/6) + lt olive gray (5Y 6/1); moist. Trace gravel

12

22 - As Above

23 - As Above

13

24 - As Above - becoming sandier at bottom

Drove 12.2' - 14.2'

25 - As describe for #'s 21, 22, & 23 w/ some carb material.

14

26 - As Above

27 - As Above

15

28 - As Above

Drove 13.6' - 16'

29 - As Above (top looked like sluff)

16

30 As Above

31 - As Above

17

32 - As Above

Drove 16' - 18'

33 - As Above

18

34 - As Above

35 - As Above

19

36 - As Above

Drove 17.9' - 20'

NOTES: #21-24 Good for analysis

#25-28 - Excellent for analyses

#30-32 good " "

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/30/93 Borehole Number: 03193-Site 2

Rig Geologist: Theresa Suttangelo Company: ASI

	FEET	
37 - Sandy clay / clay w/ Sand, lt. brown (5YR5/6) trace gravel & carb material moist		
38 - As Above	21	Drove 19.9'-22'
39 - As Above		
40 - As Above		
41 - Top - sloft, bottom - as Above - No gravel	22	
42 - As Above		
43 - As Above	23	Drove 21.6'-24'
44 - As Above		
45 - As Above	24	
46 - As Above		
47 - Sand & gravel, lt brown (5YR5/6), Abundant clay (moist)	25	Drove 23.8'-25.8'
48 - As Above		
49 - Gravel, abundant Sand, trace clay; Dry	26	
50 - As Above w/ some clay		
51 - As Above	27	Drove 25.8'-27.9'
52 - As Above w/ trace clay		
53 - Sand & gravel, lt. brown (5YR5/6) some clay; Dry	28	
54 - As Above w/ abundant clay; moist		
55 - As Above	29	Drove 27.8'-29.9'
56 - As Above		

NOTES: #37-44 (excluding 41) - excellent for Analysis
#45 & 46 - good
#47 - OK
#48 - poor
#53-56 poor

PRELIMINARY WELL-SITE FIELD LOG

Date: 6/30/93

Borehole Number: 03193

Rig Geologist: Theresa Santangelo

Company: ASI

FEET

57 - TOP - sloff - bottom - Clayey sand ~~stone~~, lt. olive gray (5Y 6/1) iron stain; very moist

58 - TOP as above; bottom as above w/ some gravel & wet

59 - ~~[illegible]~~ bottom - sandy claystone, mottled lt. olive gray (5Y 6/1) & lt. brown (5YR 6/6) some carb material; moist

60 - Clayey sandstone; moist

31

32

Drove 29.8'

TD=32'

33

34

NOTES:

#58 - good for analysis

#59 - good " "

#60 - excellent " "

PRELIMINARY WELL-SITE FIELD LOG

Date: 7/1/93 Borehole Number: 03293 - Sirex

Rig Geologist: Theresa Sottangelo Company: ASI

FEET

1 - empty
2 - empty
3 - fell out of liner - Sandy gravelly top soil Dark yellowish brown (10YR4/2) Dry
4 - as Above
5 - 2½ full stuff - saved in baggies
6 - Silty sand & gravel, grayish orange (10YR7/4); Dry
7 - As Above
8 - As Above
Drilled out NO samples
9 - As Above
10 - As Above
11 - As Above
12 - As Above
13 - Top = stuff Clayey sand & gravel, lt. brown (5YR5/4); moist
14 - As Above
15 - As Above
16 As Above
17 - As Above
18 Top = stuff, bottom Sand & gravel, abundant clay lt brown (5YR5/6) Dry - moist
19 - as above w/ only some clay
20 - As above
21 - As above

1 — Drove 0-2'
2 — Drove 1.9'-3.5'
3 — Drove 4.1'-5.9'
4 — Drove 5.9'-8'
5 — Drove 7.8'-8.3
6 — Drove 8.5'-10.5'
7 — 8
8 — 9

NOTES: #4 poor for analysis
#6-8 " " "
#9-12,13 " " "
#14-16 ok " "
#18-21 poor " "

PRELIMINARY WELL-SITE FIELD LOG

Date: 7/1/93 Borehole Number: 03293

Rig Geologist: Theresa Samangelo Company: AST

FEET

22 - Top = sluff, Bottom - clayey sand & gravel, lt. brown (5YR5/6) moist.
23 - As Above
24 - As Above
25 - As Above
26 - As Above
27 - As Above
28 - As Above
29 - Top As Above; bottom = sandy Clay/Clayey sand, lt brown (5YR5/6) some carb material; moist
30 - As Above, but mottled w/lt olive gray (5Y6/1)
31 - As Above
32 - As Above
33 - As above
34 - Top sluff - bottom - as Above
35 - As Above
36 - As Above
37 - As Above
38 - Top sluff; bottom As Above but becomming more clayey
39 - As Above
40 - As Above
41 - As Above; but becoming less clayey again like abov

11 — Drove 10.3'-12'
12
13 — Drove 11.9'-14'
14
15 — Drove 13.9'-16'
16
17 — Drove 15.7-18'
18
19 — Drove 17.7'-20'

sample interval

NOTES: # 22-25 - Poor for analysis
26-33 - good for analysis
34-41 - excellent

PRELIMINARY WELL-SITE FIELD LOG

Date: 7/1/93 Borehole Number: 03293

Rig Geologist: Theresa Santangelo Company: ASI

FEET

42 - TOP Sluff - bottom AS Above, but NOT mottled

43 - AS Above — 21 — Drove 19.8' - 22'

44 - AS Above

45 - AS Above — 22 —

46 - AS Above

47 - AS Above — 23 — Drove 21.8' - 24'

48 - AS Above w/ trace gravel

49 - AS Above — 24 —

50 - AS Above

51 - AS Above — 25 — Drove 23.7' - 26'

52 - AS Above

53 - AS above — 26 —

54 - Sluff & NOT in contact w/ casing, only string of soil (emptied)

55 - AS Above — 27 — Drove 25.9' - 28'

56 - Sandy clayey/clayey sand, lt brown (5YR 5/6) trace gravel moist.

57 - TOP as above; bottom - clayey gravel, dark yellowish brown (10YR 4/2); moist — 28 —

58 - TOP - Sluff; bottom sand & gravel, some clay; Dry

59 - Clayey sand & gravel, lt brown (5YR 5/6); moist — 29 — Drove 27.6' - 30'

60 - Sand & gravel, lt brown (5YR 5/6) some clay moist

61 - AS Above

NOTES: #50-53 - excellent for analysis

#56 - poor " "

#58-61 - poor " "

PRELIMINARY WELL-SITE FIELD LOG

Date: 7/1/93 Borehole Number: 03293

Rig Geologist: Theresa Santangelo Company: ASI

	FEET
62 - Sand & gravel, lt brown (5YR 5/6) Abundant clay moist	
63 - Clayey Sand, lt brown " " , Abundant gravel; moist to wet	31
64 - Sand, some gravel trace clay; wet	
65 - Silty Sandstone, dk yellowish orange (10YR 6/6) moist to wet.	32
TD = 32	33
	34
	35
	36
	37
	38
	39

Drove 29.8' - 32

NOTES:

Appendix A-3

Site 1

Drilling, Soil Sampling, and Hydroprobe Access Tube Installation Field Notes

060993 LAH

0730 LAH arrived at Sub yard
Driller not in had to reschedule
pre-ev. meeting waited for driller
and Mark Thornbrough

0815 Driller arrived, did not have
correct casing. Brought 5½" Solid
stem casing.

Must have 3½" max diam.

Layne supplied 5½" augers
when we asked for 2" augers

Casing is 3½" ID

0830 RFP drill - locked down
Called Tim Stein, told him
we can't use them if
they can't give us the
3½" borehole we asked
for he will call back

1000 T. Stein called back. He located
the augers + bit we needed.
Sent drillers to pick them up.

Dean Bennett Supply Co.
Dean Bennett 286-1500
1770 E. 61 Ave

Chuck Albritton Mobile 670-1505
Beep 0632

Grant @ home 733-4158

Tim Stein 755-1281

Kunkel @ home 986-0562

Carey Consumables 6214
6629

Traffic 3313 (Newton Robe)
Joe, Mike, Dave, Rose
Kaz(?)

Nick Kusaldas Hm. 420-8245
w.k. 469-6660
RFP 5892

Recharge Proj. #
989083

LAH 060993 2

1130 Drillers returned to site with augers. Setting up Pre-Ev.

1300 Met at inner east gate at pre-ev.

LA Hoot
RM Zeiker
GC Evenson
MG Waltermire
M Thornbrough
D Kaskie
William Stanton Layne Env.
Roger McKay Layne Env.

Pam McCorkle EG+G Const. Cont

Mike Pepping EG+G (Drums)

Warren Dawson EG+G
L.A Johnson EG+G
Stan Lazinski EG+G

LAH 060993 3

1320 Pam began meeting at Site
Safety Auditors checking up.
Exclusion Zones
Stepoff pads
Completed ~~dr~~ meeting

1400 Met with Rob Smith at Work trailer. Rob says there's a glitch in the H+S Plan, can't drill till next week. Will call in an Aerotek HSS.

LAH 060993

0730 GAII arrived at west gate to meet GCE to learn about neutron probe use + transportation.

0735 GCE arrived

Neutron Probe

Secured vehicle w a net

Grant will have a class on 6/17 from 9:00-11:00 User Custodian class for a radioactive class

H+S Plan behind front seat

Storage unit in Lakewood
Keyed lock
Lock down to copy machine on right.

Conex key has a blue tag is attached to the padlock key.

For VADOSE

Grant has a log book.
Scott always with.

AB-2 + AB-1 water level measure with an electric tape.

Log AB-2, AB-3, AB4
AB-1 (bent?) so don't meas. w/Probe.
Traffic gives a Courier Receipt
final grant throws away once complete

Material Transfer GA17

Arriving at trailer
HSS fills out Contamination Survey, 3 smears - collar, case, cable (before use)
per EMRG
periodically clean case of dust

Post use 3 smears - collar, case cable

then fill out material Transfer tag

1-6 061093 GAH

Hydroprobe manual behind seat of truck

Film badge control box is on Grant's desk @ ofc.

Probe Operation

14 hours to charge

Charge supposedly good for 6 weeks

Dot in lower left of window if battery is low.

Markers on cord with ink on them are rust

Does not hurt probe to be submersed. 15' marker @ 4.0 ft.

Display always on.

Position sitting on top of casings

1-7 061093 GAH

Press start and count

Standard Count
10' away from any hydrogen source (include humans)
(See Section 2.6)

061093
GAH

1-8 061593 LAH

Wednesday

0730 LAH arrived on site - (Subsyd)
0930 LAH gathering Supplies

0930 Called Rob Smith for Holes #'s + sample #s.

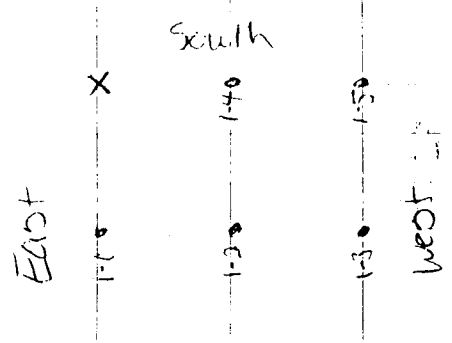
Not left messg

0935 Heading out to Recharge location.

H+S Gregg Brott
Drums Deanna Kaskie
Geo LAHost
Driller Roger McKay
Helper Bill Stanton

1000 Setting up to drill on site 1

Configuration Site 1



1-9 061693 LAH

Drillers have 63 brass liners
We have 30 brass liners
" " 25 plastic "
118 total

Liners will be numbered begining at ground surface and increasing with depth.
1
2
3
4 etc...

Site 1-1

1105 Sampling 0-2.0 ft.
measured depth 1.9 with sluff.

1113 Sampling 2.0-4.0

Hole Sluffed in 1 ft. had to drill out 1 ft of sluff from 3.0 to 4.0 ft.
Sluff kept falling back in.

1133 Driller going in with a 3 in. spoon to try to get the sluff

LAH

061693
Wednesday

1-10

Out to 4.0 ft.
Hole has widened at top (to approx. 2.0 ft down. St.11 looks like 3" diameter below 2.0 ft.

1140 Measured depth at 4.0 ft so 3.0" spoon was successful in removing stuff

Sampling 4.0 to 6.0.

1146 Measured depth 6.0 ft.

1148 ~~Measured~~ LAH Sampling 6.0-8.0
~0.3 in of stuff fell in hole while removing rod.

Bedrock noted in sample tube 1-16 (~7.5 ft to 8.0 ft)
Very silty claystone.

TD in Site 1-1 8.0 ft
Will drill out another few inches to make room for tip on casing.

LAH

061693

1-11

1207 Cuttings not coming up auger so we'll have to clean out with spoon to 8.3 ft.

Could not get casing into bore-hole so tried reaming.

Rocks are a problem are scouring sides of borehole and not allowing PVC ~~in~~ casing in borehole.

Driller will go back to yard to try and find slightly larger augers.

1330 Left site to return to sub-yard.

1345 Called NJK to discuss problem. He suggested we use the aluminum casing on the starter holes and pound in with a sledge.

061693 12

1400 Talked to R. Smith and told him our problems.

Nick said we must do a standard count on the borehole with the probe within 15 minutes of when the casing is inserted. Must measure very accurately the interval counted because we'll use calibration samples at those intervals.

Nick said it's better to use smaller casing than to drill a larger borehole.

We can use the aluminum casing and do standard counts with the probe. The different materials will be corrected for in the calculations using different calib. curves for the different holes.

1450 Left RFP for evening.

3

061793
Thursday

Sample #'s
BH 00001AS - 00005AS

Location No's
02093 - 04493

Borehole ~~2~~ 1-1 to 2093

0130 - Getting clarification from RMZ + NJK on how to proceed.

Waiting on health + safety instrument calibration

1100 Headed out to Site 1.

1030 Begun drilling out 1-1 (02093) with the ~4" auger.

1105 Drilled out with 4" auger couldn't get casing down the hole still. Only got casing to approx 7.2 ft. down.

Weather wet misty rain

1106. - told drillers to leave casing at 7.2 ft. Will drill next hole an extra 2.0 ft. to allow room for sluff to fall in and still get casing to desired depth. Told drillers to hold until I do a probe reading on this hole

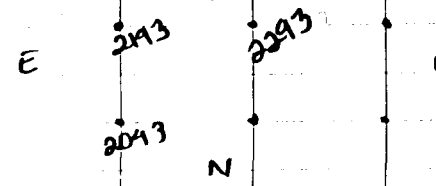
~~0203~~

Probe	Std. Count	02093
1	6th notch	4901
2	8th notch	4621
3	10th notch	4865
4	12th notch	4520
5	14th notch	5051
~~6~~	~~16th notch~~	
~~7~~		
~~8~~		
~~9~~		
~~10~~		

Location 02193A5

1124 Began sample 0.0-2.0'

Personnel onsite
Roger McKay
Bill Stanton
L. Host
G. Brott.



Drove sample to ~~to~~ 2.0ft. however when measured, hole was at 1.7ft due to sluff fall in.

1128 driving 2.0-4.0 (sample will have sluff at top). 0.3" of sluff.

Sluffed in to 3.6' will drill out to 4.0 before driving next sample.

* Driller forgot sample tubes (liners) bagged all of sample.

061793
Thursday

LAH

1146 Drillers cleaning out hole with 3" sampler to 4.0 ft.

1152 Driving sample 4.0-6.0 ft. Sampled to 6.0' but sluffed back in to 5.3' so driller will clean out with 3.0" sampler.

Large rocks have fallen into borehole will have to try + pulverize. borehole diameter will be questionable to at least 6 ft due to all of the borehole cleaning and tripping in + out of borehole.

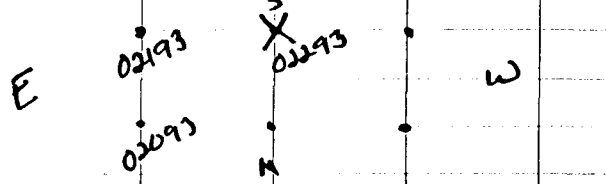
1220 Could not get thru rock at 6.0 ft. Will offset 1.0 ft. and try again.

Break for lunch. Drillers will decon augers while we're gone.

LAH

061793
Thursday

1320 Began sampling 0.0-2.0'
02293



Sampled to 2.0'; 0.5 ft of sluff fell in hole.

1325 Sampling 2.0-4.0 (sluff from above will be in hole.)

1334 Driving sample 4.0-6.0 ft. there was ~0.3' sluff hole measured to 3.7' b-4 sample. We are driving sample before drilling out

1340 Hit rock at 4.3'. Will try to drill through.
Had to drill to 6.0 ft. Could not sample thru rock.

1400 ~~Sampling 6.0-8.0~~ LAH
Cleaned out hole to 5.8'

5.8'-7.8'

1405 Sampling ~~6.0-8.0~~
Drove ~~the~~ Sampler 2.0' but hole measured at 1.0 so we must have 0.8' Sluff in hole.

1415 Drove sample rod ~~to~~ to 8.8' due to the 1 ft of sluff in hole.
Driller later said 8.7'
Bedrock was in bottom of sample spoon. Had one liner full of Silty-Claystone with caliche stringers.

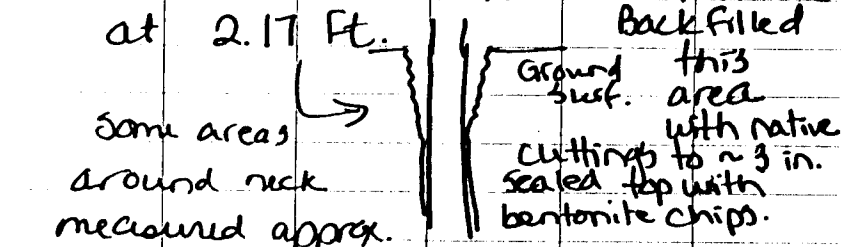
Told driller to drill a sump in bottom of borehole to allow sluff to fall in but not affect depth of casing

1425. Had to send neutron probe back to Lakewood due to traffic's schedule.
We will cover the casing

Thursday

on this borehole with plastic for the night. Borehole should not loose much moisture to to 100% humidity conditions (heavy misty to drizzly condts) put aluminum casing in borehole Casing measured 10.0 ft. + length of conical tip. Measured 2.0 ft from ground surface to top of casing.

Measured depth of caved in section around neck of borehole at 2.17 ft.



Some areas around neck measured approx. 1.5 ft.
This means these first ~~to~~ two feet's readings will be questionable in this borehole at best.

1500 Left field for day. Rain and at end of the borehole.

LAH 6/17/93

061893
Friday

0730 - Met with Rose and Roger re: air rotary: Roger says air rotary will blow out hole more than augers (i.e. cause more damage to formation) and I realized it would dry the formation so we nixed that idea.

Drillers can't decon so it's standby today due to decon delay.

We called off drilling anyway due to inclement weather. Misting rain, predicted to become heavy at times.

0840 Neutron Probe Readings
02093

PVC stick up = 3'
1st reading on 3rd Notch, reading = 5069
2nd reading on 4th notch, reading = 4846

061893
Friday

NOTCH	Reading
5	5550
6	5319
7	4776
8	4615
9	4904
10	4976
11	4633
12	4536
13	4925
14	5077
~~15~~ 6/10/93	

NOTCH	READING
1	2981
2	5368

BOREHOLE 5022, PVC STICK UP = 2'2"

NOTCH	Reading
1	7228
2	7068
3	7825
4	7097
5	6933
6	6824
7	6373
8	5688
9	5772
10	6549
11	6895

NOTCH	READING
12	63[illegible]
13	6554

1030 Completed Recharge Activities for day

1-22 062193 LAH

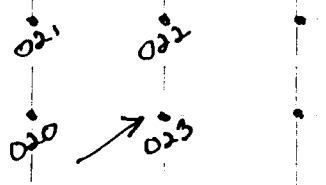
Monday

0730 LAH arrived at Sub yard, RFP. Gathering supplies and personnel to drill.
Waiting on instrument calibration
Drillers deconned augers

0815 Drillers headed out to site to set up rig. Waiting on TJD and Greg Brott to return with calibrated instrument.

Weather: Sunny, high of 85-90°F expected. Predicted afternoon thundershowers.

Will set up to drill 02393.



LAH 62193

Monday

1-23

0855 Sampling 0-2.0' on 02393
0.4" sluff fell in at 2.0-4.0
Will drive sampler to 6.0 without cleaning out.

0920 Sampling 6.0-8.0. Some sluff had fallen into hole.
got to 6.7' and hit sampler refusal. Will go in and drill to 7.0 ft.

this series will contain sluff the sampler was full and was only driven to 6.7' started at 5.0' so there was at least 1.0 ft. of sluff.

0935 Driller cleaned out hole to 6.0' and is driving sample from 6.0-8.0' if we have full recovery, top 0.7' will be sluff. (Liner # ~~11.0~~ 17)
LAH 62193

062193 CAH

0941 Sampled to 8.0', did not encounter bedrock will drive another sample

Bedrock encountered in 8.0'-10.0' sample. Bedrock at approx. 9.25' Sandy claystone to clayey sandstone

Drilled to 11.0 ft with 3¼ in auger will drill out with 4.0 in auger to F.D. to disturb borehole diameter as little as possible.

Installed casing ~~(4.0 in o.~~ 3.0 in.) p.v.c.

We are using # 10 sieve and sieving native material to put down in air space between casing and borehole (any voids)

Alt taking standard count with neutron probe
final reading: M 7663

M.
1031 7798 Did not appear to go thru the 32-8 sec. counts as shown in instruct. book.

1037- Counting 02393

1st	notch	4934
2nd	"	5130
3rd	"	4827
4th	"	4626
5th	"	4866
6th	"	4802
7th	"	4768
8th	"	4592
9th	"	4262
10th	"	4538
11th	"	4430
12th	"	4159
13th	"	5302
14th	"	6183
15th	"	

LAH 062193 1-26

1100 Moved rig to location
02493

Sampled 0.0-2.0'
top two liners empty
3rd liner ½ full with topsoil
4th full.

1105 Sampled 2.0-4.0.
measured to 3.9'
rock in btm. of shoe at 3.9'

1113 Sampling 3.9-5.9'
Drove sampler to 6.0
measured after sampler
was removed to 5.6'

1128 was only able to drive to
7.0 ft. on next run (6.0-8.0)
on rock. Will drill out to
7.0 ft and try to sample.

LAH 062193 1-22
LAH
Monday

1134 Drilling out with 3¼" auger
trying to get past rock.

Drilled out to 7.5 ft. to get
past rock. When sampler was
removed, hole sluffed in to 6.0 ft.
- Told driller to clean out hole
to 7.5' with 3" spoon. We
will then drive a sample to
7.5' to 9.5' feet. Will probably
be in rock by then.

1200 Hole keeps caving. We will
clean out with 4.0 in. auger
and try again.

1215 Taking a break to cool down.

1230 attempting to clean out
hole again.

1236 - Started a new standard count on probe. Did not do it the same way as in instruction book.

Pressed "STD" displayed "ready"
then "step" displayed a #
" "step" displayed a "P-#"
" "step" displayed a "new std ct?"
pressed "enter" it then started counting.

1238 Driller reported hole measured to 7.5' - sampling 7.5-9.5'
Bedrock in sample at approx. 8.5'.

1245 EG+G shut down all drilling due to lightening in the area.

1255 Neutron Probe Standard Count
Display 57702.
pressed "Step" P 7716
" " Chi 0.88

1345 Returned to site to finish drilling out and to install casing.

Installed aluminum casing

1405 - Neutron Probe Readings

1st Notch	7359	
2	7678	7718
3	7009	
4	6794	
5	7351	
6	7201	
7	6610	
8	6672	
9	6570	
10	6336	
11	6694	
12	8544	
13	10047	
~~14~~		
~~15~~		

1430 Had to pack up for day due to need for neutron probe to leave site.

TSD to take probe to West gate then get rad instrument calibrated.

1520 LAH + TSD Left site for day.

LAH 6/2/93

0730 LAH arrived onsite. Arranged with Const. Coord. to have Theresa, Danas Warner + Greg Brott pre-evéd.

0815 Gathering supplies, drillers decanning.

0915 Setting up to drill 02593.

02593

Theresa taking samples + directing drilling. See her notes re this hole's samples

0945 Taking neutron probe stand-and count.

S 7695
P 7702
Chi 0.95

02293 LAH
~~Wednesday~~ LAH
Tuesday 6/22/93

Preparing tensiometers for installation.
~~in~~ tensiometer lengths are measured from the middle of the porous cup to the line delineating the gage assembly.

When cleaning out 02593 to put casing in, driller had to drill thru a rock so borehole is probably pretty badly slowered. Also took so long to drill that probably generated alot of heat drying out soil before we could take readings on it

Neutron Probe Readings.
1st set before backfilling with sieved material from drum. Cuttings were too dry pulverized rock.

62293
LAH

Notch	1	4392
	2	5375
	3	5102
	4	4616
	5	4601
	6	4178
	7	4154
	8	4119
	9	4263
	10	4477
	11	4467
	12	4455
	13	4396
	14	5096
	15	

Second set of readings taken after PVC was backfilled (these readings suspect)

NOTCH:	Reading	NOTCH	Reading
1	4523	7	4415
2	5470	8	4317
3	5114	9	4449
4	4905	10	4620
5	4709	11	4539
6	4360	12	4529
		13	4487
		14	4451

2nd set of readings 6/22/93 LAH

Notch	Reading
1	4583
2	5516
3	5180
4	4851
5	4754
6	4402
7	4394
8	4296
9	4331
10	4522
11	4677
12	4582
13	4491
14	4423
15	5195

Somehow got too many measurements - probably counted one notch twice.

6/22/93
LAH

LAH 02393 1

Wednesday

0130 LAH arrived at ASI Sub yard Preparing to go out in field

0820 Heading out to site with Drillers, TSB + Greg Boot. Weather sunny, High of 80°F predicted

0830 Drilled out 02693 to ~100 ft. with 4" auger

0840 Installed 10' length of casing.

0845 Counting with neutron probe:

Notch	Reading				
1	4276	5	5181	10	4503
2	4604	6	4619	11	5116
3	4698	7	4650	12	5132
4	4809	8	4642	13	5614
		9	4685	14	6002
				15	

18 06 16 93

10:30 Arrived at first location to begin WL measurements in well point. Began a Well Point #5.

6/16/93

06 21 93 19

7:15 Picked up soil moisture gauge.

7:45 Met traffic at west gate

8:00 Obtained new soil [illegible]

8:55 Arrived at [illegible] recharge site installed 2 boreholes & took soil moisture counts

14:25 Left site

6/21/93

JAR 062293

7:00 Picked up soil moisture gauge.

8:00 [illegible] w/ Pan M.

8:35 Arrived at 1st Recharge site.

9:05 Drillers arrived on site

9:15 Drilling began boring 02593

Drove the spoon from 0' to 2' hole depth = 2'

Drove spoon from 2' to 4' hole depth = 3.6 so there's 0.4 of sluff. Driller is going to drive to 6.0' & collect the 0.4 feet of sluff in sluff barrel

Spoon driven from 3.6'-6.0' sluff barrel contained about 0.4' helper threw it out

JAR 062293 11

bottom of hole measured 5.6' ∴ 0.4' of sluff all sleeves full

Next drive attempting to drive to 8 feet.

Drove sampler to 8.0'. Depth of hole measured 7.8' ∴ 0.2' of sluff to sample through on next run. All sleeves full

Drove sampler to 10.0'. Depth of hole = 9.7'

Drillers left to get 5 foot sample barrel.

We will attempt to clean out the hole w/ the 5' sample barrel because it has a 3.5 inch OD this method did not work.

Drilled out boring w/ 4" augers to about 10 feet. Bottom of hole = 8 feet. So we went back in w/ the 3" OD sampler to clean the hole out. TD = 9.8'

We were able to push the PVC to 3.6 feet

13:30 Began drilling borehole # 02693

Drove spoon 0-2'. bottom of hole measured 2'

Drove spoon 2'-4'. Bottom of hole measured 4.4'

Drove spoon to 6'. Bottom of hole measured 5.4 ∴ there's 0.6' of sluff to drive over in next sample.

Drove spoon from 5.4'-8.0 Measured 6.8 Sluffed into hole 1.2 ft. will try to clean out by driving sampler to 9.0 ft. should get 1.2 ft sluff + 1 ft sample.
Sampled to 9.0 ft Bedrock at between 8.0 and 8.5.

23.

1430 Cleaning up location
1445 Left Site for Subyard
TSD to get rad instrument calibrated

14:30 JSD met traffic to transport soil moisture probe.

15:00 obtained new rad meter

15:20 left site & transported ~~rad~~ JSD inst. back to storage.
Soil moisture

JSD 062293

7:00 Picked up soil moisture guage.

7:40 Met traffic at west gate

8:30 Arrived at recharge site #1 began drilling to reem hole out. Installed casing in 02693.

8:55 Cleaned up site.

Returned to trailer to get info. on next site.

10:30 Drums were being moved off site.

10:50 Connie Dodge & Rob Smith arrived on site

11:00 Shut down due to faulty meter

11:05 ~~Be~~ began drilling
Drove sample 0'-2' hole measured 1.85'

11:15 Shut down due to inst. failure

11:30 Returned to trailer

12:00 Met w/ Mark & headed out to field area W-11

Took a background reading on road south of propane tank w/ instrument # B089G
Reading = 1779 cpm

Background check for inst. # A532R = 2,379 cpm.

Fitted all of area W-11

LSD 6/23/93

Appendix A-4

Site 2

Drilling, Soil Sampling, and Hydroprobe Access Tube Installation Field Notes

1

62393
Wednesday

LAH

0900 Cleaning up site, preparing to move on to Site 2
LAH to go with S Thompson to do neutron counts at STP for vadose

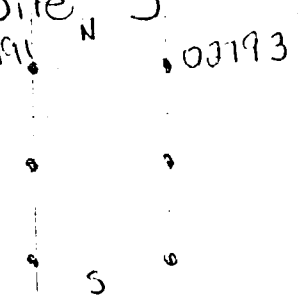
0925 Taking standard count on probe at the STP

S 7716
P 7695
Chi .89

entered new S count

1224 - Back at Recharge - Drilling on Site S

02793



Personnel: Roger McKay Driller
Bill Stanton Helper
Greg Brott Aerotek
L. Host ASI

LAH

062393
Wednesday

1

TSD took sample from 0.0-2.0 before lunch. Hole caved to 1.85.

1230 Drove sampler to 4.0 ft. Hole caved to 3.0. Cleaning out hole with sampler.

Drove this sampler to 5.0 ft. So liners 9 + 10 will be sluff + thrown away.

1245 Drove sampler 5.0-7.0 Hole stayed open + was measured to 7.0.

1255 Driving sample 7.0-9.0'. Measured to 8.8' (0.2 ft of sluff).

1312 Drove sampler to 11.0 ft. Hole measured to 10.8 ft.

1330 Drove spoon to 11.5 then hit refusal. Will have to drill out.

062393
Wednesday

1357 Drilled down to 12.0 ft to get thru rock. Will use the 0.5 ft from ~~11.0~~ 11.5-12.0.
Driller measured to 11.8
Will sample to 14.0

** Note: Rogers measurements have not been corrected for the 0.1 ft his tape is off. Dallas did correct for these. Will need to correct all of Rogers measurements. Told Roger to keep measuring the way he's used to doing it and we will correct later.

1400 Driving sample to 14.0'. Full recovery

1410 Driving sample to 16.0

1420 Driving sample to 18.0 ft. Measured to 17.8'

062393
Wednesday

1500 Drilled out hole to 18.0 ft. Hole slumped to 17.0. Driller ~~drill~~ sampled to 19.0' so top was slump. Measured hole to 19.0'

1521 Measured hole to 21.0 ft. drove sample 19-21.0 ft.

1530 Sampled to 23.0 ft. Driller measured hole to 23.0 ft

Sampled to 25.0 ft.

Sampled to 27.0 ft hole measured to ~~29~~ 26.5' will drive sample to 29.0' appears to be bedrock.

Sampled to 31.0 ft. to bottom foot is v.f.g sandstone. top foot was slump. Setting casing to 31.0 ft. Drilling out to 32.0 ft. Hole stayed open to 32.0 ft.

1655

1-41 062393 LAH

1709 tried to push casing could not push the whole way down. tried to pull casing out casing broke in borehole at threads. trying to pull out with augers.

1730 LAH 6/23/93
1530 Could not get casing out - will have to drill through. Will cover borehole to prevent moisture loss and drill out tomorrow

1730 LAH 6/23/93
1530 Unloading core boxes and trash changing out.

1750 LAH & Greg Brott left site for day

6/23/93
LAH

LAH 062493 1-41
Thursday

0800 LAH had doctor's appt. TSD filling in this a.m. See her field book for notes on a.m. drilling.

Talked to Rm2 (0730) she said she needs to show Woodward-Clyde Site 1 & get permission to install tensiometers while they are drilling if not we will have to install today. I told her she will have to relieve me on the rig if we have to do today. Told her to talk to Geoprobe guys since she's at the trailer and I'm not at RFP.

0930 LAH arrived at trailer
1000 LAH relieving TSD at location 02793. See TSD's field book for notes on this hole.
TSD reported G. Brott did not arrive till 0810

062493
Thus.

1300 We don't have enough clean augers to drill 02893. Decon pad is closed indefinitely due to Woodward Clyde personnel problems (dosimeters yanked due to expired rad training). Decided to field decon cleanest augers with Liquinox + triple rinse so we could keep on drilling and we're not taking characterization samples.

1353 Taking 1st sample on 02853 0.0 - 2.0' measured to 2.1 ft.

02441 02443 02893

1400 Sampled 2.1 - 4.0 Caved in to 3.6'

1410 Sampled 4.0 - 6.0 Caved to 5.9'

062493
Thus.

1430 - Sampled to 8.0 ft. Caved to 7.7'. Sample rod is hanging on a rock. Told Roger to drill out with 4.0" auger to 8.0 ft to get thru rock. Data from 0.0 - 8.0 would have been questionable anyway due to cave ins and scouring (concerned that 0.0 - 8.0 will dry out too much before counting if we drill it out today since we won't be able to finish hole today).

Got ok from grant to use augers (smears clean)

1446 Rm2 coming to site to relieve me while I install tensiometers

Drilled out to 8.0 ft. Hole caved 7.5'

Sampled 7.5 - 9.5 ∴ top 0.5' probably sluff

9.5 – 11.5 Split spoon
Slough to 11.2
11.5 – 13.6 Split spoon
13.6 – 15.3 – Split spoon
1545 some slough
1610 15.3 – 17.1 – Split spoon
1600 Shut down due to notice from ASI trailer that the Victoreen Victoreen Model 458 (rads), had not been calibrated –

1615 Drillers left site

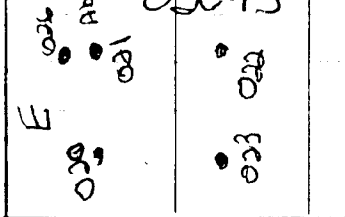
1625 RMZ + Greg Brott brought instrument back to Truck DCD Calibrate.

LAH installed lysimeters at Site 1 with Geoprobe Terry
Jerry

0730 LAH arrived onsite. Drillers were at Subyard RMZ to cover rig this morning (see hr notes re drilling).
Deanna Kaskie to do drums
Greg Brott H+S
Roger McKay - Driller
Bill Stanton - Driller Helper
Weather is sunny warm.

0900 LAH measuring casing at Site 1, checking ~~lysi~~ tensiometers.

Borehole No.		Height of Casing
02093	PVC	3.05 ft
02193	abandoned	
02293	alum	2.10 ft.
02393	PVC	1.95 ft
02493	Alum	0.40 ft
02593	PVC	1.70 ft
02693	PVC	0.85 ft ← casing moved when trying to remove plug



1-

062593
Friday

6/17

0905 Met Woodward Clyde Geologist Bob Waddell

0920 Rob Smith stopped by Site 1 and we discussed ~~to~~ the status of installation.

0925 Measuring casing heights Rob suggested wetting (slowly) bentonite collars.

0936
Tensiometers

12 in. 22 centibars
Still full of water
pumped once, went back to 22 centibars

6 in. 30 centibars
Still full of water
pumped once, 28 cb.

24 in. - 0.2 ft short of TD. 36 centibars
after 3 pumps (still had water

AH

062593
Friday

1-4

18 in. 50 centibars full of water

36 in 10 cbars (water level in tensiometer was below ground surf refilled reservoir, filled tensiometer still read 12 ~~to~~ centibars

~~1014 Hydroprobe Standard Count~~ GAH 6/25/93 meas. at btm of notch.

* measuring from very top of fittings.

Hydroprobe notch measurements (begin of cord.)

Notch 1	3.4 ft (btm of 1 m mark
2	~~1.41~~ .42 is 1 m)
3	~~0.57~~ .57
4	.41
5	.56
6	.44
7	.56
8	.45
9	.52
10	.49

11	.53
12	.48
13	.59
14	.44
15	.51
16	.46
17	.54
18	.46
19	.54
20	.49
21	.53
22	.97
23	1.00
24	1.000
25	1.00
26	0.97
27	1.0
28	0.99
29	1.1
30	1.0
31	1.0
32	1.0
33	1.0
34	1.0
35	0.99

1045 Neutron Probe Std. Count
Before Count: S 7752
P 7716
Chi 1.05

After Count: S 7700
P 7752
Chi 0.75

Borehole 02893

1330 Relieved Rose as Rig Geo.
Drillers were able to recover broken auger. Hole had caved with rocks to about 8.0 ft. Drilling out with 4.0 in. auger. Will not install casing all the way to bedrock. Don't want to loose another auger.

Could only get casing to 23.0 ft. Will install casing then backfill with material Rose saved.

Will be a very questionable borehole.

6/25/93

1350 Neutron Probe counts

Notch		2nd count
15	4926	4840
16	5400	4647
17	5458	
18	4621	
19	4361	
20	4387	
21	4452	
22	4494	
23	5155	
24	5705	
25	6385	
26	6325	
27	6173	
28	6329	
29	5791	
30	5578	
31	5866	
32	6139	
33		

062593
Friday

1500 Turning drum Sampler over to Yankey.

Attempted to find status of drillers. May be on decon pad.

1515 Preparing to leave RFP for day.

1530 left site for day. Drillers are on Decon pad. Will notify GCE when they leave.

LAH
6/25/93

062893
Monday

0730 LAH arrived onsite.
- Greg Brott to be H&S since J. Yancey filling in for Don Nelson on ~~the~~ 903 pad.
- TSN to drill for LAH until noon.
- Drillers are deconning till we get ready to go today.
-

0845
Checking Tensiometers at Site 1

6 in. 68 centibars
2 pumps refilled the chamber - 56 cb

24 in. 6 centibars
may have been dried out during pumps
22 cb

18 in. 78 centibars
4 pumps filled chamber
52 cb

062893
Monday

36 in. 0 centibars
dry?
91 pumps to fill chamber
12 cb (bubbles rising)

12 in. 60 centibars
2 pumps to fill chamber
44 cb.

last pressure reading after ~5 min (from refill of chamber.

0915 LAH left site for office

Will analyze these sample for:
6 samples
1.) Main Test
Diffusivity - Capillary Moisture (Triaxial Chamber)
2.) Grain Size (when done with main)
3.) Spec Gravity
4.) Moisture content (first)

Advanced		LSM
1 dist		1 dist
1 undist		1 undist
Between	(% fines)	
20-30	60-70	

LAH LAH

562893
Monday

1338 Taking Neutron Probe
Std. Count

Before Count
S 7700
P 7752
Chi. 0.75

After Count
S 7662
P 7700
Chi: 0.90

1350 TSD took over drilling
LAH Checking Tensiometers at
Site 1.

6 in 70 cb.
1 pump. Numerous air
bubbles at top.
54 cb

24 in 22 cb
water level below groundsurf.
31 pumps to fill
24 cb

62893
Monday

18 in. 70 cb
2 pumps to fill
54 cb

36 in. 4 cb.
83 pumps to fill
18 cb

12 in. 62 cb
2 pumps to fill
52 cb

1400 Heading back to Subyard to
LAH 6/28/93 ~~reco~~ pick samples to send
to lab.

6 28 93
LAH

6/28/13

0700 Arrived at RFP Sub yard
0715 GCE + LAA to site 1 to
read tensiometers

6 in. 74 cb.
1 pump to refill chamber
56 cb

24 in. 10 cb
51 pumps to refill chamber
20 cb

18 in. 76 cb
3 pumps to refill chamber
54 cb

36 in. 0 cb
85 pumps to refill chamber
10 cb

12 in. 68 cb
1 pump to refill chamber
50 cb

7:30 Arrived on site

8:00 Retrieved new rad Inst.

8:30 Arrived at Recharge site 2 at Boring 02793

8:45 Drilling began. Sent augers down hole, augered into broken casing & pulled it out of the hole.

Hole was reamed to 32'. Augers came up wet. We measurement was taken & water depth = 28.5'. The hole was open to 29'

I asked the drillers to install the casing just shy of 28.5'

After consulting w/ Laurie H. the plan is to install the casing to 30'.

The casing would not go deeper than 5 ft, ∴ the hole was

reamed to 10' w/ the 4" augers ~~then cleaned out using the sampler~~. The hole was open to 23'. Roger cleaned out the hole using the 3 1/4" augers.

0945 LAH took over for TSD

1000 Casing would still not go in past 10.0'. Told drillers to auger to ~~15.0'~~ LAH 12.0 ft with 4" augers, clean out hole and try again to install casing.

1045 Casing still would not go in hole. Put drillers on standby to consult with Rmz & JRK on what to do.

1115 Rmz and Kunkel ok'd drilling with 4.0" auger to TD. Rmz did not want to use smaller casing. Kunkel said it was ok

28 62493 LAH

1130 Thursday

Had to fill out RFP clearance just for MGW.

1145 - Lunch

1215 - Resumed drilling on 02793 with 4" auger. Taking standard count with neutron probe.

Recorded readings in LAH field book.

Rest of field notes are in LAH field book.

LAH
6/24/93

02493 6/17

1130 Thursday

Had to fill out RFP clearance just for MGW

1145 - Lunch

1215 - Resumed drilling on 02793 with 4" auger. Taking stand and count with neutron probe.

Recorded readings in LAH field book

Rest of field notes are in LAH field book

LAH
6/24/93

7:45 arrived on-site obtained new rad inst.

8:45 arrived at site 2 & began drilling borehole 02993.

Drove the first spoon from 0-2'. Bottom of hole = 1.9' 1.9'

Drove next spoon 2'-4' bottom of hole read 3.8' 3.7

Drove sample 4-6' Bottom of hole = 5.8' 5.7'

Drove sample 6' = 5.7'-3' bottom of hole = 7.1'

Driller went back in attempting to drill to 9'

Drove sample 7.1'-9', bottom of hole = 8.2'

Since hole kept falling in we attempted to drill to 9'

Augered down to 7.5' & broke of part of bit in hole.

062893 ZBD

Went back in hole w/ different bit & drilled down to 9 feet

Bottom of hole measured 8 feet after we pulled out

Will drive 8'-10'
Bottom of hole = 10.1'

Drove from 10.1'-12'
Bottom of Hole = 11.8'

Drove Next sample from 11.8'-14'
Bottom of hole = 13.4'

Drove Next sample from 13.4'-16'
Bottom of hole = 15.8'

Driller having extreme difficulty ~~drill~~ pulling equip out of hole.
∴ is going to drill it out.

11:30 Driller was AT 12' when I left site. I told him to drill TO 16' & STOP WORK

BOREHOLE MEASUREMENTS - UN CORRECTED

HK 062893 3

1155 LAH arrived at site

1155 Drove Sampler to 18.1'
Had drilled to 16.0 ft.

1205 Drove sampler and measured to 20.0.

1212 Drove sampler and measured to 22.2 ft.

1230 Took a break to get water + gatorade. (H + S Break)

1245 Sampling 24.0-26.0
Driller reported hitting rocky layer at ~ 25.5. Sampler "bouncing hard"
Sampled to 26.0, measured to 26.1'
Sampled to 28.0'
Shifted to 27.4'

1325 Drove sampler to 29.0'
measured to 28.9'

1332 Sampling 28.9-31.0.
hit wet sand at 31'

02893 RMZ

0835 Arrive at Site 2, 02893.
Crew: Deanna Kaskie, Greg Brott, Driller Roger McKay, and helper; Bill Stanton
0840 Set up site and begin drilling ~~drive~~ Augered down to 17.6
0855 Begin sampling w/ split spoon
17.6-19.6 Drove sample
Slough to 19.0
19.0-21.0 Drove sample
0900 Rob Smith, CTR, visited site
Slughed to 20.4
20.4-22.5 Drove sample
0923 Slughed to 22.0
Used plastic liners beginning at 20.4-22.5 interval
0935 22.5-24.5 (Jammed sampler down) left down to 22.5
Slughed to 24.0
0955 Augered to 24.5

COC 989083

02893 6/25/93

Having trouble w/ plastic liners - bending, sliding up. Return to brass for next sample interval.
24.5-26.0 Drove sample
Difficulty driving this interval. Stopped .5' shy of 2.0 interval
1005 Open to 26.0. Shoe shows rock (boulder) fragments at base. Attempting to drive a sample
~~26.0~~ 26.0-26.8 Augered. Slughed to 25.2
1045 Now trying to drive through ~~boo~~ boulder (cobble).
25.2-27.0 Picked up slough - Discarded contents of sampler. Apparently we are past the boulder (cobble)
~~27.0-29.0 drove long~~
1055 27.0-29.0 drove sample
Slughed to 28.9
1107 28.9-30.9
Slughed to 30.8
1120 "

Recharge 6/25/93
O 2843

1120 Augering.
1123 Take off auger about 2' down in hole.
6 1138 Drillers return w/ 10" OD augers. Plan is to over-drill and lock into broken augers to pull them out of the hole.
1210 Did not work. Drillers left site to call office for fishing tool. Break for lunch at 12:15.
12:15 Leave site ☆

☆ Left augers in hole. Bagged cuttings. Shovelered excess cuttings into hole to keep moisture in. Tamped down. Hole moisture should be okay.

7:30 Arrived on site, was informed that the HNu was not functional & needed to be brought back to Hanco. Guest left to exchange HNu.

Discussed remainder of project w/ rose & Laurie.

Copied forms for project & caught up paper work.

Drillers moved rig onto new location.

Went on stand by till Steve arrived at least.

10:30 Arrived at site 2 boring 03083

10:40 Drilling began.

Drove the 1st spoon 0-2'
bottom of the hole read 1.9'

Sampler driven 2'-4'
bottom of hole = 3.8'

10:52 Drove next sample 3.8'-6'
BOTTOM of hole = 5.1'

11:05 Drilled out hole to 6.0'

Drove sample from 6.0'-~~7.2~~ 8'
Bottom of hole = 7.2'

Drove sample 8'-10'
Bottom of hole = 9.2'

11:32 Drilled OUT TO 10' pulled out, bottom of hole measure 9.3' deep.

11:43 Drove next spoon from 9.3'-12'
bottom of hole = 11.85'

Drove 12'-14'
Bottom = 13.6'

Drove Sample from 13.6'-16'
Bottom of hole = 15.9'

Drove 15.9'-18'

BOTTOM of hole = ~~17.8~~ 17.7'

12:20 Drilled OUT TO 18' because equipment getting hung up in hole

Bottom of hole = 17.2'

13:00 Drove sample 17.3'-19'
BOTTOM of hole - 19.1'

Drove Sample from ~~at~~ 19.1' TO 21.2.
Bottom of hole - 21.2'

13:11 Drove next spoon 21.2'-23'
Bottom of hole = 23'

Drove sample 23'-25'
Bottom of hole = 24.9'

13:33 Drove Sample 24.9'-
Bottom of hole = 26.7'

13:45 Drove Sample 26.7'-29'
Bottom of hole = 28.9'

13:36 Previous STD Readings
S = 7700
P = 7752
CHI = 0.75

13:37 Began STD COUNT
Readings = S = 7668
P = 7700
CHI = 0.99

Drove sample 28.9'-31'
Bottom = 30.8'

14:14 Began Drilling TO TD

14:25 TOP Auger broke w/ ~25' of Auger in the hole
Drillers Dug Down ~1.5' TO Get TO joint & Attached a new auger.

15:05 Began Drilling again

15:30 Reached TD at 32'. hole open TO 29.7'
Installed casing TO 28.75'
backfilled around casing

15:37 Began soil moisture readings
(OVER)

Bottom of hole = 7' ∴ We went in w/ the sampler to clean out the hole.

Sampler went from 7'-9' w/ extreme difficulty. Bottom of hole = 9.1'

Because of it was so difficult to hammer the spoon down. Roger did not feel we could sample the next interval. ∴ he continued to drill to a depth of 12'. Bottom of hole = 12.2'

10:28 Drove Sampler from 12.2'- Bottom of hole = 13.6'

Drove Next sample from 13.6'-16' Bottom of hole = 16'

10:45 Drove Next Sample from 16'-18' Bottom of hole = 17.9'

10:57 Drove Next sample from 17.9' to 20' Bottom of hole = 19.9'

Drove sample from 19.9'-21 Bottom of hole at 21.6'

11:17 Drove Sample from 21.6'-24' Bottom of hole = 23.6'

Driller was having difficulty getting tools out of hole & needed to drill out. To 24'

11:35 Previous STD COUNTS TAKEN:
S = 7700
P = 7752
Chi = 0.75

11:36 Began STD COUNT
S = 7650
P = 7700
CHI = 1.22

Bottom of hole after drilling = 23.8'

11:5[illegible] Drove Sample from 23.8'-25.8' Bottom of hole = 25.9'

Drove Sampler from 25.9'- 27.9'
Bottom of hole = 27.8'

Drove Sampler from 27.8'- 29.9'
Bottom of hole = 29.8'

Drove Sampler from 29.8'- 31.9'
Bottom of hole = 31.4'

12:45 Began drilling OUT TO TD w/ 4" Augers Drilled out TO 32'

13:40 Bottom of the hole = 30'

Bottom of casing set at 30'

Stick up - 2.45'

13:45 Began Soil moisture readings (see form)

14:30 left site

[illegible] Received soil samples to Hal

10:20 Arrived at site 2 borehole 03293

10:30 Drillers moved rig & left to get a drum.

10:50 Drillers returned to site

10:55 Drilling began

Drove 1st spoon 0'-2'
Bottom of hole = 1.9

10:55 Drove next spoon 1.9'- ~~2~~3.5'
Bottom of hole = 2.8'

Drilled out to 4.1'

Drove next Sample from 4.1'-5.9'
Bottom of hole = 5.7'

Drove spoon 5.9'- 8'
Bottom of hole = 7.8' - ~~7.8'~~

Drove Spoon - 7.8' ~ 8.3'
Could not drive any further so we drilled out to 8.5' could

12:45 not drill any further so we tried sampling again

12:45 Drove spoon from 8.5' to 10.5'
bottom of hole = 10.3'

Drove next spoon from
10.3' - 12'
Bottom of hole ~~12'~~ 11.9'
Top 0.2' should be sluff

13:10 Drove spoon 11.9' - 14'
Bottom of hole = 13.8'

13:25 Drilled out because of difficulty getting spoon out of hole. Bottom of hole = 13.8'

13:54 Drove next spoon from
13.8' - 16'
Bottom of hole = 15.7'

13:58 Drove next spoon from 15.7' - 18
Bottom of hole = 17.7

Drove next spoon 17.7' - 20'
Bottom of ~~shoe~~ hole = 19.8'

Drove next shoe 19.8' - 22'
Bottom of hole = 21.9'

Drove next sample 21.9' - 24'
Bottom of hole = 23.5'

14:25 Drilled out to 24'
Bottom of the hole = 23.7'

Previous Std count
S = 7700
P = 7752
CHI = 0.75

14:32 Begun Std count.
S = 7647
P = 7700
CHI = 1.12

14:44 Drove next spoon 23.7' - 26'
Bottom of hole = 25.9'

Drove next spoon 25.9' - 28'
Bottom of hole = 27.6'

2

46 070193 LSD

15:03 Drove next spoon 27.6 - 30'
Bottom of hole = 29.8'

15:13 Drove next spoon 29.8' - 30' 32'
Bottom of hole - 31.3'

15:30 Drilled out to 33'
Bottom of the hole = 30.8'

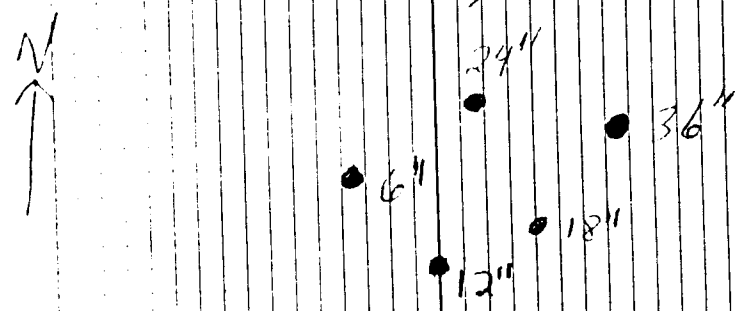
16:25 4:25 Casing was installed to 31' 11"
using 3" OD PVC
3', 1" stickup

16:30 Started probe reading

hole was backfilled

21 071693 42

8:00 Primed all tensiometers
9:00 Arrived at site 2
set up locations & moved
rig onto 1st spot
installed five tensiometers
in the following orientation



124 91 - 2191 10.8'
02793 - 124 9.6, 02793 - 211 = 6.2
02893 - 124 = 7.05, - 02793 = 4.65, 211 = 7.7
03093 - 124 = 4.95, - 211 = 11.5, - 2893 = 4.65
03193 - 124 = 9.7, - 211 =

Appendix A-5

Monitoring Field Notes

~~6/28/93~~ LAH

6/29/93 Tuesday

0700 Arrived at RFP Sub yard

0715 GCE + LAH to Site 1 to read tensiometers

6 in. 74 cb
1 pump to refill chamber
56 cb

24 in. 10 cb
57 pumps to refill chamber
20 cb

18 in. 76 cb
3 pumps to refill chamber
54 cb

36 in 0 cb
85 pumps to refill chamber
10 cb

12 in. 68 cb
1 pump to refill chamber
50 cb

LAH 7/19/93

0715 LAH arrived at Sub yard.

0930 LAH + JWY arrived at Site 2 to put sunscreens around tensiometers

Site 2

36" - 36 cb Still full of water - 4 pumps to top off
~~6 cb~~ 32 cb

24" - 0 cb 59 pumps to fill (may have been empty)
6 cb

18" - 42 cb 3 pumps to fill
38 cb
~~40 cb~~

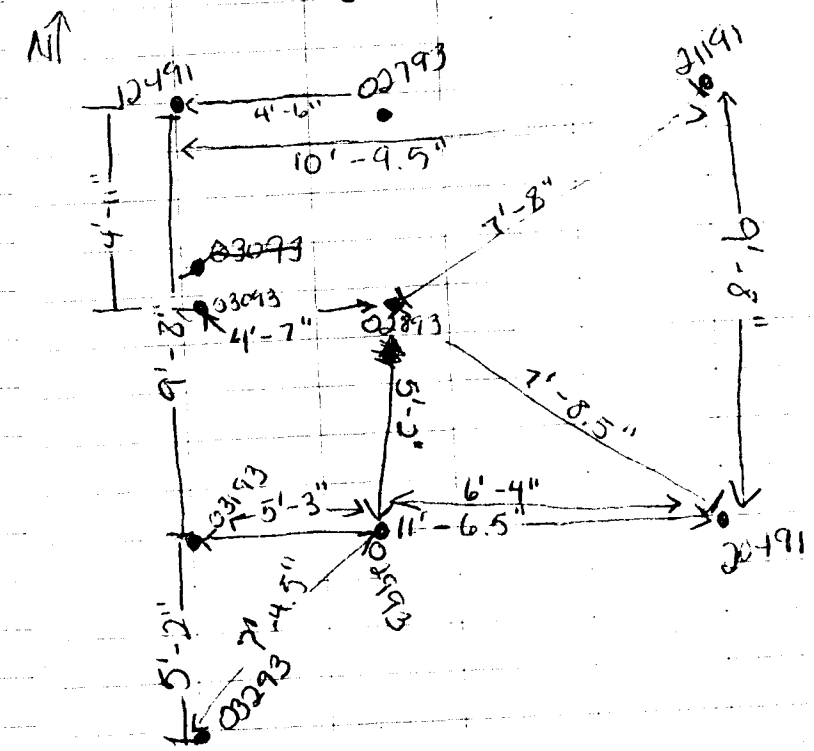
12" - 64 cb 3 pumps to fill
~~40 cb~~ 42 cb

6" - 47 cb 3 pumps to fill
~~40 cb~~ 42 cb

HoD 071993

1017 Completed Sunscreens at Site 2.
Began measuring off distances

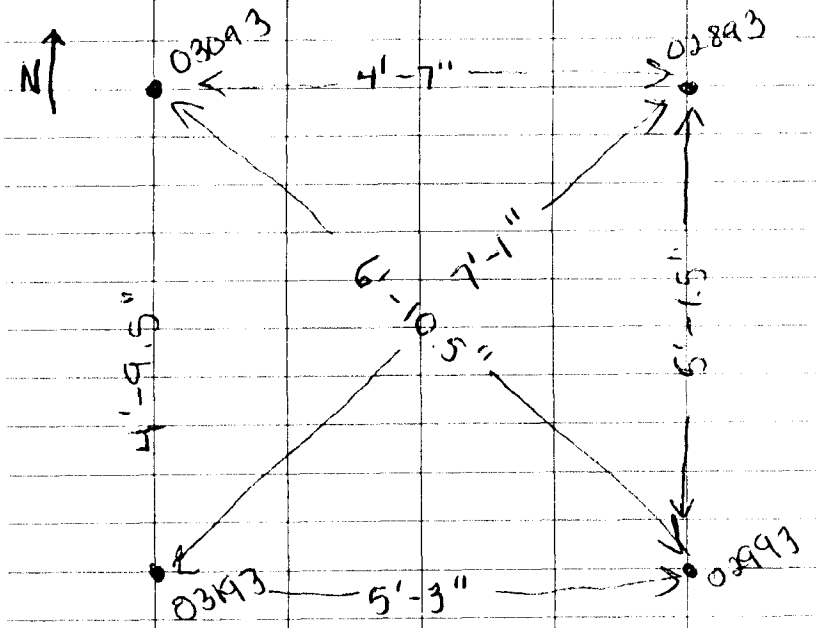
12491 to 21191 10'-9.5"
to 02793 4'-6.0"
02793 is 2.5" South of a line |b| 12491 + 21191



Hol 07 19 93

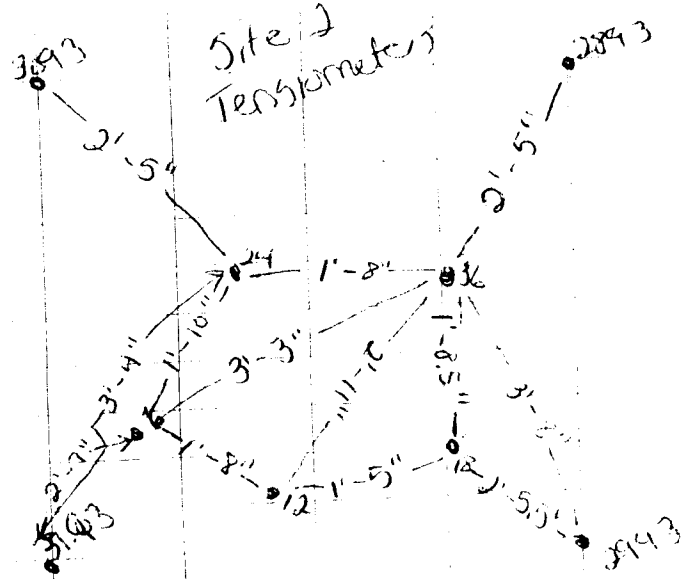
Diagonal |b| 21191 + 03193 14'-7.5"

measured 03093 off a line |b| 6.5"
12491 + 03193



1-62 071493

Site 2 Tensiometers



1-63 071493

110c Moved to Site 1 Tensiometers

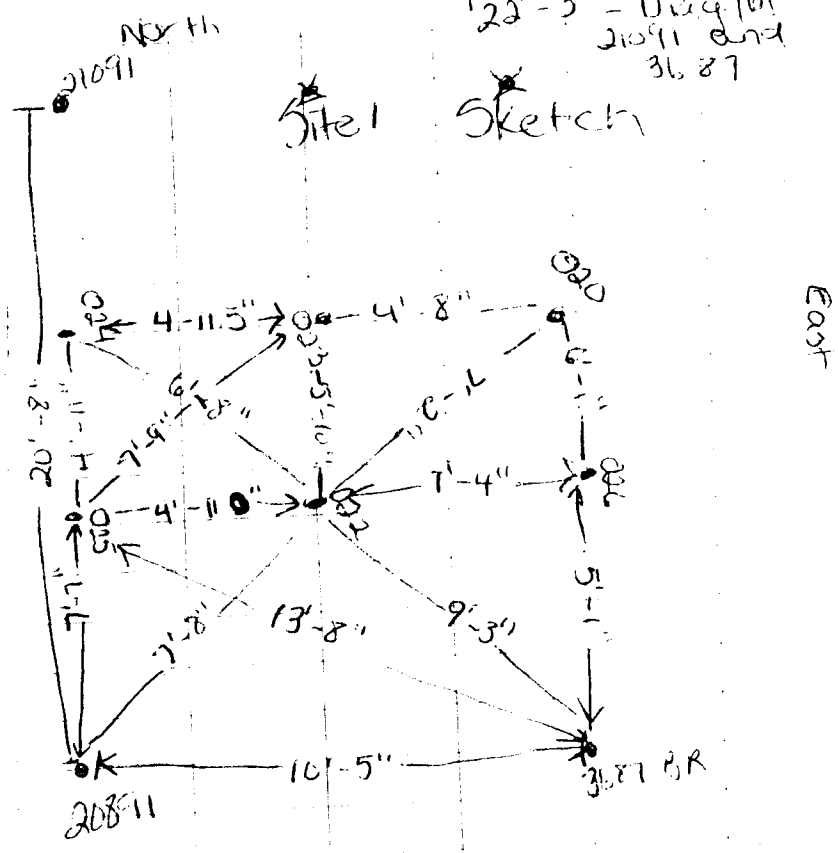
18"	0 cb	48 pumps to refill (dry)
24"	74 cb	45 pumps to refill
	38 cb	
6"	0 cb	22 pumps to fill
	40 cb	
12"	76 cb	5 pumps to fill
	42 cb	
36"	- Dry - to be replaced	

1-64 071993 LAH

Monday

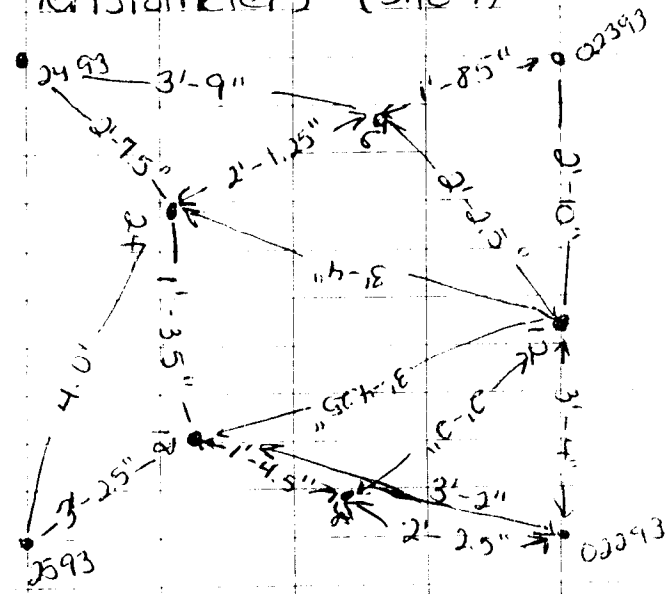
22'-3" - Diag 161
21091 and
3687

Site 1 Sketch



1-65 071993 LAH

Tensiometers (Site 1)



1215 Completed measurements and screening at Site 1. Headed back to office

LAH

072193

Wednesday

0715 LAH arrived at sub-yard began working on samples

0900 - D. Kuskie + LAH arrived at Site 2 to cement probe tubes and tensiometers.

1100 - LAH + DK returned to trailer. LAH working on samples. DK to go + buy a rake.

- RMZ + LAH discussed samples
- LAH worked on collecting samples. ~~DK~~ RDK assisted.

~~0430~~

1630 - LAH left site for day

LAH
072193

1-66 1-67

072293

Thursday

LAH collected samples and delivered to lab with JRK. (C5m lab).

LAH
072293

LAH

LAH 072393 1-68

Friday

~~1400~~ 1330 LAH arrived at subyard. MDK + LAH preparing site 1 w/cement collars.

1630 LAH + MDK left site for day

LAH 072393

1-69 072693 LAH

Monday

0730 LAH arrived at sub yard. Adjusting notches on neutron probe.

0930 LAH + TDY began putting concrete collars around the tensiometers at site 1. Had to borrow 1 bag cement from W Clyde.

1145 Broke for lunch

1300 LAH + TDY Back to site 1 to count before start of artificial recharge and to put sunscreens back on tensiometers.

1337 Began standard count at site 1.
weather ≈ 85-90° F
Breezy, sunny, low humidity.

1-10

~~02~~ 72693 LAH

Monday

S 10877
P 7700
Chi 1.11

New Count (Std 7/26/93)

S 7711
P 10877
Chi. 1.01

Started Counting at Site 1
02093 (FBGS - ft below grd. surf.)

~~B~~ Notes (TOC 1.1 ft)	Count
R- 1.0 (FBGS)	6351
R- 1.5	5853
R- 2.0	4487
R- 2.5	5224
R- 2.97	5107
4	4585
6	5066
8	4527
10	5210

~~TD~~ LAH

LAH 072693

Monday

1-71

02293 (TOC 2.15)	Reading
R- 2.0'	6139
R- 2.5'	6374
R- 2.97'	7013
3	7739
4	6929
6	6771
8	5798
10	6733
12	6644
14	6968

02393 (TOC 1.0 ft)	Reading
R- 1.0'	3571
R- 1.5'	4532
R- 2.0'	5190
R- 2.5'	5011
R- 2.97'	4833
4	5062
6	4740
8	4848
10	4750
12	4561
14	4382
16	6272

CAH

072693
Monday

Tensiometers - Site 1

18"	42 cb	50 cb
24"	58 cb	60 cb
6"	64 cb	64 cb
12"	~~7~~ 70 cb	70 cb

02493 (TOC -.35)

R-1.0	10575
R-1.5	9395
R-2.0	8251
R-2.5	1257
R-2.97	7763
4	7099
6	7569
8	7154
10	6768
12	9142
14	8595

CAH

02693
Monday

02593 (TOC)-1.0'

R-1.0	3913
1.5	4205
2.0	4744
2.5	5577
2.97	5050
4	4673
6	4480
8	4734
10	4576
12	4624

02693 (TOC 0.87')

R-1.0	4309
R-1.5	4144
R-2.0	3986
R-2.5	4389
R-2.97	4658
4	4858
6	4855
8	4791
10	4546
12	5361
14	6215

1-74 072693 LAH

~~03~~ Tuesday

~~03~~

1545 LAH + TDY to Site 2 to take pre-artif.-rechg counts

Counts in TDY's field notebook.

Tensiometers

6"	42 cb
12"	74 cb
18"	50 cb
24"	38 cb
36"	42 cb.

* Probe was wet when removed from 02993.

Noted condensation on inside of access tubes at 027, 028.

1700 Completed counting 3 of the six holes. 027, 028, + 02993. T. Yancey not feeling well so we called it a day.

LAH

~~027~~

LAH 7/27/93

LAH 072793 1-75

Tuesday

0710 Standard Count

S 7711

P 10877

Chi 1.01

Weather - Sunny Breezy ~75° F

New Count

S 7790

P 7711

chi 0.96

0725 Arrived at Site 2 to finish pre-art. rchg. Counts at Site 2. (03093, 03193 + 03293).

Counts in T. Yancey's field book.

Put 6 rain guages at various locations around site, mostly on (taped to) access tubes and a well casing.

CONTENTS

PAGE NO.	REFERENCE	DATE

JDY 07-26-93 (1)

13:00 LAH & JDY arrived at Recharge Site 1 to do Nuetron probe measurements.

1337 - STANDARD Count
Approx 90° F, breezy, Sunny, low relative humidity.

13:40 - Previous Standard Count
S = 10877
P = 7700
CHI = 1.11

Standard Count for 7/26

13:51 S = 7711
P = 10877
Chi = 1.01

13:52 Started Counting on 02093.

②

7-26-~~46~~ 93 JDY

JDY

JDY

7-26-93

③

02093

NOTCH	Count
R-1.0 ft BGS	6351
R-1.5	5853
R-2.0	4487
R-2.5	5224
R-2.97	5107
4	4585
6	5066
8	4527
10	5210
~~12~~ JDY	

02293

14:07

NOTCH	Count
START AT: R-2.0	6139
R-2.5	6374
R-2.97	7013
~~JDY R~~ 3 @ JDY	7739
~~JDY R~~ 4	6929
6	6771
8	5798
10	6733
12	6644
14	6968

02393

14.18

NOTCH	Count
R-1.0	3571
R-1.5	4532
R-2	5190
R-2.5	5011
R-2.97	4833
4	5062
6	4740
8	4848
10	4750
12	4561
14	4382
16	6272

14.29

NOTCH	Count
R-1.0	10575
R-1.5	9395
R-2.0	8251
R-2.5	7257
R-2.97	7763
4	7099
6	7569
8	7154
10	6768

(4)

7-26-93

02493

NOTCH	Count
12	9142
14	8595

02593

1440

NOTCH	Count
R-1	3913
R-1.5	4205
R-2.0	4744
R-2.5	5577
R-2.97	5050
4	4673
6	4480
8	4734
10	4576
12	4624

02693

1450

NOTCH	Count
R-1.0	4309
R-1.5	4144
R-2.0	3986
R-2.5	4389
R-2.97	4658

IDY

IDY 7-26-93 (5)

02693

NOTCH	Count
4	4858
6	4855
8	4791
10	4546
12	5361
14	6215
~~16~~ IDY	

1501 Went back to trailer for a break.

1545 Site 2 -

02793

NOTCH	COUNT
R-1.0	5402
R-1.5	5964
R-2.0	5846
R-2.5	5757
R-2.97	5512
4	5178
6	5003
8	4820
10	4832
~~12~~ ~~14~~ IDY	

(6)

7-26-93

02793

NOTCH	COUNT
12	4591
14	4943
16	4708
18	4712
20	4427
21	4537
22	6081
23	6334
24	6578
25	6246
26	6349
27	6160
28	6237
29	6062
30	5854
31	5580
32	5714
33	6007
34	5784
35	5268
36	6396
37	7107
10M/38	7818

(7)

7-26-93

02893

16:14

NOTCH	COUNT
R-10	4257
R-15	4582
R-20	4588
R-25	4627
R-297	4555
4	4688
6	4702
8	4752
10	5078
12	5106
14	5310
16	4719
18	4620
20	4564
21	4470
22	5839
23	5763
24	6693
25	6280
26	6456
27	6204
28	5777
29	5602

(8) 7-26-93 1Dy

02893

NOTCH	COUNT	NOTCH	COUNT
30	6108	~~35~~ 1Dy	
31	6264	~~36~~ 1Dy	
~~32~~ 1Dy		~~37~~ 1Dy	
~~33~~ 1Dy		~~38~~ 1Dy	
~~34~~ 1Dy			

02993
16:34

NOTCH	COUNT	NOTCH	COUNT
R-1	5263	23	6005
R-1.5	6335	24	6261
R-2	5868	25	6829
R-2.5	6173	26	6302
R-2.97	5484	27	6365
4	4850	28	6332
6	5185	29	6411
8	4784	30	6395
10	4868	31	6573
12	4945	32	6580
14	4747	33	6567
16	4605	34	5152
18	4950	35	4352
20	4801	36	4407
21	4809	37	4601
22	4768	10M/38	12174

1Dy 07-26-93 (9)

17:05 - Returned to trailer.
Broke for the day.

1Dy 07-26-93

(10) 7-27-93 JDY

07:28 - Arrived at Site 2, LAH & TJ to do Counting on Auction Probe.

03093

NOTCH	COUNT	NOTCH	COUNT
R-1	4550	23	6967
R 1.5	5077	24	7135
R-2	5700	25	6899
R-2.5	5650	26	6833
R-2.97	5399	27	6637
4	5068	28	6839
6	5303	29	6794
8	5203	30	6985
10	4985	31	6716
12	4784	32	6590
14	5302	33	6956
16	4899	34	6381
18	4951	35	5492
20	5642	36	5846
21	6495	37	7050
22	6897	~~10M/38~~	JDY

7:58 Probe was wet when brought up.
Did not register sat. counts!

Probe was dried off before we moved to next hole.

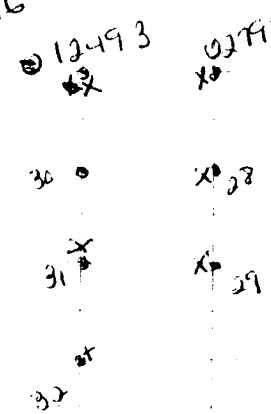
JDY 7-27-93 (11)

08:01
03193

NOTCH	COUNT	NOTCH	COUNT
R-1	4383	23	5955
R-1.5	5465	24	6669
R-2.0	5680	25	6321
R-2.5	5553	26	6283
R-2.97	5798	27	6287
4	5897	28	6067
6	5245	29	6054
8	5065	30	5938
10	5194	31	6091
12	4855	32	6170
14	5002	33	6184
16	4640	34	6353
18	4730	35	6033
20	5437	36	5992
21	6436	37	6251
22	6244	~~10M/38~~	JDY

072793 LAH

12493 02793



X = rain gauge locations

Site 2 tensiometers

36" - 40 cb
24" - 46 cb
18" - 50 cb
12" - 75 cb
6" - 70 cb

* Probe was wet when removed from 03093.

LAH 072993

0755 LAH + JWY checking tensiometers at Sites 1 & 2

Site 1

6" 28 cb (dry)
12" 76 cb
18" 2 cb (dry) 44 after filling
24" 74 cb

Site 2

6" 72 cb
12" 78 cb
18" 52 cb
24" 46 cb
36" 42 cb

(12) 7-27-93 JDY

1 08:27
03293

NOTCH	COUNT	NOTCH	COUNT
R-1	3658	23	5870
R-1.5	5082	24	5563
R-2.0	5124	25	6190
R-2.5	5198	26	6235
R-2.97	5166	27	6166
4	4598	28	6151
6	4767	29	5832
8	4610	30	5826
10	4448	31	5349
12	4763	32	5083
14	4755	33	5982
16	4568	34	6198
18	4639	35	6308
20	4729	36	6284
21	4543	37	5530
22	4619	10M/38	14076

08:54 Removed probe from 03293. Probe was wet when pulled out.

08:56 Left site to return to trailer.

JDY 072793

JDY 073093 (13)

0810 - Arrived at STP-995
TDY & JST Set up

08:15 - Began Sampling:

AB492 TOP
Spec Con: 247
Temp: 191
pH: 7.0

MID
Spec Con: 296
Temp: 17.8
pH: 7.2

BOTTOM
Spec Con: 198
Temp: 17.9
pH: 6.8

1400ml

(14) 07-30-93 JDY

08:35 AB392 Top
Spec Con: 200
Temp: 22.5
pH: 7.5

Mid
Spec Con: 230
Temp: 20.3
pH: 7.1

Bottom
Spec Con: 221
Temp: 19.1
pH: 7.1

1500 me

JDY
07 30 93

JDY 08-02-93 ~~(14)~~ (2) JDY

09:00 Arrived at Site 1, JDY and LAH.

12" - 0 - Probably Dry
24" - 0 - Dry
18" - 0
6" - 0

09:12 Site 2
24" - 31 cb
12" - 75 cb
36" - 44 cb
18" - 58 cb
6" - 0 - Dry

09:21 Site 1 for Readings.
24" - 40 cb
6" - 54 cb
12" - 62 cb
18" - 57 cb

JDY
080293

0645 LAH arrived at subyard gathering equipment to go count Site 2 (Pre rchg. count.

0700 Left subyard to go to site 2.
0720 Began Std. Count

Weather: Overcast
misting rain
~ 60°F

* See TDY's field book. For probe readings

Tensiometers (Site 2)

6"	69 cb
24"	10 cb
36"	44 cb
18"	58 cb
12"	77 cb

Casing Heights

027	1.0	030	
028	0.94	031	.93
029	0.97	032	1.0

Site 1 Tensiometers

12"	74 cb	(almost dry)
6"	72 cb	
24"	72 cb	
18"	72 cb	(appears dry)

1115 Completed all probe readings headed back to subyard.

080393

(16) 08-03-93 JDY

07.15 Arrived at Site 2
TDY: [illegible]
[illegible] Standard Count
S: 7711
P: 10871
Chi: 1.01

Weather on 8/3/93.
Approx 60 degrees misting rain, very cloudy, overcast.
No rain collected in rain gages
Standard Count for 8/3/93

S = 7813
P = 7711
Chi = 0.72

02993 - 29.0' - Water detected with water level indicator.

08-03-93 (17)

07:29
02993

NOTCH	COUNT	
R-1.0	5311	
P 1.5	6246	
R-2.0-5861 (1) R2.5	6020	
(2) R-2.97	5516	3-5058
4	4879	
6	5253	
8	4806	
10	4877	
12	4964	
14	4796	
16	4659	
18	4849	
20	4771	
21	4869	
22	4759	
23	5949	
24	6343	
25	6789	
26	6344	
27	6341	
28	6459	
29	6359	
30	6465	

(18) 08-03-93

03093

NOTCH	Count	NOTCH	Count
31	6600	35	4328
32	6439	36	4453
33	6591	37	4563
34	5156		

03093
~~03093~~ 28.5' - water indicated by water level indicator.

08.00 03093

NOTCH	Count	NOTCH	Count
R-1.0	4537	21	6416
R-1.5	5147	22	7016
R-2.0	5782	23	7032
R-2.5 (1)	5676	24	7121
(2)	5328	25	6875
(3)	5024	26	6927
4	5255	27	6557
6	4943	28	6814
8	5152	29	6782
10	5012	30	6944
12	4723	31	6664
14	5336	32	6629
16	4980	33	7032
18	4908	34	6409
20	5620	35	5483

(19) 080393

03015	NOTCH	COUNT
	36	5741
	37	6572

03193 - 30' - water detected

R-1.0	4393	28	6023
1.5	5371	29	6095
2.0	5602	30	5912
2.5 (1)	5491	31	6054
2	5847	32	5968
3	5862	33	6126
4	5981	34	6125
6	5250	35	5916
8	5131	36	5975
10	5257	37	6232
12	4917	10m	10554
14	5146		
16	4747		
18	4649		
20	5443		
21	6433		
22	6141		
23	5967		
24	6722		
25	6434		
26	6223		
27	6250		

(20)

080393

[03293] Water at 29.4 ft.

R-1.0	3565	30	5726
-1.5	5126	31	5388
-2.0	5139	32	5081
2.5 (1)	5204	33	6049
2.97 (2)	5131	34	6163
3	4921	35	6404
4	4718	36	6280
~~5~~ 6	4704	37	5511
~~6~~ 8	4706		
~~7~~ 10	4480		
12	4780		
14	4811		
16	4588		
18	4674		
20	4673		
21	4537		
22	4739		
23	5953		
24	5486		
25	6254		
26	6261		
27	6247		
28	6070		
29	5886		

(21)

080393

[028931]

No water measured in Casing

~~60~~ R-1.0		4177
	1.5	4603
	2.0	4605
	(1) 2.5	4614
	(2) 2.97	4632
	3	4576
	4	4526
	~~5~~ 6	4680
	~~6~~ 8	4874
	~~7~~ 10	4990
	~~8~~ 12	5302
	~~9~~ 14	5458
	~~10~~ 16	4464
	18	4670
	20	4783
	~~21~~ 21	4693
	~~22~~ 22	5720
	~~24~~ 23	5834
	~~26~~ 24	6654
	~~28~~ 25	6311
	~~30~~ 26	6354
	~~32~~ 27	6188
	~~34~~ 28	5821
	~~36~~ 29	5666
	~~38~~ 30	6148
	31	6411
	32	Bm of Csg
	33	
	34	
	35	
	36	
	37	

02793

30.75 ft water level

R-1.0	5252		28	6095
1.5	6041		29	5953
2.0	5760		30 avg	5870 < 5710
2.5 (1)	5651		31	5716 ~~5848~~
2.97 (2)	5376		32	5848
3	5013		33	6011
4	5109		34	5830
~~5~~			35	5380
6	4962		36	6403
8	4876		37	7139
10	4801		10m	7882
12	4599			
14	5014			
16	4757			
18	4790			
20	4439			
21	4575			
22	6215			
23	6420			
24	6646			
25	6381			
26	6515			
27	6286			

Site 1 02093 Began ≈ 10:15

R-1.0		6291
R-1.5		5598
R-2.0		4347
(1) 2.5		5015
(2) 2.97		5003
3		4763
4		4572
5		
6		5092
7		
8		4534
9		
10		5158
11		
12		
13		

BTM

(24) 080393

02293	R-2.0	5735	avg
		5768	
	R-2.5	6163	
	R-2.97	7033	
	3	7828	
	4	6952	
	6	6838	
	8	5722	
	10	6742	
	12	6128	
	14	6172	btm

02393	R-1.0	3542
	R-1.5	4492
	R-2.0	5108
	R-2.5	4958
	R-2.97	4852
	3	4972
	4	5092
	6	4757
	8	4842
	10	4723
	12	4606
	14	4287
	16	6280

(25) 080393

02493	R-1.0	10498
	R-1.5	9237
	R-2.0	8235
	R-2.5 (1)	7155
	R-2.97 (2)	7710
	3	7171
	4	7029
	6	7548
	8	7121
	10	6722
	12	9171
	13	10348

02593	R-1.0	3923
	1.5	4080
	2.0	4895
	2.5 (1)	5471
	2.97 (2)	~~5~~ 5058
	3	4955
	4	4705
	6	4516
	8	4754
	10	4659
	12	4593

080393

02693	R-1.0	4182	
	R-1.5	4186	
	2.0	3900	
	2.5	4421	
	2.97	4594	
	3	4718	
	4	4793	
	6	~~4793~~	4920
	8	4745	
	10	4678	
	12	5245	
	14	6245	

1115 - Completed pre-recharge probing. Headed back to Subyard.

1130 - CAH + TDY arrived at Subyard.

JDY 080396

JDY

~~080393~~ JDY
080493

MDK and TDY arrived at
1400 Site 2, to begin counting.

Previous Standard Count

S = 7816
P = 7813
Chi = 1.12

080493 Standard Count

S = 7784
P = 7816
Chi = ~~0.77~~ 0.86

Weather: Breezy/Windy
Approx. 75°
Overcast/cloudy.

Began Counting at Site 2. 1405

080493

mdh

	NOTCH	COUNT	NOTCH	COUNT
02993	R-1.0	6048	12	4934
	R-1.5	6336	14	4892
	R-2.0	5866	16	4592
	R-2.5	6061	18	4894
	R-2.97	5444		
	3	5098		
	4	4798		
	6	5263		
	8	4942		
	10	4851		

~~mdh 03093~~ * moisture inside casings

MDK and ~~MDK~~ arrived at Site 2 at 2 00 (1400)

mdh

080493

03093	NOTCH	COUNT	NOTCH	COUNT
	R-1.0	5218	8	5073
	R-1.5	5293	10	5001
	R-2.0	5814	12	4883
	R-2.5	5714	14	5276
	R-2.97	5401	16	5006
	3	5168	18	4847
	4	5215		
	6	5001		

* moisture inside casings

03293	NOTCH	COUNT	NOTCH	COUNT
	R-1.0	3863	6	4782
	R-1.5	4928	8	4505
	R-2.0	5107	10	4518
	R-2.5	5143	12	4743
	R-2.97	5013	14	4626
	3	4960	16	4572
	4	4768	18	4730

* moisture inside casings

080493

03193	NOTCH	COUNT	NOTCH	COUNT
	R-1.0	4808	6	5268
	R-1.5	5356	8	5151
	R-2.0	5529	10	5325
	R-2.5	5513	12	4931
	R-2.97	5773	14	4966
	3	5896	16	4738
	4	6046	18	4744

* moisture inside casing

02893	NOTCH	COUNT	NOTCH	COUNT
	R-1.0	4689	6	4570
	R-1.5	4784	8	4800
	R-2.0	4666	10	5067
	R-2.5	4561	12	5194
	R-2.97	4654	14	5348
	3	4690	16	4729
	4	4629	18	4655

* moisture inside casing

02793	NOTCH	COUNT	NOTCH	COUNT
	R-1.0	6378	6	4974
	R-1.5	6118	8	4843
	R-2.0	5784	10	4888
	R-2.5	5690	12	4625
	R-2.97	5333	14	5069
	3	5066	16	4764
	4	5225	18	4719

* moisture inside casing

ended site 2 at 3:30

1657 Began 2nd count at Site 2

02993				
	R-1.0	6039	10	4889
	1.5	6215	12	4965
	2.0	5857	14	4922
	2.5	6062	16	4723
	2.97	5353	18	4871
	3	5031		
	4	4823		
	6	5324		
	8	4855		

(32) 080493

1706 03093

R-1.0	5248	10	5026
1.5	5272	12	4737
2.0	5734	14	5258
2.5	5623	16	4999
2.97	5328	18	4987
3	5130		
4	5300		
6	4949		
8	5117		

1719 Moved to Site 1 Casing wet (condens)

02093

R-1.0	6407
1.5	5494
2.0	4316
2.5	5098
2.97	4979
3	4813
4	4613
6	5019
8	4593
10	5150

(33) 080493

02293
1726
Alum
Csg
(Dry)

R 2.0	7397	12	6714
2.5	6229	13 ~~14~~	6820
2.97	7217		
3	7715		
4	6802		
6	6763		
8	5746		
10	6741		

02393
Condens.
in Casing
1734

R 1.0	4307	6	4764
1.5	4636	8	4918
2.0	5144	10	4666
2.5	4939	12	4596
2.97	4882	14	4359
3	4962	16	6213
4	5041		

02493
Alum Csg
Dry
1743

R 1.0	10499	4	7157
1.5	9255	6	7524
2.0	8165	8	7124
2.5	7300	10	6689
2.97	7715	12	9169
3	7197	~~13~~ 14	8538

0940 DJK + LAH to Site 2 to check tensiometers

6" 72cb
12" 78cb
18" 62cb
24" 3 cb (dry)
36" 47cb

0955 Site 1

6" 74cb.
12" 76cb.
24" 72 cb.
18" 78cb

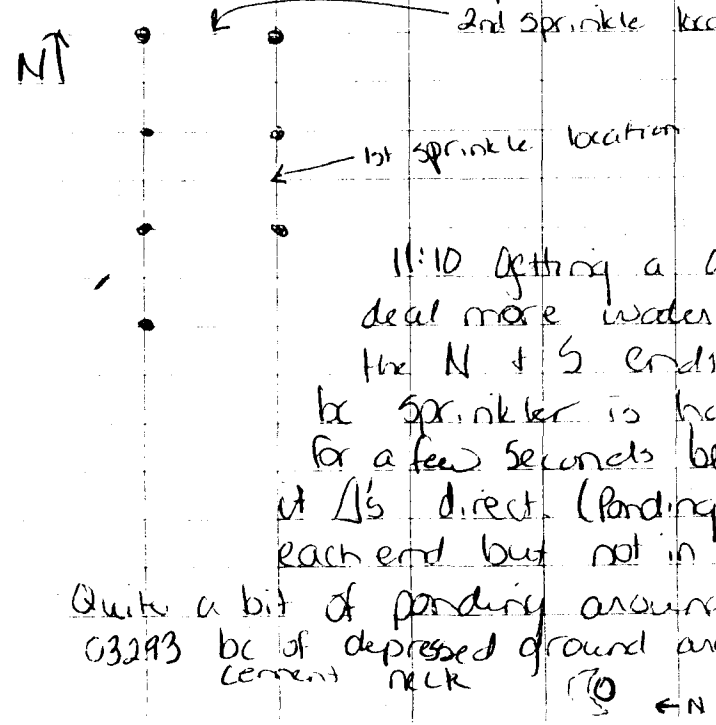
1015 Arrived back at subupend. TDY + R Smith heading to Site 2 to start rectrodge.

1030 LAH arrived at site 2 TDY + R.S. Setting up

1045 Weather:
Sunny (very few thin clouds)
Breezy
~75°F

1046 Sprinkling began at site 2. Using R Smiths oscillating sprinkler (one he had yesterday)

1106 Decided to Δ sprinkler setting to oscillate in only 1 direction



11:10 Getting a great deal more water at the N + S ends bc sprinkler is hanging for a few seconds before it Δ's direct. (Ponding at each end but not in center).

Quite a bit of ponding around 03293 bc of depressed ground around cement neck

1132 Rain gage on 03293 had 1.0 in. Moved sprinkler 6 ft N so heaviest sprinkling would be in the center of tensiometer area.

Not a great deal of surface water movement was noted on ~~North~~ south end.

1138 quite a bit of ponding occuring on N side of site

1142 Shut off sprinkler to refill water tank. Some run off was occuring at north end. hopefully some of the ponded water will infiltrate while tank is being refilled.

1153 03093 still has some ponded water around it

1155 Rain gage on 02793: 0.5 in.
02893: 0.2 in.
02993: 0.65 in.
03093: 0.4 in.
03193: 0.3 in.
03293: 1.0 in.

12:00 Temp 78°F (Shaded).

12:19 Began sprinkling again most of ponding had either dried or soaked in.

1224 Already noting considerable ponding.

1225 Considerable r.o to the north.

01249 gage has	1.0 in	@	1233
03193	0.9	@	1234
02993	1.0		@1235
03093	0.4		"
02793	0.7		1238

1241 Shut down recharge because of excessive r.o.
Used ~ 175 gal of water pumped at 25 g/9:10

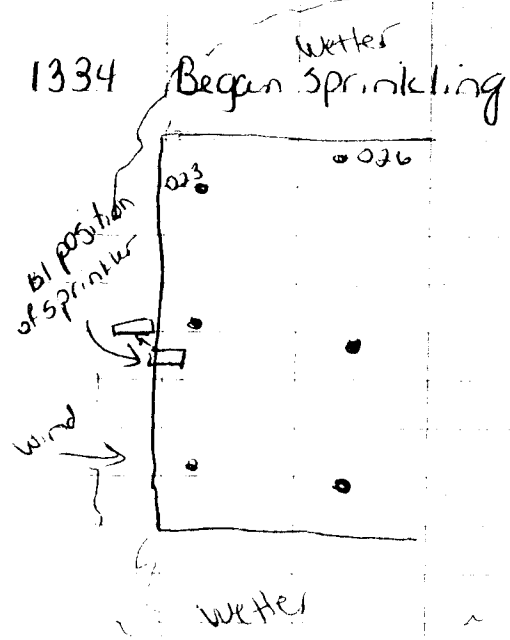
12:42 final gage measurements
1246: 027 0.65 in.
028 ~ ~~0.03~~ 0.3 in
029 1.1 in.
030 0.4
031 1.1 in
032 ~ 1.1 in.
12493 0.5 in

12:49 left Site 2 to prepare
Site 1 for rdng.
Temp 18°F.

1327 Arrived at Site 1
12" Tens. ~68 cb
6" 68cb
24" 62cb
18" 70cb.

1330 weather Very breezy
wind from north
~ 75°F
Rain appears likely
Near over cast skies

1334 Began sprinkling



Started with 150 gal of water

1345 LAH checking Site 2
Very little ponding left around
- 03093 Only
6" tens. 62cb
24" tens dry.
12" 70 cb.
18" 62 cb

1-86 080493

1350 Very slight ponding near 02693
Approx 50 gal sprinkled so far.
Trace of water in rain gage at 02693.

Pump 25 gal/10:05

1410 More ponding on the NE side of area near 02093

1424 R.O. flowing to NE + NW

1425 Water flow ceased due to empty tank. Rob to get more LAH to site to W/TDY + ~~DJK~~ MDK

1510 Resumed sprinkling with a full tank.
All ponding had soaked in or evaporated when sprinkling restarted.

1520 R.O. Toward NW + NE occuring outside of fenced area.

1-87 080493

R.O. does not appear to be coming from within study area (fence

1523 1550

Rain Gages	02593	0.4 in.	0.6
	02293	0.4 in	0.6
	02393	trace (blocked)	
at former	T 36"	0.2 in.	0.4
	3687	0.2 in.	0.4
	02693	0.3 in.	0.5
	02093	0.2 in.	0.3
fence corner		0	0.6

1623 This rate appears to be good for this location. It does not look like much water is running off from within the fenced area and not much ponding is occuring

1626 Ran out of water, ceased sprinkling

026	0.6	Corner	0.85
020	0.5	3687	0.55
T 36"	0.5		
022	0.8		
023	0.1		
025	0.85		

(34) 080493

02593 R 1.0 4252 6 4562
Casing is damp to wet 1.5 4263 8 4562/4736
1752 2.0 4852 10 4589
2.5 5433 12 4588
2.95 5001
3 4857
4 4747

02693 R 1.0 4238 6 4712
Casing contains moisture 1.5 4094 8 4795
1801 2.0 3924 10 4683
2.5 4342 12 5349
2.95 4619 14 4329
3 4737
4 4853

(35) 0805 93

0126 Std Count
S 7784
P 7816
Chi .86

New Count
S 7845
P 7784
Chi 0.95

0157 - CES & Tony arrived at Site
2 to:
Check rain gauges
Tensiometer reading
Fix 24" Tensiometer

Rain		Tensiometers	
02793	1.8"	6"	48 cb
02893 - Knocked over tape [illegible]		24"	8 cb (dry)
02993	1.2"	36"	47 cb
~~Se~~ 03093	1.0"	48"	62 cb
03193	1.2"	12"	48 cb
03293	1.0"		
12491	1.2"		

CES/TDY 080593 Count p. 36

	Notch	Count	Notch	Count
02793	R-1.0	6208	6	4963
	R-1.5	6135	8	4787
	R-2.0	5766	10	4799
	R-2.5	5629	12	4655
	R-2.97	5447	14	5005
	3	5074	16	4789
	4	5189	18	4673

* Moisture in casing

02893	R-1.0	4733	6	4675
	R-1.5	4749	8	4696
	R-2.0	4628	10	4973
	R-2.5	4656	12	5207
	R-2.97	4674	14	5320
	3	4676	16	4745
	4	4619	18	4719

* Moisture in casing

02983	R-1.0	5931	6	5184
	R-1.5	6411	8	4859
	R-2.0	5793	10	4974
	R-2.5	6082	12	4969
	R-2.97	5346		
	3	5029	14	4825
	4	4794	16	4601
			18	4948

CES/TDY 080593 p. 37

	Notch	Count	Notch	Count
03093	R-1.0	5297	6	4945
	R-1.5	5180	8	5078
	R-2.0	5757	10	5146
	R-2.5	5737	12	4082
	R-2.97	5372	14	5257
	3	5110	16	5032
	4	5214	18	4912

* Moisture in casing

	Notch	Count	Notch	Count
03193	R-1.0	4899	6	5326
	R-1.5	5504	8	5211
	R-2.0	5597	10	5348
	R-2.5	5566	12	4866
	R-2.97	5403	~~16~~ 14	5060
	3	5934	~~18~~ 16	4612
	4	5947	18	4696

	Notch	Count	Notch	Count
03293	R-1.0		4	4686
1.0	[illegible]	4118	6	4778
1.5	[illegible]	5031	8	4743
2.0	[illegible]	5084	10	4573
2.5	[illegible]	5301	12	4777
2.973	[illegible]	5051	14	4692
3.0	[illegible]	5043	16	4668
			18	4671

CES/TDY

080593

Site 1 Notch Co

P 38

8/5/93

P 39

080593

Time: 0930 24"
Took Tensiometer reading 37 cb. left for Site 1.

CES & TDY to Site 1 Time: 0935

Rain		Tensiometer	
02093	0.5"	6"	38 cb
02293	.9"	24"	75 cb (dry)
Hole	.5"	18"	79 cb (dry)
02393	0.1"	12"	75 cb
NW Post	0.8"		
02593	0.8"		
02693	0.7"		
3687BR	0.5"		

CES/TDY 080593 P(40)

	Notch	Count	Notch	Count
02093	1.0	6442	3	4738
	1.5	5546	4	4553
	2.0	4318	6	4971
	2.5	4960	8	4569
	2.97	4958	10	5129

* Moisture in casing

02293	1.0 ~~2.0~~	136	4 ~~8~~	6857
	1.5 ~~2.5~~	2540	6 ~~10~~	6717
	2.0 ~~2.97~~	7115	8 ~~12~~	5729
	2.5 ~~3~~	6238	10 ~~13~~	6731
	2.97 ~~4~~	7066	12	6540
	3 ~~6~~	7689	~~13~~	
			14	6655

* Moisture in casing

02393	1.0	4393	6	4684
	1.5	4630	8	4924
	2.0	5034	10	4646
	2.5	5005	12	4561
	2.97	4789	14	4398
	3	4880	16	6284
	4	5065		

* Moisture in casing

CES/TDY 080593 P(41)

	Notch	Count	Notch	Count
02493	1.0	10472	6	7585
	1.5	9325	8	7152
	2.0	8030	10	6768
	2.5	7260	12	9344
	2.97	7745	14	8453
	3	7310	~~16~~ 8	
	4	7172		

* Moisture in casing

02593			4	4792
	1.0	4279	6	4604
	1.5	4198	8	4843
	2.0	4837	10	4550
	2.5 ~~2.97~~	5421	12	4725
	2.97 ~~3~~	5106		
	3	4964		

* Moisture in casing

02693				
	1.0	4185	6	4785
	1.5	4152	8	4751
	2.0	3969	10	4623
	2.5	4358	12	5223
	2.97	4513	14	6381
	3	4695		
	4	4924		

* Moisture in casing

CES/TDY 080593 (p. 42)

Checked Tensiometer at 11:00 am at site #2

24" Tensiometer 48 cbs

11:30 Jim Kunkel came out to site 2 with University of Georgia students. Showed Nuetron Probe.

11:45 Returned to trailer.

JDY 080593

JDY 080593 (43)

14:54 Started to rain (hard)

15:35 Jby & Jwy arrived at site 2 to take rain guage measurements

12491 >0.1

02893 >0.1

02993 0.15

03293 0.1

03193 >0.1

03093 0.1

02793 - very few drops

15:40 Quit Raining

15:42 Arrived at Site 1 to tape up rain guages. No readings available except for 2

NW Post - Drill rig blocked. rainfall - no reading.

Hole - 0.1

15:50 Started to rain again, left for Subyard

0808 JDY & MDK arrived at Site 1 to measure rain guages.

All rain guages show >0.1 in of water.

The rain guage located in the hole has 0.2 in of water.

Tensiometers

18in =	79 cb	dry
24in	76 cb	dry
6in	40 cb	not dry
12in	75 cb	not dry

0820 moved to Site #2

Site 2

0825 All rain guages show <0.1 in of water

TENSIOMETERS

IN	cbars	FILL
6	33	not dry
12	60	not dry
18	62	not dry
24	52	not dry
36	48	not dry

0835 left site 2

08:56 JWY & TDY arrived at Site 2 for probe readings.

Previous Standard Count
S - 7845
P - 7784
Chi - 0.95

09:00 080693 Standard Count
S - 7840
P - 7845
Chi - 1.15

080693 JDY

Weather: ≈ 70°
Sunny

02793 - 31.68' encountered water

02893 - Dry
02993 - 29.1' water
03093 28.42' water
03193 - 29.9' water
03293 - 29.36' - water

All casing at Site 2 has condensation in it.

09:10

02793	NOTCH	Count	NOTCH	Count
	R1.0	6357	10	4868
	R1.5	6193	12	4535
	R2.0	5676	14	5113
	R2.5	5597	16	4789
	R2.97	5417	18	4801
	3	5027	20	4385
	4	5150	21	5261
	6	4910	22	6146
	8	4818	23	6318

JDY 080693

02793 (cont)	NOTCH	COUNT	NOTCH	COUNT
	24	6484	32	5710
	25	6407	33	5949
	26	6431	34	5918
	27	6163	35	5300
	28	6325	36	6374
	29	6075	37	7278
	30	5902	104/38	7633
	31	5751		

09:43

02893	NOTCH	COUNT	NOTCH	COUNT
	R1.0	4772	24	5748
	R1.5	4740	25	6565
	R2.0	4628	26	~~6320~~
	R2.5	4562	27	~~6372~~
	~~R2.97~~ 3	~~4779~~	28	~~6160~~
	4	4726	29	~~5721~~
	6	4613	30	6105
	8	4694	31	6414 bottom
	10	4974	~~38~~ Dry	
	12	5043	~~33~~ Dry	
	14	5161	~~34~~ Dry	
	16	5383	35 Dry	
	18	4775	~~36~~ Dry	
	20	4660	~~37~~ Dry	
	21	4657	~~104/38~~	
	22	4554		
	23	4778		
		5750		

26-6297
27-6202
28-5809
29-5582

R2.97 4779

080693

10:05 02993

NOTCH	COUNT	NOTCH	COUNT
R1.0	6061	23	5973
R1.5	6388	24	3886
R2.0	5711	25	6701
R2.5	5974	26	6468
R2.97	5355	27	6284
3	5003	28	6416
4	4816	29	6460
6	5314	30	6303
8	4781	31	6505
10	4834	32	6603
12	4948	33	6695
14	4847	34	5174
16	4578	35	4339
18	4860	36	4396
20	4806	37	4567
21	4830		
22	4846		

10:37 03093

NOTCH	COUNT	NOTCH	COUNT
R1.0	5498	3	5133
R1.5	5344	4	5254
R2.0	5762	6	4977
R2.5	5686	8	5097
R2.97	5399	10	5020

03093 (Cont)

NOTCH	COUNT	NOTCH	COUNT
12	4836	28	6796
14	5335	29	6849
16	5075	30	6984
18	5015	31	6599
20	5599	32	6537
21	6351	33	7066
22	6947	34	6331
23	6907	35	5515
24	7113	36	5855
25	6924	37	6489
26	6844		
27	6583		

11:07 03193

NOTCH	COUNT	NOTCH	COUNT
R1.0	4915	12	4905
R1.5	5406	14	5032
R2.0	5577	16	4644
R2.5	5510	18	4875
R2.97	5755	20	5413
3	5883	21	6475
4	5978	22	6272
6	5325	23	5985
8	5060	24	6791
10	5287	25	6312

080693

	03193 (cont)	NOTCH	COUNT	NOTCH	COUNT
		26	6272	33	6082
		27	6338	34	6446
		28	5981	35	6072
		29	6046	36	5852
		30	5898	37	6250
		31	6061	10M/38	6916
		32	6150		

11:36	03293	NOTCH	COUNT	NOTCH	COUNT
		R10	4132	21	4556
		R1.5	5112	22	4597
		R2.0	5121	23	5947
		R2.5	5136	24	5714
		R2.97	5055	25	6324
		3	4949	26	6176
		4	4638	27	6329
		6	4742	28	6038
		8	4606	29	5793
		10	4424	30	5686
		12	4806	31	5371
		14	4674	32	5084
		16	4586	33	6035
		18	4688	34	6061
		20	4738	35	6217

080693

03293	NOTCH	COUNT	~~NOTCH~~ JDY	COUNT
	36	6252	10M/38	
	37	5552	12011	

12:00 Left Site 2 for Subyard. Arrived at Site 1 to count access tubes. TDY & JWY

02093	NOTCH	COUNT	~~NOTCH~~ JDY
1445-1450	R10	6457	
	R1.5	5412	
	R2.0	4308	
	R2.5	5064	
	R2.97	4924	
	3	4789	
	4	4662	
	6	5086	
	8	4607	
	10	5113	

080693

02393

1451 - 1506

NOTCH	COUNT
R 1.0	4350
R 1.5	4610
R 2.0	5040
R 2.5	4849
R 2.97	4757
3	4926
4	5041
6	4833
8	4329
10	4673
12	4544
14	4236

02493

1507 - 1515

alum tube

NOTCH	COUNT
R 1.0	10365
R 1.5	9340
R 2.0	8162
R 2.5	7291
R 2.97	7726
3	7203
4	7219
6	7619
8	7028
10	6812
12	9144
14	8327

080693

02593

1516 - 1525

NOTCH	COUNT
R 1.0	4255
R 1.5	4262
R 2.0	4843
R 2.5	5398
R 2.97	5082
3	4894
4	4677
6	4531
8	4751
10	4572
12	4737

02293

1526 - 1535

alum tube

NOTCH	COUNT
R 1.0	115
R 1.5	2406
R 2.0	7167
R 2.5	6308
R 2.97	7077
3	7575
4	6836
6	6697
8	5800
10	6744
12	6594
14	6571

080693

02693

1536-
1545

NOTCH	COUNT
R-1.0	4256
R 1.5	4065
R 2.0	3908
R-2.5	4402
R 2.97	4532
3	4621
4	4836
6	4762
8	4854
10	4666
12	5356
14	6321

mdh

mdh

080793

0855 TDY & MDK arrived at Site 1 to measure new gauges

Weather was warm, 75°, very slight breeze, few clouds

Previous Standard Count

S = 7840

P = 7845

Chi = 1.15

080793 Standard Count

S = 7827

P = 7840

Chi = 0.89

(56) 080793 ymdk

Rain Gauges	IN
3687	0.2 in
2693	0.0
02093	0.1
02393	0.1
hole in ground	0.2
02593	0.2
NW post	0.0
20891	0.0

Tensiometers	cbars	
12 in	66	not dry
6 in	48	not dry
24 in	76	dry
18 in	80	dry

ymdk 080793 (57)

02093 0903 - 0910

NOTCH	COUNT	NOTCH	COUNT
R-1.0	6401	3	4776
R-1.5	5455	4	4629
R-2.0	4365	6	4937
R-2.5	5035	8	4543
R-2.97	4844	10	5099

02293 0911 - 0917

NOTCH	COUNT	NOTCH	COUNT
~~R-1.0~~ ymdk	~~7122~~ ymdk	6	6715
~~R-1.5~~ ymdk		8	5777
R-2.0	7122	10	6809
R-2.5	6357	12	6594
R-2.97	7116	14	6488
3	7603		
4	6894		

080793

02393 0918 - 0927

NOTCH	COUNT	NOTCH	COUNT
R1.0	4231	6	4762
R1.5	4547	8	4874
R2.0	5098	10	4677
R2.5	4920	12	4659
R2.97	4773	14	3390
3	4825	16	6291
4	5085		

02493 0928 - 0935

NOTCH	COUNT	NOTCH	COUNT
R-1.0	10399	4	7196
R-1.5	9313	6	7546
R-2.0	8124	8	7034
R-2.5	7248	10	6754
R-2.97	7779	12	9086
3	7234	14	8301

080793

02593 0936 - 0943

NOTCH	COUNT	NOTCH	COUNT
R1.0	4254	3	4986
R1.5	4211	4	4746
R2.0	4951	6	4555
R2.5	5393	8	4760
R2.97	5005	10	4533
		12	4635

02693 0944 - 0952

NOTCH	COUNT	NOTCH	COUNT
R1.0	4227	4	4821
R1.5	4158	6	4794
R2.0	3886	8	4764
R2.5	4357	10	4743
R2.97	4624	12	5810
3	4684	14	6266

Left Site 1 at 0953

080793

0955 TDY + MDK arrived at Site 1

Weather @ 80°

Rain Gauges

	IN
02993	0.3 in
02893	<0.1
02793	0.1
12491	0.2
03093	0.1
03193	0.1
03293	<0.1

Tensiometers

36 in	50 cb	not dry
24 in	54 cb	not dry
6 in	41 cb	not dry
12 in	55 cb	not dry
18 in	64 cb	not dry

mdk mdk

02793 1002 – 1010

NOTCH	COUNT	NOTCH	COUNT
R1.0	6406	6	5030
R1.5	6160	8	4721
R2.0	5745	10	4710
R2.5	5631	12	4595
R2.97	5350	14	4955
3	5001	16	4754
4	5151	18	4727

02893 1011 – 1022

NOTCH	COUNT	NOTCH	COUNT
R1.0	4719	6	4734
R1.5	4770	8	4780
R2.0	4561	10	4969
R2.5	4613	12	5232
R2.97	4749	14	5510
3	4716	16	4787
4	4550	18	4697

(62) 030793 wsh

02993 1023- 1032

NOTCH	COUNT	NOTCH	COUNT
R10	6053	6	5334
R15	6217	8	4830
R20	5748	10	4876
R25	5973	12	4834
R297	5380	14	4767
3	5003	16	4568
4	4873	18	4830

03093 1033- 1043

NOTCH	COUNT	NOTCH	COUNT
R10	5541	6	4938
R15	5293	8	5113
R20	5793	10	4921
R25	5668	12	4910
R297	5306	14	5316
3	5183	16	4992
4	5244	18	4918

wsh 030793 (63)

03193 1044- 1053

NOTCH	COUNT	NOTCH	COUNT
R10	4763	6	5331
R15	5494	8	5169
R20	5571	10	5270
R25	5517	12	4848
R297	5957	14	5159
3	5897	16	4656
4	5952	18	4673

03293 1054- 1103

NOTCH	COUNT	NOTCH	COUNT
R10	4016	6	4738
R15	5074	8	4646
R20	5173	10	4579
R25	5179	12	4745
R297	5040	14	4621
3	4372	16	4728
4	4671	18	4626

left Site 1 at 1106

080893

Jim Kunkel advised Tracy not to do neutron probes

080893

080 Jim Kunkel advised Tracy not to do neutron probes

Tensiometers — Site 1

	in	cb	
1440	18"	80 cb	dry
	24"	74	dry
	12"	75	dry
	6"	66	dry

Rain gauges dry

Site 2

1450 in	cb	
6	72	dry
12	74	not dry
18	66	not dry
24	55	not dry
34	51	not dry

Rain gauges dry

08-11-93 JDY JDY

07:30 ST & TY arrived at STP for Vadose Sampling

07:47 AB492 BOT
S 205
T 17.8
P 7.5

MID
S 292
T 18.0
P 7.1

TOP
S 254
T 18.3
P 7.5

08:00
AB392 BOT
S 222
T 19.1
P 7.3

MID
S 239
T 18.6
P 7.2

TOP
S 221
T 19.4
P 7.4

1350ml

(48) 081193 mdh mdh 081193 69

VDY + MDK arrive at Site 1 at 1314

Weather was hot @ 90°

Slight breeze; few clouds

All rain gauges at Site 1 were dry

TENSIOMETER	Site P	
6	72 cb	not dry
12	75 cb	not dry
18	80 cb	dry
24	76 cb	dry

Previous Count

S = 7827

P = 7840

Chi = 0.89

Standard Count

S = 7784

P = 7827

Chi = 0.94

02093 1323 - 1329

NOTCH	COUNT	NOTCH	COUNT
R1.0	6288	4	4652
R1.5	5343	6	4957
R2.0	4430	8	4565
R2.5	5001	10	5144
R2.97	4869		
3	4742		

02293 1330 - 1336

NOTCH	COUNT	NOTCH	COUNT
R1.0	--	4	6888
R1.5	--	6	6683
R2.0	6854	8	5698
R2.5	6242	10	6859
R2.97	7005	12	6682
3	7489	14	6537

081193

wdh

02393 1337 - 1344

NOTCH	COUNT	NOTCH	COUNT
R1.0	4165	6	4710
R1.5	4686	8	4843
R2.0	5105	10	4677
R2.5	5077	12	4520
R2.97	4674	14	4360
3	4898	16	6154
4	4978		

02493 1345 - 1357

NOTCH	COUNT	NOTCH	COUNT
R1.0	10027	4	7096
R1.5	9351	6	7645
R2.0	8104	8	7624
R2.5	7272	10	6834
R2.97	7441	12	8595
3	7405	14	9706

Cap was broken so 2 in of stick-up from aluminum

wdh

081193

02593 1358 - 1404

NOTCH	COUNT	NOTCH	COUNT
R1.0	4225	4	4684
R1.5	4235	6	4644
R2.0	4874	8	4776
R2.5	5371	10	4601
R2.97	5020	12	4603
3	4945		

02693 1405 - 1410

NOTCH	COUNT	NOTCH	COUNT
R1.0	4161	4	4828
R1.5	4105	6	4727
R2.0	3862	8	4770
R2.5	4326	10	4709
R2.97	4512	12	5361
3	4643	14	6290

081193 mdh

TDY + MDK arrived at Site 2 at 1414. All rain gauges dry 1416 - 1439

02793 31.65 encountered water

NOTCH	COUNT	NOTCH	COUNT
R1.0	6259	25	6359
R1.5	6043	26	6468
R2.0	5587	27	6107
R2.5	5494	28	6096
R2.97	5279	29	6027
3	4888	30	5882
4	5110	31	5826
6	4959	32	5731
8	4855	33	6025
10	4833	34	5800
12	4583	35	5351
14	4949	36	6313
16	4811	37	7095
18	4833	104/38	7549
20	4465		
21	4519		
22	6152		
23	6331		
24	6475		

mdh 081193

• Water levels

02793	31.65'
02893	dry
02993	29.15'
03093	28.55'
03193	30.00'
03293	29.40'

02893 1440 - 14:56

NOTCH	count	NOTCH	COUNT
R1.0	4643	22	5779
R1.5	4749	23	5796
R2.0	4624	24	6626
R2.5	4665	25	6264
R2.97	4765	26	6344
3	4652	27	6165
4	4627	28	5780
6	4689	29	5563
8	4837	30	5991
10	5029	31	6408
12	5174		
14	5585		
16	4747		
18	4674		
20	4533		
21	4590		

water level = dry

(74) 081193 wdh

02993 1457 - 1519

NOTCH	COUNT	NOTCH	COUNT
R1.0	5712	23	6069
R1.5	6247	24	6317
R2.0	5832	25	6256
R2.5	6062	26	6348
R2.97	5455	27	6230
3	5021	28	6292
4	4718	29	6416
6	5242	30	6361
8	4831	31	6586
10	4881	32	6565
12	4930	33	6648
14	4842	34	5047
16	4677	35	4376
18	5033	36	4392
20	4831	37	4502
21	4830		
22	4739		

water level = 29.15

wdh 081193 (75)

03093 1520 - 1540

NOTCH	COUNT	NOTCH	COUNT
R1.0	5493	22	6965
R1.5	5390	23	6968
R2.0	5776	24	7062
R2.5	5635	25	6986
R2.97	5343	26	6863
3	5035	27	6542
4	5169	28	6811
6	4917	29	6766
8	5119	30	6919
10	5060	31	6648
12	4692	32	6526
14	5351	33	7035
16	4966	34	6262
18	4954	35	5583
20	5575	36	5777
21	6337	37	6378

water level = 28.55

031193

03193 1542 - 1604

NOTCH	COUNT	NOTCH	COUNT
R10	4841	22	6284
R15	5523	23	5961
R20	5501	24	6753
R25	5432	25	6429
R2.97	5749	26	6249
3	5958	27	6242
4	6043	28	5986
6	5241	29	6007
8	5163	30	5967
10	5204	31	6162
12	4940	32	6177
14	5082	33	6003
16	4735	34	6231
18	4728	35	5971
20	5403	36	5920
21	6432	37	6415
		38	6444

water level = 30.00

031193

03293 1605 - 1630

NOTCH	COUNT	NOTCH	COUNT
R10	3935	22	4796
R15	5050	23	5006
R20	5090	24	5639
R2.5	5071	25	6317
R2.97	5032	26	6212
3	4955	27	6258
4	4720	28	6141
6	4702	29	6842
8	4642	30	5754
10	4591	31	5370
12	4804	32	5026
14	4674	33	6120
16	4692	34	6164
18	4751	35	6307
20	4763	36	6303
21	4592	37	5489
		38	11734

water level = 29.40'

(78)

031193

Site 2

TENSIOMETER	Cb	
6	74	DRY
12	78	NOT DRY
18	68	NOT DRY
24	57	NOT DRY
36	52	NOT DRY

My 081193

081393

(79)

Arrived Site 1 8:10am

	S	P	CW
Previous Standard Count	7784	7827	0.94
Today's Stand Count	7809	7784	1.02

Rain Gauge	Inches
3687	dry
2693	
02093	
02393	
Hole	
02593	
NW Post	
20891	

Tensiometers	C-Bars	
12"	75	dry
6"	76	dry
24"	76	dry
18"	78	dry

Weather: approx. 60°, sunny

(80)

081393

TDY/CES

Time: 0821 : 0829

02093	Mesh	Count	Notch	Count
	R 1.0	6286	3	4746
	R 1.5	5423	4	4576
	R 2.0	4328	6	4908
	R 2.5	5078	8	4510
	R 2.97	4954	10	5157

Time: 0829 : 0836

02293				
	2.0	6618	6	6721
	2.5	6269	8	5695
	2.97	6971	10	6732
	3	7590	12	6601
	4	6769	~~14~~ 13	6875

Time 0836 - 0846

02393				
	1.0	4088		
	1.5	4627	6	4758
	2.0	5097	8	4800
	2.5	4800	10	4767
	2.97	4824	12	4575
	3	4934	14	4419
	4	5004	16	6229

TDY/CES

081393

(81)

Time: 0847 : 0855

02493	Notch	Count	Notch	Count
	R 1.0	10039	4	7066
	1.5	9226	6	7676
	2.0	8187	8	7113
	2.5	7174	10	6791
	2.97	7462	12	8662
	3	7277	14	9423

Time: 0855 : 0902

02593				
	1.0	4209	3	4928
	1.5	4149	4	4711
	2.0	4992	6	4632
	2.5	5355	8	4741
	2.97	4913	10	4617
			12	4703

Time: 0902 - 0910

02693				
	1.0	4236	4	4889
	1.5	4120	6	4800
	2.0	3907	8	4819
	2.5	4380		
	2.97	4998	10	4696
	3	4704	12	5355
			14	6276

left side I 0915

(82) 081393 TDY/CES

Arrived Site 2 09:44

* All Rain Guages are dry

0917 – 0924

	Notch	Count	Notch	Count
02793 ~~613~~	1.0	6135	6	4926
	1.5	5986	8	4782
	2.0	5591	10	4797
	2.5	5582	12	4526
	2.97	5388	14	5038
	3	4980	16	4816
	4	5111	18	4732

Time: 0924 – 0934

02893	1.0	4605	6	4703
	1.5	4749	8	4789
	2.0	4728	10	4940
	2.5	4552	12	5158
	2.97	4805	14	5559
	3	4701	16	4831
	4	4594	18	4669

Tensiometer	Cb	
24"	57	Not dry
36"	54	Not dry
6"	73	dry
12"	79	dry
18"	68	not dry

TDY/CES 081393 (83)

Time: 0934 – 0944

	Notch	Count	Notch	Count
02993	1.0	5789	6	5269
	1.5	6118	8	4842
	2.0	5724	10	4923
	2.5	5978	12	4947
	2.97	5346	14	4814
	3	5001	16	4641
	4	4804	18	4865

Time: 0944 – 0953

03093	1.0	5445	6	4886
	1.5	5387	8	5133
	2.0	5690	10	5097
	2.5	5659	12	4792
	2.97	5375	14	5407
	3	5090	16	5033
	4	5199	18	4940

Time: 0953 – 10:04

03193	1.0	4777	6	5341
	1.5	5340	8	5136
	2.0	5641	10	5245
	2.5	5549	12	4908
	2.97	5840	14	5206
	3	5842	16	4742
	4	6080	18	4736

TPY/CES

081393

Time 10:04 - 10:12

	Notch	Count	Notch	Count
03293	1.0	3981	6	4683
	1.5	5135	8	4574
	2.0	5151	10	4569
	2.5	5198	12	4723
	2.97	5029	14	4612
	3	4885	16	4577
	4	4641	18	4725

Left Site 2 at 1044 a.m.

CES

081393

09:18 TPY & JWY Arrived at Site 1 for Neutron Probe Counting.

Previous Standard Count
S - 7809
P - 7784
Chi - 1.02

08-16-93 Standard Count
S - 7836
P - 7809
Chi - 1.06

Weather: 76°, Slight breeze Sunny.

08/16/93

Site #1 Tensinometers
& 24" ≈ & cintabars, Dry - Pre Pump -
(No sunshading)
60cb Post Pump

Tensiometer
18' ≈ & cintabars, Dry - Pre Pump
≈ 64cb Post Pump

6' ≈ 75 cintabars, Dry, - Pre Pump.
≈ 70cb Post Pump

12' ≈ 76 cintabars, Dry - Pre Pump.
≈ 70cb Post Pump.

0935 02093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6174	3	4676
R1.5	5394	4	4543
R2.0	4382	6	5026
R2.5	4944	8	4543
R2.97	4978	10	5136

09:46

08-16-93

09:47 02293

NOTCH	COUNT	NOTCH	COUNT
R2.0	6416	6	6721
R2.5	6080	8	5751
R2.97	6964	10	6722
3	7463	12	6505
4	6831	~~2.97~~ 14	6284

09:55 02393

NOTCH	COUNT	NOTCH	COUNT
R1.0	3955	6	4715
R1.5	4617	8	4891
R2.0	5100	10	4612
R2.5	4824	12	4581
R2.97	4754	14	4345
3	4906	16	6205
4	4907		

10:04 02493

NOTCH	COUNT	NOTCH	COUNT
R1.0	10032	4	7083
R1.5	9734	6	7694
R2.0	8238	8	7016
R2.5	7152	10	6888
R2.97	7429	12	8550
3	7394	14	9544

08-16-93

JDY

10:16 02593

NOTCH	COUNT	NOTCH	COUNT
R1.0	4189	4	4596
R1.5	4117	6	4450
R2.0	4894	8	4829
R2.5	5310	10	4580
R2.97	4996	12	4710
3	4904		

10:27 02693

NOTCH	COUNT	NOTCH	COUNT
R1.0	4210	6	4725
R1.5	4108	8	4867
R2.0	3905	10	4774
R2.5	4265	12	5361
R2.97	4571	14	6312
3	4716		
4	4806		

10:38 Left back to Subyard for Lunch.

12:06 Returned to Site 2 to finish Neutron Probe counting (JDY & JWY)

Pre-Pump
Tensiometers
6" - 0 - dry
12" - 76 -
18" - 71 - 1/2 dry
24" - 60 - not dry
36" - 55 - not dry

All rain guages are dry.

12:56
Post Pump
Tensiometers
6" - 56 cb
12" - 68 cb
18" - 64 cb
24" - 44 cb
36" - 49 cb

12:10
02793

NOTCH	COUNT	NOTCH	COUNT
R10	6037	6	4947
R15	6017	8	4777
R20	5631	10	4850
R25	5607	12	4532
R297	5367	14	5157
~~298~~ 3	5035	16	4741
4	5041	18	4760

12:21
02893

NOTCH	COUNT	NOTCH	COUNT
R10	4582	6	4624
R15	4804	8	4747
R20	4697	10	5080
R25	4617	12	5213
R297	4734	14	5465
3	4673	16	4694
4	4543	18	4686

12:33
02993

NOTCH	COUNT	NOTCH	COUNT
R10	5763	6	5253
R15	6106	8	4835
R20	5732	10	4786
R25	5886	12	4923
R297	5213	14	4760
3	4990	16	4597
4	4757	18	4909

12:44
080993

NOTCH	COUNT	NOTCH	COUNT
R10	5430	6	4889
R15	5264	8	4982
R20	5731	10	5022
R25	5599	12	4855
R297	5263	14	5306
3	5154	16	4875
4	5112	18	4880

08-16-93

JDY

12:56
03193

NOTCH	COUNT	NOTCH	COUNT
R1.0	4737	6	5272
R1.5	5442	8	5308
R2.0	5490	10	5301
R2.5	5448	12	4836
R2.97	5779	14	5109
3	5979	16	4714
4	5953	18	4756

1:11
03293

NOTCH	COUNT	NOTCH	COUNT
R1.0	3931	6	4811
R1.5	4929	8	4617
R2.0	5056	10	4518
R2.5	4977	12	4769
R2.97	5036	14	4721
3	4773	16	4642
4	4573	18	4763

13.23 Left Site 2, took post-pump readings at site 1. See pg 86.

1325 Went back to Subyard.

JDY

08-18-93

09:30 Arrived at Site 1 for neutron Probe counting (JDY & JWY)

9:35 Previous Standard count
S - 7842
P - 7836
Chi - 1.10

9:48 Todays Standard count
S - 7862
P - 7842
Chi - 0.90
NOTE: NUMBERS RECORDED BY John Yancey

9:35 Site 1 rain guages:
All rain guages are dry.
Weather - 75°, overcast, breezy

9:40 Site 1 Tensiometers:
6" - 75cb/Dry
12" - 76cb/
24" - 57cb/dry
36" -
18" - 0cb/Dry

08-18-93

Jay

09:53

~~10:03~~ Jay 02093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6137	3	4698
R1.5	5354	4	4604
R2.0	4411	6	5056
R2.5	5065	8	4570
R2.97	4892	10	5192

10:00 02293

NOTCH	COUNT	NOTCH	COUNT
R2.0	6298	6	6743
R2.5	6039	8	5718
R2.97	7010	10	6733
3	7431	12	6528
4	6807	Jay 13	6688

10:09 02393

NOTCH	COUNT	NOTCH	COUNT
R1.0	3916	6	4706
R1.5	4628	8	4855
R2.0	5042	10	4659
R2.5	4942	12	4535
R2.97	4798	14	4351
3	4866	16	6268
4	4900		

Jay

08-18-93

10:20 02493

NOTCH	COUNT	NOTCH	COUNT
R1.0	9936	4	7062
R1.5	9795	6	7719
R2.0	8083	8	7002
R2.5	7195	10	6882
R2.97	7499	12	86246
3	7313	14	9385

1031 02593

NOTCH	COUNT	NOTCH	COUNT
R1.0	4045	4	4635
R1.5	4138	6	4791
R2.0	4991	8	4713
R2.5	5400	10	4594
R2.97	5030	12	4695
3	4880		

10:40 02693

NOTCH	COUNT	NOTCH	COUNT
R1.0	4198	4	4776
R1.5	4128	6	4782
R2.0	3894	8	4785
R2.5	4306	10	4634
R2.97	4534	12	5313
3	4602	14	6247

10:55 moved to Site 2 to check rain guages and tensiometers

All rain guages are dry.

10:56 Tensiometers

6" 0/dry
12" 0/dry
18" 74cb/not dry
24" 62cb/not dry
36" 54cb/not dry

11:00 Went back to trailer to get water level indicator and to break for lunch.

JDy 8/18/93

02:40 Arrived at Site 2 to began Neutron Probe Counting. (JDY & JWY)

Took water level measurements.

Dan B. brought another indicator, so these are the readings

02793 - ~~Dry~~ 31.31 JDY
02893 - Dry
02993 - 30.16

03093 - 28.61
03193 - 29.84
03293 - 29.38
03/8/93 JDY

~~The water level indicator was broken, so we couldn't get readings.~~

02:50

02793	NOTCH	COUNT	NOTCH	COUNT
	R1.0	6068	21	4678
	R1.5	6007	22	6178
	R2.0	5622	23	6412
	R2.5	5580	24	6557
	R2.91	5275	25	6385
	3	5002	26	6493
	4	5194	27	6131
	6	4965	28	6433 ~~6065~~ JDY
	8	4792	29	6017
	10	4813	30	6041
	12	4515	31	5761
	14	4982	32	5772
	16	4740	33	5976
	18	4723	34	5850
	20	4502	35	5286
			36	6313
			37	7039
			10H/38	7405

08-18-93 TDY

1521

~~1521~~ TDY 02893

NOTCH	COUNT	NOTCH	COUNT
R1.0	4645	22	5768
R1.5	4638	23	5797
R2.0	4624	24	6668
R2.5	4584	25	6345
R2.97	4643	26	6321
3	4691	27	6201
4	4622	28	5752
6	4622	29	5540
8	4780	30	6121
10	4984	31	6405 T.D
12	5099	~~32~~ TDY	
14	5573	~~33~~ TDY	
16	4640	~~34~~ TDY	
18	4626	~~35~~ TDY	
20	4702	~~36~~ TDY	
21	4571	~~37~~ TDY	

These are accurate readings

Due to the late start (see 7 Lightning storm warnings - no work allowed, we only counted the next 4-10 feet. We will catch these on 8/20/93 to T.D.

15:42 - 15:59

02993

NOTCH	COUNT	NOTCH	COUNT
R1.0	5757	6	5245
R1.5	6228	8	4889
R2.0	5727	10	4907
R2.5	6061	12	4843
R2.97	5353	14	4672
~~R~~ 3	4962	16	4642
4	4756	18	4825

1400 - 1412

03093

NOTCH	COUNT	NOTCH	COUNT
R1.0	5459	6	4949
R1.5	5289	8	5062
R2.0	5696	10	4934
R2.5	5508	12	4834
R2.97	5358	14	5356
3	4985	16	4992
4	5229	18	4883

081893

1613 - 1623
03193

NOTCH	COUNT	NOTCH	COUNT
R1.0	4655	6	5221
R1.5	5286	8	5070
R2.0	5562	10	5238
R2.5	5401	12	4854
R2.97	5824	14	5182
3	5892	16	4676
4	6036	18	4722

1624 - 1634
03293

NOTCH	COUNT	NOTCH	COUNT
R1.0	3795	6	4731
R1.5	4994	8	4642
R2.0	5115	10	4556
R2.5	5065	12	4934
R2.97	4974	14	4679
3	4903	16	4560
4	4607	18	4811

082393

picked up probe 1200

Site 1 12:12 JW/+ MDK

1215 Previous Standard Count
S = 7842
P = 7836
Ch = 1.10

1217 Today's Standard Count
S = ~~7779~~ 7777
P = 7842
Ch = 1.05

1218 Site 1 Neutronetera

	PRE	POST 1315
6"	0 dry	56
12"	0 dry	62
18"	0 dry	52
24"	0 dry	56

1219 all rain gauges dry

weather 40°, hot, slight breeze
no clouds

082393

wdh
JWY

02093 1221 - 1228

NOTCH	COUNT	NOTCH	COUNT
R 1.0	6230	3	4639
R 1.5	5232	4	4549
R 2.0	4278	6	4940
R 2.5	4883	8	4488
R 2.97	4889	10	5227

02293 1229 - 1236

NOTCH	COUNT	NOTCH	COUNT
R 2.0	6204	6	6609
R 2.5	6067	8	5658
R 2.97	7037	10	6792
~~R 2.97~~ 3	7343	12	6573
~~R 2.97~~ 4	6609	13	6795

02393 1237 - 1247

NOTCH	COUNT	NOTCH	COUNT
R 1.0	3781	6	4744
1.5	4602	8	4840
2.0	4980	10	4733
2.5	4842	12	4563
2.97	4691	14	4234
3	4855	16	6272
4	4862		

wdh

082393

02493 1248 - 1258

NOTCH	COUNT	NOTCH	COUNT
R 1.0	10049	4	7047
1.5	9645	6	7504
2.0	7974	8	6972
2.5	7113	10	6853
2.97	7499	12	8649
3	7357	14	9183

02593 1259 - 1306

NOTCH	COUNT	NOTCH	COUNT
R 1.0	4069	3	4940
1.5	4144	4	4613
2.0	4836	6	4571
2.5	5331	8	4763
2.97	5006	10	4636
		12	4689

02693 1307 - 1316

NOTCH	COUNT	NOTCH	COUNT
R 1.0	4119	4	4766
1.5	4122	6	4725
2.0	3864	8	4660
2.5	4265	10	4690
2.97	4529	12	5309
3	4684	14	6448

Left Side #1 1317

(104) 082393 mdh JWY

1318 arrived at Site 2

1319 All rain gauges dry

1320 Site 2 Vensimeters

	PRE		1412 POST
6"	= 0 dry		62
12"	= 0 dry		58
18"	= 76	lots bubbles	64
24"	= 64	few bubbles	44
36"	= 58	" "	52

02793 1319 - 1328

NOTCH	COUNT	NOTCH	COUNT
R 1.0	6035	4	5167
1.5	5982	6	4959
2.0	5558	8	4741
2.5	5423	10	4783
2.97	5193	12	4605
3	5027		

mdh 082393 (105)

02893 1329 - 1337

NOTCH	COUNT	NOTCH	COUNT
R 1.0	4558	4	5402
1.5	4665	6	~~4[illegible]~~ 4616
2.0	4620	8	4625
2.5	4586	10	4771
2.97	4758	12	5088
3	4676		

02993 1338 - 1346

NOTCH	COUNT	NOTCH	COUNT
R 1.0	5694	4	4803
1.5	6092	6	5324
2.0	5667	8	4764
2.5	5928	10	4901
2.97	5282	12	4933
3	4936		

106 082393 mdh SWY

03093 1346 - 1354

NOTCH	COUNT	NOTCH	COUNT
R 10	5516	4	5207
15	5412	6	4981
20	5683	8	5080
25	5536	10	5011
2.97	5313	12	4830
3	5112		

03193 1355 - 1403

NOTCH	COUNT	NOTCH	COUNT
R 10	4603	4	5990
15	5312	6	5205
20	5471	8	5048
25	5426	10	5227
2.97	5721	12	4830
3	5982		

mdh 082393 107

03293 1404 - 1412

NOTCH	COUNT	NOTCH	COUNT
R 10	3804	4	4545
15	4923	6	4702
20	4934	8	4669
25	5119	10	4458
2.97	5064	12	4832
3	4841		

Left Set 2 1413

dropped off probe 1418

108

~~082393~~ TDY
082493

TDY

09.30 Went to site 1 to measure tensiometers

09:35 Site 1 Tensiometers
RMZ & TDY

6" 70 cb - dry
12 73 cb - dry
18" 72 cb - OK
24" 70 cb - OK

9:45 Returned to trailer.

109

CES/TDY ~~082393~~
082593

CES & TDY arrive at Site 1 at 7:35 a.m.
Weather 65° - partly cloudy

Rain Guages are all dry

Tensiometer

6	74 cb	dry
12	73 cb	dry
18	75 cb	dry
24	72 cb	dry

Standard Count (Previous)
S = 7842
P = 7836
Chi = 1.1

Standard Count
S - 7792
P - 7842
Chi - .98

082593

CES
TDY

7:45 - 7:53

02093	Notch	Count	Notch	Count
	R-1.0	6143	4.0	4542
	R-1.5	5236	6.0	4963
	2.0	4215	8.0	4536
	2.5	4854	10.0	5139
	2.97	4874		
	3.0	4696		

7:54 - 8:03

02293				
	~~1.0~~	—	—	4.0	6592
	~~1.5~~	—	—	6.0	6766
	2.0		6044	8.0	5675
	2.5		6043	10.0	6754
	2.97		6941	12.0	6613
	3.0		7240	14.0	6296

8:04 - 8:14

02393				
	1.0		3684	6.0	4777
	1.5		4523	8.0	4831
	2.0		5102	10.0	4687
	2.5		4816	12.0	4587
	2.97		4734	14.0	4394
	3.0		4771	16.0	6181
	4.0		5002		

8:15 - 8:22

02593				
	1.0	4040	4.0	4694
	1.5	4241	6.0	4480
	2.0	4860	8.0	4714
	2.5	5322	10.0	4634
	2.97	5010	12.0	4658
	3.0	4871		

CES
TDY

082593

8:23 - 8:34

02493	Notch	Count	Notch	Count
	1.0	9996	4.0	7028
	1.5	9540	6.0	7636
	2.0	8048	8.0	7009
	2.5	7077	10.0	6814
	2.97	7385	12.0	8619
	3.0	7297	14.0	9218

8:35 - 8:42

02693				
	1.0	4242	4.0	4816
	1.5	4120	6.0	4774
	2.0	5882	8.0	4828
	2.5	4269	10.0	4670
	2.97	4475	12.0	5327
	3.0	4607	14.0	6314

Left side 1 at 8:45

Arrived at Side 2 at 8:45
Rain Guages are empty/dry

Tensiometers

6	0 cb	dry
12"	0 cb	dry
18"	76 cb	not dry
24"	66 cb	not dry
36"	59 cb	not dry

112 082593 CES TDY

Side 2

02793 DTW 31.3

Notch	Count	Notch	Count
0847-0910			
1.0	5882	23	6315
1.5	5848	24	6595
2.0	5457	25	6349
2.5	5518	26	6402
2.97	5165	27	6102
3	5016	28	6360
4	5051	29	6029
6	4978	30	5874
8	4665	31	5709
10	4758	32	5704
12	4533	33	5952
14	4934	34	5796
16	4684	35	5347
18	4774	36	6227
20	4489	37	7047
21			
22	4500	38	7367
22	6116		

CES TDY 082593 113

02893 0910 - 0930

DTW dry

These are accurate readings

Notch	Count	Notch	Count
1.0	4595	21	4584
1.5	4734	22	5782
2.0	4674	23	5833
2.5	4552	24	6652
2.97	4652	25	6308
3	4586	26	6291
4	4586	27	6197
6	4689	28	5747
8	4754	29	5692
10	4983	30	5990
12	5163	31	6492
14	5590		
16	4639		
18	4587		
20	4671		

02993 DTW 29.31

1.0	8
1.5	10
2.0	12
2.5	14
2.97	16
3	18
4	
6	

0-25

03093

1.0	8
1.5	10
2.0	12
2.5	14
2.97	16
3	18
4	
6	

114

082593

CES TDY

	Notch	Count	Notch	Count
03193	1.0		6	
	1.5		8	
	2.0		10	
	2.5		12	
	2.97		14	
	3		16	
	4		18	
03293	1.0		6	
	1.5		8	
	2.0		10	
	2.5		12	
	2.97		14	
	3		16	
	4		18	

8-25-92

CES TDY

082593

115

0931 - 0945

02993	Notch	Count	Notch	Count
DTW	1.0	5748	21	4861
29.31	1.5	6126	22	4803
	2.0	5767	23	5980
	2.5	5975	24	6400
	2.97	5259	25	6811
	3	4994	26	6396
	4	4728	27	6374
	6	5240	28	6478
	8	4743	29	6362
	10	4942	30	6368
	12	4929	31	6663
	14	4725	32	6595
	16	4685	33	6697
	18	4946	34	5032
	20	4847	35	4301
			36	4446
			37	4500

~~Pensiometers~~

12" 0

0945 - 10:17

03093				
DTW	1.0	5472	22	7074
28.61	1.5	5359	23	6872
	2.0	5780	24	7119
	2.5	5586	25	6932
	2.97	5277	26	6977
	3	5073	27	6577
	4	5167	28	6768
	6	4937	29	6918
	8	5029	30	6919
	10	5010	31	6709
	12	4735	32	6448
	14	5393	33	6988
	16	4980	34	6214
	18	4991	35	5527
	20	5658	36	5762
	21	6455	37	6034

116

10:18-10:37

03/93

PTW

29.9

082593

TPY CES

Notch	Count	Notch	Count
1.0	4564	22	6272
1.5	5265	23	6002
2.0	5483	24	6780
2.5	5482	25	6397
2.97	5789	26	6325
3	5874	27	6281
4	5928	28	5970
6	5286	29	5926
8	5178	30	6007
10	5290	31	6075
12	4867	32	6112
14	5200	33	6162
16	4700	34	6117
18	4673	35	5967
20	5469	36	6033
21	6462	37	6187
		38	6403

TPY CES

10:40-11:03

082593

117

03293

PTW

29.3

Notch	Count	Notch	Count
1.0	3806	23	5813
1.5	5089	24	5448
2.0	5047	25	6249
2.5	5030	26	6260
2.97 3.5	4917	27	6230
3 4.5	4865	28	6113
4 6	4512	29	5907
6 8	4643	30	5786
8 10	4712	31	5285
10 12	4522	32	5116
12 14	4850	33	6098
14 16	4649	34	6147
16 18	4556	35	6303
18 20	4725	36	6250
20 21	4652	37	5416
21 22	4521	38	13157
22	4785		

Left Site #2 11:05 a.m.

08-25-93

CONTENTS

PAGE NO.	REFERENCE	DATE

1DY 090293 (1)

0925 - 1DY & JWY arrived at Site 1 for Nuetron Probe reading.

Weather: ≈60°, Cloudy, slightly to mod. humid, slightly breezy, possible showers

0929 Previous Standard Count

S - 7792

P - 7842

Chi - 0.98

Today's Standard Count

S - ~~7822~~ 1DY 7839

P - ~~7792~~ 1DY 7792

Chi - ~~1.05~~ 1DY 0.86

All Tensiometers read 0 and are dry.

All rain guages are dry.

09:46 02093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6028	6	4920
R1.5	5086	8	4516
R2.0	4282	10	5182
R2.5	4854	~~12~~ ~~10~~	
R2.97	4748		
3	4735		
4	4523		

09:58 02293

NOTCH	COUNT	NOTCH	COUNT
R2.0	5816	6	6657
R2.5	5985	8	5663
R2.97	7069	10	6717
3	7422	12	6584
4	6635	14 13	6808

10:20 02393

NOTCH	COUNT	NOTCH	COUNT
R1.0	3705	8	4891
R1.5	4663	10	4638
R2.0	4991	12	4589
R2.5	4740	14	4404
R2.97	4662	16	6121
3	4830		
4	5006		
6	4654		

10:47 - 0248

NOTCH	COUNT	NOTCH	COUNT
R1.0	9961	6	7690
R1.5	9555	8	6918
R2.0	7985	10	6801
R2.5	7054	12	8756
R2.97	7465	14	8964
3	7118		
4	7014		

10:56 - 02593

NOTCH	COUNT	NOTCH	COUNT
R1.0	4061	6	4540
R1.5	4145	8	4841
R2.0	4816	10	4579
R2.5	5334	12	4675
R2.97	4947	14	
3	4784		
4	4621		

11:06 02693

NOTCH	COUNT	NOTCH	COUNT
R1.0	4129	4	4782
R1.5	3958	6	4779
R2.0	3780	8	4799
R2.5	4274	10	4669
R2.97	4480	12	5314
3	4576	14	6321

118

090893

CES
TDY

Arrival Site # 8[illegible]
Weather is cool and clear - yet
slightly breezy - approximately 60°F
Rain gauges have water [illegible]
[illegible] ~~[illegible]~~
~~[illegible]~~ on the next page

Tensiometers

6	cb	zero & dry
12	cb	zero & dry
18	cb	zero & dry
24	cb	zero & dry

Standard Count (Previous)

S 7839
P 7792
Chi .86

Standard Count

S - 7801
P - 7839
Chi - 1.03

CES
TDY

090893

119

20891 Rain gauge 0.5"
3687 - Rain gauge 0.7"
02[illegible] - Gauge [illegible]
02593 - Gauge 0.5"
Hole in ground 0.6"
02093 - 0.3" (gauge)
02393 - Gauge 0.3"
NW Corner 0.3"

02093 08:50 - 0900

	Notch	Count	~~Notch~~	~~Count~~
R	1.0	6142		
	1.5	5020		
	2.0	4256		
	2.5	4885		
	2.97	4759		
	3.0	4698		
	4.0	4564		
	6.0	4870		
	8.0	4548		
	10.0	5237		

120

CES TDY

090893

0900-0906
02293

Notch	Count	Notch	Count
2.0	4641	6.0	6672
2.5	~~5024~~ 6224	8.0	5706
2.97	7034	10.0	6636
3.0	7370	12.0	6567
4.0	6641	14.0	6729

0907-0915
02393

Notch	Count	Notch	Count
1.0	3916	6.0	4676
1.5	4522	8.0	4853
2.0	4996	10.0	4647
2.5	4744	12.0	4522
2.97	4613	14.0	4324
3.0	4720	16.0	6245
4.0	4896		

0916-0926
02493

Notch	Count	Notch	Count
1.0	10042	4.0	7134
1.5	9571	6.0	7741
2.0	7972	8.0	7014
2.5	7007	10.0	6780
2.97	7449	12.0	8641
3.0	7264	14.0	8945

CES TDY

090893

21

0926-0933
02593

Notch	Count	Notch	Count
1.0	4405	4.0	4572
1.5	4465	6.0	4535
2.0	4869	8.0	4802
2.5	5343	10.0	4634
2.97	4934	12.0	4647
3.0	4937		

0933-0945
02693

Notch	Count	Notch	Count
1.0	4459	4.0	4958
1.5	4088	6.0	4800
2.0	3845	8.0	4843
2.5	4227	10.0	4743
2.97	4474	12.0	5441
3.0	4555	13.0	5720

Left Site 1 0945

Arrived Site 2 at 0948

Temisometers

6"	0 cb dry
12	0 dry
18	24 cb
24	74 cb
36	68 cb

122

090893

CES TD4

Side 2 - 0950-1027

02793

DTW 31.92

(measured from top of casing)

Notch	Count	Notch	Count
1.0	5919	23	6394
1.5	5739	24	6504
2.0	5339	25	6267
2.5	5472	26	6473
2.97	5042	27	6157
3.0	5130	28	6302
4	5137	29	6112
6	4900	30	5859
8	4756	31	5731
10	4928	32	5710
12	4625	33	6011
14	4886	34	5933
16	4770	35	5325
18	4745	36	6184
20	4426	37	6925
21	4599	38	7483
22	6098		

CES TD4

090893

123

1027-1046

02893

(DTW-dry)

Notch	Count	Notch	Count
1.0	4860	18	4704
1.5	4718	20	4738
2.0	4695	21	4608
2.5	4650	22	5749
2.97	4801	23	5737
3	4670	24	6837
4	4577	25	6338
6	4665	26	6495
8	4792	27	6186
10	4990	28	5780
12	5179	29	5596
14	5509	30	6139
16	4733	31	6283

Rain Gauges

02793	0.4"	03093	0.5"
02893	0.5"	03193	0.7"
02993	0.8"	03293	0.5"
12491	0.3"		

124

090893

CES
TDY

1046 - 1110
02993
DTW - 30.5'
from top of
casing

Notch	Count	Notch	Count
1.0	5782	24	6396
1.5	6045	25	6735
2.0	5683	26	6414
2.5	5871	27	6384
2.97	5142	28	6380
3.0	4891	29	6370
4	4777	30	6424
6	5272	31	6719
8	4802	32	6618
10	4954	33	6556
12	4882	34	4992
14	4782	35	4189
16	4641	36	4443
18	4899	37	4465
20	4699	38	9222
21	4854		
22	4677		
23	5974		

*Probe was wet-wiped it off

125

090893

CES
TDY

1110 - 11:30
03093
DTW - dry

Notch	Count	Notch	Count
1.0	5775	22	7043
1.5	5254	23	7067
2.0	5592	24	7236
2.5	5517	25	6889
2.97	5305	26	6864
3.0	5035	27	6602
4.0	5160	28	6880
6.0	4901	29	6695
8.0	5138	30	6992
10.0	~~5750~~ 5076	31	6708
12.0	4758	32	6610
14.0	5523	33	7060
16.0	4992	34	6006
18.0	4971	35	5615
20.0	5535	36	5806
21.0	6392	37	5905
		~~38~~	

1130 - 1154
03193
DTW 30.8'
from top of
casing

Notch	Count	Notch	Count
1.0	4782	24	6793
1.5	5219	25	6438
2.0	5412	26	6359
2.5	5434	27	6354
2.97	5710	28	6113
3.0	5901	29	5987
4	6016	30	6012
6	5314	31	6145
8	5115	32	6151
10	5279	33	6170
12	4941	34	6013
14	5151	35	6120
16	4832	36	5985
18	4766	37	6162
20	5438	38	6787
21	6457		
22	6193		
23	5817		

126 090893 TPY CES

1155-1220

0328

PTW 30.44' (from top of casing

Notch	Count	Notch	Count
1.0	4583	24	5566
1.5	5148	25	6272
2.0	5037	26	6327
2.5	4989	27	6259
2.97	5036	28	6168
3.0	4842	29	5885
4	4647	30	5715
6	4732	31	5325
8	4623	32	5128
10	4594	33	6048
12	4809	34	6251
14	4463	35	6225
16	4581	36	6255
18	4788	37	5407
20	4833	38	
21	4616		
22	4683		
23	5862		

Left Site 2 at 1225
and returned to AST trailer
C. Shirley
090893

091593

0830 arrived Site 1

Standard Count (Previous)
S = 7849
P = 7801
Chi = 0.74

Standard Count
S = 7893
P = 7849
Chi = 1.05

Weather Sunny & clear, breezy
@ 60°F

Rain gauges have ~~the~~ water
02093 = 0.2 in ; 02393 = 0.7 in ; 02593 = 0.5 in ; 3687 = 2.6 in

Tensiometer Readings

		PRE	POST	tensiom gauge
4	dry	0	46 cb	8.9 in
12	dry	0	52 cb	20891 = 0.5 in
18	dry	0	58 cb	
24	dry	0	42 cb	

091593

02093 0834 - 0848

NOTCH	COUNT	NOTCH	COUNT
R 1.0	6233	3	4687
1.5	4923	4	4573
2.0	4314	6	4913
2.5	4280	8	4589
2.97	4774	10	5200

02293 0849 - 0901

NOTCH	COUNT	NOTCH	COUNT
R 2.0	7350	6	6677
2.5	6381	8	5779
2.97	7035	10	6745
3	7317	12	6596
4	6508	13	6871

02393 0902 - 0914

NOTCH	COUNT	NOTCH	COUNT
R 1.0	4335	6	4719
1.5	4722	8	4894
2.0	4947	10	4617
2.5	4745	12	4621
2.97	4708	14	4328
3	4815	16	6355
4	4861		

091593

mth mth

02493 0915 - 0935

Count	NOTCH	COUNT	NOTCH
1.0	10584	3	7338
1.5	9425	4	7091
2.0	7920	6	7586
2.5	7177	8	6962
2.97	7394	10	6720
		12	8613
		14	8839

02593 0936 - 0956

COUNT	NOTCH	COUNT	NOTCH
1.0	4420	4	6339
1.5	4309	6	4533
2.0	4870	8	4763
2.5	5313	10	4630
2.97	4812	12	4749
3	4803	~~13~~ mth	

02693 0957 - 1010

~~Left Site 1~~ mth

Count	NOTCH	Count	notch
1.0	4770	4	4692
1.5	4106	6	4819
2.0	3847	8	4770
2.5	4287	10	4765
2.97	4449	12	5349
3	4604	14	6444

Left Site 1 1011

091593

1308 arrived at Site 2

Rain gauges

12491	0.4 in
03093	0.5 in
03193	0.3 in
03293	bee in it - no reading
02993	0.3 in
02893	0.5 in
02793	0.7 in

02793 1314 - 1327

Count	Notch	Count	Notch
R1.0	6392	6	4910
1.5	5834	8	4692
2.0	5386	10	4791
2.5	5345	12	4613
2.97	5089	14	4878
3	4919	16	4810
4	5055	18	4802

2987 depth to water 02793

Tensiometers

	PRE	POST
6" =	0 dry	46 cb
12" =	0 dry	24 cb
18 =	72 cbs	52 cb
24 =	70 cbs	42 cb
36 =	69 cbs	60 cb

mb

02893 1328 - 1340

COUNT	NOTCH	COUNT	NOTCH
R 10	~~29~~4879	6	4778
15	5069	8	4835
20	5166	10	4983
25	5335	12	5215
2.97	5266	14	5452
3	5104	16	5452
4	4890	18	4645

02893 dry well

02993 1340 - 1355

COUNT	NOTCH	COUNT	NOTCH
10	6322	6	5186
15	6007	8	4808
20	5055	10	4845
25	5832	12	4801
2.97	5166	14	4841
3	4972	16	4785
4	4717	18	5024

02993 dry well

mb

03093 1355 - 1405

Count	Notch	Count	Notch
10	6394	6	4990
15	5725	8	5092
20	5964	10	4946
25	5602	12	4946
2.97	5261	14	5447
3	5058	16	4914
4	5250	18	4851

03093 dry well

03193 1406 - 1420

Count	Notch	Count	Notch
10	4881	6	5276
15	5317	8	5142
20	5435	10	5273
25	5341	12	4871
2.97	5712	14	5163
3	6043	16	4671
4	5884	18	3679

29.82 depth to water fr 03193

091593

03293 1421 - 1435

COUNT	NOTCH
10	4536
15	5243
20	5039
25	4937
297	4991
3	4918
4	4526
6	4629
8	4727
10	4616
12	4801
14	4584
16	4567
18	4805

2954 depth to water for 03293

Left Site 2 1438

mdh

mdh
JWY

0810 arrived site #1

Standard Count (Previous)

S = 7849

P = 7801

Ch = 0.74

Standard Count

S = 7808

P = 7849

Ch = 1.12

Weather cool + overcast
@ 50°

Rain gauges were dry; no water

Thermometer

	PRE	POST
6 =	59 cb	56 cb
12 =	68 cb	58 cb
18 =	72 cb	59 cb
24 =	72 cb	52 cb

02093 0823 - 0833

NOTCH	COUNT	NOTCH	COUNT
R1 0	6294	3	4663
1 5	4918	4	4623
2 0	4350	6	4925
2.5	4780	8	4500
2.97	4763	10	5161

02293 0928 - 0936

NOTCH	COUNT	NOTCH	COUNT
R2 0	~~4259~~ 7235	6	6707
2 5	6354	8	5728
2 97	6970	10	6706
3	7367	12	6658
4	6595	13	6056

02393 0834 - 0857

NOTCH	COUNT	NOTCH	COUNT
R1 0	4259	6	4721
1 5	4597	8	4871
2 0	4942	10	4547
2 5	4711	12	4589
2 97	4735	14	4349
3	4844	16	6204
4	4829		

02493 0901 - 0917

NOTCH	COUNT	NOTCH	COUNT
R1 0	10412	4	7148
1 5	9559	6	7560
2 0	7815	8	7887
2 5	7003	10	6825
2 97	7496	12	8643
3	7251	14	8621

02593 0918 - 0928

NOTCH	COUNT	NOTCH	COUNT
R1 0	4223	4	4522
1 5	4297	6	4574
2 0	4916	8	4773
2 5	5221	10	4651
2 97	4978	12	4692
3	4731		

02693 0937 - 0950

NOTCH	COUNT	NOTCH	COUNT
R1 0	4711	4	4707
1 5	4119	6	4760
2 0	3757	8	4699
2 5	4227	10	4736
2 97	4501	12	5362
3	4523	15	5731

0952 Left Site #1

1330 Arrived at Site #2

Tensiometers

	PRE	POST
6	64 cb	54 cb
12	dry	40 cb
18	68 cb	62 cb
24	58 cb	52 cb
36	64 cb	60 cb

Rain gauges were dry

Depth to Water

02793	31.88
02893	dry
02993	20.72
03093	dry
03193	29.83
03293	29.56

02793 STARTED 13:39 - 1407

COUNT	READ	COUNT	READ
R1 0	6324	23	6387
1 5	5937	24	6532
2 0	5275	25	6408
2 5	5351	26	6453
2 97	5104	27	6089
3	4946	28	6323
4	5004	29	6066
6	5000	30	5904
8	5845	31	5764
10	4805	32	5712
12	4510	33	5895
14	5057	34	5779
16	4818	35	5325
18	4786	36	6216
20	4493	37	6895
21	4572	38	7282
22	6104		

091793

mdh

02893 1408 - 1436

COUNT	NOTCH	COUNT	NOTCH
R10	4711	18	4739
15	4987	20	4670
20	5007	21	4703
25	5236	22	5852
2.97	5141	23	5784
3	5020	24	6794
4	4662	25	6403
6	4674	26	6459
8	4782	27	6234
10	4955	28	5804
12	5190	29	5544
14	5346	30	6176
16	4658	31	6507

Started to rain at 1435

mdh

091793

02993 1437 - 1504

COUNT	NOTCH	COUNT	NOTCH
R10	6218	23	6082
1.5	6064	24	6319
2.0	5522	25	6789
2.5	5255	26	6369
2.97	5127	27	6382
3	4812	28	6430
4	4689	29	6346
6	5168	30	6335
8	4682	31	6680
10	4936	32	6583
12	4866	33	6627
14	4903	34	4949
16	4769	35	4281
18	4882	36	4403
20	4831	37	4432
21	4980	38	7880
22	4745		

03093 1505- 1536

NOTCH	COUNT	NOTCH	COUNT
R1.0	6397	22	7041
1.5	5743	23	7040
2.0	5841	24	7181
2.5	5549	25	6809
2.97	5273	26	6878
3	5053	27	6531
4	5182	28	6710
6	4916	29	6696
8	5031	30	6971
10	5044	31	6581
12	4767	32	6527
14	5462	33	7022
16	4934	34	6141
18	4929	35	5527
20	5579	36	5644
21	6297	37	5860

03193 1537- 1605

NOTCH	COUNT	NOTCH	COUNT
R1.0	4957	23	5863
1.5	5244	24	6763
2.0	5360	25	6445
2.5	5376	26	6288
2.97	5724	27	6229
3	5887	28	6068
4	5944	29	5929
6	5129	30	5879
8	5088	31	6102
10	5285	32	6138
12	4827	33	5981
14	5178	34	6057
16	5609	35	6034
18	4658	36	5999
20	5499	37	6225
21	6447	38	6574
22	6263		

091793

mdk
JWY

03293 1606 - 1630

NOTCH	COUNT	NOTCH	COUNT
R10	4506	23	5900
15	5295	24	5525
20	5070	25	6331
25	4993	26	6203
297	4939	27	6216
3	4841	28	6054
4	4598	29	5923
6	4666	30	5738
8	4635	31	5299
10	4607	32	5077
12	4876	33	6159
14	4498	34	6219
16	4532	35	6298
18	4791	36	6235
20	4726	37	5390
21	4591		
22	4632		

1633 left Site #2

MDK
JWY
MIKE BENSKI

092093

0915 arrived at Site #2

Pam gauge

02793 - 0.3 in
02893 = 0.0 in
02993 = 0.4 in
03093 = 0.3 in
03193 = 0.3 in
12491 = 0.4 in

Venturometers

6 = 16 cb
12 = 24 cb
18 = 58 cb
24 = 56 cb
34 = 61 cb

0940 Pump started
1145 out of water

02993 = 1.1 in
03193 = 0.5 in
03093 = 1.0 in
12491 = 1.4 in
02893 = 1.1 in
02793 = 1.3 in

092093

1310 arrived at Site #1

Rain gauges

20891 = 0.4 in
02593 = 0.4 in
ground = 0.3 in
02393 = 0.3 in
02093 = 0.0 in
3487 BR = 0.4 in

Tensiometers

6 = 68 cb
12 = 72 cb
24 = 54 cb
18 = 78 cb

1519 Water Out

20891 = 0.4 in
02593 = 1.0 in
ground = 0.9 in
02393 = 0.4 in
02093 = 0.8 in
3487 BR = 0.4 in

200 gallons to begin; 12 left

Tuesday Sept. 21, 1993

Site 2 Arrival 8:18 A.M.

~~Raining~~ Hot, Clear Sunny day, High expected ~80°F

Tensiometers

6 = 11 cb
12 = 11 cb
18 = 26 cb
24 = 51 cb
36 = 57 cb

Mike Bonski
John Yancey

Rain gauges

02793 = 1.2 in.
02893 = 0.7 in.
02993 = 1.0 in.
03093 = 1.0 in.
03193 = 0.5 in.
12491 = 1.3 in.

Tank has 200 gallons to start

Pump started at 8:25 A.M.

Pump shut off at 9:39 A.M. after 100 gallons - run-off had started.

Rain gauges

02793 = 1.5 in.
02893 = >1.0 in.
02993 = 1.5 in.
03093 = 1.3 in.
03193 = 0.7 in.
12491 = 1.5 in.

Sept. 21, 1993 John Yancey / Mike Bemski

Site 1 - Arrived 9:48 A.M.
with 100 gallons in tank

Tensiometers	Rain gauges
6 = 44 cb	02093 = 0.8 in.
12 = 52 cb	02393 = 0.5 in.
18 = 76 cb	02593 = 1.0 in.
24 = 48 cb	20891 = 0.4 in.
(no water)	3687BR = 0.4 in.

Pump started 9:52 A.M.
Pump off (automatically) at 10:53 A.M.
~ 10 gallons left in tank
Run off substantial

Rain gauges
02093 = 1.1 in.
02393 = 0.5 in.
02593 = 1.3 in.
20891 = 0.4 in.
3687BR = 0.5 in.

~ 90 gallons pumped in 1 hour

Total sprinkled as of 11:40 - 09/21/93:

Site 1 - 1.2 in
Site 2 - 1.7 in.

09/21/93
GROUND H_2O READINGS.

12:14 ARRIVED BACK @ SITE #2
SET UP EQUIPMENT

Rain Gauges	Tensiometers
02793 = 1.50"	0.6" = 5 cb
02893 = 1.00" (EMPTIED)	12" = 10 cb
02993 = 1.50"	18" = 28 cb
03093 = 1.20"	24" = 48 cb
03193 = 0.40"	36" = 50 cb
12491 = 1.50"	

12:24 STARTED PUMP & SPRINKLER @ #2
12:35 ALREADY OBSERVING WATER RUNNING OFF OF SITE; HOWEVER AN UNMEASURABLE AMOUNT OF H_2O HAS BEEN PLACED DOWN. THEREFORE I FEEL IT WOULD NOT BE PRUDENT TO MOVE TO THE NEXT SITE. THERE WOULD BE NO WAY OF TRACKING THE AMOUNT OF WATER AT EACH SITE.
12:42 STOPED PUMP & MOVED TO SITE #1
PLACED ≈ 0.1" H_2O @ #2.
12:47 ARRIVED @ SITE #1.

Rain Gauges	
02093 = 1.0"	20891 = 0.4"
02393 = 0.5"	3687BR = 0.5"
02593 = 1.3"	GROUND = 0.3" (EMPTIED)

09/21/93

GROUN H_2O Recharge

12:53 STARTED PUMP & SPRINKLER @ #1

13:00: AGAIN OBSERVING RUN OFF FROM SITE AND AN UNMEASABLE AMOUNT OF H_2O HAS BEEN PLACED. I FEEL MOVING AT THIS TIME WOULD BE A WASTE OF TIME AND ENERGY.

13:15: QUIK CHECK AT SITE #2, ALL H_2O in RAIN GAUGE @ 02293, WHICH HAD 0.1" IN IT, IS NOW EMPTY. I CAN ONLY ASSUME THAT IT EVAPORATED IN THAT 30 MIN TIME SPAN.

13:23: STOPED PUMP & SPRINKLER MOVED BACK TO SITE #2. PLACED ~ 0.1" @ #1.

13:25: ARRIVED BACK @ SITE #2

13:27: STARTED PUMP & SPRINKLER @ #2

13:29: NOTICE RUN OFF ALMOST IMEDATLY.

13:47: RAN OUT OF GAS STOPED SPRINKLING @ SITE #2. PLACED ~ 0.1".

14:11: ARIVED BACK @ TRAILER, COMPLETED TASK FOR TODAY.

[signature]
09/21/93

MIKE BEMSKI
DEANNA KASKIE

092293

0815 [illegible] + Site 2

0827 Cold, wet, + raining @ 50°F

tensiometers

6 = 8 cb
12 = 11 cb
18 = 20 cb
24 = 38 cb
56 = 51 cb

tank has 200 gallons

pump started 0830

rain gauges

	ORIGINAL	100 gal
ground	= 0.0 in	0.5 gal
12491	= 1.6 in	1.9 in
02793	= 1.7 in	2.3 in
~~02893~~		
02993	= 1.7 in	2.1 in
03093	= 1.1 in	1.3 in
03193	= 0.7 in	1.0 in

0938 ~~100~~ 115 gallons down
120

092293

Arrived Site #1 0959

Tensiometers

6 = 34 cb
12 = 38 cb
18 = 72 cb
24 = 0 cb

Rain gauges	RIGINAL	45 min
20891 =	0.4 in	0.5 in
36873R =	0.6 in	0.65 in
02093 =	1.4 in	1.7 in
02393 =	0.7 in	0.8 in
02593 =	1.3 in	1.4 in
top of pole =	0.0 in	0.1 in
ground =	0.0 in	0.3 in

1002 started pumping 80 gal.
1048 out of water
1050 Left Site #2

10-12 gallons remaining

092293

Arrived at Site #1 1320
Began running pump 1336
stopped 1410 @ 130 gal.

28891 = 0.8 in
36873R = 1.9 in
02093 = 2.3 in
02393 = 1.0 in
02593 = 1.9 in
top of pole = 0.1 in
ground = 0.7 in

Site #2 1415 @ 70 gal.

02793 = 2.7 in
03093 = 1.4 in
03193 = 1.2 in
02993 = 2.2 in
ground = 0.7 in
12491 = 2.1 in

Left site #2 500

10-12 gallons remaining

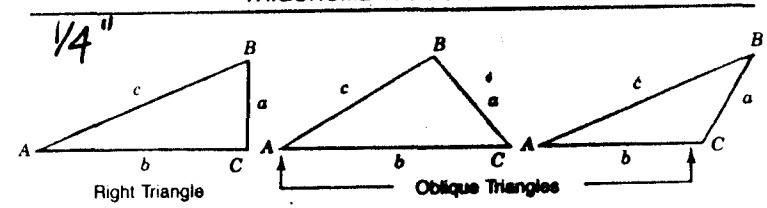
152

FGG ID # - 2369
CUSTODIAN: Grant Evenson
Manf. ID # - H30089809
6/17/90 - ASSAY DATE

9624

TRIGONOMETRIC FORMULÆ

1/4"



Solution of Right Triangles

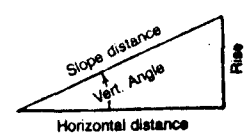
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b} = \cot B$, $c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B$, $b = \sqrt{(c+a)(c-a)} = c\sqrt{1 - \frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$.
A, b	B, a, c	$B = 90° - A$, $a = b \tan A$, $c = \frac{b}{\cos A}$.
A, c	B, a, b	$B = 90° - A$, $a = c \sin A$, $b = c \cos A$.

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A + B = 180° - C$, $\tan \frac{1}{2}(A - B) = \frac{(a-b)\tan \frac{1}{2}(A+B)}{a+b}$, $c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2}$, $\sin \frac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{b\,c}}$, $\sin \frac{1}{2} B = \sqrt{\frac{(s-a)(s-c)}{a\,c}}$, $C = 180° - (A + B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{b\,c \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL



Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert angle = 5° 10'. From Table, Page IX. cos 5° 10' = .9959. Horizontal distance = 319.4 × .9959 = 318.09 ft.

Horizontal distance also = Slope distance minus slope distance times (1 − cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. Cosine 5° 10' = .9959. 1 − .9959 = .0041. 319.4 × .0041 = 1.31. 319.4 − 1.31 = 318.09 ft.

When the rise is known, the horizontal distance is approximately: − the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft., slope distance = 302.6 ft. Horizontal distance $= 302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.

MADE IN U.S.A.

(4) 09/02/93 TDY

11:17 ARRIVE @ SITE #2. TAKE H_2O Levels
02793 = 31.16' 03093 = 28.88'
02893 = DRY 03193 = 29.86'
02993 = 29.50' 03293 = 31.16'

11:26 TENSIOMETER READINGS.
6" = 0 DRY 24" = 68 cb
12" = 0 DRY 36" = 62 cb
18" = 62 cb

11:30 LEFT SITE #2 DUE TO INCREASING RAIN

11:35 RETURNED HYDRO PROBE TO STORAGE CONNEX, & RETURNED TO TRAILER

NOTE: STORM ~~FORM~~ FRONT SEEMS SLOW MOVING. STARTED RAINING ≈ 10:00, NO ~~[illegible]~~ WIND MOVING THE STORM AROUND. NO SIGN OF THE STORM LETTING UP.

mlk jy 092493 (5)

1305 arrive Site #1

Rain gauges

02093 = 2.4 in broke after 50 gall.
02393 = 1.0 in = 1.4 in
02593 = 1.9 in = 2.3 in
20891 = 0.7 in = 1.0 in
3687BR = 1.8 in = ~~2.2 in~~ emptied
ground = 0.5 in = 0.3 in
post = dry = dry

Tensiometers

6" = 24 cb
12" = 18 cb
24" = dry -- jet filled top needs to be replaced
18" = 76 cb

(6) 092493 mdk gy

arrived at Site #2 1400

Rain gauges

	PRE	POST
02793	2.7 in	3.3 in
02993	2.3 in	2.5 in
03093	1.4 in	1.6 in
03193	1.2 in	1.4 in
12491	2.1 in	2.5 in
* ground	0.6 in	0.5
03293	0.0 in	0.0 in

ver 90 gal

Tensiometers

6" = 10 cb
12" = 15 cb
18" = 20 cb
24" = 25 cb
36" = 42 cb

left site #2 1510

Emptied all rain gauges on both sites

MDK gy 092793 (7)

07:30 Arrived at RFP, picked supplies (NOTE: Time getting dosemeters)

0845 Arrived at Site 2.

Previous Count
S - 7849
P - 7801
chi - 0.76

New Count
S - 7812
P - 7849
chi - 1.11

No water in rain guages.

Tensiometers:

	Post
6 = 16 cb	18 cb
12 = 20 cb	22 cb
18 = 24 cb	24 cb
24 = 26 cb	26 cb
36 = 38 cb	38 cb

(8)

092793

0856-0914 02793

NOTCH	Count	NOTCH	Count
R1.0	6706	6	4903
1.5	6262	8	4786
2.0	5643	10	4806
2.5	5425	12	4543
2.97	5229	14	4976
3	4982	16	4682
4	5002	18	4763

0915-0932 02893

NOTCH	COUNT	NOTCH	COUNT
1.0	4592	6	4713
1.5	5003	8	4846
2.0	5190	10	5040
2.5	5403	12	5097
2.97	5410	14	5606
3	5109	16	4641
4	4786	18	4614

092793 (9)

0933-0948 02993 0933-0948

NOTCH	COUNT	NOTCH	COUNT
1.0	6345	6	5241
1.5	6282	8	4834
2.0	5836	10	4853
2.5	5898	12	4947
2.97	5108	14	4819
3	4814	16	4766
4	4797	18	4919

0949-1009 03093 0949-1009

NOTCH	COUNT	NOTCH	COUNT
1.0	6730	6	4947
1.5	5706	8	5059
2.0	5909	10	4970
2.5	5112	12	4875
2.97	5364	14	5539
3	5178	16	4940
4	5252	18	4970

(0)

092743

1010-1032 03193 1010 - 1032

NOTCH	COUNT	NOTCH	COUNT
1.0	5368	6	5312
1.5	5678	8	5098
2.0	5647	10	5275
2.5	5400	12	4910
2.97	5797	14	5156
3	5854	16	4736
4	5833	18	4676

1033-1050 03293 1033 - 1050

NOTCH	COUNT	NOTCH	COUNT
1.0	4611	6	4690
1.5	5394	8	4650
2.0	5270	10	4622
2.5	5061	12	4802
2.97	4949	14	4601
3	4744	16	4617
4	4561	18	4675

092793

(11)

NOTCH	COUNT	NOTCH	COUNT
1.0			
1.5			
2.0			
2.5			
2.97			
3			
4			

092793

11:26 arrived at Site 1

No water in rain gauges.

Tensiometers

			OST
6 =	30cb	=	20cb
12 =	20cb	=	24cb
18 =	78cb	=	58cb
24 =	Broken - need to replace jet fill cup.		

1129-1139 02093 1129-1139

NOTCH	COUNT	NOTCH	COUNT
1.0	6641	3	4609
1.5	4889	4	4533
2.0	4310	6	4915
2.5	4833	8	4433
2.97	4816	10	5214

02293 1140-1151

	NOTCH	COUNT	NOTCH	COUNT
R	2.0	7879	6	6504
	2.5	7735	8	5771
	2.97	7755	10	6727
	3	7517	12	6750
	4	6569	14	5921

02313 1152 - 1203

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	4474	4	4824
	1.5	4904	6	4701
	2.0	5000	8	4748
	2.5	4689	10	4552
	2.97	4614	12	4581
	3	4727	14	4292
			16	6330

092793

02493 1204-1216

NOTCH	COUNT	NOTCH	COUNT
R 1.0	10670	4	7110
1.5	9405	6	7677
2.0	7908	8	7010
2.5	7056	10	6745
2.97	7355	12	8696
3	7296	14	8424

02593 1217-1223

NOTCH	COUNT	NOTCH	COUNT
R 1.0	4601	3	4776
1.5	4398	4	4558
2.0	4843	6	4500
2.5	5176	8	4700
2.97	4849	10	4645
		12	4748

092793

02693 1224-1233

NOTCH	COUNT
R 1.0	4915
1.5	4374
2.0	3847
2.5	4317
2.97	4455
3	4626
4	4805
6	4682
8	4802
10	4697
12	5412
13	5641

092993

web

0800 arrived at Site #1
All rain gauges dry

Tensiometers

		POST	
6	32cb	32 cb	
12 =	24cb	26 cb	
18 =	74cb	62 cb	
24 =	broken	56 cb	fixed

Standard Count
S = 7849
P = 7801
Cu = 0.76

S = 7812
P = 7849
Cu = 0.95

Weather cool, clear w/ slight breeze @ 60°F

web

092993

02095 0815 - 0827

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	4641	3	4727
	1.5	4927	4	4583
	2.0	4280	6	4755
	2.5	4802	8	4431
	2.97	4782	10	5291

02293 0828 - 0842

	NOTCH	COUNT	NOTCH	COUNT
R	2.0	7826	6	6585
	2.5	7189	8	5682
	2.97	7800	10	6635
	3	7493	12	6654
	4	6546	14	6023

02393 0843 - 0904

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	4439	4	4781
	1.5	4913	6	4831
	2.0	4926	8	4608
	2.5	4745	10	4413
	2.97	4636	12	4560
	3	4787	14	4416
			16	6304

(18) 092993 wdh

02493 0905 - 0916

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	10616	4	6988
	1.5	9391	6	7553
	2.0	7777	8	7119
	2.5	6964	10	6832
	2.97	7308	12	8795
	3	7220	14	8397

02593 0917 - 0926

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	4541	4	4527
	1.5	4461	6	4544
	2.0	4782	8	4807
	2.5	5152	10	4537
	2.97	4827	12	4780
	3	4785		

02693 0927 - 0942

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	4935	4	4646
	1.5	4349	6	4754
	2.0	3843	8	4836
	2.5	4322	10	4719
	2.97	4447	12	5348
	3	4574	13	5732

wdh 092993 (19)

1100 MOVE PROBE TO RED TRUCK??

~~0945~~ arrived at Site ~~#~~ 2 CALLED ROSE

all rain gauges dry
weather @ 75°F clear, warm

TENSIOMETERS	POST
6 = 21 cb	22 cb
12 = 28 cb	28 cb
18 = 28 cb	28 cb
24 = 28 cb	28 cb
36 = 38 cb	38 cb

02793 1104 - 1140

	NOTCH	COUNT	NOTCH	COUNT
R	1.0	6506	4	4719
	1.5	6130	8	4593
	2.0	5526	10	4728
	2.5	5383	12	4787
	2.97	5112	14	4977
	3	4999	16	4733
	4	5025	18	4735

(79) 092993 rdb

02793 cont.

20	4447	30	5969
21	4572	31	5778
22	6136	32	5690
23	6445	33	6104
24	6563	34	5935
25	6493	35	5317
26	6490	36	6219
27	6083	37	6900
28	6394	38	7338
29	6009	~~39~~	

Depth to Water = 29.7 ft

rdb 092993 (21)

02893 1141 - 1212

NOTCH	COUNT	NOTCH	COUNT
E 1.0	4629	25	6591
1.5	4847	26	6516
2.0	5224	27	6252
2.5	5391	28	5730
2.97	5427	29	5618
3	5021	30	6264
4	4806	31	6787
6	4649	32	
8	4790	33	
10	4918	34	
12	5178	35	
14	5501	36	
16	4660		
18	4627		
20	4723		
21	4601		
22	5885		
23	6000		
24	6936		

no water in well 02893

092993 mdk

02993 1218 - 1248

Depth to Water 29.7 ft

NOTCH	COUNT	NOTCH	COUNT
R1.0	6353	25	6775
1.5	6268	26	6643
2.0	5741	27	6412
2.5	5886	28	6354
2.97	5227	29	6424
3	4913	30	6408
4	4691	31	6585
6	5155	32	6495
8	4788	33	6582
10	4875	34	4851
12	4848	35	4308
14	4843		
16	4588		
18	4968		
20	4754		
21	4834		
22	4745		
23	5991		
24	6397		

Conversation w/ Traci indicating a change in procedure -- 03093 - 10 ft 03193 - TD 03293 - 10 ft = 4 holes to TD; not 3

mdk 092993

02993, cont.

36	4334
37	4498
38	6831

03093 1249 - 1301

NOTCH	COUNT	NOTCH	COUNT
R1.0	6642	10	4957
R1.5	5714	12	4853
2.0	5962	14	5475
2.5	5638	16	4998
2.97	5339	18	~~[illegible]~~ 5008
3	5050		
4	5199		
6	4845		
8	5110		

dry well

probe making strange electronic hum after initial engagement.

(24) 092993 mdh

03193 1302-1333 [dry 29.82ft]

NOTCH	COUNT	NOTCH	COUNT
R1.0	5315	27	6446
1.5	5724	28	6016
2.0	5712	29	6001
2.5	5462	30	5899
2.97	5764	31	6073
3	5919	32	6137
4	5295	33	6079
6	5066	34	6169
8	5220	35	6022
10	4943	36	6014
12	5093	37	6026
14	4628	38	6650
16	4729		
18	5373		
20	6532		
21	6451		
22	6147		
23	5878		
24	6763		
25	6484		
26	6132		

noise continuing re probe
(TICKING white counting)

mdh 092993 (25)

03293 1334-1344

NOTCH	COUNT	NOTCH	COUNT
R1.0	4702	6	4678
1.5	5383	8	4478
2.0	5216	10	4621
2.5	5085	12	4852
2.97	5036	14	4569
3	4758	16	4645
4	4521	18	4798

depth to water = 29.64ft

hum continued

1345 left site

John Young

(26) 10/01/93 JWY MDK

GROUND H_2O RECHARGE

07:30 ARRIVED @ RFP FOR MEETING W/ ROSS ZIELER. (UNABLE TO DO: MONDAY)

08:30 ROUNDED UP SUPPLIES, LEFT FOR FIELD.

JWY MDK 10/01/93 (27)

0835 arrive at Site #1

Weather warm, clear ~65°F

Previous Standard Count

S = 7868

P = 7849

Chi = 1.05

Todays Standard Count

S = 7869

P = 7868

Chi = 0.91

Tensiometers		POST
6	= 38 cb	40
12	= 30 cb	30
18	= 74	68
24	= 70	60

All rain gauges dry.

10/01/93

mk

0850 02093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6579	3	4666
1.5	4943	4	4574
2.0	4363	6	4866
2.5	4892	8	4515
2.97	4753	10	5319

0909 02293

NOTCH	COUNT	NOTCH	COUNT
R2.0	7639	6	6580
2.5	7053	8	5643
2.97	7670	10	7113
3	7385	12	6633
4	6576	13	5715

0921 02393

4423

NOTCH	COUNT	NOTCH	COUNT
R1.0	~~[illegible]~~	6	4697
1.5	4858	8	4641
2.0	4965	10	4668
2.5	4626	12	4439
2.97	4623	14	4388
3	4743	16	6180
4	4869		

mk

10/01/93

0945 02493

NOTCH	COUNT	NOTCH	COUNT
R1.0	10489	4	7040
1.5	9224	6	7610
2.0	7763	8	7105
2.5	6899	10	6751
2.97	7397	12	8677
3	7149	14	8121

0954 02593

NOTCH	COUNT	NOTCH	COUNT
R1.0	4491	4	4532
1.5	4394	6	4592
2.0	4922	8	4716
2.5	5197	10	4599
2.97	4899	12	4756
3	4818	~~14~~	

1000 02693

NOTCH	COUNT	NOTCH	COUNT
R1.0	4807	4	4672
1.5	4339	6	4748
2.0	3864	8	4768
2.5	4214	10	4659
2.97	4445	12	5410
3	4596	13	5793

10/01/93

1015 arrived Site #2
all rain gauges dry
Weather @ 70°F

TENSIOMETERS

	POST
6 = 28 cb	28
12 = 30	30
18 = 30	30
24 = 30	30
36 = 38	36

1016 02793

NOTCH	COUNT	NOTCH	COUNT
R1.0	6558	6	4971
1.5	6156	8	4722
2.0	5567	10	4807
2.5	5520	12	4603
2.97	5141	14	4971
3	4964	16	4796
4	4993	18	4707

02893

NOTCH	COUNT	NOTCH	COUNT
R1.0	4619	6	4860
1.5	5292	8	4985
2.0	5250	10	5056
2.5	5403	12	5234
2.97	5067	14	5508
3	4787	16	4668
4	4610	18	4625

02993

NOTCH	COUNT	NOTCH	COUNT
R1.0	6319	6	5336
1.5	6175	8	4732
2.0	5757	10	4883
2.5	5787	12	4775
2.97	5162	14	4753
3	4928	16	4724
4	4731	18	4928

(32)

10/01/93

03092

NOTCH	COUNT	NOTCH	COUNT
R1.0	6576	29	6811
1.5	5715	30	6883
2.0	5892	31	6661
2.5	5736	32	6624
2.97	5376	33	6950
3	5987	34	6897
4	5164	35	5447
6	4903	36	5702
8	5069	37	5881
10	4948		
12	4866		
14	5433		
16	5042		
18	4894		
20	5580		
21	6451		
22	7001		
23	7057		
24	7101		
25	6932		
26	6787		
27	6475		
28	6768		

10/01/93

(33)

1128 03193

NOTCH	COUNT	NOTCH	COUNT
R1.0	5335	4	5211
1.5	5717	8	5152
2.0	5632	10	5148
2.5	5500	12	5293
2.97	5788	14	4796
3	5960	16	5227
4	5950	18	4728

10/01/93

1140 03293

NOTCH	COUNT	NOTCH	COUNT
R1.0	4722	26	6226
1.5	5390	27	6289
2.0	5251	28	6173
2.5	5095	29	5893
2.97	4952	30	5650
3	4840	31	5296
4	4534	32	5997
6	4687	33	5986
8	4691	34	6144
10	4581	35	6285
12	4880	36	6204
14	4563	37	5361
16	4567	38	6362
18	4643		
20	4803		
21	4591		
22	4677		
23	5938		
24	5601		
25	6282		

10/08/93

D. Kaskie, S. Yancey

0942 arrived at Site 1

Previous Count

S 7869
P 7868
Ch 0.91

New Count

S 7847
P 7869
Ch 0.99

Tensiometers		POST
6 =	58 cb	56 cb
12 =	42 cb	42 cb
18 =	0 cb (dry)	48 cb
24 =	0 cb (dry)	60 cb

all rain gauges = 0.2 in

Weather cold, foggy, sleeting

@ 30°F

10/08/93

mlh

02093	NOTCH	COUNT	NOTCH	COUNT
	R1.0	6588	4	#541
	1.5	4909	6	4894
	2.0	4315	8	4526
	2.5	4882	10	5236
	2.97	4801		
	3	4609		

02293	NOTCH	COUNT	NOTCH	COUNT
	R2.0	7704	6	6540
	2.5	7012	8	5626
	2.97	7474	10	6791
	3	7360	12	6658
	4	6597	13	5748

02393	NOTCH	COUNT	NOTCH	COUNT
	R1.0	4277	6	4671
	1.5	4849	8	4888
	2.0	4960	10	4636
	2.5	4727	12	4530
	2.97	4635	14	4394
	3	4673	16	6223
	4	4626		

mlh

10/08/93

02493	NOTCH	COUNT	NOTCH	COUNT
	R1.0	10311	4	7673
	1.5	9328	6	7013
	2.0	7957	8	6700
	2.5	6949	10	8631
	2.97	7692	12	8662
	3	7124	14	8283

02593	NOTCH	COUNT	NOTCH	COUNT
	R1.0	4474	4	4550
	1.5	4357	6	4657
	2.0	4864	8	4802
	2.5	5158	10	4693
	2.97	4806	12	4748
	3	4924	~~mlh~~	

02693	NOTCH	COUNT	NOTCH	COUNT
	R1.0	4798	4	4645
	1.5	4346	6	4672
	2.0	3785	8	4872
	2.5	4239	10	4835
	2.97	4486	12	5228
	3	4630	13	5747

10/08/93

1154 Arrived at Sit. 2

All rain gauges 0.2 in

Weather cold, overcast ~30°F

Tensiometers		Post
4 =	52 cb	50 cb
12 =	40 cb	40 cb
18 =	38 cb	40 cb
24 =	36 cb	34 cb
36 =	38 cb	38 cb

02793

NOTCH	COUNT	NOTCH	COUNT
R1.0	6422	24	6429
1.5	6088	25	6377
2.0	5701	26	6561
2.5	5502	27	6207
2.97	5266	28	6279
3	4984	29	5959
4	5016	30	5995
6	4960	31	5760
8	4719		
10	4860	32	5639
12	4624	33	5959
14	4931	34	5961
16	4696	35	5182
18	4707	36	6262
20	4468	37	6840
21	4531	38	7261
22	6094		
23	6377		

10/08/93

02893

NOTCH	COUNT	NOTCH	COUNT
R1.0	4648	20	4582
1.5	4916	21	4635
2.0	5142	22	5928
2.5	5248	23	5982
2.97	5345	24	6817
3	5114	25	6469
4	4741	26	6452
6	4729	27	6289
8	4839	28	5836
10	4965	29	5685
12	5199	30	6220
14	5471	31	6786
16	5727		
18	4666		

10/08/93

02993

NOTCH	COUNT	NOTCH	COUNT
R1.0	6102	22	4618
1.5	6186	23	5931
2.0	5792	24	6338
2.5	5816	25	6779
2.97	5261	26	6329
3	4832	27	6355
4	4774	28	6331
6	5203	29	6354
8	4777	30	6354
10	4976	31	6655
12	4845	32	6666
14	4790	33	6608
16	4625	34	4941
18	4920	35	4257
20	4813	36	4328
21	4819	37	4408
		38	7196

10/08/93

03093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6651	23	6944
1.5	5716	24	7182
2.0	5929	25	6882
2.5	5687	26	6979
2.97	5424	27	6605
3	5127	28	6724
4	5213	29	6835
6	5002	30	7050
8	4979	31	6584
10	4986	32	6616
12	4860	33	6923
14	5477	34	6083
16	4960	35	5581
18	4969	36	5645
20	5629	37	5755
21	6427		
22	7140		

10/08/93

03193

NOTCH	COUNT	NOTCH	COUNT
R1.0	5211	24	6783
1.5	5675	25	6431
2.0	5611	26	6318
2.5	5422	27	6308
2.97	5854	28	6045
3	5970	29	5973
4	5777	30	5953
6	5261	31	6198
8	5106	32	6187
10	5217	33	6124
12	4827	34	5943
14	5164	35	6125
16	4636	36	5972
18	4665	37	6254
20	5532	38	6748
21	6491		
22	6233		
23	5875		

(44)

10/08/93

mah

03293

NOTCH	COUNT	NOTCH	COUNT
R1.0	4635	23	5824
15	5348	24	5604
20	5087	25	6278
25	5083	26	6210
2.97	4976	27	6223
3	4787	28	6014
4	4568	29	5937
6	4651	30	5791
8	4760	31	5350
10	4523	32	5085
12	4847	33	5997
14	5434	34	6164
16	4622	35	6208
18	4785	36	6255
20	4771	37	5419
21	4523	38	6234
22	4716		

M

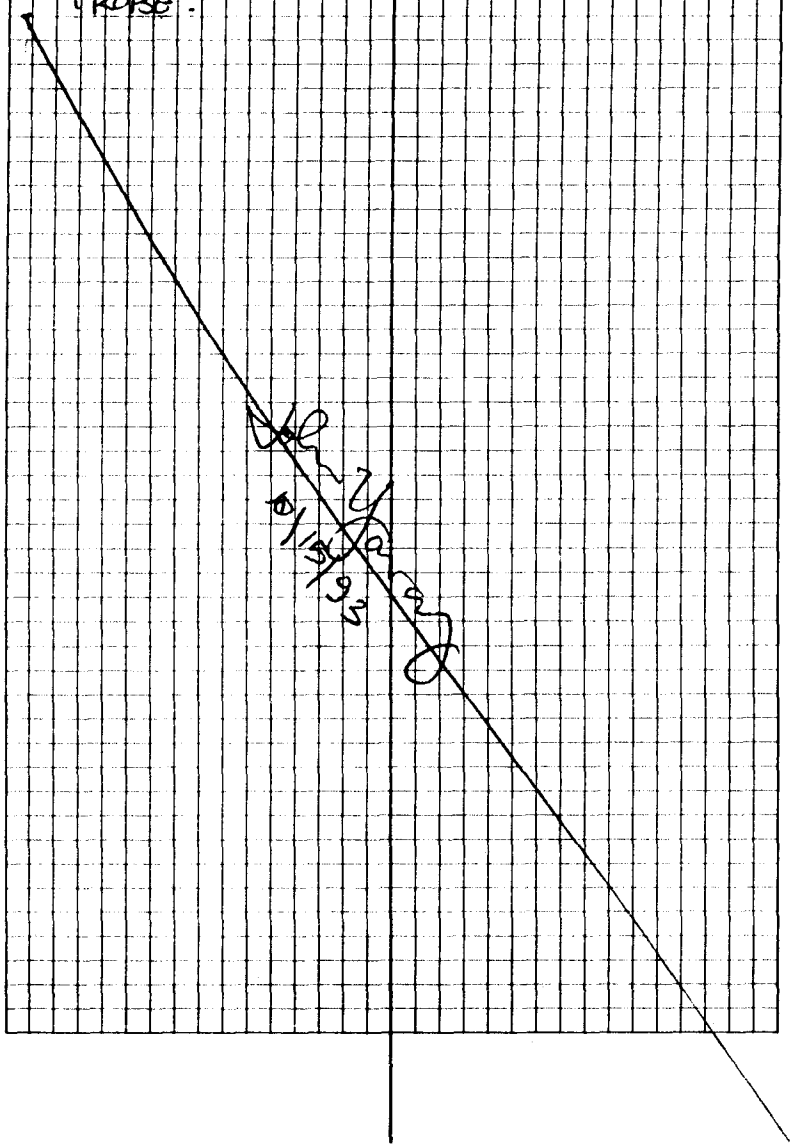
10/19/93

(45)

GROUND WATER RECHARGE - OU2.

07:30 - ARRIVED @ RFP, READYED SUPPLIES.

0800 - LEFT FOR FIELD, PICKED UP NEUTRON PROBE.



10/15-93

pdh
pdh

0855 Arrive at Site 1
Weather cool, few
clouds, light wind ~50°F

Previous Std Count
S: 7875
P: 7847
Chi: 0.96

No rain in gauges -- dry

Today's Std Count
S: 7880
P: 7875
Chi: 0.99

Tensiometer		POST
6	= 68 cb	64 cb
12	= 58 cb	58 cb
18	= 74 cb	62 cb
24	= 68 cb	56 cb

02093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6457	3	4634
1.5	4665	4	4502
2.0	4277	6	4801
2.5	4910	8	5200
2.97	4704	10	5245

02293

NOTCH	COUNT	NOTCH	COUNT
R2.0	7521	6	6597
2.5	6913	8	5654
2.97	7515	10	6347
3	7406	12	6658
4	6521	13	5829

02393

NOTCH	COUNT	NOTCH	COUNT
R1.0	4351	6	4683
1.5	4878	8	4767
2.0	4990	10	4654
2.5	4677	12	4577
2.97	4567	14	4358
3	4728		
4	4759	14	6326

10/15/93

	02493	NOTCH	COUNT	NOTCH	COUNT
		R10	10345	4	7003
		15	9265	6	7695
		20	7868	8	6960
		25	6982	10	6802
		2.97	7303	12	6313
		3	7229	14	8221

10:28	02593	NOTCH	COUNT	NOTCH	COUNT
		R10	4424	4	4666
		15	4438	6	4474
		20	4867	8	4676
		25	5258	10	4691
		2.97	4882	12	4709
		3	4915		

	02693	NOTCH	COUNT	NOTCH	COUNT
		R10	4714	4	4758
		15	4241	6	4691
		20	3863	8	4860
		25	4292	10	4793
		2.97	4494	12	5320
		3	4580	13	5742

10/15/93

1255 arrived at Site 2

TENSIONETERS

	POST
4 = 60 cb	58 cb
12 = 52 cb	50 cb
18 = 50 cb	48 cb
24 = 48 cb	44 cb
34 = 46 cb	46 cb

Rain gauges

02793 - 0.2 in

02993 - 0.1 in

rest - dry

1Ø1593

mdh mdh

02793

NOTCH	COUNT	NOTCH	COUNT
R1.0	6375	23	6263
1.5	6131	24	6572
2.0	5622	25	6474
2.5	5565	26	6594
2.97	5162	27	6196
3	5063	28	6311
4	5031	29	6148
6	4952	30	5851
8	4821	31	5722
10	4861	32	5832
12	4576	33	6030
14	4958	34	5857
16	4707	35	5305
18	4750	36	6212
20	4431	37	7022
21	4577	38	7110
22	6136		

1Ø1593

02893

NOTCH	COUNT	NOTCH	COUNT
R1.0	4536	18	4715
1.5	4766	20	4802
2.0	5127	21	4634
2.5	5225	22	5885
2.97	5244	23	5872
3	4952	24	6992
4	4694	25	6528
6	4690	26	6469
8	4758	27	6259
10	5024	28	5760
12	5201	29	5719
14	5387	30	6200
16	4626	31	6862

10/593

02993

NOTCH	COUNT	NOTCH	COUNT
R1.0	6163	23	5859
1.5	6098	24	6356
2.0	5765	25	6727
2.5	5946	26	6461
2.97	5187	27	6375
3	4822	28	6466
4	4731	29	6467
6	4858	30	6372
8	4739	31	6711
10	4909	32	6638
12	4785	33	6675
14	4874	34	4954
16	4669	35	4274
18	4889	36	4446
20	4705	37	4534
21	4909	38	6956
22	4749		

10/593

03093

NOTCH	COUNT	NOTCH	COUNT
R1.0	6480	22	7139
1.5	5583	23	6951
2.0	5826	24	7131
2.5	5608	25	6915
2.97	5308	26	6974
3	5066	27	6540
4	5236	28	6814
6	4961	29	6752
8	5089	30	6894
10	4941	31	6663
12	4867	32	6512
14	5435	33	7088
16	4980	34	6178
18	4988	35	5457
20	5570	36	5743
21	6333	37	5846

10-19-93 Joy

0815 Arrived at Site 2 to check rain guages & tensiometers.
Weather: ≈ 45°, slight breeze, sunny.

08:30: SUDDEN MOVEMENT OF A FOG FRONT.

Rain Gauges
36-87BR - 1.2"
All rain guages indicate 1.2 inches at Site 1.

Tensiometers:

6"	8 cb
12"	9 cb
18"	76 cb
24"	72 cb

0822 Arrived at Site 2 to check rain gauges, tensiometers and do 2 sites w/ probe.

Previous Standard Count
S = 7880
P = 7875
Chi = .99

10-19-93

Todays Standard Count
S = 7824
P = 7880
Chi = 1.06

08:30 FOG FRONT MOVED IN DURING STANDARD COUNT.

0822 08:30

NOTCH	COUNT	NOTCH	COUNT
R 1.0	5600	22	6289
R 1.5	5769	23	5960
R 2.0	5732	24	6009
R 2.5	5472	25	6499
R 2.91	5740	26	6337
3	5901	27	6300
4	6026	28	5954
6	5288	29	5934
8	5136	30	5928
10	5327	31	6195
12	4808	32	6077
14	5187	33	6014
16	4671	34	6117
18	4667	35	6011
20	5466	36	5911
21	6522	37	6048
		38	6376

10-19-93

08:50 FOG FRONT HAS MOVED ON.

Tensiometers

6" - 6cb
12" - 10cb
18" - 12cb
24" = 26cb
36" = 40cb

all rain gauges read approx. .8-1.0 inches.

08:56

03293	NOTCH	COUNT	NOTCH	COUNT
	1.0	4886	18	4740
	1.5	5497	20	4771
	2.0	5326	21	4532
	2.5	5088	22	4690
	2.97	5041	23	5958
	3	4827	24	5508
	4	4534	25	6323
	6	4708	26	6310
	8	4684	27	6334
	10	4592	28	6198
	12	4841	29	5899
	14	4456	30	5813
	16	4589	31	5316

03293 (cont)	NOTCH	COUNT	NOTCH	COUNT
	32	4991	36	6123
	33	6104	37	5407
	34	6264	38	5473
	35	6261		

09:16: LEFT FIELD FOR CONDOR, LOOK UP HYDRO-PROBE.

10-20-93

07:30 Arrived at Site 1 for (TDY & Jay) Probe counting, rain gauge & tensiometer readings.

Tensiometers

	PRE		POST
6" =	10 cb	8	cb
12" =	8 cb	8	cb
18" =	34 cb	34	cb
24" =	68 cb	50	cb

Rain Gauges

No water in gauges; however, now started falling ≈ 07:25.

Weather: Cold, approx. 40°; Snow: light, wind chill ≈ 38°, cold.

07:46: Stopped Snowing.

10-20-93

Previous Standard Count

S = 7824
P = 7880
chi = 1.06

Today's Standard Count

S = 7856
P = 7824
chi = 0.81

02093	NOTCH	COUNT	NOTCH	COUNT
	1.0	6929	3	4631
	1.5	4754	4	4531
	2.0	4536	6	4985
	2.5	4840	8	4557
	2.97	4728	10	5264

02293	NOTCH	COUNT	NOTCH	COUNT
	R 2.0	8277	6	6631
	2.5	7566	8	5673
	2.97	7868	10	6823
	3	7588	12	6588
	4	6686	13	
			14	5657

10-20-93

TDJ

SITE #1: GROUND H_2O RECHARGE

01:54

02393	NOTCH	COUNT	NOTCH	COUNT
	1.0	4652	6	4716
	1.5	5171	8	4684
	2.0	5195	10	4647
	2.5	4645	12	4494
	2.97	4684	14	4424
	3	4719	16	6243
	4	4857		

02493	NOTCH	COUNT	NOTCH	COUNT
	1.0	10957	4	7857
	1.5	9451	6	7642
	2.0	7863	8	7014
	2.5	7085	10	6923
	2.97	7420	12	8756
	3	7236	14	8848

TDJ

10/20/93

TDJ

SITE #1 GROUND H_2O RECHARGE

~~AREND @ SITE #2 TENSIOMETER~~

02593:	NOTCH	COUNT	NOTCH	COUNT
	1.0	4760	4	4638
	1.5	4549	6	4585
	2.0	5087	8	4660
	2.5	5167	10	4641
	2.97	4889	12	4810
	3	4801	14	

02693:	NOTCH	COUNT	NOTCH	COUNT
	1.0	5054	6	4793
	1.5	4312	8	4836
	2.0	3874	10	4756
	2.5	4235	12	5370
	2.97	4560	13	5693
	3	4458		
	4	4718		

10/20/93

GROUD H_2O RECHARGE

0828: ARRIVED @ SITE #2: Rain Gauges, Tensiometer & HydroProbe Readings.

Rain Gauges:
Dry - all

Tensiometers:		PRE		Post	
12"	12 ~~16~~"	= 12	cb ;	12	cb
18"	18 ~~24~~	= 16	cb ;	16	cb
36	~~24~~ ~~18~~	= 36	cb ;	34	cb
24"	24"	= 22	cb ;	20	cb
6"	~~18~~ 6"	= 8	cb ;	8	cb

(NOTE: TENSIOMETER MESH UP BY TRACI -)

02793	NOTCH	COUNT	NOTCH	COUNT
	1.0	6889	8	4837
	1.5	6339	10	4788
	2.0	5824	12	4577
	2.5	5663	14	5009
	2.97	5242	16	4839
	3	5069	18	4747
	4	5166		
	6	4960		

10/20/93

SITE #2: GROUND H_2O RECHARGE

02893	NOTCH	COUNT	NOTCH	COUNT
	1.0	4868	6	4699
	1.5	5006	8	4839
	2.0	5087	10	4897
	2.5	5167	12	5240
	2.97	5326	14	5515
	3	5041	16	4669
	4	4776	18	4672

02993	NOTCH	COUNT	NOTCH	COUNT
	1.0	6595	6	5254
	1.5	6272	8	4765
	2.0	5717	10	4921
	2.5	5972	12	4909
	2.97	5247	14	4717
	3	4947	16	4736
	4	4802	18	4982

03093	NOTCH	COUNT	NOTCH	COUNT
	1.0	6888	6	4947
	1.5	5930	8	5071
	2.0	6037	10	5049
	2.5	5615	12	4754
	2.97	5358	14	5496
	3	5038	16	4941
	4	5208	18	5003

10/20/93

SITE # 2: GROUND H_2O RECHARGE

03193	NOTCH	COUNT	NOTCH	COUNT
	1.0	5561	6	5250
	1.5	5756	8	5082
	2.0	5821	10	5166
	2.5	5485	12	4897
	2.97	5779	14	5201
	3	5915	16	4646
	4	5877	18	4737

03293	NOTCH	COUNT	NOTCH	COUNT
	1.0	4794	6	4726
	1.5	5484	8	4688
	2.0	5342	10	4560
	2.5	5089	12	4748
	2.97	5009	14	4485
	3	4729	16	4699
	4	4558	18	4752

09:30: LEFT FIELD FOR CONVEX TO LOCK UP Hydro Probe.

09:35: Locked up Probe & Left for the day Weather Conditions are the same, Temps seem to be droping ≈ 34°F.

10/20/93

10/20/93

GROUND H_2O RECHARGE OU2

(68)

10/22/93

GROUND H_2O RECHARGE OU_2

JWY TDY

WEATHER CONDITIONS: CLEAR & SUNNY HIGH today ≈ 60°F, almost no wind (Looks like a Nice day)

08:00: ARRIVED @ SITE #1,
Took Standard Count:

Previous Count	Today's Count
S = 7855	S = 7886
P = 7824	P = 7855
X = 0.81	X = 0.75

RAIN GAUGES ARE EMPTY.

FIELD CREW: JOHN YANCEY & TRACI YANCEY - ASI

08:15 TENSIOMETER'S READINGS.

06:	Depth	Reading		Depth	Reading
08:15	6"	= 12 cb	09:15	6"	= 12 cb
Pre Count	12"	= 12 cb	Post Count	12"	= 12 cb
	18"	48 cb		18"	= 46 cb
	24"	= 74 cb		24"	= 52 cb

STARTED COUNTING TUBES @ SITE #1

08:20:	# 02093	Notch	Count	Notch	Count
	SITE #1	1.0	6875	3	4483
		1.5	4787	4	4433
		2.0	4437	6	4849
		2.5	4867	8	4539
		2.97	4814	10	5307

JWY

JWY TDY

10/22/93

(69)

GROUND H_2O RECHARGE OU_2

# 02293	Notch	Count	Notch	Count	08:27
SITE #1	2.0	8101	6	6649	
	2.5	7365	8	5739	
	2.97	7879	10	6740	
	3	7468	12	6554	
	4	6582	14	5617	

# 02393	Notch	Count	Notch	Count	08:30
SITE #1	1.0	4675	6	4732	
	1.5	5068	8	4794	
	2.0	5044	10	4664	
	2.5	4701	12	4600	
	2.97	4578	14	4435	
	3	4711	16	6266	
	4	4818			

# 02493	Notch	Count	Notch	Count	08:42
SITE #1	1.0	10846	4	6980	
	1.5	9413	6	7724	
	2.0	7999	8	6987	
	2.5	6984	10	6833	
	2.97	7398	12	8774	
	3	7312	14	8896	

JWY

10/22/93

GROUND H_2O RECHARGE 01/2

0852	#02593	NOTCH	COUNT	NOTCH	COUNT
	SITE #1	1.0	4673	4	4560
		1.5	4596	6	4493
		2.0	5082	8	~~4647~~ 4788
		2.5	5123	10	4610
		2.97	4815	12	4846
		3	4845		

09:01	#02693	NOTCH	COUNT	NOTCH	COUNT
	SITE #1	1.0	5083	4	4705
		1.5	4295	6	4734
		2.0	3841	8	4811
		2.5	4243	10	4728
		2.97	4459	12	5399
		3	4596	~~4614~~ 13	5712

09:09 : COMPLETED COUNTING ACCESS TUBES @ #1

09:10 : ARRIVED @ SITE #2
Rain Gauges are Empty

09:11 : TENSIOMETER READINGS

09:11	DEPTH	READING	10:40	DEPTH	READING
PRE COUNT	6' =	12 cb	POST COUNT	6' -	12 cb
	12' =	18 cb		12' -	18 cb
	18' =	20 cb		18' -	22 cb
	24' =	24 cb		24' -	22 cb
	36' =	33 cb		36' -	32 cb

10/27/93

GROUND H_2O RECHARGE 01/2

STRETCHED COUNTING TUBES

# 02793	NOTCH	COUNT	NOTCH	COUNT	09:12
SITE #2	1.0	6786	23	6369	
	1.5	6200	24	6491	
	2.0	5804	25	6440	
	2.5	5776	26	6451	
	2.97	5181	27	6121	
	3	5052	28	6330	
	4	5048	29	6187	
	6	5001	30	5938	
	8	4797	31	5787	
	10	4800	32	5807	
	12	4575	33	5973	
	14	4842	34	5926	
	16	4706	35	5361	
	18	4737	36	6285	
	20	4486	37	6821	
	21	4622	38	7047	
	22	6135			

NOTE: Clouds off ~~there~~ to the West are dark and look as if it may be Snowing up in the Mountains; however, the Sunny is still out. There are clouds moving in from the West.

09:48 CURRENT TEMP ≈ 45°F.

(72)

10/22/93

GROUND H_2O RECHARGE OU2

09:35 #02893

SITE #2

NOTCH	COUNT	NOTCH	COUNT
1.0	4705	18	4732
1.5	4946	20	4697
2.0	5101	21	4733
2.5	5249	22	5894
2.97	5308	23	5944
3	4951	24	6793
4	4738	25	6592
6	4770	26	6633
8	4811	27	6264
10	5021	28	5807
12	5313	29	5728
14	5314	30	6126
16	4655	31	6763

JWY TDG

(73)

10/22/93

GROUND H_2O RECHARGE OU2

#02993 09:53

SITE #2

NOTCH	COUNT	NOTCH	COUNT
1.0	6463	23	6088
1.5	6217	24	6333
2.0	5777	25	6858
2.5	5934	26	6365
2.97	5290	27	6475
3	4883	28	6492
4	5665	29	6431
6	5115	30	6339
8	4730	31	6593
10	4846	32	6625
12	4868	33	6676
14	4813	34	4900
16	4802	35	4291
18	4941	36	4361
20	4800	37	4549
21	4876	38	6673
22	4785		

JWY TDG

10/22/93

GROUND H_2O RECHARGE OU2

10:15	03093	NOTCH	COUNT	NOTCH	COUNT
	SITE #2	1.0	6890	22	7043
		1.5	5863	23	7020
		2.0	5944	24	7240
		2.5	5685	25	6893
		2.97	5322	26	6925
		3	5143	27	6497
		4	5312	28	6759
		6	5023	29	6818
		8	5152	30	6934
		10	4958	31	6786
		12	4856	32	6528
		14	5571	33	6958
		16	4927	34	6100
		18	5032	35	5527
		20	5534	36	5612
		21	6355	37	5791

Relocated Notch 21.5 to the 38 Notch location. 38 Notch location had no Real Notch. Counts where taken by holding cord while probe counted.

10:29 = Clouds off to the West clearing alittle. Current Temp ≈ 40°F ; Slight Breeze.

11:00 = Current Temp 55°F

10/22/93

GROUND H_2O RECHARGE OU2

03093 =	NOTCH	COUNT	NOTCH	COUNT	10:38
SITE #2	1.0	5474	23	5926	
	1.5	5846	24	6804	
	2.0	5835	25	6471	
	2.5	5561	26	6306	
	2.97	5856	27	6375	
	3	6009	28	6083	
	4	5825	29	6903	
	6	5227	30	5898	
	8	5101	31	6180	
	10	5231	32	6162	
	12	4908	33	6105	
	14	5204	34	5991	
	16	4684	35	6092	
	18	4669	36	5943	
	20	5338	37	6148	
	21	6521	38	6517	
	22	6291			

(76) 10/22/93 Jury TDY

GROUND H_2O RECHARGE OU2

# 03293 =	NOTCH	COUNT	NOTCH	COUNT	11:00
	1.0	4725	23	5877	
	1.5	5412	24	5557	
	2.0	5343	25	6302	
	2.5	5014	26	6244	
	2.97	4968	27	6246	
	3	4738	28	6145	
	4	4571	29	5877	
	6	4709	30	5769	
	8	4666	31	5303	
	10	4650	32	5040	
	12	4786	33	6021	
	14	4535	34	6273	
	16	4709	35	6332	
	18	4727	36	6324	
	20	4851	37	5329	
	21	4511	38	5657	
	22	4673			

SITE # 2

11:22 COMPLETED COUNTING TUBES -
11:30 - LEFT FIELD FOR CONNEX TO LOCK UP NEUTRON PROBE.
12:00 LEFT FOR THE DAY

John Yancy
10/22/93

APPENDIX B

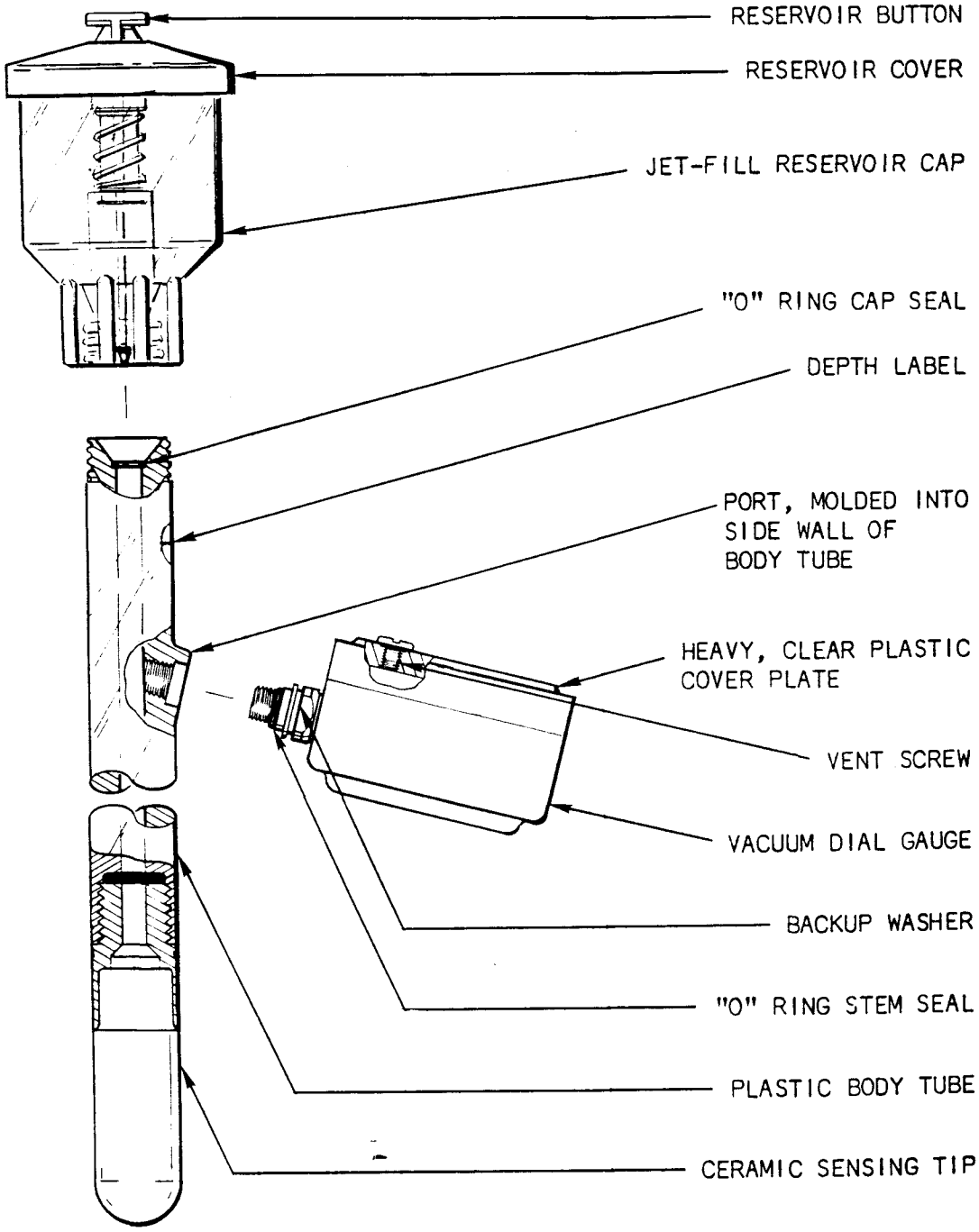
FIELD MONITORING EQUIPMENT

Appendix B-1

Jet Fill Tensiometer Model 2725A Instruction Manual

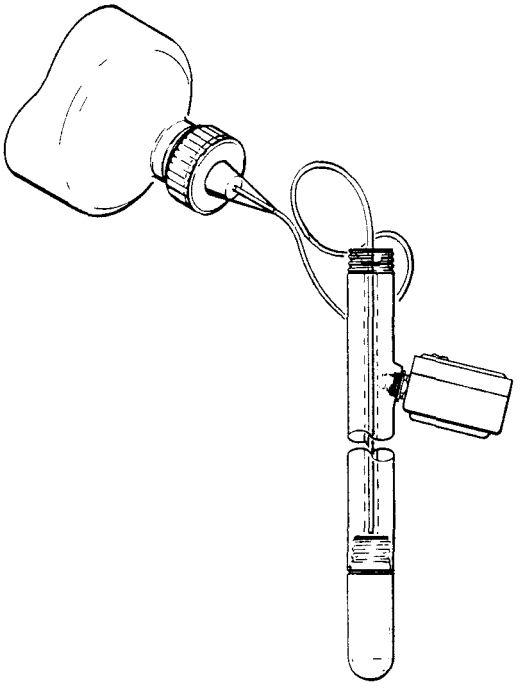
2725A OPERATING INSTRUCTIONS

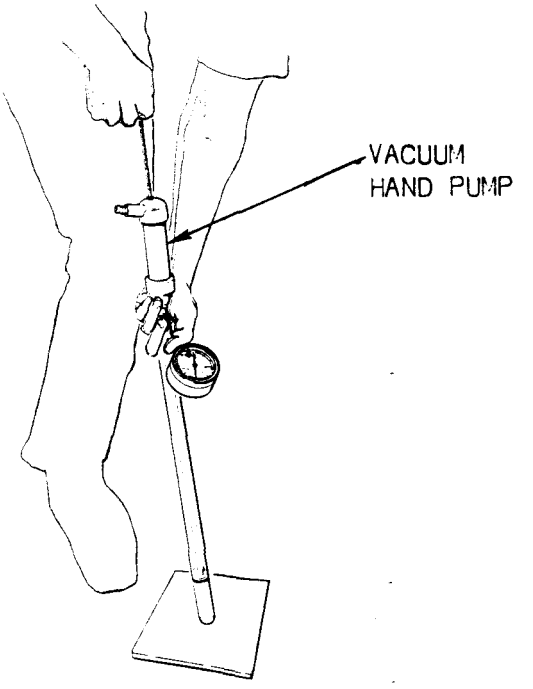
JET FILL TENSIOMETER **MODEL A**



SOILMOISTURE EQUIPMENT CORP.
P.O. Box 30025
Santa Barbara, CA 93105
U.S.A.
Telephone No. 805-964-3525 • Telex No. 65-8424 • Fax No. 805-683-2189 • Cable Address: SOILCORP

SOILMOISTURE®

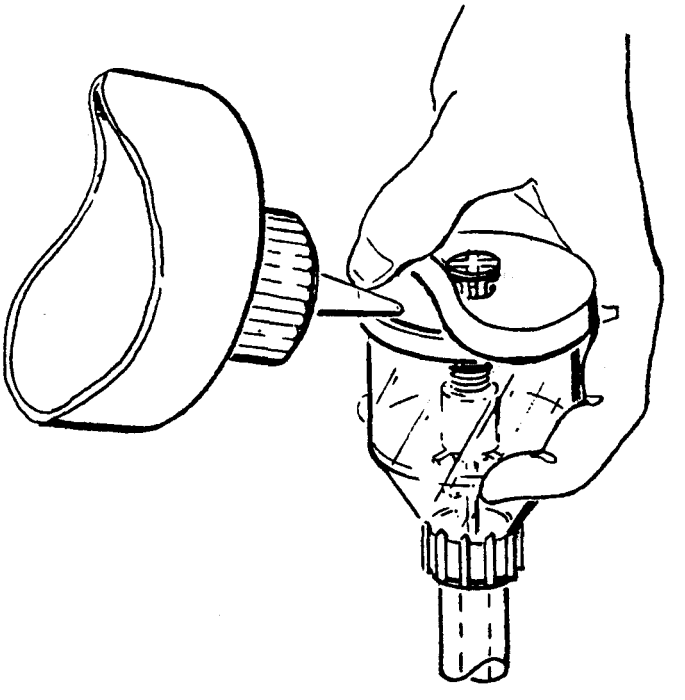




Screw tubular spout onto the filler bottle and insert tubular spout into the bore of the tensiometer body tube down to the bottom of the tensiometer. Squeeze the filler bottle to fill tensiometer body full of fluid.

Allow the tensiometer body tube to remain in a vertical position until fluid completely saturates the sensing tip and begins to drip from the end of the tip. If a group of tensiometers is being filled, they can be placed in a deep sink or empty bucket for support during the tip wetting process. Let the fluid drip from the tip for about 5 minutes to wet thoroughly.

When the sensing tip is thoroughly wetted, fill the unit completely to the top and pull a vacuum within the tensiometer using the vacuum hand pump supplied with the Service Kit. Let the sensing tip of the tensiometer set on a board for support while the rubber end of the vacuum hand pump is held in tight contact with the "O" ring cap seal of the tensiometer. Pulling up on the pump handle will create a vacuum within the tensiometer causing air to bubble out from the stem of the dial gauge. After each pumping with the vacuum hand pump, refill the tensiometer completely to the top with water. This pumping operation should be repeated four or five times until no further air is seen to bubble from the stem of the dial gauge. The unit is then sealed by screwing the Jet Fill Reservoir Cap in place on the top of the body tube.



To fill the Jet Fill Reservoir Cap, peel the resilient neoprene reservoir cover back from the top of the reservoir and fill the reservoir 3/4 full of Soilmoisture Blue Solution.

a spade to accept the tensiometer. Make sure that the soil is packed firmly around the tensiometer after it is set in place.

In loose cultivated soils, such as frequently encountered in commercial row crops, it is possible to simply push the tensiometer into the soil without coring a hole. This method of installation is completely satisfactory where applicable. Here again, be sure that the surface soil is packed firmly around the body tube after installation.

In rocky soils, a soil auger such as our Model 230 Soil Auger, 2", 3" or 4" size, can be used to core out a hole to accept the tensiometer. In this case, the soil removed is screened to remove large pebbles and rocks. The screened soil is then used to backfill around the tensiometer. A 1/4" mesh screen is usually suitable for screening the soil.

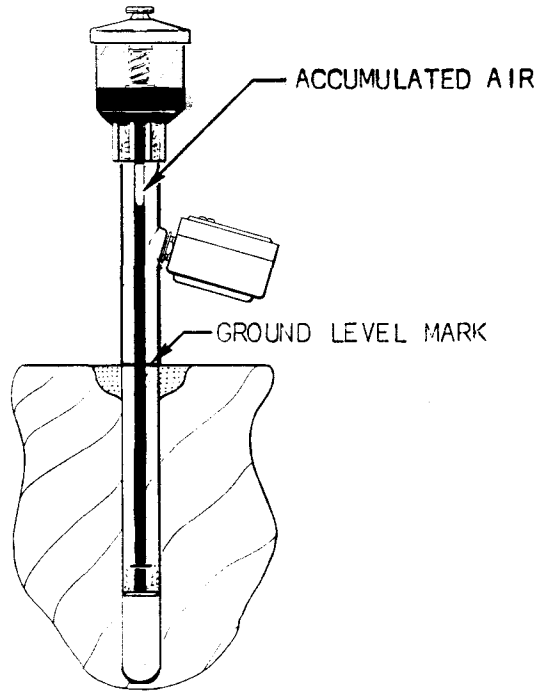
In difficult installations, such as in rocky soils or deep installations, a slurry of water and soil can be made up and poured into the bottom of the hole. The sensing tip of the tensiometer is then pushed into the slurry to assure good contact between sensing tip and soil. Large holes cored to accept the tensiometer are always backfilled and the soil at the surface tamped tightly around the body tube.

After installation, several hours may be required before the tensiometer reads the correct soil suction value. This is due to the disturbance to the soil caused by the installation procedure. The correct reading will be reached more quickly in moist soils than in dry soils.

After this initial installation period, the tensiometer will accurately indicate the soil suction value and will follow closely changes in soil suction from hour to hour.

TO SERVICE IN THE FIELD

The Jet Fill Tensiometer is completely weatherproof and requires very little servicing other than occasionally pushing the button on the Jet Fill reservoir to remove accumulated air within the tensiometer.



If the soil in which the tensiometer has been installed is moist and the soil suction readings are low, very little air will accumulate in the body tube of the tensiometer. If, however, the tensiometer has been installed in relatively dry soil and soil suction values are in the range of 40 to 60 centibars, air will accumulate rather quickly for the first few days after installation. This initial accumulation of air is due to air coming out of solution and air detaching itself from the internal walls of the tensiometer when it is exposed to high vacuums for the first time. After initial installation, check the tensiometer every day or two and remove accumulated air by pushing the button of the Jet Fill reservoir.

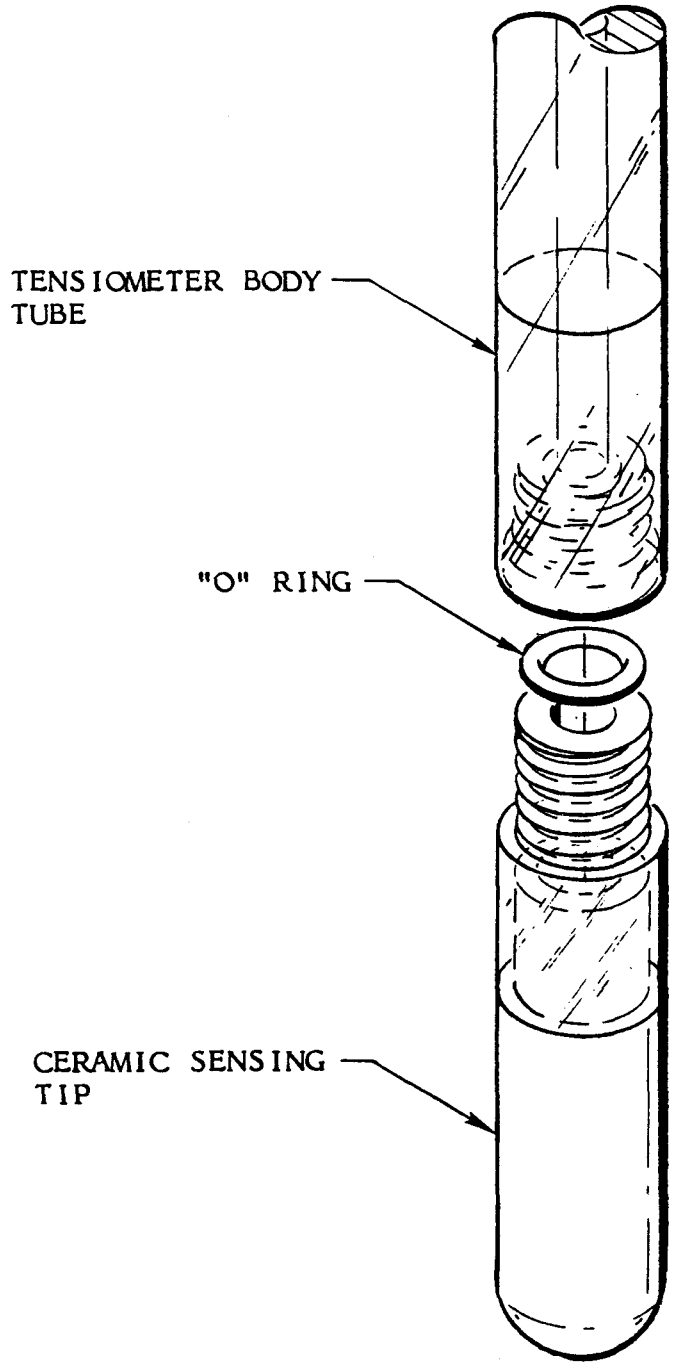
After the first few air removal servicing operations, the rate of air accumulation will drop off markedly, and air removal servicing will then be required only on a weekly or longer basis. Since the Jet Fill operation is so convenient and does not disturb soil moisture conditions, it is suggested that the reservoir button be pushed down to service the unit after each reading that is made on the tensiometer. By this means, internal air will be limited to a minimum, which will assure maximum sensitivity of the instrument. Due to the fast filling action, the tensiometer will recover to its correct reading within a few minutes after servicing.

NOVEMBER 1986

NOTICE

MODEL 2725 JET FILL TENSIOMETER

In order to improve protection during shipment, our Model 2725A Jet Fill Tensiometer is packed with the Ceramic Sensing Tip removed. To assemble the unit, invert the Tensiometer Body and insert the "O" Ring into the threaded end of the Plastic Body Tube, making sure it is seated at the bottom of the hole. Next, screw the Ceramic Sensing Tip into the Body Tube until it makes a tight seal on the "O" Ring. Do not over-tighten the Ceramic Sensing Tip into the Body Tube. The "O" Ring makes the vacuum seal, not the threads. Damage to the threads may occur as a result of excessive tightening of the Ceramic Sensing Tip. Refer to the Operating Instructions for further assembly procedures.



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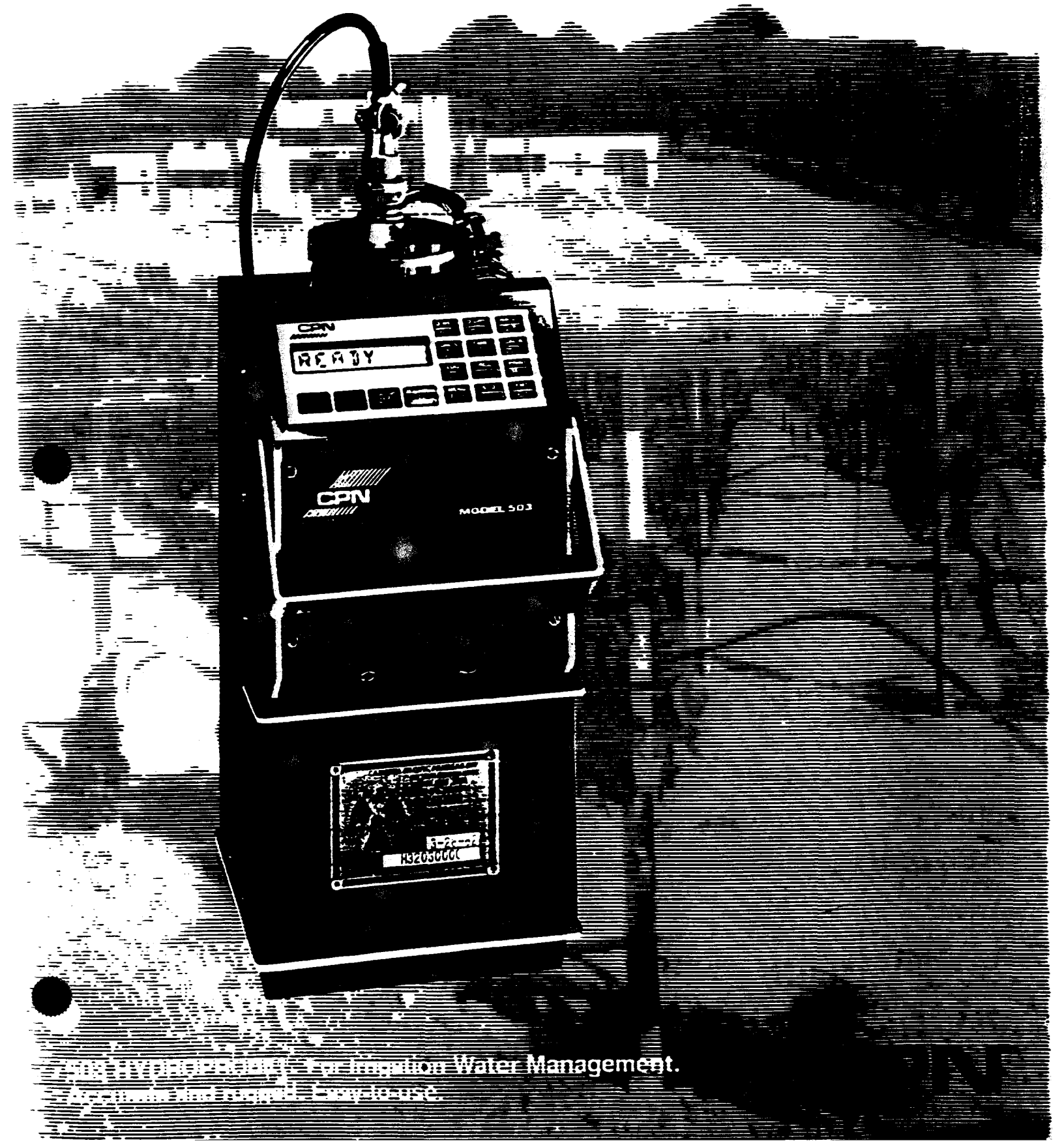
Appendix B-2

503 DR Hydroprobe Description



503 HYPROPROBE™. For Irrigation Water Management.
Accurate and rugged. Easy-to-use.

1.0 GENERAL

1.1 INTRODUCTION

The Model 503DR HYDROPROBE, NEUTRON DEPTH MOISTURE GAGE measures the sub-surface moisture in soil and other materials by use of a probe containing a source of high energy neutrons and a slow (thermal) neutron detector. The probe is lowered into a pre-drilled and cased hole (1.5 or 2 inch diameter). Hydrogen as present in the water in the soil slows the neutrons down for detection. The moisture data is displayed directly in units of interest on an above surface electronic assembly which is integral to the source shield assembly.

The gage is supplied with a 12 foot cable and five adjustable cable stops. Additional stops and longer cable lengths are available.

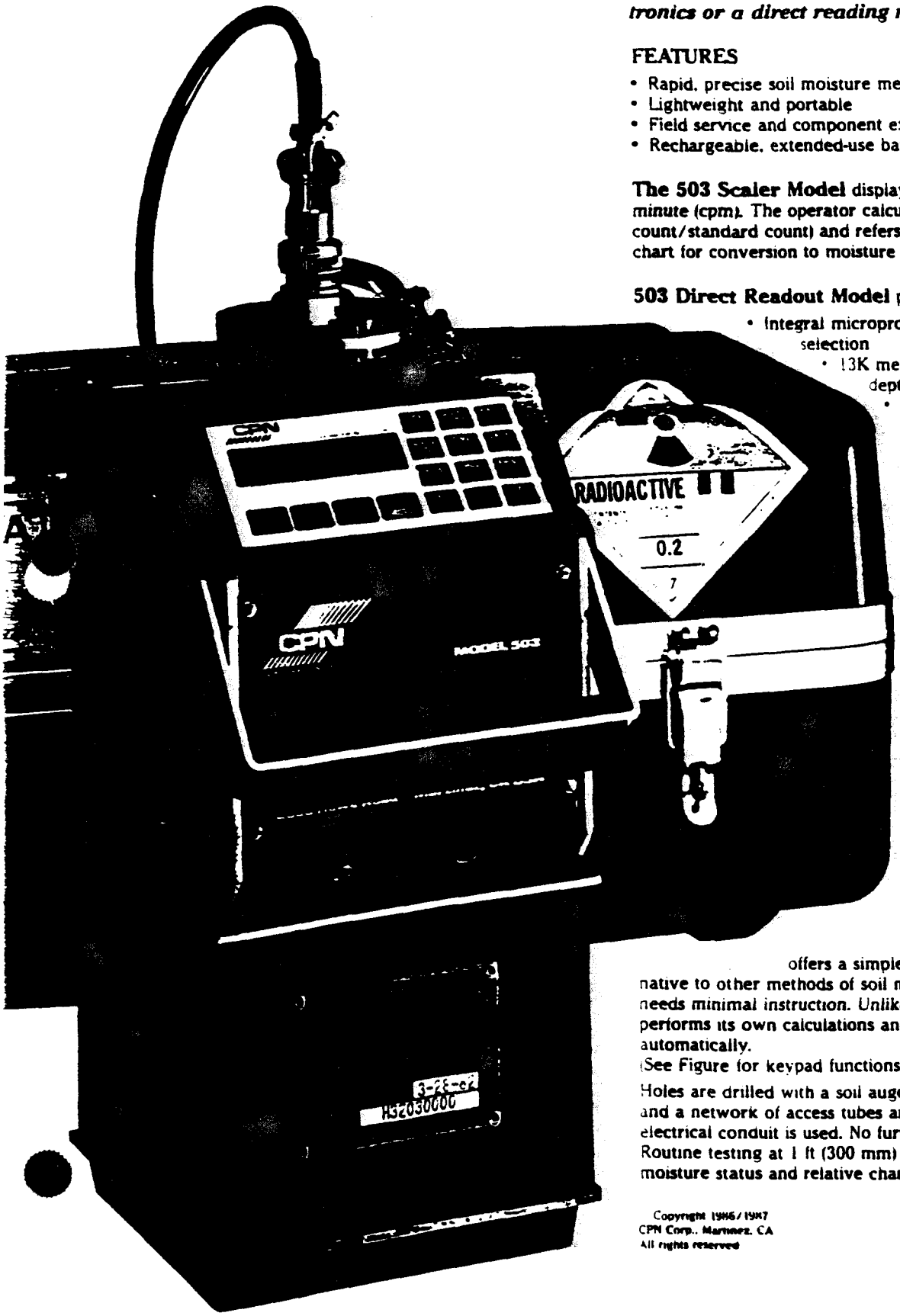
Upon retraction of the probe into the shield, the probe locks automatically in place for transportation.

The complete assembly is supplied with a plastic shipping and carrying container which contains; accessory items, cable, instruction manual, charger, and other materials which the operator may wish to carry.

1.2 SPECIFICATIONS

FUNCTION:	Sub-surface moisture measurements.
RANGE:	0 to 32% vol, (0.32 gm/cc), (20 pcf), (3.84 in/ft).
PRECISION:	0.24% at 24% vol at one minute.
COUNT TIME:	1, 4, 16, 32, 64, and 256 sec.
TEMP:	0 TO 70oC operating.
POWER:	AA NICAD batter pack (0.5 Ah) 8 cells.
BATTERY LIFE:	500-1000 Charge-discharge cycles.
CONSUMPTION:	6.5 mA avg. (allows more than 3000 each 16 sec counts).
RECHARGE:	14 hours at C/10 via wall charger.
DISPLAY:	8 character alpha/numerical Liquid-Crystal Display. Easily readable in direct sunlight.
DATA STORAGE:	3072 cells of; counts, identifiers, or keyboard entry of auxiliary values. Format operator programmable. 0-15 key and 0-15 count per record
DATA OUTPUT:	RS232C serial dump to external printer, computer, CRT or coupler.
CALIBRATION:	8 ea user programmed (linear).
UNITS:	User selectable: in/ft, pcf, gm/cc, % vol, cm/30cm, count and count ratio.
NEUTRON SOURCE:	50 mCi Americium-241/Be
ENCAPSULATION:	Double Sealed Capsule, CPN-131
SHIELDING:	Silicon based paraffin
SHIPPING:	Radioactive Material, Special Form, N.O.S., UN2974 Transport Index 0.1 Yellow II Label USA DOT 7A, Type A Package
SPECIAL FORM APPROVAL:	USA/0115/S
CONSTRUCTION:	Aluminum with epoxy paint or hard-anodize finish. Stainless steel wear parts
SURFACE UNIT:	15.7#, 6.8"Wx7.0"Dx14.0"H (7.12),(172.7x177.8x355.6)
PROBE: Model -2	2.3#, 1.865" dia x 12.7"L (1.043), (47.4 dia x 322.6)
Model -1.5	1.7#, 1.500" dia x 12.7"L (0.771), (38.1 dia x 322.6)
CARRYING & SHIPPING:	36.5#, 24"W x 13"D x 10"H (16.56), (609.6 x 330.2 x 254)

CPN® 503 HYDROPROBE®



The 503 HYDROPROBE® is the most accurate, rugged and easy-to-use soil moisture probe available today. The HYDROPROBE® is available with scaler electronics or a direct reading microprocessor.

FEATURES

- Rapid, precise soil moisture measurements at repeatable sites
- Lightweight and portable
- Field service and component exchange with tools provided
- Rechargeable, extended-use battery pack

The 503 Scaler Model displays test results in counts per minute (cpm). The operator calculates the count ratio (field count/standard count) and refers to the laminated calibration chart for conversion to moisture content.

503 Direct Readout Model provides:

- Integral microprocessor for simple function selection
- 13K memory logging of 1023 records in 3 depths-per-site format
- Data transfer to a PC computer or printer via RS232C serial interface
- Storage and recall selection of linear calibrations for 16 soil types
- Operator selected time of test, logging format, and units of measurement:

counts per minute	pcf
count ratio	gcc
inches per foot	
% moisture	

APPLICATIONS

- Irrigation scheduling: commercial management and consultant services.
- Worldwide agronomic research and extension
- Groundwater hydrology and wastewater management.

SIMPLICITY OF OPERATION

This state-of-the-art instrument offers a simple to operate but superior alternative to other methods of soil moisture monitoring. The operator needs minimal instruction. Unlike other instruments, the 503 DR performs its own calculations and records test results automatically.

(See Figure for keypad functions.)

Holes are drilled with a soil auger to the depth of the root zone and a network of access tubes are installed. Standard irrigation or electrical conduit is used. No further site maintenance is required. Routine testing at 1 ft (300 mm) depth intervals provides soil moisture status and relative changes throughout the root zone.

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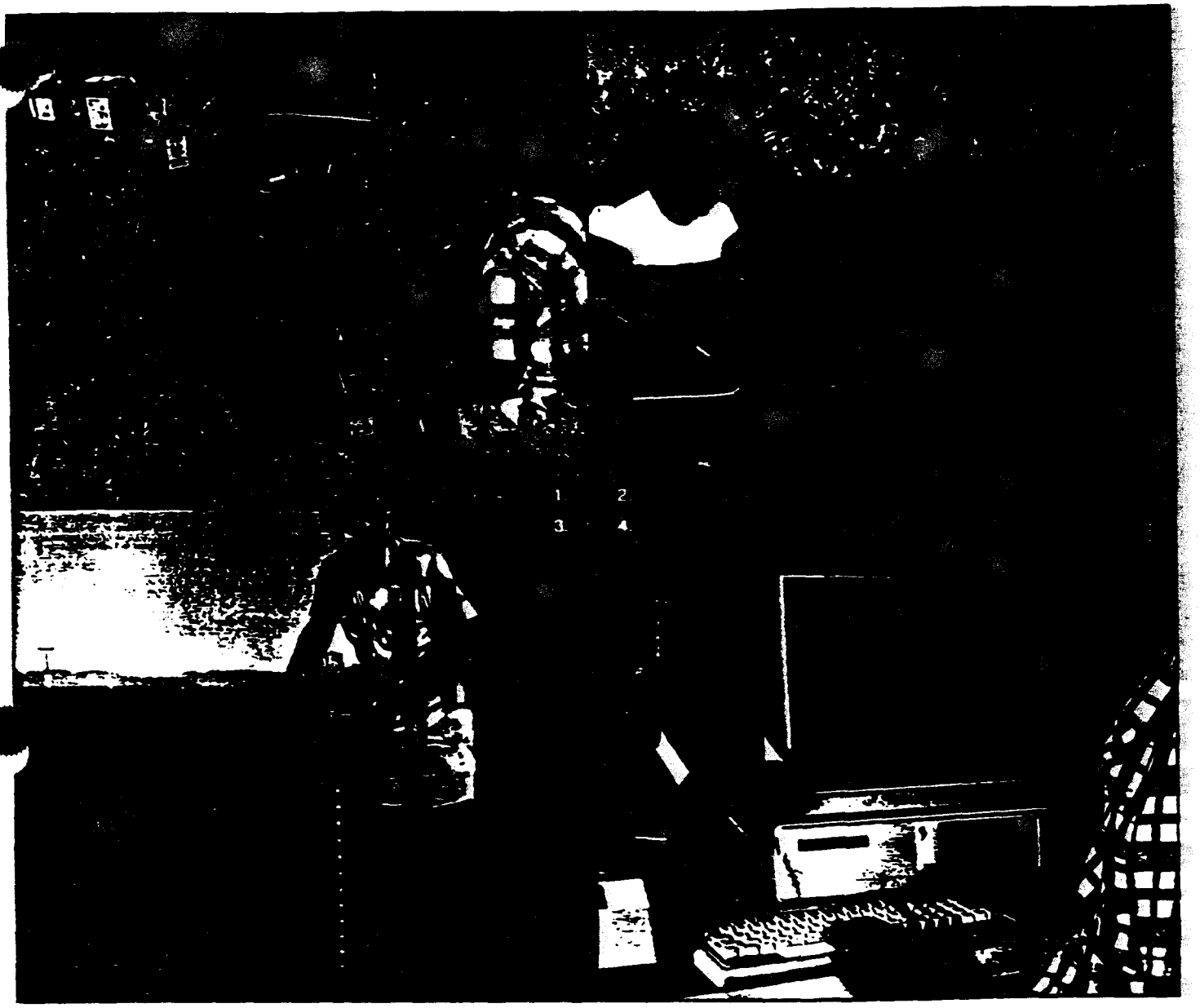
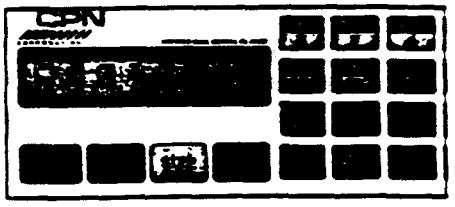


(1) field monitoring of Australian cotton crop; (2) field monitoring of Napa Valley vineyard under drip irrigation; (3) soil augering for access tube installation; (4) data transfer to Irrigation Water Management Program.



503 DR keypad/display

IRRIGATED AGRICULTURE

A program of soil moisture monitoring allows an irrigator to:

- Improve crop yields
- Determine when and how much to irrigate
- Monitor root development
- Improve irrigation efficiency and optimize system design
- Conserve water, energy, and agrichemicals

IWM PROGRAM

The Irrigation Water Management Program, available from CPN Corp, accepts stored HYDROPROBE® data to build a field history file and generate reports of soil moisture status and irrigation forecasts. Ideal for the consultant and large farm manager.

ENVIRONMENTAL MANAGEMENT

The HYDROPROBE® is an effective tool for leakage detection from buried fuel tanks, pipelines, and wastewater management units.

RUGGED AND RELIABLE

Aluminum construction with stainless steel wear parts. Lightweight, shock and water resistant. Built-in reference standard for periodic performance check and calibration update.

PRECISE

Instrument precision for a 16-second test at 2.88 in/ft (0.24 gcc) moisture: ±0.05 in/ft (± 0.004 gcc).

USER ORGANIZATIONS

U.S. Department of Agriculture
Bureau of Reclamation
Soil Conservation Service
Environmental Protection Agency
Department of Water Resources
County Irrigation Districts
University Extension Services

SPECIFICATIONS

ORDERING INFORMATION

No. 503520 HYDROPROBE®, 503 DR-2.0, DIRECT READING NEUTRON MOISTURE PROBE. 1.865" (47.4 mm) probe shell diameter, for in-place measurement of subsurface soil moisture. Programmable microprocessor provides formatted data storage and transfer capability. Complete with molded, plastic shipping and storage case, lock and keys, 12 ft. (3.66 m) cable, sign kit, wipe test kit, certificate, tool kit and access tube adapter. 115/230 volt AC battery charger and battery pack of eight welded AA NICAD cells. Operating instructions.

No. 503515 HYDROPROBE®, 503 DR-1.5, DIRECT READING, same as No. 503 DR-2.0 except with 1.5" (38.1 mm) probe shell diameter.

No. 503020 HYDROPROBE®, 503-2.0, SCALER MODEL, same as No. 503 DR-2.0 except with counts-per-minute readout for calibration chart conversion to soil moisture content.

No. 503015 HYDROPROBE®, 503-1.5, SCALER MODEL, same as No. 503-2.0 except with 1.5" (38.1 mm) probe shell diameter.

No. 503 IWM IRRIGATION WATER MANAGEMENT PROGRAM. A self-contained software program which accepts moisture readings from the 503 DR, appends them to a data base, and generates irrigation management reports, including timing and quantity of irrigation. The IWM program and the RS232C serial interface from the 503 DR are compatible with most personal computers and printers.

Factory calibration is provided for use in thin-walled aluminum, plastic (PVC), and electrical conduit: 1.5 or 2.0" nominal diameters. *Please specify upon ordering.*

CPN provides a full line of quality tools & equipment for the installation and maintenance of access sites and for field calibration of the HYDROPROBE®.

PERFORMANCE

FUNCTION:	Subsurface soil moisture measurements for irrigation scheduling, agronomic research, and groundwater hydrology.
RANGE:	0.0 to 4.8 in/ft. (0.0 to 0.40 gcc)
PRECISION at 1 min:	± 0.024 in/ft. (± 0.002 gcc)
COUNTING TIME:	1, 4, 16, 32, 64, or 256 seconds, selected by operator.
OPERATING TEMP.:	32° to 140°F (0° to 60°C)
POWER:	Battery pack of 8 welded NICAD cells.
CONSUMPTION:	10mA avg. Allows more than 600 16 second counts.
RECHARGE:	14 hours via wall charger.
DISPLAY:	Large, 8 character dot matrix liquid crystal display. Easily readable in direct sunlight.

503 Direct Readout Model (Only):

UNITS:	Operator selectable: cpm, count ratio, inches per foot, % moisture, pcf, and gcc
MEMORY STORAGE:	1023 records in three-depths-per-site format.
SERIAL INTERFACE:	RS232C upload to a PC computer or printer.
CALIBRATION:	Operator selected linear calibrations for 16 soil types.

Radiological:

NEUTRON SOURCE:	50mCi (1.85×10^3 MBq) Americium-241/Be
ENCAPSULATION:	Double sealed capsule, CPN 131
DOSE RATE AT HANDLE:	Less than .5 mrem/hr. (5μSv/hr)
SHIPPING:	Radioactive Material, Special Form, N.O.S., UN2974, Transport Index 0.2, Yellow II Label, USA DOT 7A, Type A
SPECIAL FORM APPROVAL:	USA/0150/S

An NRC or agreement state license is required for domestic use. Contact CPN Corp. for assistance in obtaining the operator training required for a license.

SERVICE

The modular design of the 503 allows repairs by simple component exchange. Replacement parts can be shipped within one working day.

TRAINING

CPN Corp. offers comprehensive training on the use of CPN instruments, either at your facility or ours. Training topics inlcude safety, equipment operation, applications and field maintenance.

DIMENSIONS/SHIPPING WEIGHTS

MODEL NUMBER	WIDTH	DEPTH	HEIGHT	WEIGHT
INSTRUMENT 503 & 503 DR	6.8" (172 mm)	7.0" (177 mm)	14.0" (355 mm)	15.7 lbs. (7.12 kg)
INSTRUMENT & CARRYING CASE 503 & 503 DR	24.0" (609 mm)	13.0" (330 mm)	10.0" (254 mm)	35.5 lbs. (16.56 kg)

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2830 Howe Road
Martinez, California 94553

MIDWEST
6185-D Shamrock Court
Dublin (Columbus), Ohio 43017

NORTHWEST
P.O. Box 84055
Vancouver, WA 98684

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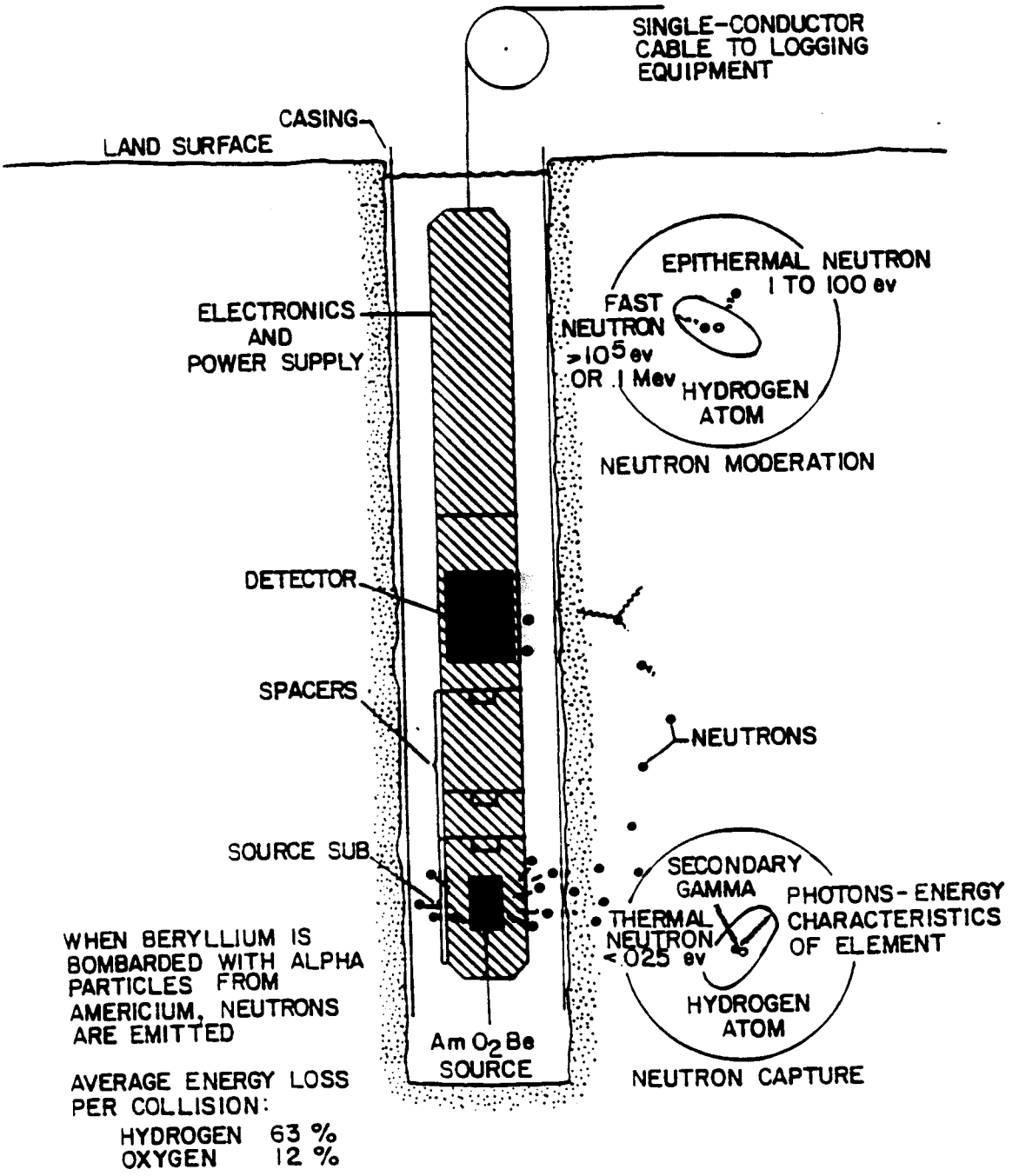


Figure A-1 Equipment and principles of neutron moisture logging (after Keys and MacCary, 1971).

APPENDIX B

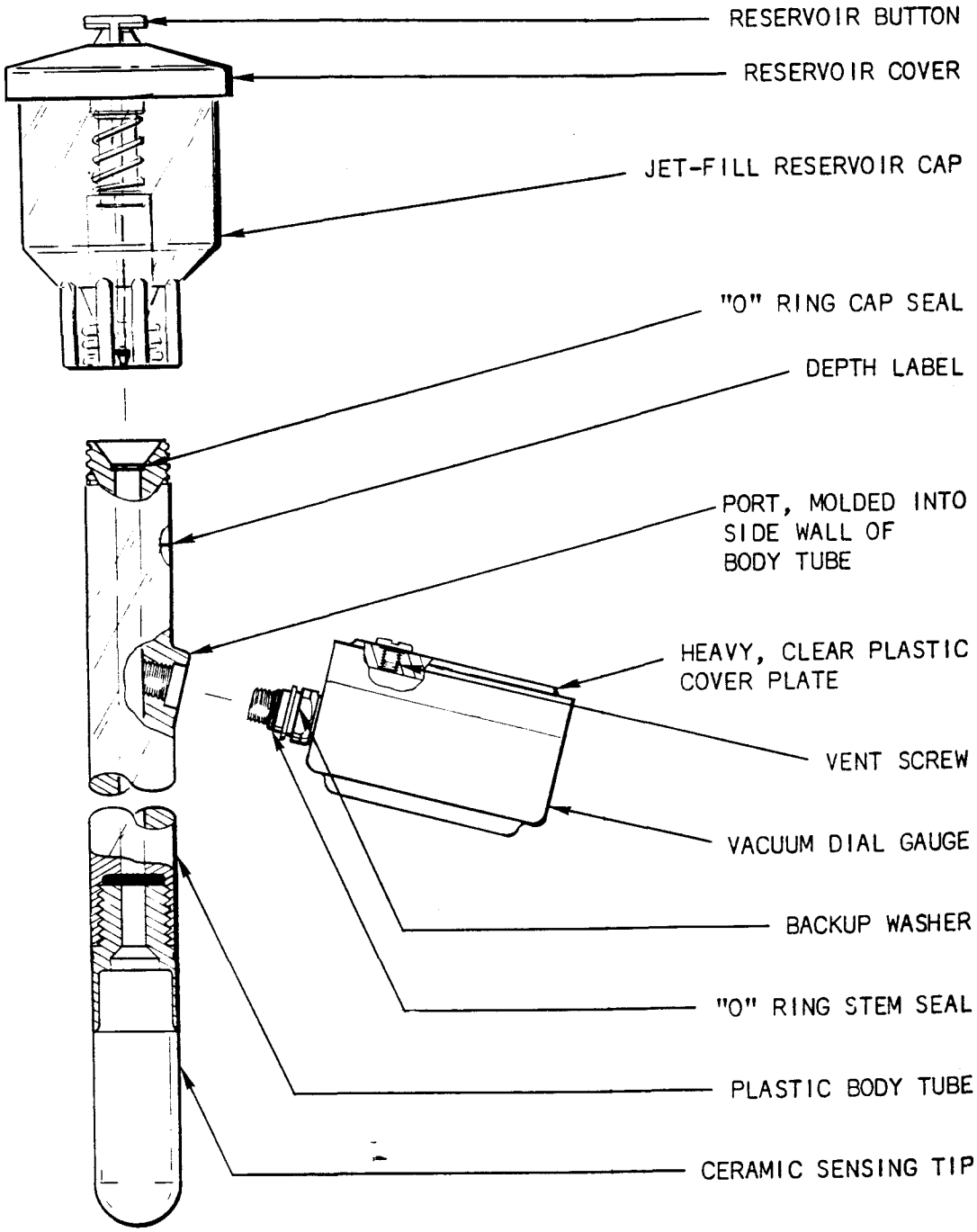
FIELD MONITORING EQUIPMENT

Appendix B-1

Jet Fill Tensiometer Model 2725A Instruction Manual

2725A OPERATING INSTRUCTIONS

JET FILL TENSIOMETER **MODEL A**



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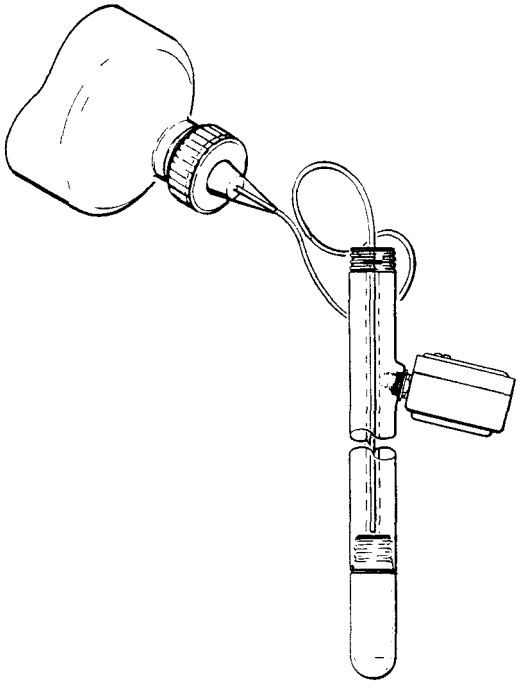
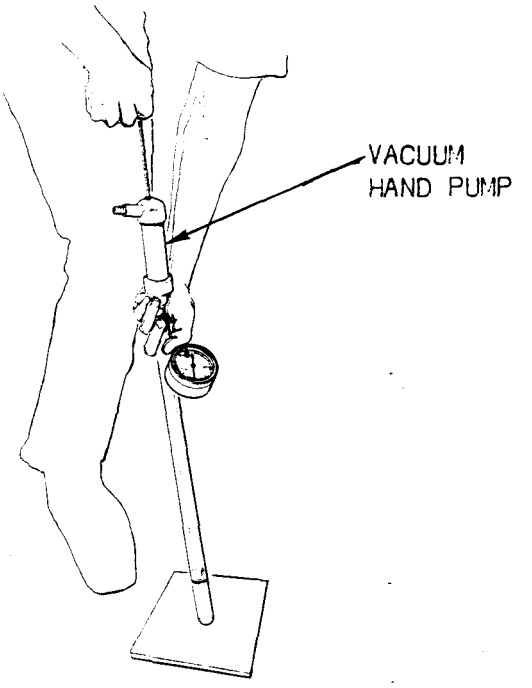
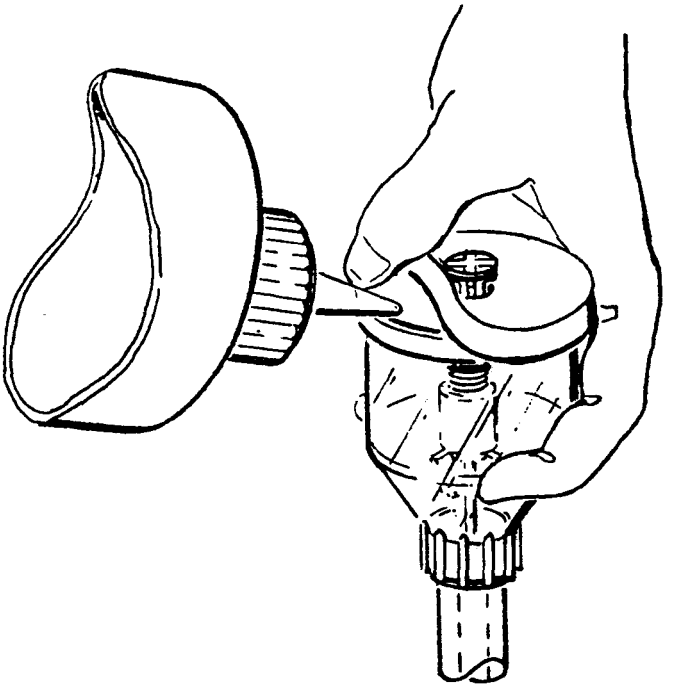




Screw tubular spout onto the filler bottle and insert tubular spout into the bore of the tensiometer body tube down to the bottom of the tensiometer. Squeeze the filler bottle to fill tensiometer body full of fluid.

Allow the tensiometer body tube to remain in a vertical position until fluid completely saturates the sensing tip and begins to drip from the end of the tip. If a group of tensiometers is being filled, they can be placed in a deep sink or empty bucket for support during the tip wetting process. Let the fluid drip from the tip for about 5 minutes to wet thoroughly.

When the sensing tip is thoroughly wetted, fill the unit completely to the top and pull a vacuum within the tensiometer using the vacuum hand pump supplied with the Service Kit. Let the sensing tip of the tensiometer set on a board for support while the rubber end of the vacuum hand pump is held in tight contact with the "O" ring cap seal of the tensiometer. Pulling up on the pump handle will create a vacuum within the tensiometer causing air to bubble out from the stem of the dial gauge. After each pumping with the vacuum hand pump, refill the tensiometer completely to the top with water. This pumping operation should be repeated four or five times until no further air is seen to bubble from the stem of the dial gauge. The unit is then sealed by screwing the Jet Fill Reservoir Cap in place on the top of the body tube.



To fill the Jet Fill Reservoir Cap, peel the resilient neoprene reservoir cover back from the top of the reservoir and fill the reservoir 3/4 full of Soilmoisture Blue Solution.

a spade to accept the tensiometer. Make sure that the soil is packed firmly around the tensiometer after it is set in place.

In loose cultivated soils, such as frequently encountered in commercial row crops, it is possible to simply push the tensiometer into the soil without coring a hole. This method of installation is completely satisfactory where applicable. Here again, be sure that the surface soil is packed firmly around the body tube after installation.

In rocky soils, a soil auger such as our Model 230 Soil Auger, 2", 3" or 4" size, can be used to core out a hole to accept the tensiometer. In this case, the soil removed is screened to remove large pebbles and rocks. The screened soil is then used to backfill around the tensiometer. A 1/4" mesh screen is usually suitable for screening the soil.

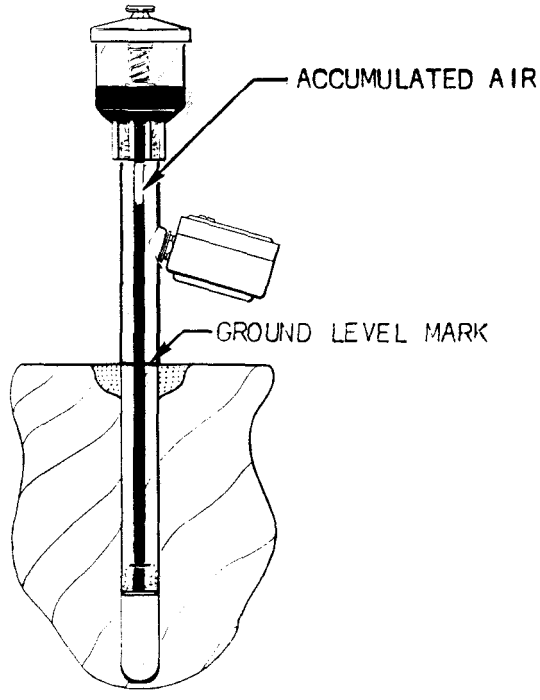
In difficult installations, such as in rocky soils or deep installations, a slurry of water and soil can be made up and poured into the bottom of the hole. The sensing tip of the tensiometer is then pushed into the slurry to assure good contact between sensing tip and soil. Large holes cored to accept the tensiometer are always backfilled and the soil at the surface tamped tightly around the body tube.

After installation, several hours may be required before the tensiometer reads the correct soil suction value. This is due to the disturbance to the soil caused by the installation procedure. The correct reading will be reached more quickly in moist soils than in dry soils.

After this initial installation period, the tensiometer will accurately indicate the soil suction value and will follow closely changes in soil suction from hour to hour.

TO SERVICE IN THE FIELD

The Jet Fill Tensiometer is completely weatherproof and requires very little servicing other than occasionally pushing the button on the Jet Fill reservoir to remove accumulated air within the tensiometer.



If the soil in which the tensiometer has been installed is moist and the soil suction readings are low, very little air will accumulate in the body tube of the tensiometer. If, however, the tensiometer has been installed in relatively dry soil and soil suction values are in the range of 40 to 60 centibars, air will accumulate rather quickly for the first few days after installation. This initial accumulation of air is due to air coming out of solution and air detaching itself from the internal walls of the tensiometer when it is exposed to high vacuums for the first time. After initial installation, check the tensiometer every day or two and remove accumulated air by pushing the button of the Jet Fill reservoir.

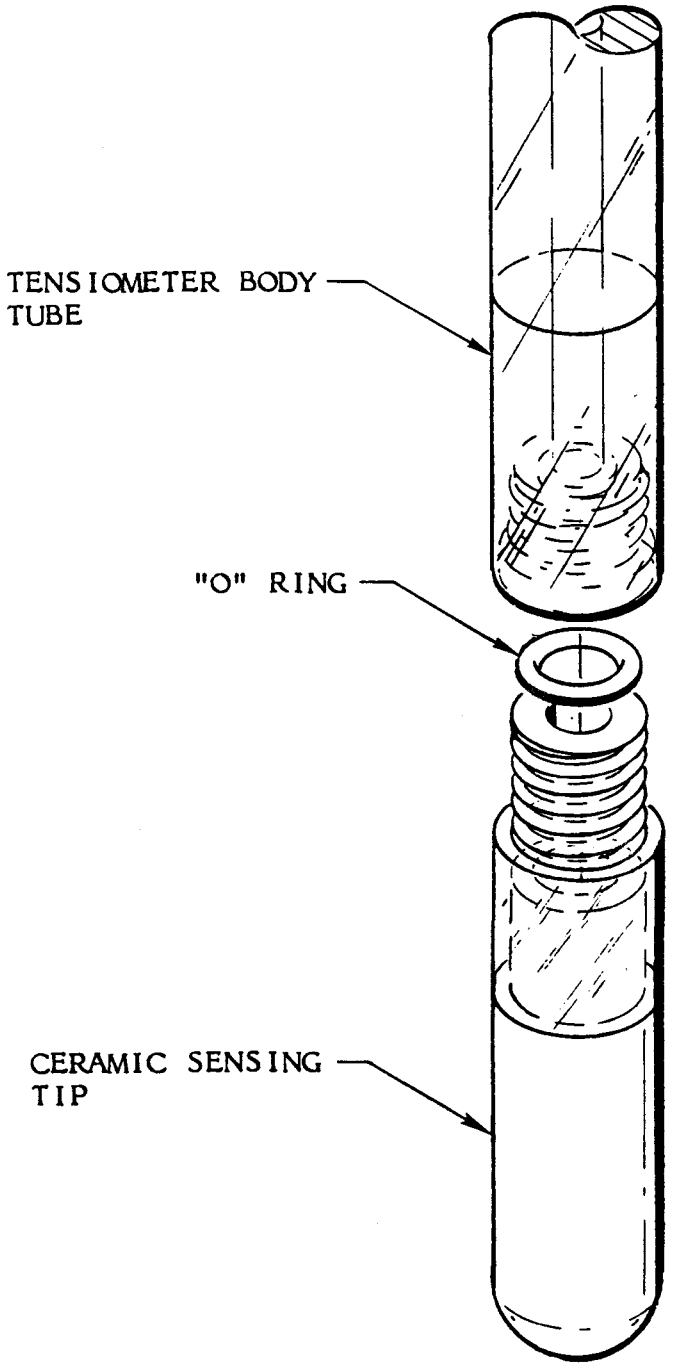
After the first few air removal servicing operations, the rate of air accumulation will drop off markedly, and air removal servicing will then be required only on a weekly or longer basis. Since the Jet Fill operation is so convenient and does not disturb soil moisture conditions, it is suggested that the reservoir button be pushed down to service the unit after each reading that is made on the tensiometer. By this means, internal air will be limited to a minimum, which will assure maximum sensitivity of the instrument. Due to the fast filling action, the tensiometer will recover to its correct reading within a few minutes after servicing.

NOVEMBER 1986

NOTICE

MODEL 2725 JET FILL TENSIOMETER

In order to improve protection during shipment, our Model 2725A Jet Fill Tensiometer is packed with the Ceramic Sensing Tip removed. To assemble the unit, invert the Tensiometer Body and insert the "O" Ring into the threaded end of the Plastic Body Tube, making sure it is seated at the bottom of the hole. Next, screw the Ceramic Sensing Tip into the Body Tube until it makes a tight seal on the "O" Ring. Do not over-tighten the Ceramic Sensing Tip into the Body Tube. The "O" Ring makes the vacuum seal, not the threads. Damage to the threads may occur as a result of excessive tightening of the Ceramic Sensing Tip. Refer to the Operating Instructions for further assembly procedures.



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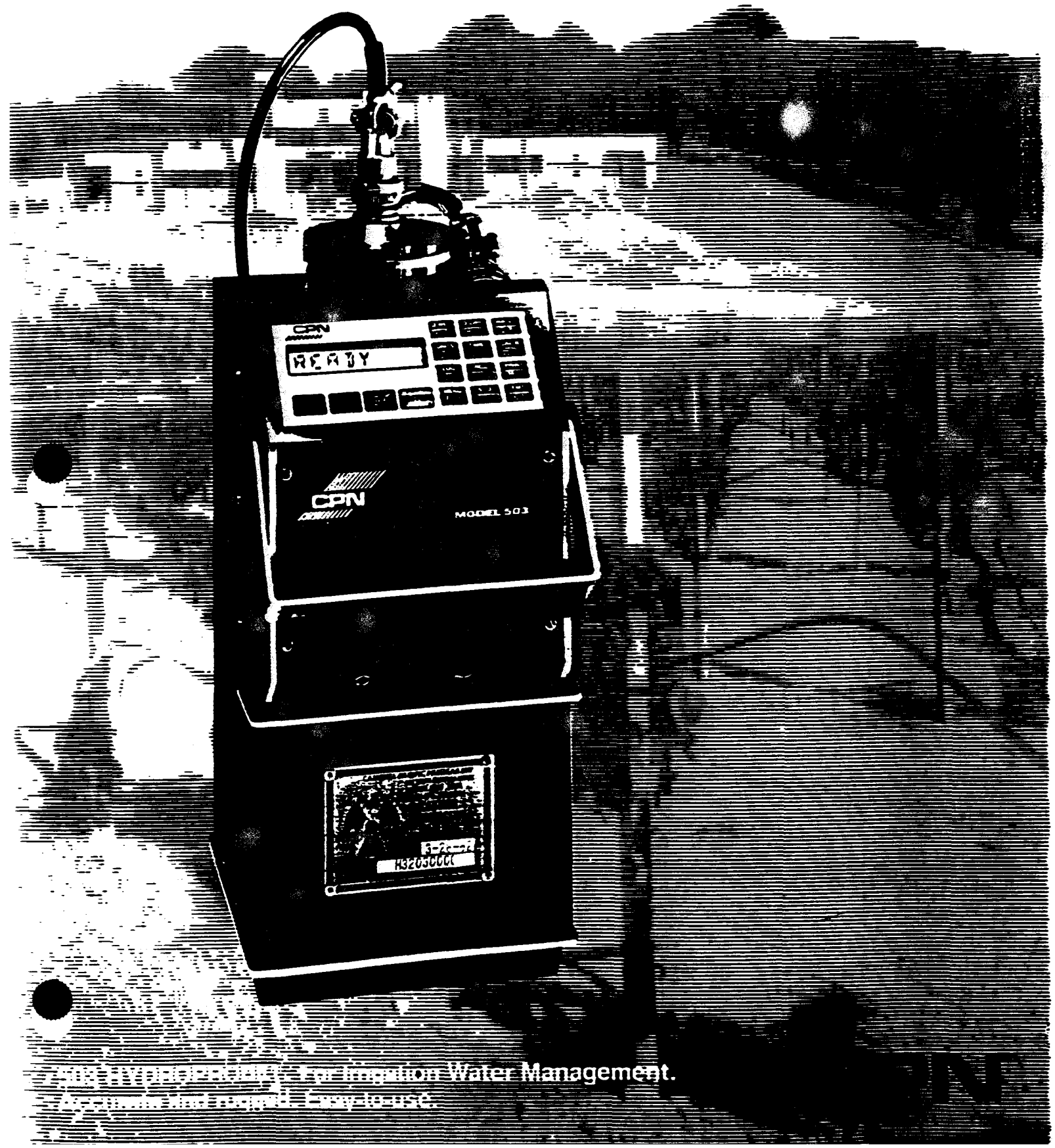
Appendix B-2

503 DR Hydroprobe Description



503 HYDROPROBE. For Irrigation Water Management.
Accurate and rugged. Easy to use.

1.0 GENERAL

1.1 INTRODUCTION

The Model 503DR HYDROPROBE, NEUTRON DEPTH MOISTURE GAGE measures the sub-surface moisture in soil and other materials by use of a probe containing a source of high energy neutrons and a slow (thermal) neutron detector. The probe is lowered into a pre-drilled and cased hole (1.5 or 2 inch diameter). Hydrogen as present in the water in the soil slows the neutrons down for detection. The moisture data is displayed directly in units of interest on an above surface electronic assembly which is integral to the source shield assembly.

The gage is supplied with a 12 foot cable and five adjustable cable stops. Additional stops and longer cable lengths are available.

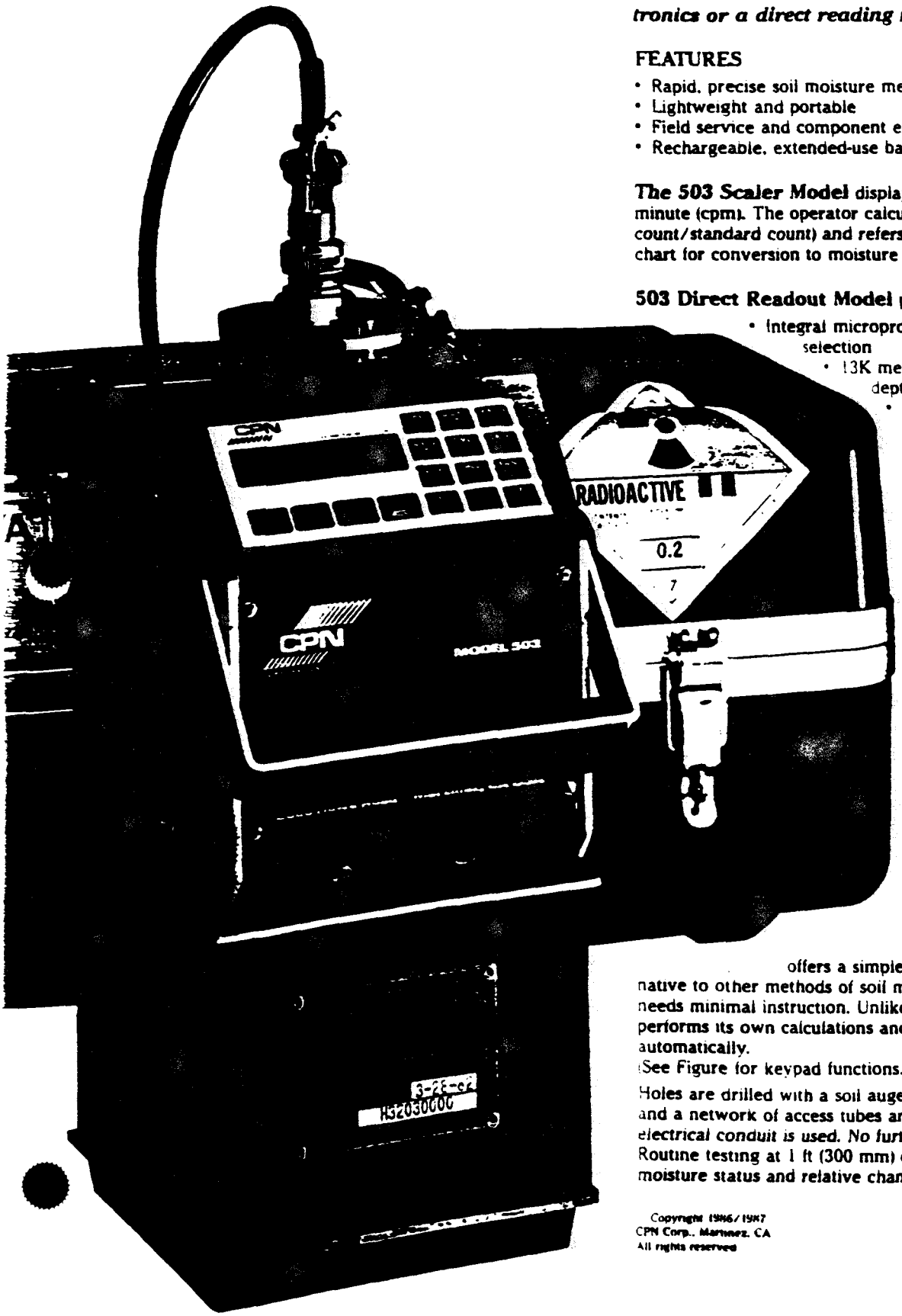
Upon retraction of the probe into the shield, the probe locks automatically in place for transportation.

The complete assembly is supplied with a plastic shipping and carrying container which contains; accessory items, cable, instruction manual, charger, and other materials which the operator may wish to carry.

1.2 SPECIFICATIONS

FUNCTION:	Sub-surface moisture measurements.
RANGE:	0 to 32% vol, (0.32 gm/cc), (20 pcf), (3.84 in/ft).
PRECISION:	0.24% at 24% vol at one minute.
COUNT TIME:	1, 4, 16, 32, 64, and 256 sec.
TEMP:	0 TO 70oC operating.
POWER:	AA NICAD batter pack (0.5 Ah) 8 cells.
BATTERY LIFE:	500-1000 Charge-discharge cycles.
CONSUMPTION:	6.5 mA avg. (allows more than 3000 each 16 sec counts).
RECHARGE:	14 hours at C/10 via wall charger.
DISPLAY:	8 character alpha/numerical Liquid-Crystal Display. Easily readable in direct sunlight.
DATA STORAGE:	3072 cells of; counts, identifiers, or keyboard entry of auxiliary values. Format operator programmable. 0-15 key and 0-15 count per record
DATA OUTPUT:	RS232C serial dump to external printer, computer, CRT or coupler.
CALIBRATION:	8 ea user programmed (linear).
UNITS:	User selectable: in/ft, pcf, gm/cc, % vol, cm/30cm, count and count ratio.
NEUTRON SOURCE:	50 mCi Americium-241/Be
ENCAPSULATION:	Double Sealed Capsule, CPN-131
SHIELDING:	Silicon based paraffin
SHIPPING:	Radioactive Material, Special Form, N.O.S., UN2974 Transport Index 0.1 Yellow II Label USA DOT 7A, Type A Package
SPECIAL FORM APPROVAL:	USA/0115/S
CONSTRUCTION:	Aluminum with epoxy paint or hard-anodize finish. Stainless steel wear parts
SURFACE UNIT:	15.7#, 6.8"Wx7.0"Dx14.0"H (7.12),(172.7x177.8x355.6)
PROBE: Model -2	2.3#, 1.865" dia x 12.7"L (1.043), (47.4 dia x 322.6)
Model -1.5	1.7#, 1.500" dia x 12.7"L (0.771), (38.1 dia x 322.6)
CARRYING & SHIPPING:	36.5#, 24"W x 13"D x 10"H (16.56), (609.6 x 330.2 x 254)

CPN® 503 HYDROPROBE®



The 503 HYDROPROBE® is the most accurate, rugged and easy-to-use soil moisture probe available today. The HYDROPROBE® is available with scaler electronics or a direct reading microprocessor.

FEATURES

- Rapid, precise soil moisture measurements at repeatable sites
- Lightweight and portable
- Field service and component exchange with tools provided
- Rechargeable, extended-use battery pack

The 503 Scaler Model displays test results in counts per minute (cpm). The operator calculates the count ratio (field count/standard count) and refers to the laminated calibration chart for conversion to moisture content.

503 Direct Readout Model provides:

- Integral microprocessor for simple function selection
- 13K memory logging of 1023 records in 3 depths-per-site format
- Data transfer to a PC computer or printer via RS232C serial interface
- Storage and recall selection of linear calibrations for 16 soil types
- Operator selected time of test, logging format, and units of measurement:

counts per minute	pcf
count ratio	gcc
inches per foot	
% moisture	

APPLICATIONS

- Irrigation scheduling: commercial management and consultant services.
- Worldwide agronomic research and extension
- Groundwater hydrology and wastewater management.

SIMPLICITY OF OPERATION

This state-of-the-art instrument offers a simple to operate but superior alternative to other methods of soil moisture monitoring. The operator needs minimal instruction. Unlike other instruments, the 503 DR performs its own calculations and records test results automatically.

(See Figure for keypad functions.)

Holes are drilled with a soil auger to the depth of the root zone and a network of access tubes are installed. Standard irrigation or electrical conduit is used. No further site maintenance is required. Routine testing at 1 ft (300 mm) depth intervals provides soil moisture status and relative changes throughout the root zone.

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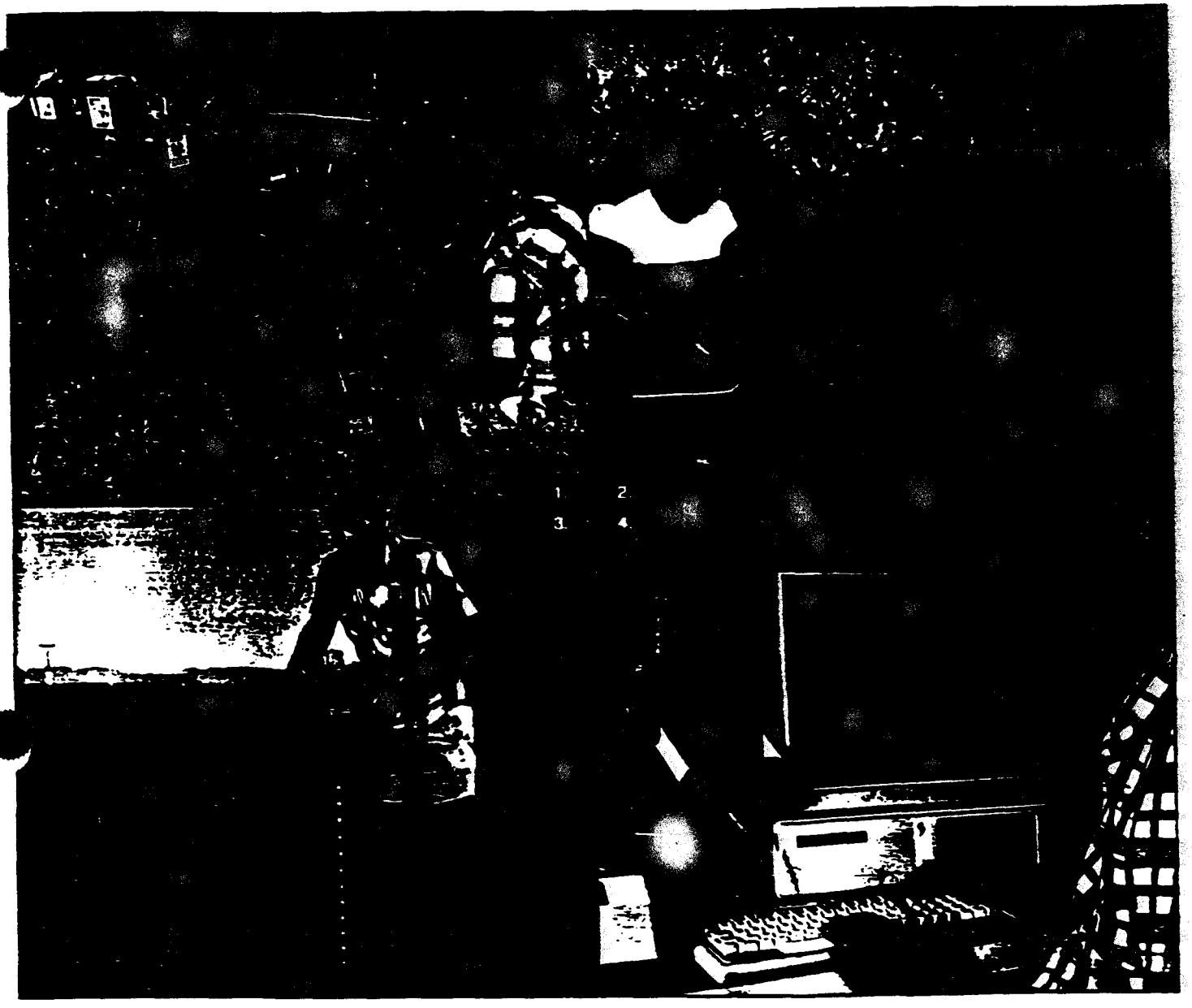
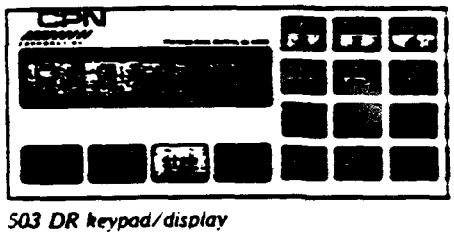


(1) field monitoring of Australian cotton crop; (2) field monitoring of Napa Valley vineyard under drip irrigation; (3) soil augering for access tube installation; (4) data transfer to Irrigation Water Management Program.



503 DR keypad/display

IRRIGATED AGRICULTURE

A program of soil moisture monitoring allows an irrigator to:

- Improve crop yields
- Determine when and how much to irrigate
- Monitor root development
- Improve irrigation efficiency and optimize system design
- Conserve water, energy, and agrichemicals

IWM PROGRAM

The Irrigation Water Management Program, available from CPN Corp, accepts stored HYDROPROBE® data to build a field history file and generate reports of soil moisture status and irrigation forecasts. Ideal for the consultant and large farm manager.

ENVIRONMENTAL MANAGEMENT

The HYDROPROBE® is an effective tool for leakage detection from buried fuel tanks, pipelines, and wastewater management units.

RUGGED AND RELIABLE

Aluminum construction with stainless steel wear parts. Lightweight, shock and water resistant. Built-in reference standard for periodic performance check and calibration update.

PRECISE

Instrument precision for a 16-second test at 2.88 in/ft (0.24 gcc) moisture: ±0.05 in/ft (± 0.004 gcc).

USER ORGANIZATIONS

U.S. Department of Agriculture
Bureau of Reclamation
Soil Conservation Service
Environmental Protection Agency
Department of Water Resources
County Irrigation Districts
University Extension Services

SPECIFICATIONS

ORDERING INFORMATION

No. 503520 HYDROPROBE®, 503 DR-2.0, DIRECT READING NEUTRON MOISTURE PROBE. 1.865" (47.4 mm) probe shell diameter, for in-place measurement of subsurface soil moisture. Programmable microprocessor provides formatted data storage and transfer capability. Complete with molded, plastic shipping and storage case, lock and keys, 12 ft. (3.66 m) cable, sign kit, wipe test kit, certificate, tool kit and access tube adapter, 115/230 volt AC battery charger and battery pack of eight welded AA NICAD cells. Operating instructions.

No. 503515 HYDROPROBE®, 503 DR-1.5, DIRECT READING, same as No. 503 DR-2.0 except with 1.5" (38.1 mm) probe shell diameter.

No. 503020 HYDROPROBE®, 503-2.0, SCALER MODEL, same as No. 503 DR-2.0 except with counts-per-minute readout for calibration chart conversion to soil moisture content.

No. 503015 HYDROPROBE®, 503-1.5, SCALER MODEL, same as No. 503-2.0 except with 1.5" (38.1 mm) probe shell diameter.

No. 503 IWM IRRIGATION WATER MANAGEMENT PROGRAM. A self-contained software program which accepts moisture readings from the 503 DR, appends them to a data base, and generates irrigation management reports, including timing and quantity of irrigation. The IWM program and the RS232C serial interface from the 503 DR are compatible with most personal computers and printers.

Factory calibration is provided for use in thin-walled aluminum, plastic (PVC), and electrical conduit: 1.5 or 2.0" nominal diameters. *Please specify upon ordering.*

CPN provides a full line of quality tools & equipment for the installation and maintenance of access sites and for field calibration of the HYDROPROBE®.

PERFORMANCE

FUNCTION:	Subsurface soil moisture measurements for irrigation scheduling, agronomic research, and groundwater hydrology.
RANGE:	0.0 to 4.8 in/ft. (0.0 to 0.40 gcc)
PRECISION at 1 min:	± 0.024 in/ft. (± 0.002 gcc)
COUNTING TIME:	1, 4, 16, 32, 64, or 256 seconds, selected by operator.
OPERATING TEMP.:	32° to 140°F (0° to 60°C)
POWER:	Battery pack of 8 welded NICAD cells.
CONSUMPTION:	10mA avg. Allows more than 600 16 second counts.
RECHARGE:	14 hours via wall charger.
DISPLAY:	Large, 8 character dot matrix liquid crystal display. Easily readable in direct sunlight.

503 Direct Readout Model (Only):

UNITS:	Operator selectable: cpm, count ratio, inches per foot, % moisture, pcf, and gcc
MEMORY STORAGE:	1023 records in three-depths-per-site format.
SERIAL INTERFACE:	RS232C upload to a PC computer or printer.
CALIBRATION:	Operator selected linear calibrations for 16 soil types.

Radiological:

NEUTRON SOURCE:	50mCi (1.85×10^3 MBq) Americium-241/Be
ENCAPSULATION:	Double sealed capsule, CPN 131
DOSE RATE AT HANDLE:	Less than .5 mrem/hr. (5μSv/hr)
SHIPPING:	Radioactive Material, Special Form, N.O.S., UN2974, Transport Index 0.2, Yellow II Label, USA DOT 7A, Type A
SPECIAL FORM APPROVAL:	USA/0150/S

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SERVICE

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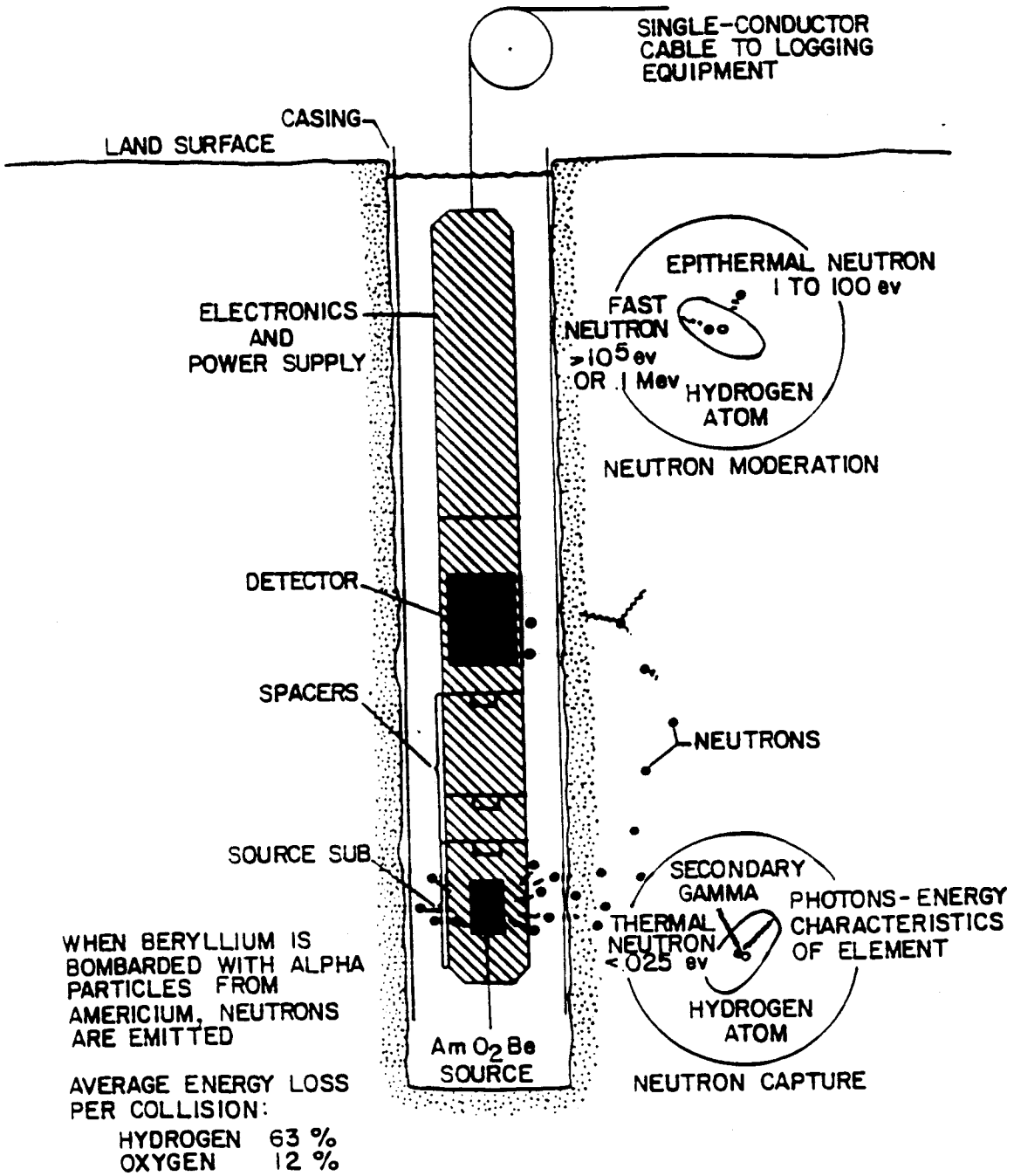

Figure A-1 Equipment and principles of neutron moisture logging (after Keys and MacCary, 1971).

APPENDIX C

GEOTECHNICAL LABORATORY PROCEDURES AND ANALYTICAL REPORTS

Appendix C-1

Colorado School of Mines (CSM) Laboratory Procedure

CSM Lab Procedure

DRAFT

Harold W. Olsen,[1] Arthur T. Willden,[2] Nicholas J. Kiusalaas,[3] Karl R. Nelson,[4] and Eileen P. Poeter[5]

VOLUME-CONTROLLED HYDROLOGIC PROPERTY MEASUREMENTS IN TRIAXIAL SYSTEMS

REFERENCE: Olsen, H. W., Willden, A. T., Kiusalaas, N. J., Nelson, K. R., and Poeter, E. P., **"Volume-Controlled Hydrologic Property Measurements In Triaxial Systems,"** Hydraulic Conductivity and Waste Contaminant Transport in Soils, ASTM STP 1142, David E. Daniel and Stephan J. Trautwein, lEds., American Society for Testing and Materials, Philadelphia, 1993.

ABSTRACT: New capabilities for hydrologic property measurements in triaxial systems include: (1) volume-controlled and simultaneous measurements of hydraulic conductivity and one-dimensional specific storage of a saturated test specimen; and (2) volume-controlled measurements of hydraulic conductivity, matric potential, and the variation of these properties with the moisture content of an unsaturated test specimen.

For volume control of hydraulic conductivity measurements in both saturated and unsaturated test specimens, a single-carriage flow pump equipped with an infuse-withdraw actuator generates identical flow rates into and out of opposite ends of a test specimen. For volume control of one-dimensional deformation of saturated specimens, a dual-carriage flow pump equipped with two identical infuse-withdraw actuators generates identical flow rates of water from (or into) the ends of a test specimen and into (or from) a hydraulic piston that deforms the specimen axially. By dimensioning the hydraulic piston to maintain the volumetric and axial deformations equal, radial deformation of the specimen is prevented. An additional flow pump provides volume control of the moisture content of an unsaturated specimen.

KEYWORDS: hydraulic conductivity, compressibility, specific storage, capillary pressure, matric potential, suction, flow pumps.

---

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[3]Geological Engineer, Advanced Sciences Inc., 405 Urban Street, Lakewood, CO 80228.

[4]Associate Professor, Department of Engineering, Colorado School of Mines, Golden, CO 80401.

[5]Associate Professor, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401.

DRAFT

INTRODUCTION

Since the late 1970's, applications of the constant-flow method for hydraulic-conductivity measurements have been increasing in both research and practice. This method, which involves generating a constant flow rate through a test specimen with a flow pump and measuring the pressure difference induced thereby with a transducer, has recently been accepted in ASTM Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (D5084-90). The fundamental advantage of this volume-controlled method, compared with constant-head and falling-head methods, is that hydraulic conductivity measurements can be obtained much more rapidly and at substantially smaller hydraulic gradients (Olsen et al. 1985, 1988, 1991; Aiban and Znidarcic 1989).

In recent years, applications of flow pumps in laboratory testing have been expanding for additional hydrologic properties of both saturated and unsaturated test specimens. These applications involve volume control not only for hydraulic-conductivity measurements, but also for changing the volume and/or the moisture content of test specimens in one-dimensional consolidometers and in triaxial cells. For saturated specimens in a one-dimensional consolidometer, Gill, Olsen, and Nelson (1991) introduced a volume-controlled method for superimposing direct constant-flow hydraulic-conductivity measurements on constant-rate-of-deformation (CRD) consolidation tests. For saturated specimens in triaxial cells, Olsen et al. (1991) introduced a volume-controlled method for obtaining hydraulic-conductivity versus effective-stress and/or void-ratio relationships on specimens under isotropic consolidation and rebound. For unsaturated specimens in triaxial cells, Znidarcic, Illangasekare, and Manna (1991) introduced a volume controlled method for measuring matric potential (also known as suction and capillary pressure) versus degree of saturation relationships.

This paper presents improvements to the above-mentioned volume-controlled method for saturated specimens under isotropic deformation in a triaxial cell. In addition, the paper introduces new applications of volume control for: (1) simultaneous measurements of hydraulic conductivity and specific storage on saturated specimens under one-dimensional deformation in a triaxial cell; and (2) simultaneous measurements of hydraulic conductivity, matric potential, and the variation of these properties with the degree of saturation of an unsaturated specimen in a triaxial cell.

SATURATED SPECIMENS UNDER ISOTROPIC DEFORMATION

Figure 1 illustrates a triaxial system for measuring hydraulic conductivity versus effective stress relations on specimens under isotropic consolidation and rebound. A single-carriage flow pump equipped with an infuse-withdraw actuator [P] generates identical flow rates through opposite ends of the test specimen [S] while one transducer [M] monitors the pressure difference across the specimen and a second transducer [N] monitors the pressure difference between the pore fluid in the specimen and chamber fluid in the triaxial cell. A dual-channel flow pump, equipped with identical infuse-withdraw actuators [CC], extracts (or infuses) pore fluid from (or to) the specimen, and thereby changes its volume at a constant rate. A high-pressure bellowfram [B] allows the chamber pressure to be elevated and maintained constant at high levels, on the order of 400 psi.

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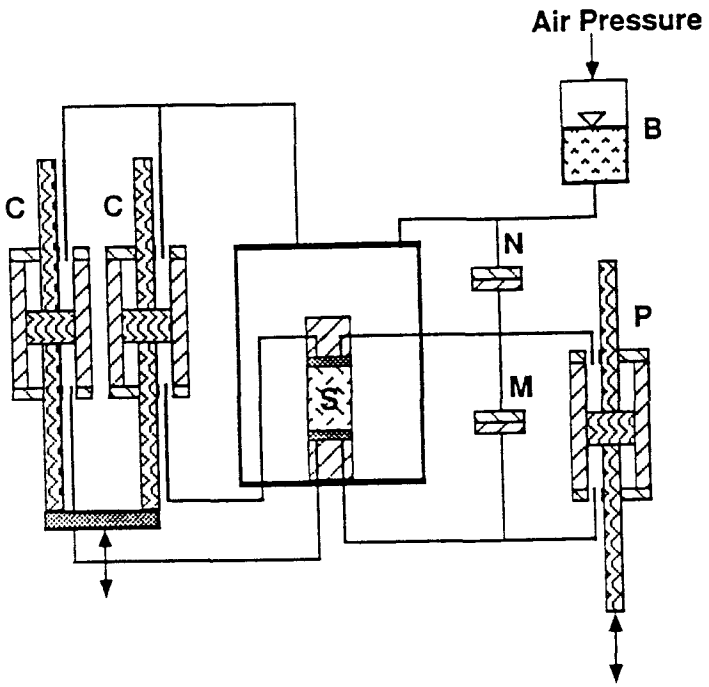

Figure 1--Triaxial system for saturated specimens under isotropic deformation.

One improvement in this system, compared with previous systems (Olsen et al. 1991), is the use of infuse-withdraw actuators not only for generating identical flow rates through opposite ends of a test specimen, but also for extracting or infusing pore water to or from the ends of the specimen. The use of infuse-withdraw actuators for this latter purpose, instead of conventional stainless-steel syringes in previous described systems, provides a means to minimize the force imposed on the saddle of the flow pump by the shafts that drive the pistons in the actuators. In figure 1, this force is proportional to the pressure difference between the pore fluid in the specimen and the chamber fluid in the triaxial cell. Alternatively, the line from the actuators to the chamber could be connected to another pressure source suitable for counteracting the force generated by the pore-water pressure in the specimen. The other improvement in this system is the use of a high-pressure bellowfram, whose design is documented elsewhere (Willden 1991). These improvements were motivated by our experience that response times needed to reach steady state for very-low hydraulic-conductivity measurements can be minimized by elevating pore fluid and chamber pressures to at least 150-200 psi.

Data obtained with the system in figure 1 on 5.08-cm diameter by 2.54-cm thick specimens of shale from Oklahoma are shown in figures 2 and 3. In these figures, the bottom plots show the time history of the effective stresses induced in the specimens during consolidation and rebound. The middle plots show the hydraulic conductivity measurements that were superimposed during consolidation and rebound. The upper plots show the hydraulic conductivity versus effective stress relationships derived from the lower and middle plots.

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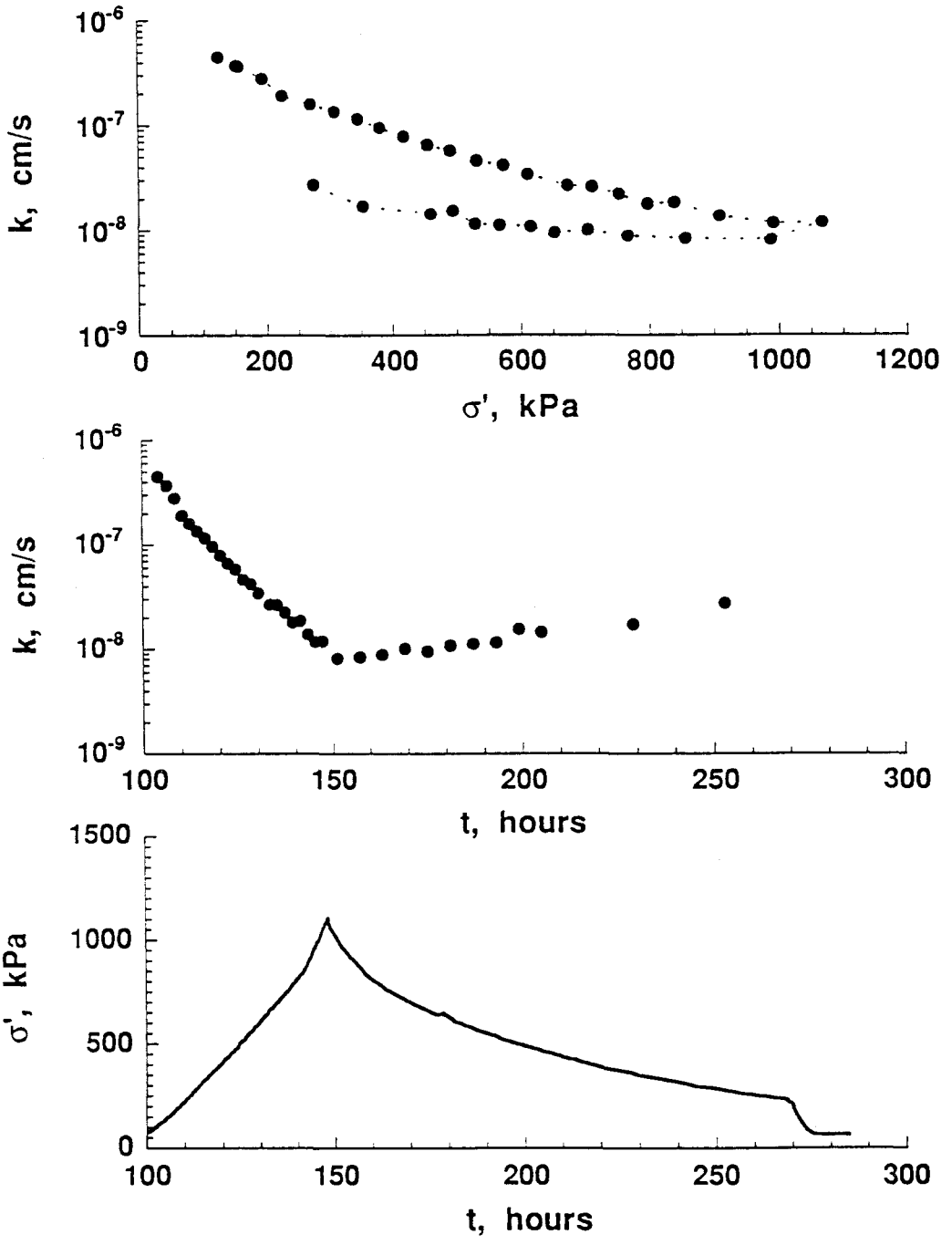

Figure 2--Elapsed time (t) versus effective stress (σ') [bottom plot] and hydraulic-conductivity (k) [middle plot] on an Oklahoma shale specimen (from 20.4-m depth) in the triaxial system illustrated in figure 1; σ' versus k relationship from data in the middle and lower plots [top plot].

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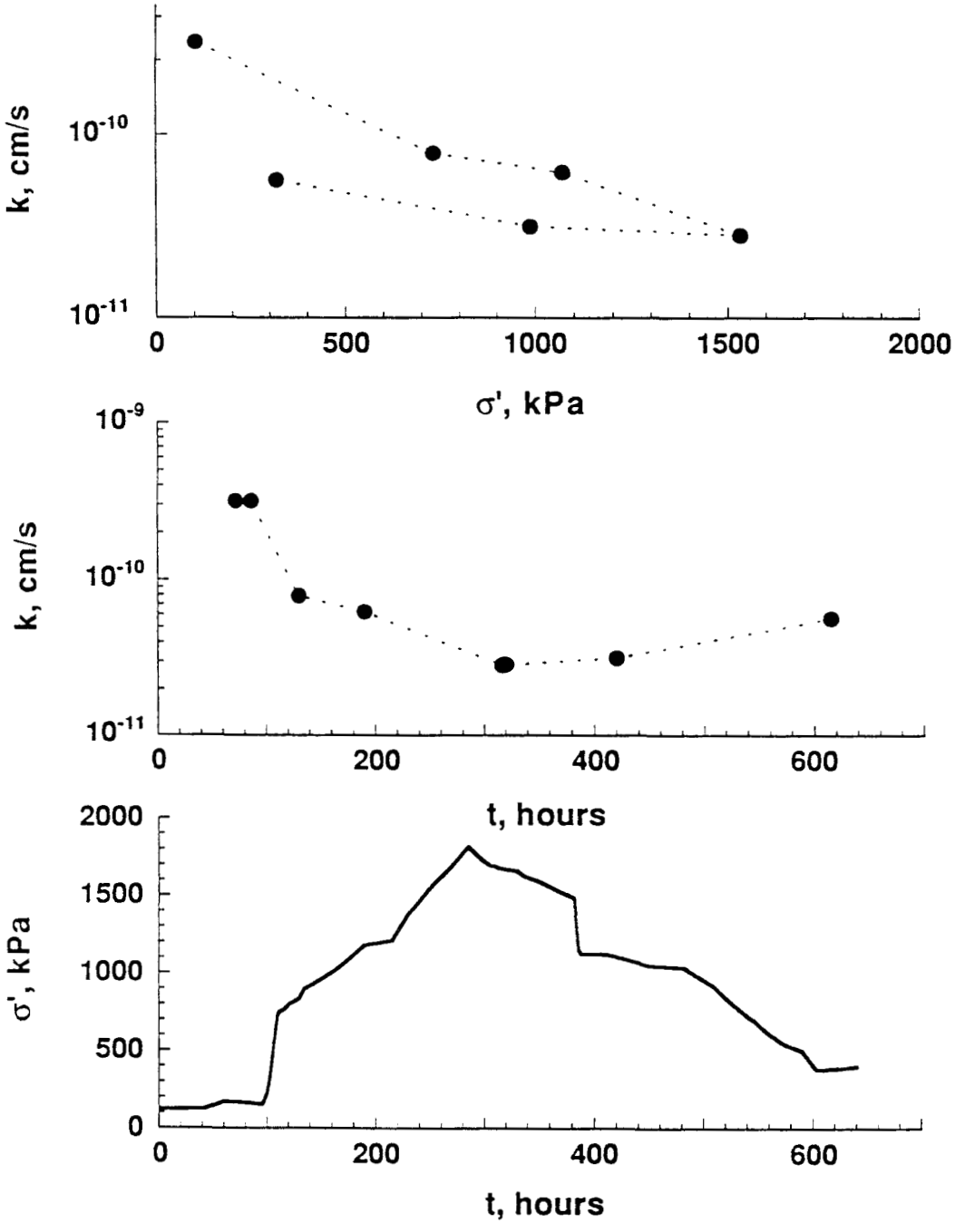

Figure 3--Elapsed time (t) versus effective stress (σ') [bottom plot] and hydraulic-conductivity (k) [middle plot] on an Oklahoma shale specimen (from 36.2-m depth) in the triaxial system illustrated in figure 1; σ' versus k relationship from data in the middle and lower plots [top plot].

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The specimens were first equilibrated for about 100 hours at low effective stresses. Thereafter, the specimens were consolidated and rebounded continuously, although in figure 3, the rate of loading was modified at elapsed times of about 105, 390, and 490 hours. Figure 2 shows 35 hydraulic-conductivity measurements in the range of 10^{-6} to 10^{-8} cm/s were obtained between elapsed times of 100 to 270 hours, or an interval of about seven days. In contrast, figure 3 shows seven hydraulic-conductivity measurements in the range of 10^{-10} to 10^{-11} cm/s were obtained before, during, and following consolidation and rebound, between elapsed times of 100 to 600 hours, or an interval of about 21 days. These data include the lowest values of hydraulic conductivity that we have measured to date.

Figures 2 and 3 illustrate that the elapsed time needed for obtaining hydraulic-conductivity versus effective-stress relationships varies with the hydraulic conductivity of the material. The governing factor is the response time needed for reaching steady state during each hydraulic-conductivity measurement, which depends on the ratio of the compressibility (or specific storage) divided by the hydraulic conductivity of the material. This ratio, which is commonly referred to as either the coefficient of consolidation or the hydraulic diffusivity, is independent of the hydraulic gradient induced during a constant-flow hydraulic-conductivity test. Our experience in this and previous studies (Olsen et al. 1985, 1988, 1991) shows response times for constant-flow hydraulic-conductivity (k) measurements in triaxial systems to be on the order of: (a) a few minutes or less for materials with k values greater than 10^{-6} cm/s, (b) a few hours for materials with k values in the range of 10^{-8} to 10^{-9} cm/s; and (c) a few days for materials with extremely low k values, in the range of 10^{-10} to 10^{-11} cm/s.

SATURATED SPECIMENS UNDER ONE-DIMENSIONAL DEFORMATION

Figure 4 shows an experimental system Willden (1991) developed for superimposing constant-flow hydraulic-conductivity measurements with one-dimensional constant-rate-of-deformation (CRD) consolidation of a test specimen in a triaxial system. This system includes the components of the system in figure 1. In addition, (a) it is equipped with a hydraulic loading system [H] for controlling the axial deformation of the specimen, (b) the upper ends of the pair of identical infuse-withdraw actuators [CC] transmit fluid to or from the hydraulic loading chamber, and (c) an additional transducer [O] measures the pressure difference between the hydraulic loading chamber and the cell chamber.

One-dimensional consolidation or rebound of the specimen is accomplished with two identical infuse-withdraw actuators [CC], driven by a dual-carriage flow pump. For one-dimensional deformation with double drainage, these actuators simultaneously withdraw (or infuse) pore fluid from (or into) opposite ends of the specimen, and transmit an identical volume of fluid to (or from) the piston loading chamber. The total volume change of the specimen equals the volume extracted from (or infused into) the top and bottom of the specimen. Alternatively, for one-dimensional deformation with single drainage, both actuators can withdraw (or infuse) pore fluid from (or into) one end of the specimen. This requires some additional valves and tubing not shown in figure 1. With either double or single drainage, the axial deformation of the specimen is maintained equal to the total volume change because the piston loading chamber has a net cross-sectional area equal to that

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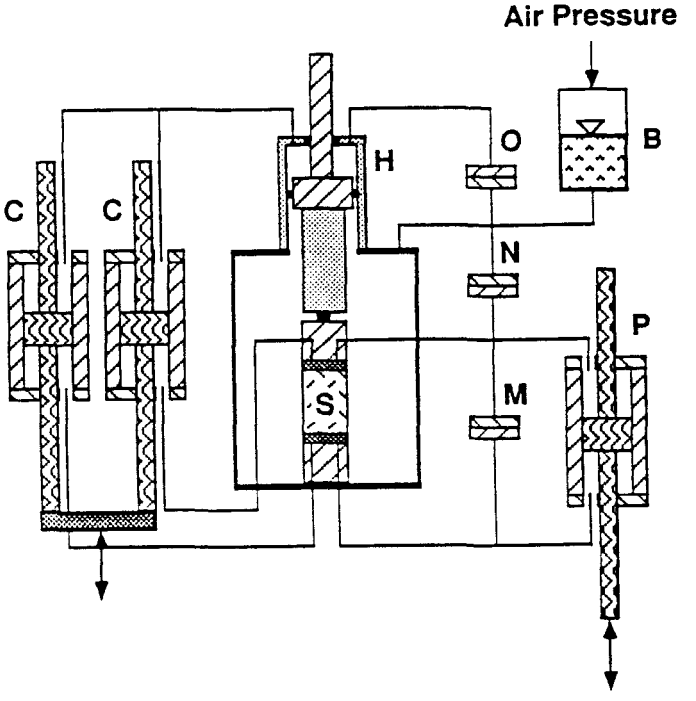

Figure 4--Triaxial system for saturated specimens under one-dimensional deformation.

of the test specimen. This constraint prevents radial deformation of the specimen, and thereby maintains the average diameter of the specimen constant during consolidation and rebound.

Data obtained with this system on a reconstituted specimen of kaolinite are presented in figure 5. This specimen was prepared from Standard Air Floated (SAF) Kaolinite from the Georgia Kaolin Company. Dry powdered clay was mixed with distilled water to form a slurry with an initial water content of 110%. The slurry was deaired under vacuum, poured into a rigid 3-inch diameter cylinder, and consolidated one-dimensionally between porous discs to a consistency with sufficent stiffness to allow a 5.08-cm diameter specimen to be trimmed and mounted in the triaxial system. The specimen was maintained under a very small effective stress while the chamber fluid pressure was elevated in three steps from 0-100, 100-200, and 200-400 psi, and allowed to equilibrate for 24 hours following each step. B-bar values measured at the end of the successive equilibration periods were 98%, 99%, and >99.5%.

In figure 5, the elapsed time scale begins at the onset of CRD consolidation with single drainage, following equilibration of the specimen at pore fluid and chamber fluid pressures of approximately 400 and 405 psi respectively. The lower plot shows the time history of the void ratio during consolidation and rebound at a constant rate of deformation of 10^{-6} s^{-1}. The middle plot shows the corresponding time history of the induced vertical and horizontal effective stresses. The upper plot shows the time history of the pore-pressure difference, Δu, across the specimen. The deformation-induced component of this pressure difference, designated as the baseline, is caused by CRD deformation with single drainage. The additional periodic changes in this

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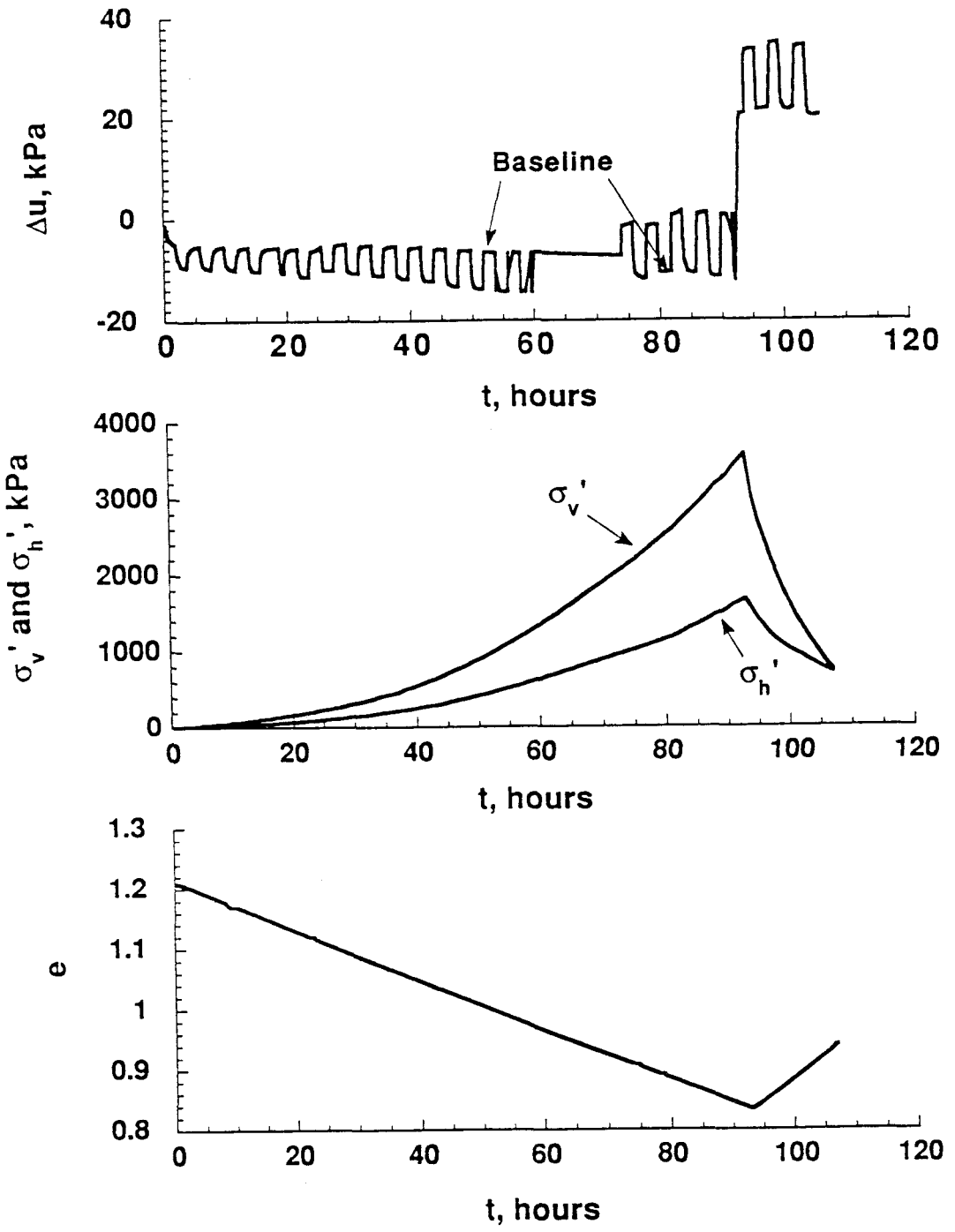

Figure 5--Elapsed time (t) versus void ratio (e) [bottom plot], pore-pressure difference across the specimen (Δu) [middle plot], and the vertical (σ_v') and horizontal (σ_h') effective stresses [top plot] on a kaolinite specimen in the triaxial system illustrated in figure 4.

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pressure difference were induced by generating a flow rate through the specimen with the infuse-withdraw actuator driven by a single-carriage flow pump. Approximately 20 constant-flow hydraulic conductivity-measurements were thus obtained during consolidation for about 93 hours and subsequent rebound for an additional 12 hours.

Constitutive relations derived from these data are shown in figure 6. The lower plot shows: the void ratio (e) versus the vertical effective stress (σ_v'); the void ratio vs the horizontal effective stress, σ_h'; and the void ratio versus K_o, where $K_o = \sigma_h'/\sigma_v'$. The upper plot shows the void ratio versus hydraulic conductivity (k), and also the void ratio versus specific storage (S_s) relationships. The specific storage is calculated from the compressibility, (a_v) which is the slope of the void ratio versus vertical effective stress relationship ($de/d\sigma_v'$).

A limitation of the triaxial system in figure 4 arises from three sources of compliance that tend to cause deviations from the zero-radial-strain condition: (a) compressibility of the pore water in the test specimen and the interconnected water in the tubing and infuse-withdraw actuators; (b) compressibility of the water in the hydraulic loading chamber and the interconnected water in the tubing and infuse-withdraw actuators; and (c) expansion of the test cell induced by axial force in the specimen. To minimize errors from these factors, very high fluid pressures were used in the test specimen, the triaxial chamber, and the hydraulic loading system. In addition, the vertical expansion of the test cell in response to the axial force generated by hydraulic loading was calibrated and taken into account in determining the thickness of the specimen throughout the test.

Willden (1991) examined deviations from the zero-lateral-strain condition by comparing direct measurements of the thickness and diameter of the specimens before and after CRD consolidation and rebound, and also by comparing the K_o values obtained during virgin consolidation with those compiled from the literature by Mayne and Kulhawy (1982). These comparisons are presented in Tables 1, 2, and 3 for four test specimens of the same kaolinite, including specimen T6 whose data were presented in figures 5 and 6.

Table 1 shows the radial strains were small compared with the vertical strains. For three of the specimens, the final diameters were approximately 0.5% larger than the initial diameters, after the specimens had been consolidated from about 12-18%. For specimen T5, the larger radial strain appears to be unreasonable, due to a value of the initial diameter that is low compared with the initial diameters of the other specimens. Comparison of Tables 2 and 3 shows the range and the average values of K_o obtained from the four kaolinite specimens (Table 2) are reasonable because they are within the range of values for kaolinite that Mayne and Kulhawy (1982) compiled from the literature (Table 3).

UNSATURATED SPECIMENS UNDER STRESS CONTROL

Figure 7 shows an experimental system for measuring hydraulic conductivity, matric potential, and the variation of these properties with the water content of a unsaturated specimen. Our initial goal for this system was to determine whether constant-flow hydraulic-conductivity measurements could be performed on an unsaturated specimen by infusing and withdrawing identical flow rates at opposite ends of the specimen with a flow pump equipped with an infuse-withdraw actuator [P].

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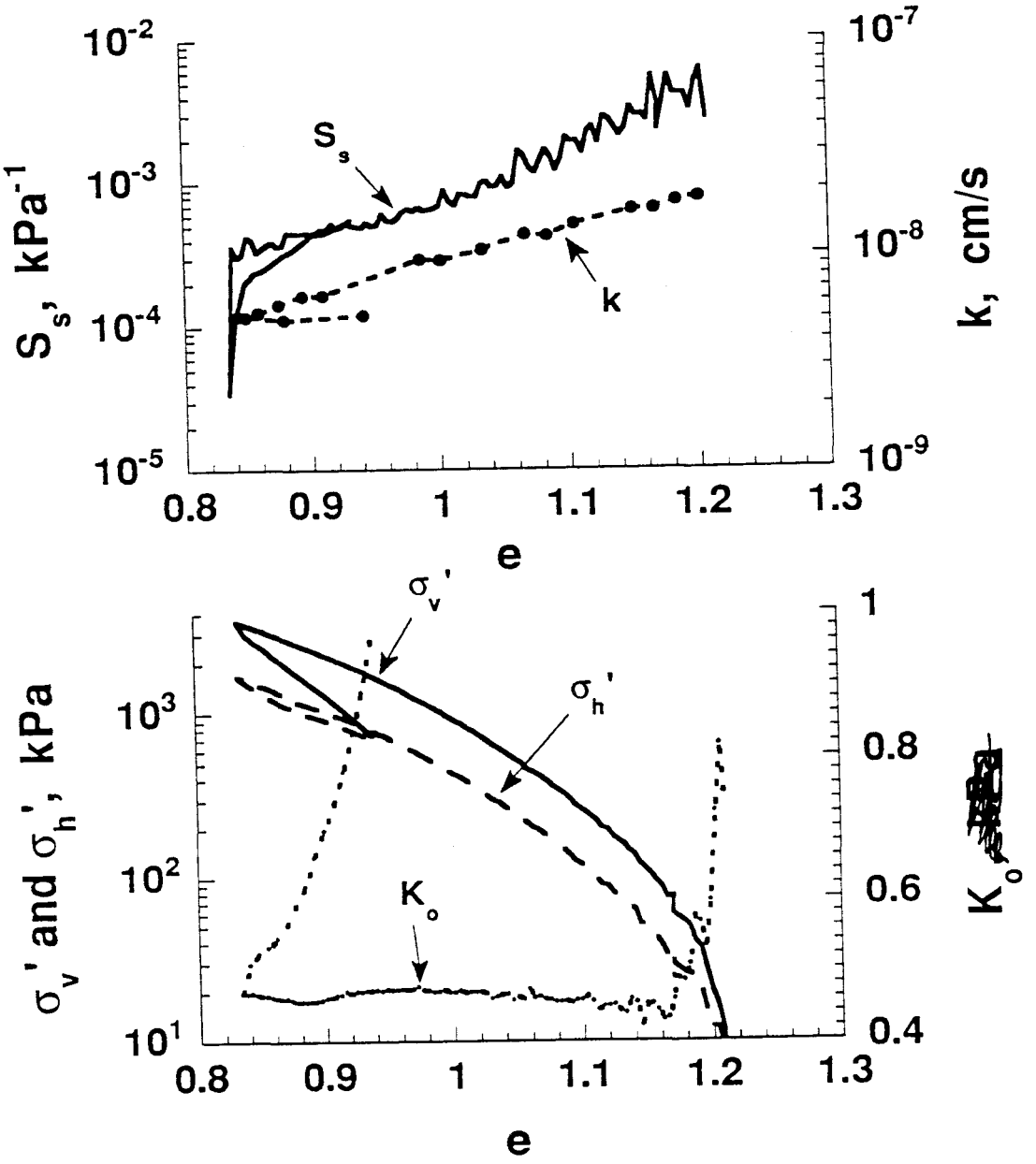

Figure 6--Constitutive relations derived from data in figure 5. Upper plot: void ratio (e) versus specific storage (S_s) and hydraulic conductivity (k). Lower plot: void ratio (e) versus vertical effective stress (σ_v'), horizontal effective stress (σ_h'), and the coefficient of lateral earth pressure ($K_o = \sigma_h'/\sigma_v'$).

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TABLE 1--Initial and final dimensions and strains for kaolinite specimens tested by Willden, 1991

Sample number	T3	T4	T5	T6
Sample height				
Initial, cm	2.236	2.103	2.280	2.201
Final, cm	1.846	1.790	1.850	1.930
Vertical strain	17.4%	14.9%	18.9%	12.3%
Sample diameter				
Initial, cm	5.130	5.110	5.060	5.130
Final, cm	5.155	5.144	5.150	5.156
Radial strain	0.5%	0.7%	1.8%	0.5%

TABLE 2--K_o values measured by Willden, 1982 on Standard Air Floated Kaolinite from Georgia Kaolin Company

Specimen	Range	Average
T3	0.46-0.50	0.49
T4	0.42-0.49	0.45
T5	0.46-0.48	0.47
T6	0.44-0.47	0.46

The pedestal and top cap have 5-bar (high-air-entry) ceramic discs through which water is transmitted to or from the specimen. The upper disc has a center hole, and is sealed with O-rings in a doughnut shaped cavity in the top cap. A hole through the center of the top cap allows pore-air pressure in the specimen to be controlled by an external pressure regulator [PR]. The water content of the specimen is varied by using a second flow pump [W] to infuse or withdraw water at the base of the specimen. Insitu stresses on the specimen can be simulated using a differential pressure regulator [DPR] to maintain a constant pressure difference between the chamber pressure and the pore-air pressure. Alternatively the specimen volume can be controlled (to a degree limited by compliance of the system) by infusing or withdrawing water into/from the triaxial chamber with a third flow pump [V].

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TABLE 3--K_o values compiled by Mayne and Kulhawy, 1982

Reference	Soil Name	K_o Value
Burland, 1967	kaolinite	0.69
Sketchley and Bransby, 1973	Spestone kaolinite	0.66
Parry and Wroth, 1976	kaolinite	0.64
Parry and Nadarajah, 1973	Spestone kaolinite	0.64
Moore and Cole, 1977	Australian kaolinite	0.56
Singh, 1971	kaolinite	0.51
Poulos, 1978	Sydney kaolinite	0.48
Moore and Cole, 1977	Australian kaolinite	0.44

One side of each of three differential pressure transducers [M,N, and Q] are connected to one of the pore-water lines into the base pedestal, where they monitor the water pressure below the 5-bar ceramic disc at the base of the specimen (P_b). The other side of transducer M monitors the water pressure in the top cap above the 5-bar ceramic disc on top of the specimen (P_t). The other side of transducer Q monitors the air pressure in the center hole of the top cap that connects with the pore-air pressure at the top of the specimen (P_a). The other side of transducer N monitors the chamber pressure (P_c).

The data presented below were obtained on an "undisturbed" sample of well-graded silty sand, having 14.5% finer than #200 sieve, from a recharge research site 3 miles north of Golden, CO. The sample was extracted from the bottom of a hole drilled with a 3 and 1/4-inch (8.3-cm) diameter hand auger, at a depth of 1.5 meters in soil overlying the approximate contact of the Denver and Arapahoe Formations (Kiusalaas 1992). The sample was obtained by using an 8-lb (35.6-N) slide hammer to advance a hollow-tube sampler equipped with a 5.08-cm diameter by 15.2-cm long brass liner. Subsequent moisture changes were minimized by placing end caps on the sample-filled liner immediately after extraction, and storing the sample in a humid room.

The test specimen was prepared by cutting a 5.08-cm section of the liner-covered sample with a diamond rock saw. The liner was cut lengthwise to eliminate frictional resistance while removing the specimen from its liner. The specimen was enclosed in a cylindrical latex membrane, mounted in the triaxial cell, and sealed between the base pedestal and top cap with O-rings. The triaxial cell chamber was filled with deaired-distilled water from an elevated reservoir (not shown). Prior to mounting the specimen, the hydraulic components of the system were saturated with deaired-distilled water. After mounting, the specimen was saturated by evacuating the air in its pore space with a vacuum pump attached to the pore-air line leading to the center hole in the top cap over the specimen. Deaired-distilled water, at atmospheric pressure in the elevated reservoir, was then allowed to flow upwards through the specimen until it appeared in the pore-air line connected to the vacuum pump. The vacuum pump was then disconnected, the pore-air

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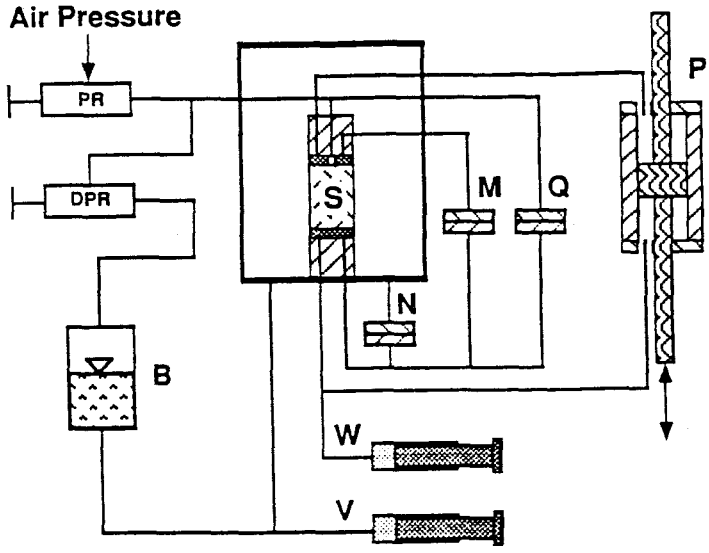

Figure 7--Triaxial system for unsaturated specimens under isotropic stress control

line was equilibrated with the atmosphere, and the differential pressure regulator was set to maintain the pressure in the chamber fluid 10 psi greater than the pressure in the pore-air line at the top of the specimen. It appears reasonable to suppose that this procedure removes most of the pore air from the specimen; however, the efficiency of this procedure for saturating test specimens has yet to be determined.

The time history of a test on the above specimen is illustrated in figures 8, 9, and 10. ΔP_{a-b} is the difference between the pore-air pressure at the top of the specimen and the water pressure below the porous stone in the base pedestal. When there is no flow through the system, and hence no head loss through the ceramic discs, this pressure difference equals that between the pore-air pressure and the pore-water pressure within the specimen, P_m, which is commonly referred to as matric potential, or suction. ΔP_{t-b} is the difference between the water pressure above the ceramic disc in the top cap, and the water pressure below the ceramic disc in the base pedestal. The response of this pressure difference to an externally generated flow of water through the specimen arises from resistance to water flow, both through the specimen and also through the ceramic discs above and below the specimen. When there is no externally generated flow through the system, finite values of ΔP_{t-b}, which are generally very small, may arise from sources within a test specimen, such as gradients in the composition and properties of the materials and/or chemical reactions among the constituents (Olsen, Nichols, and Rice 1985). In our experience, significant magnitudes of ΔP_{t-b} from sources within test specimens arise primarily in materials with extremely low hydraulic conductivities, on the order of 10^{-9} cm/s or less.

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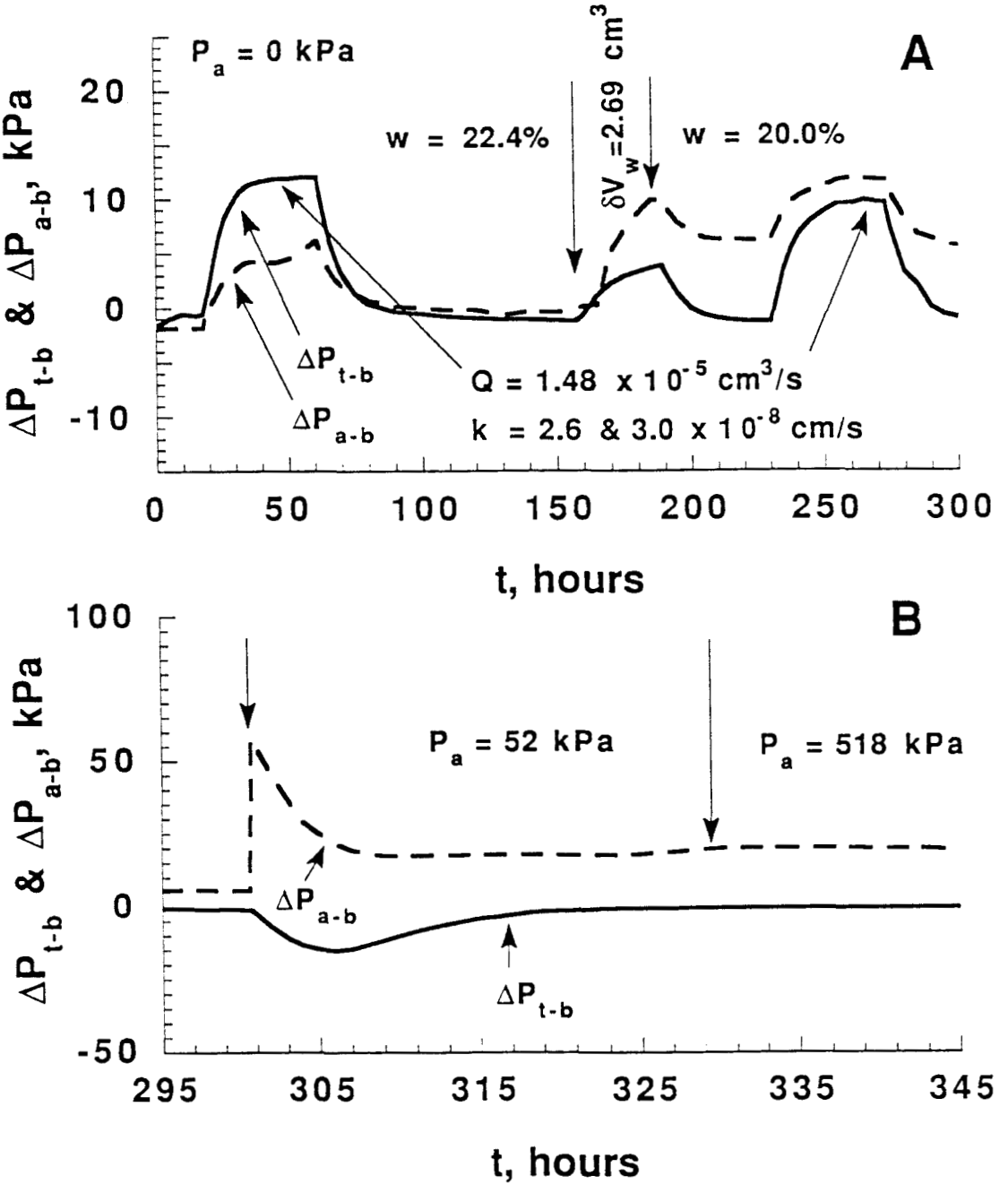

Figure 8. Data obtained during elapsed time (t) from 0 to 345 hours for a specimen in the triaxial system illustrated in figure 7. ΔP_{a-b} is difference between pore-air pressure at top of specimen and water pressure below the porous stone in the base pedestal. ΔP_{t-b} is difference between water pressures above and below the porous stones in the top cap and the base pedestal.

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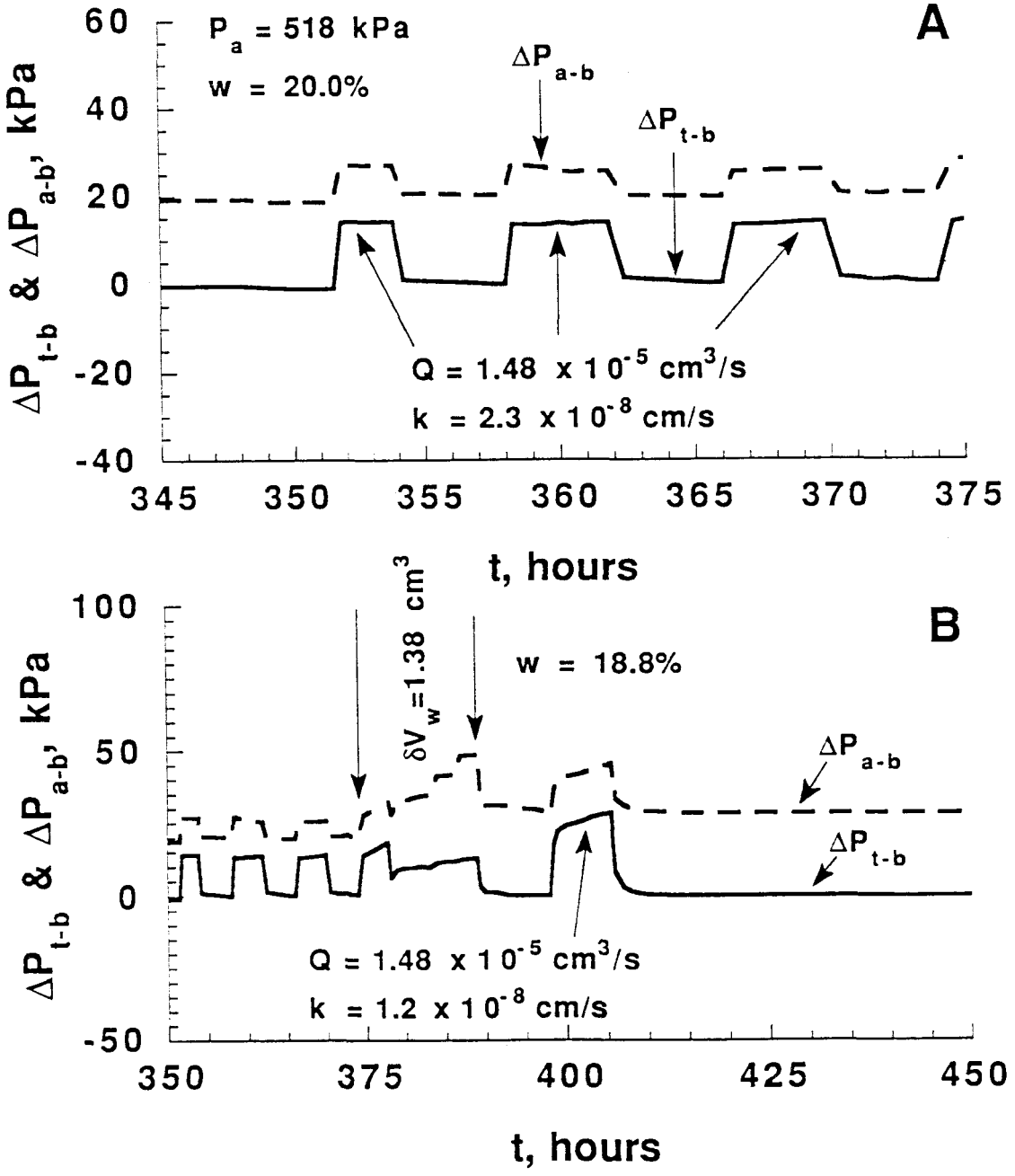

Figure 9. Data obtained during elapsed time (t) from 345 to 450 hours for a specimen in the triaxial system illustrated in figure 7. ΔP_{a-b} is difference between pore-air pressure at top of specimen and water pressure below the porous stone in the base pedestal. ΔP_{t-b} is difference between water pressures above and below the porous stones in the top cap and the base pedestal.

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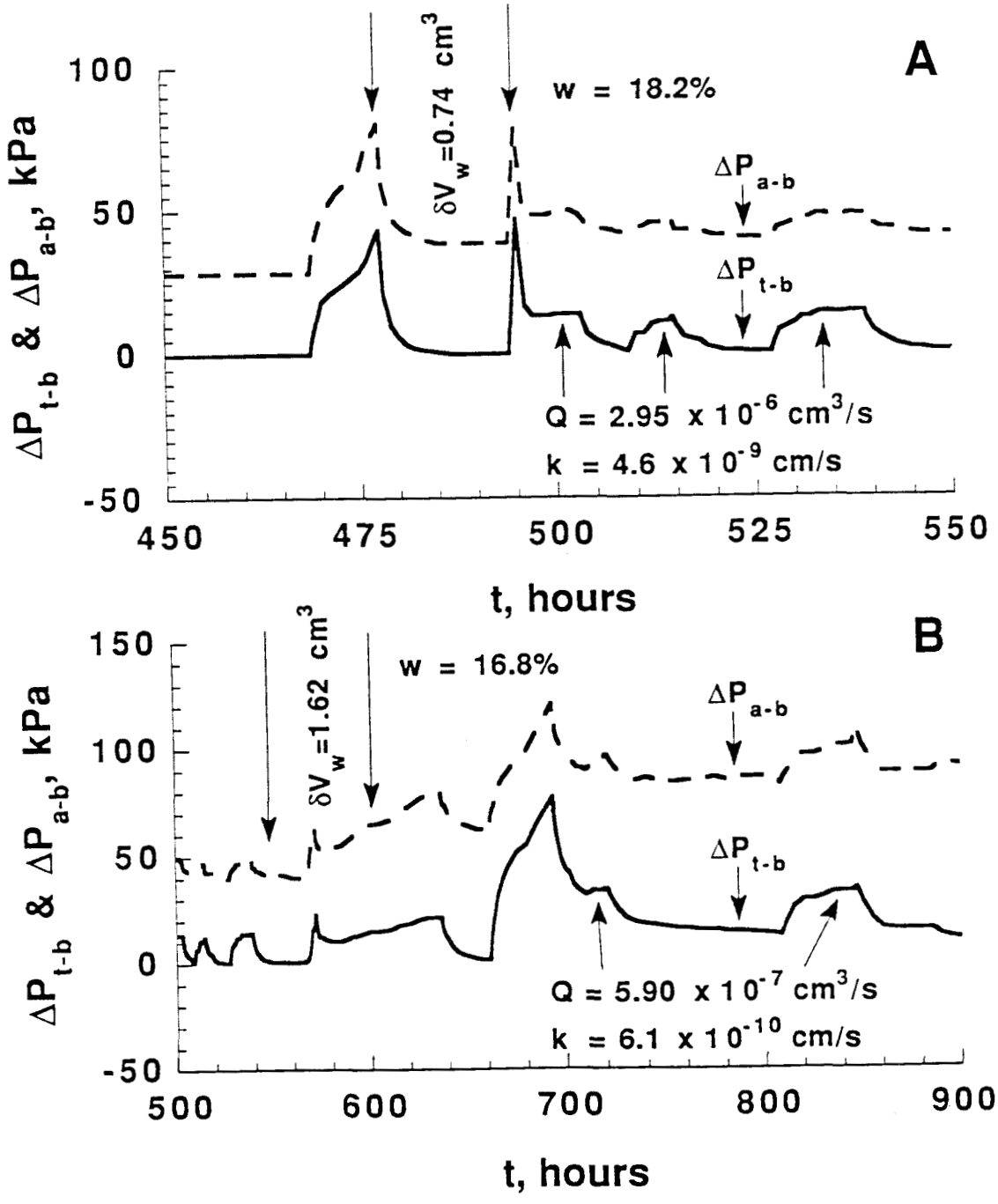

Figure 10. Data obtained during elapsed time (t) from 450 to 900 hours for a specimen in the triaxial system illustrated in figure 7. ΔP_{a-b} is difference between pore-air pressure at top of specimen and water pressure below the porous stone in the base pedestal. ΔP_{t-b} is difference between water pressures above and below the porous stones in the top cap and the base pedestal.

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Figure 8A shows the first 300 hours when the pore-air pressure was maintained at atmospheric pressure. About halfway through this period, the water content of the specimen (in % of dry soil weight) was reduced from 22.4% to 20.0% by extracting 2.69 cm^3 of pore water from the specimen. Before and after this change in water content, hydraulic-conductivity measurements was conducted by generating a flow rate of 1.48×10^{-5} cm^3/s through the specimen with a single-carriage flow pump equipped with an infuse-withdraw actuator. The hydraulic-conductivity values shown were calculated from the magnitudes of ΔP_{t-b} induced by the externally imposed flow rate. Recall that the induced values of ΔP_{t-b} include resistance to flow through both the specimen and the ceramic discs. The hydraulic conductivity did not change appreciably after reducing the water content, probably because the magnitude of ΔP_{t-b} was dominated by resistance to flow through the ceramic discs. Low hydraulic conductivity of the ceramic discs is further reflected in the induced response of ΔP_{a-b} that parallels the induced ΔP_{t-b} during the hydraulic-conductivity measurements. However, the matric potential, P_m, which equals ΔP_{a-b} when there is no flow through the specimen, increased from nearly zero to about 6 kPa after reducing the water content from 22.4% to 20.0%. Finally, note that the response times for these hydraulic conductivity measurements are on the order of 20-30 hours.

Figure 8B shows the period from 300 to 345 hours when the pore-air pressure was elevated, first to 52 kPa (7.5 psi), and second, to 518 kPa (75 psi). During the first step, ΔP_{a-b} shows the increase in pore air pressure generated a pressure difference across the lower ceramic disc that dissipated at a decreasing rate over a period of about 10 hours. Similarly, ΔP_{a-b} shows the increase in pore air pressure generated a transient difference between the fluid pressure below the lower ceramic disc and the fluid pressure above the upper ceramic disc that dissipated in about 20 hours. These transient responses were avoided in the second step by elevating the pore-air pressure and the water pressures above and below the porous stones simultaneously. The data show the matric potential, P_m, which equals ΔP_{a-b} when there is no flow through the specimen, was increased from about 6 kPa to about 16 kPa during the first step, and from about 16 kPa to about 18 kPa psi during the second step.

Figure 9A shows the period from 345 to 375 hours when three-hydraulic conductivity measurements were obtained while the pore-air pressure and the water content were maintained constant at 518 kPa and 20.0%, respectively. Note that the matric potential remained constant at 18 kPa during this time interval, and further note that this 30-hour time interval is one-tenth of the 300-hour time interval in figure 8A. The increase in pore-air pressure from 0 to 518 kPa decreased the response time for hydraulic-conductivity measurements from more than 20 hours to less than 1 hour. This change in response time is not accompanied by a significant change in the hydraulic conductivity.

Figure 9B shows the period from 350 to 450 hours. The first part of this period includes the three hydraulic-conductivity tests in figure 9A, at a substantially condensed time scale. Thereafter, 1.38 cm^3 of porewater were extracted which decreased the water content from 20.0% to 18.8%, increased the matric potential from about 18 kPa to about 30 kPa, and reduced the hydraulic-conductivity from 2.0×10^{-8} to 1.03×10^{-8} cm/s.

Figure 10A shows the period from 450 to 550 hours where the water content was decreased to 18.2%, which increased the matric potential to about 40 kPa and reduced the hydraulic conductivity to 1.03×10^{-9} cm/s.

Figure 10B shows the period from 500 to 900 hours where the decrease in the water content to 16.8% increased the matric potential to about 90 kPa, and reduced the hydraulic conductivity to 5.19 x 10^{-10} cm/s. Comparison of the response times for hydraulic-conductivity measurements in figure 9 and 10 show they increased substantially with decreasing hydraulic conductivity.

One complication in the behavior of ΔP_{t-b} first arose in figure 9B, and became more pronounced in figures 10A and 10B. In figure 9B during the hydraulic conductivity test between 395 and 410 hours, ΔP_{t-b} continued creeping upward rather than reaching a constant steady-state value. In figure 10A during the hydraulic conductivity tests between 490 and 505 hours, ΔP_{t-b} initially climbed at a rate that did not decrease with time towards a constant steady state; however, a steady state was reached by reducing the externally imposed flow rate by a factor of 3, from 14.8 to 2.95 x 10^{-6} cm^3/s. This behavior occurs again in figure 10B during the hydraulic conductivity test between 630 and 720 hours. ΔP_{t-b} initially climbed at a rate that did not decrease with time towards a constant steady state; however, an approximate steady state was reached by reducing the externally imposed flow rate by a factor of 5, from 2.95 x 10^{-6} to 5.90 x 10^{-7} cm^3/s. A second complication in the behavior of ΔP_{t-b} first appears in figure 10B, following the hydraulic-conductivity test between 630 and 720 hours and again following the test between 810 and 860 hours. ΔP_{t-b} does not return to zero after terminating the externally imposed flow rate. A pressure difference on the order of 10 kPa persists across the specimen.

Figure 11 summarizes the variations of hydraulic conductivity and matric potential that were obtained concurrently at successively lower water contents. The nearly constant hydraulic conductivity for water contents above 20%% probably reflects the upper limit controlled by the hydraulic conductivity of the 5-bar ceramic discs.

Figure 12 shows, in the upper plot, the interrelationship between the hydraulic conductivity and matric potential values in figure 11. The lower plot in this figure shows how the response time (RT) varies with pore-air pressure and decreasing magnitudes of the hydraulic conductivity. Note that the variation of response time with hydraulic conductivity, for elevated pore-air pressures at 518 kPa, are comparable to the response times for hydraulic-conductivity measurements in saturated specimens that were summarized at the end of the previous section of the paper concerning saturated specimens under isotropic deformation.

DISCUSSION

Our experience in this and previous studies (Olsen et al 1985, 1988, 1991) shows response times for constant-flow hydraulic-conductivity (k) measurements in triaxial systems to be on the order of: (a) a few minutes or less for materials with k values greater than 10^{-6} cm/s, (b) a few hours for materials with k values in the range of 10^{-8} to 10^{-9} cm/s; and (c) a few days for materials with extremely low k values, in the range of 10^{-10} to 10^{-11} cm/s. In contrast, Benson and Daniel (1990) report the following time intervals for falling-head hydraulic-conductivity tests in rigid-wall and flexible-wall permeameters: "Tests on soil with $k > 10^{-7}$ cm/s typically lasted for about 2 weeks; soils with $k < 10^{-7}$ cm/s were permeated for several months." This comparison illustrates the previously reported

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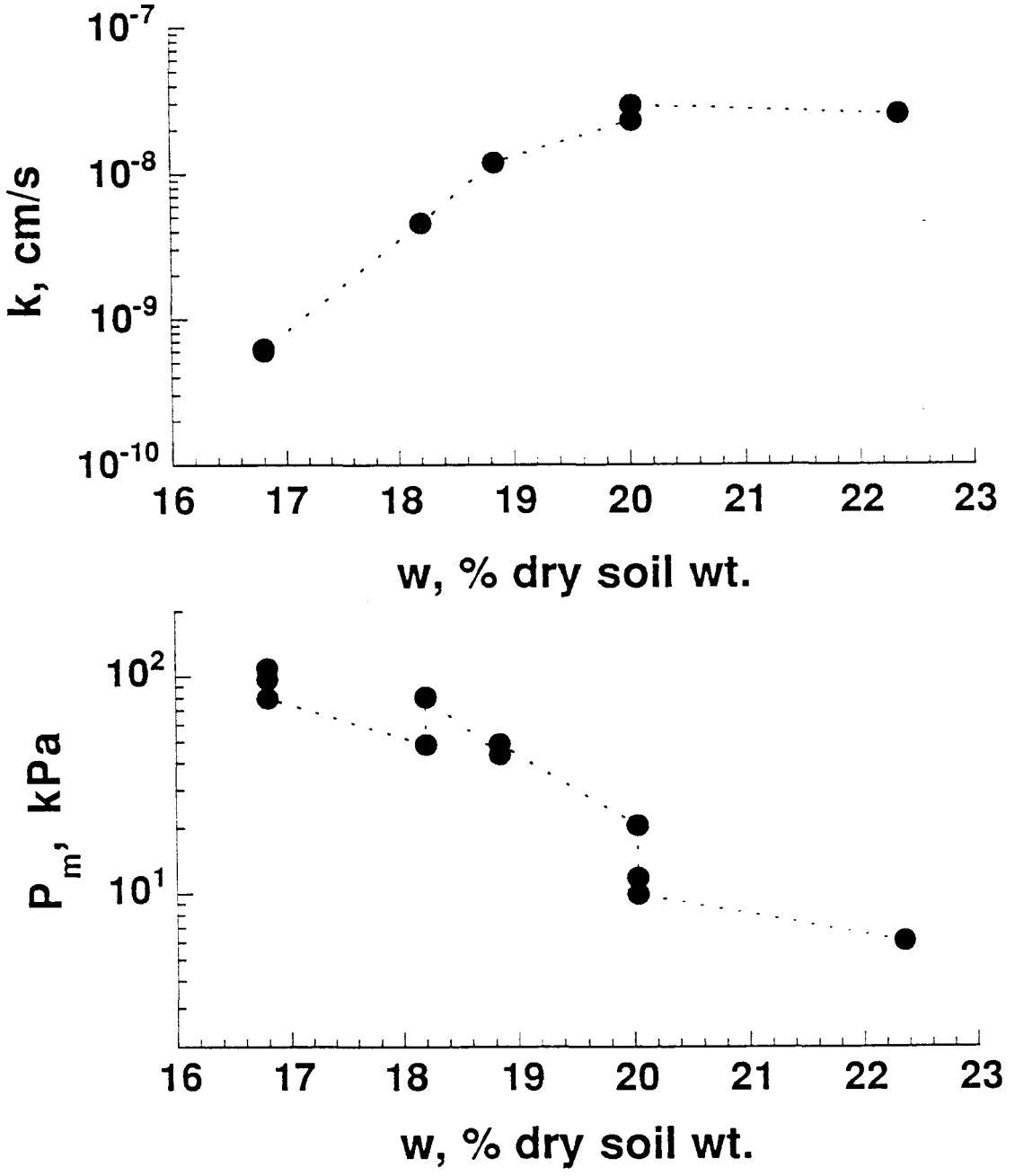

Figure 11. Water content (w) in percent of dry soil weight versus hydraulic conductivity (k) [upper plot] and matric potential (P_m) [lower plot].

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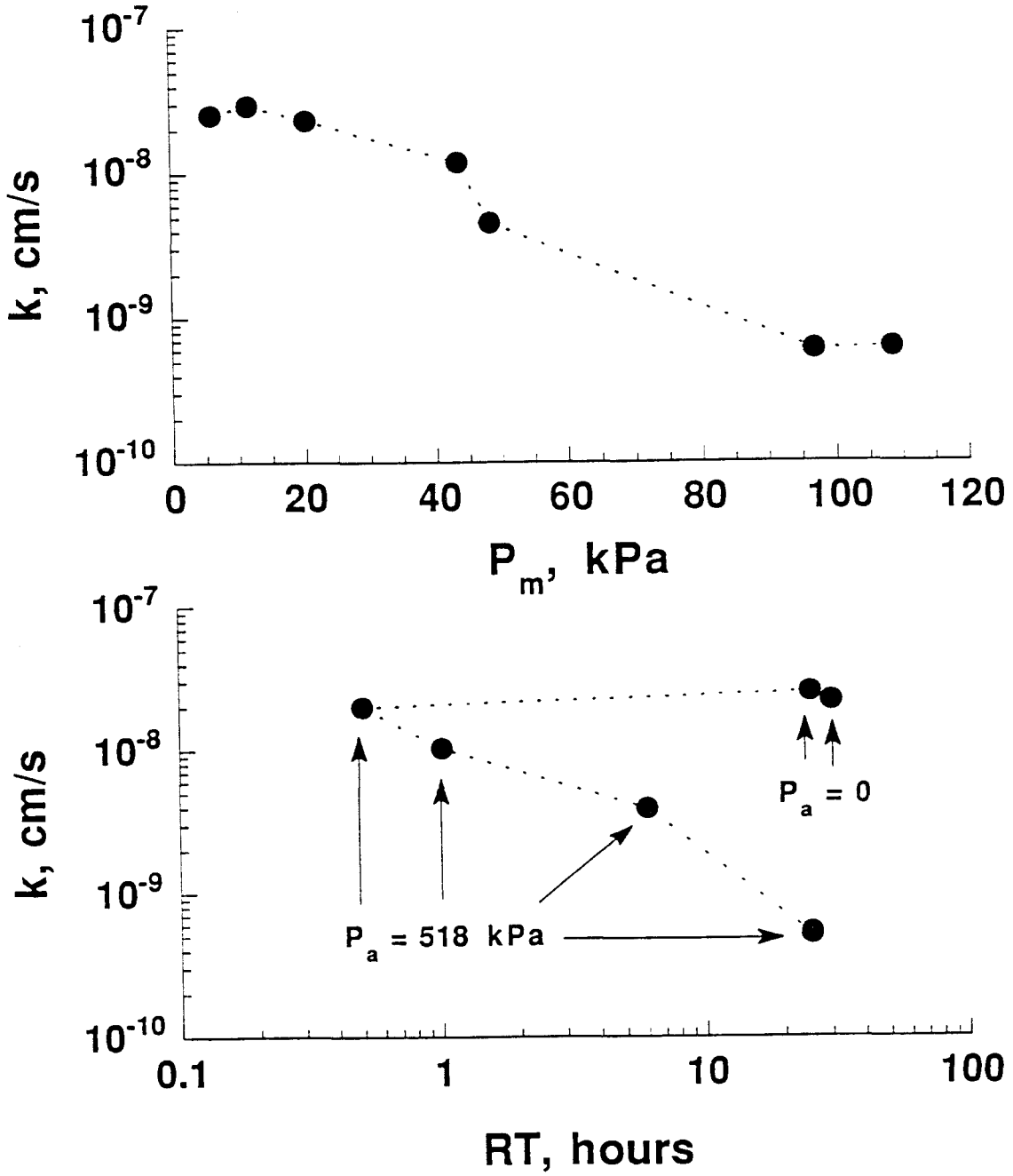

Figure 12 Hydraulic conductivity (k) versus matric potential (P_m) [upper plot] and response time (RT) [lower plot].

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fundamental advantage of the constant-flow method, compared with conventional constant-head and falling-head methods; namely, that hydraulic conductivity measurements can be obtained much more rapidly and at substantially smaller hydraulic gradients.

The development of the triaxial system in figure 4 for saturated specimens under one-dimensional deformation was preceded by a previously described system for superimposed constant-flow hydraulic-conductivity and CRD-deformation measurements in an Anteus backpressured one-dimensional consolidometer (Gill, Olsen, and Nelson 1991; Olsen et al. 1991). One advantage of the triaxial system is that it provides continuous data on the horizontal effective stress, which is unknown in conventional one-dimensional consolidometers. Another advantage is that many earth materials can be tested in triaxial systems that cannot be properly trimmed for mounting in one-dimensional consolidometers. These materials include rigid and very stiff materials like sandstones and shales. They also include gravelly materials which cannot be trimmed to the exact and uniform diameter needed to avoid sidewall leakage in one-dimensional consolidometers.

The data obtained with the triaxial system in figure 4 illustrate the infuse-withdraw actuator is a useful tool, not only for hydraulic-conductivity measurements, but also for strain-path control in triaxial systems. In this study, strain-path control is limited to the special case of one-dimensional deformation, commonly referred to as K_0 consolidation or rebound, wherein the volumetric and axial deformation rates in the specimen are maintained equal. By adding an additional flow pump for infusing or withdrawing hydraulic fluid to or from the hydraulic loading chamber, the system would be capable of controlling arbitrary combinations of vertical and volumetric deformation rates for a wide range of strain paths during either consolidation or shear phases of a triaxial test.

This volumetric approach to strain-path control in triaxial systems is attractive in that it avoids the need for instrumentation to monitor radial deformations and to counteract these deformations with feedback-induced chamber-pressure adjustments. However, the evidence presented in this paper suggests some deviations occured from the requirement of zero radial strain for one-dimensional consolidation and rebound. It remains to be determined whether, and under what conditions, these deviations can be considered negligible for practice and research, and also whether these deviations can be minimized with a more rigid triaxial cell. Nevertheless, the radial strain is small compared with the vertical strain, and therefore the system in figure 4 provides a very substantial improvement over conventional triaxial systems that allow only isotropic consolidation and rebound for simulating insitu stress conditions.

The data obtained with the triaxial system in figure 7 demonstrates the feasibility of concurrent constant-flow hydraulic-conductivity and matric-potential measurements, and the variation of these properties with the degree of saturation, for specimens of undisturbed and unsaturated soils mounted in triaxial cells. However, the data show there are limitations to the applicability of this approach when hydraulic-conductivity values become extremely low, on the order of 10^{-10} cm/s. Also the system described has limitations when the hydraulic conductivity of a specimen exceeds that of the porous stones above and below the specimen. Steps we are pursuing to minimize these limitations include: (a) adding the capability of measuring the water pressure difference across the specimen at the interfaces between the specimen surfaces and the high-air-entry porous stones, (b) adding the capability of measuring air permeability on either the same specimen or

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a replicate specimen, and (c) developing a more rigid triaxial cell that allows volume control of the specimen by infusing or withdrawing liquid to or from the triaxial cell chamber.

CONCLUSIONS

New capabilities for hydrologic property measurements in triaxial systems include: (1) volume-controlled and simultaneous measurements of hydraulic conductivity and one-dimensional specific storage of a saturated test specimen; and (2) volume-controlled measurements of hydraulic conductivity, capillary pressure, and the variation of these properties with the moisture content of an unsaturated test specimen.

For a saturated specimen, a dual-carriage flow pump consolidates the specimen one-dimensionally at a constant rate of deformation while a single-carriage flow pump periodically generates a constant flow rate through the specimen. The dual-carriage flow pump is equipped with two "infuse-withdraw" actuators that simultaneously extract pore water from opposite ends of the specimen and infuse identical quantities of water into a hydraulic piston that deforms the sample vertically. One-dimensional consolidation is achieved by synchronizing the rate of pore water extraction with the rate of vertical deformation such that the average diameter of the specimen remains constant. The single-carriage flow pump, equipped with one "infuse-withdraw" actuator, generates a constant flow rate through the specimen by infusing and withdrawing identical flow rates at opposite ends of the specimen. Vertical and horizontal effective stresses, and also the pore-water pressure difference across the specimen, are continuously monitored with differential pressure transducers.

For an unsaturated specimen, constant flow rates for hydraulic-conductivity measurements are generated by infusing and withdrawing identical flow rates at opposite ends of the specimen with a flow pump equipped with a "infuse-withdraw" actuator. The top cap and pedestal have 5-bar high-air-entry ceramic discs through which water is transmitted to or from the specimen. The upper disc has a center hole, and is sealed with O-rings in a doughnut-shaped cavity in the top cap. A hole through the center of the top cap allows pore-air pressure in the specimen to be controlled by an external pressure regulator. The water content of the specimen is varied by using a second flow pump to infuse or withdraw water at the base of the specimen. Insitu stresses on the specimen are simulated using a differential pressure regulator to maintain a constant pressure difference between the chamber pressure and the pore-air pressure. Three differential pressure transducers continuously monitor: (1) the difference between the pore-water pressures above and below the ceramic discs in the top cap and base pedestal; (2) the difference between the pore-air pressure at the top of the specimen, and the water pressure below the ceramic disc in the base pedestal; and (3) the difference between the chamber pressure and the water pressure below the ceramic disc in the base pedestal.

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Appendix C-2

CSM Geotechnical Laboratory Results

TABLE C-1

Soil- Moisture Laboratory Data for Hydroprobe Calibration
Colorado School of Mines Data

Sample Number	Borehole Number	Sample Interval (ft below grd. surf.)	Sample Length (cm)	Can Number	Can Weight (g)	can weight + wet soil (g)	can weight + dry soil (g)	Volume Water (cm^3)	Sample Volume (cm^3)	Moisture Content (% volume)	Moisture Content (% dry soil wt.)	Sample Weight (g)	Dry Bulk Density (g/cm^3)	Porosity (%)
Test	02793	14.4-14.9	1.04	21	33.87	71.61	63.71	7.9	19.58	40.34	26.47	29.84	1.52	42.5
1-1	02393	2.0-4.0	disturbed	69	15.72	35.52	33.46	2.06			11.61	17.74		
1-2	02293	2.9-3.4	1.95	22	34.15	98.82	95.17	3.65	36.58	9.98	5.98	61.02	1.67	37.05
1-3	02393	3.9-4.4	1.94	23	31.7	101.21	96.21	5	36.46	13.71	7.75	64.51	1.77	33.24
1-4	"	5.4-5.9	1.88	24	33.88	104.54	101.19	3.35	35.3	9.49	4.98	67.31	1.91	28.05
1-5	"	9.4-9.9	1.21	30	34.6	78.68	74.18	4.6	22.72	19.81	11.37	39.58	1.74	34.26
1-6	02493	4.9-5.4	2.00	31	34.74	103.69	99.17	4.52	37.55	12.04	7.02	64.43	1.72	35.26
1-7	"	5.9-6.4	1.60	33	35.01	89.7	87.88	1.81	30.04	6.02	3.42	52.88	1.76	33.58
1-8	"	8.9-9.4	1.75	35	34.86	99.1	90.59	8.51	32.77	25.97	15.27	55.72	1.7	35.82
2-1	02993	1.0-1.5	2.00	36	34.08	92.8	81.09	11.71	37.55	31.18	24.91	47.01	1.25	52.76
2-2	"	4.5-4.9	1.82	38	34.05	102.95	95.32	7.63	34.17	22.33	12.45	61.27	1.79	32.34
2-3	"	11.4-11.9	1.85	42	34.16	102.18	99.5	2.68	34.74	7.72	4.1	65.34	1.88	29.02
2-4	"	13.4-13.9	2.00	82	31.92	109.83	100.47	9.36	37.55	24.92	13.65	68.55	1.83	31.12
2-5	"	14.4-14.9	1.92	83	32.13	108.03	98.25	9.78	36.05	27.13	14.79	66.12	1.83	30.79
2-6	"	16.5-17.0	1.92	89	37.23	98.46	86.91	11.55	36.05	32.04	23.25	49.68	1.38	48
2-7	"	18.4-18.9	1.85	84	32.02	95.02	82.9	12.12	34.77	34.85	23.82	50.88	1.46	44.79
2-8	"	21.6-22.1	1.84	86	32.05	98.88	na	na						
2-9	"	22.9-23.4	1.90	38	37.38	104.71	93.34	11.37	35.68	31.87	20.32	55.96	1.57	40.81
2-10	"	7.9-9.9	disturbed	8	15.91	44.97	43.35	1.62			5.9	27.44		
2-11	"	19.4-21.5	disturbed	72	15.9	50.65	45.48	5.17			17.48	29.58		

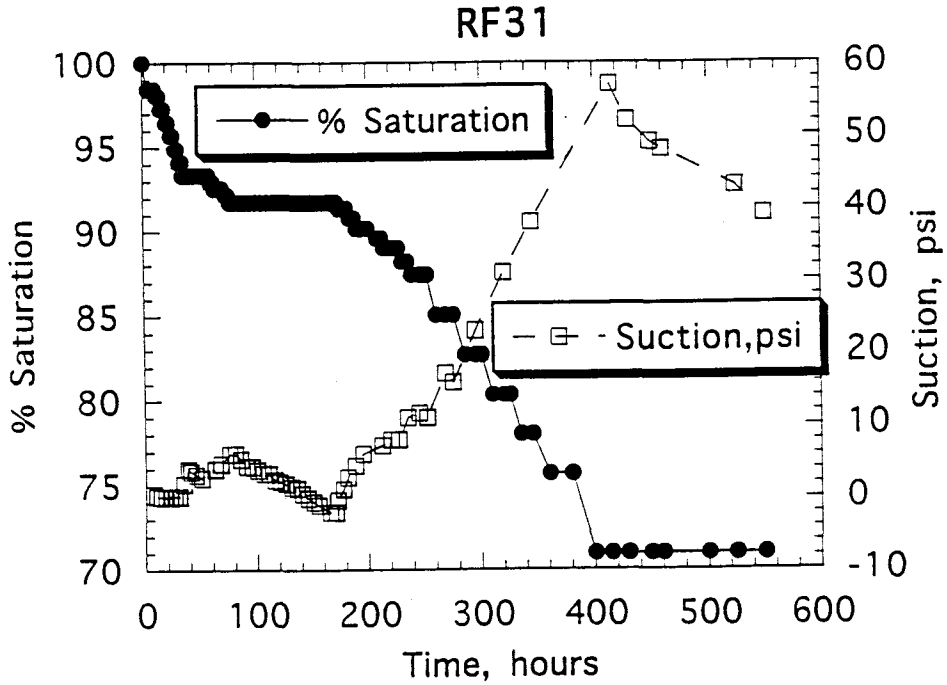
SAMPLE NUMBER	RF-31	RF1-2
INITIAL SAMPLE		
Wt. Sample + Tube (g)	243.72	
Wt. Tube (g)	58.06	
Wt. Sample-calculated (g)	185.66	
Wt. Sample-direct meas. (g)	185.03	
Tube diameter (in)	1.925	1.9250
Tube length (in)	2.05	1.7350
Tube diameter (cm)	4.8895	4.8895
Tube area (sq cm)	18.7767229	18.7767
Tube length (cm)	5.207	4.4069
Tube volume (cc)	97.7703963	82.7471
Initial w (% dry soil weight)	26.47%	0.0598
Dry sample weight (g)	146.303471	138.0367
Specific gravity (assumed)	2.65	2.6500
Dry sample volume (cc)	55.208857	52.0893
Void volume (cc)	42.5615392	30.6578
Porosity	0.43532133	0.3705
Saturated w (% dry soil weight)	0.77091868	0.5886
SAT K TEST		
Syringe	1"x3/8"	1"x3/8"
Gear	12	9
Q (cc/s)	9.2316E-05	9.2316E-04
Delta P (psi)	3.66	0.1650
INITIAL K MEASUREMENT		
L (cm)	5.1816	4.4069
A (sq cm)	18.8352934	18.7767
L/A (1/cm)	0.27510057	0.23470017
delta h (cm H20)	257.4444	11.6061
k = (L/A)(Q/delta-h) (cm/s)	9.8647E-08	1.8668E-05
AFTER SAT K TEST		
Approx. length (in)	2.04	
Approx Diameter (in)	1.928	

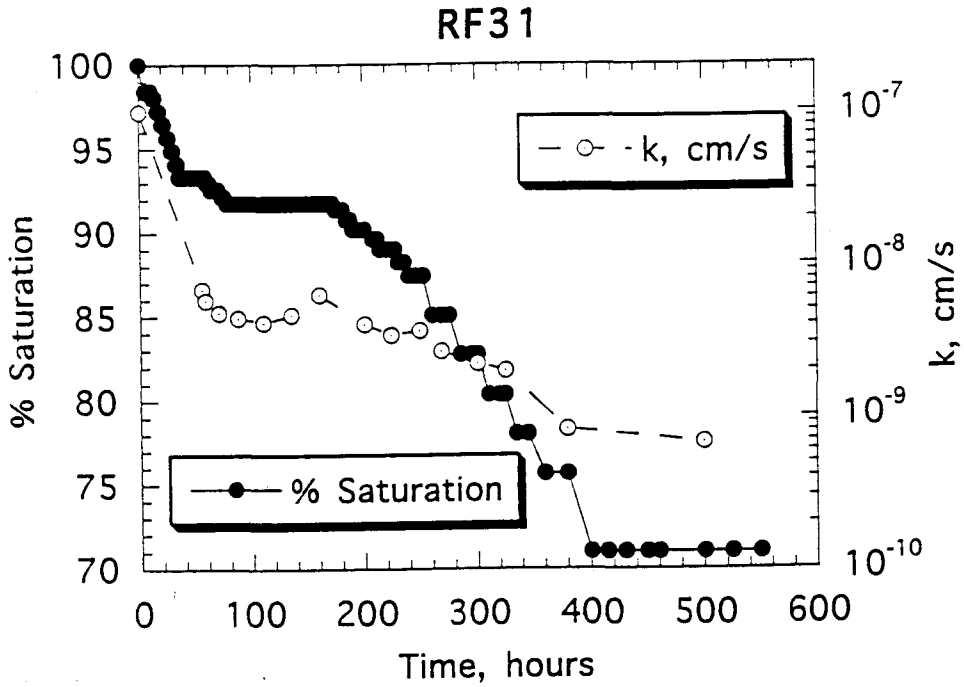
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ROCKY FLATS SAMPLES			WATER CONTENTS									
2													
3	Sample Number	Sample length	Can number	Can weight	Weight can	Weight can	Volume Water	Sample	Moisture	Moisture	Sample Weight	Dry Bulk	Porosity *
4		cm			plus wet soil	plus dry soil	(cm^3)	Volume	Content	Content	(g)	Density	(%)
5				grams	grams	grams		(cm^3)	(% volume)	(% dry soil wt)		(g/cc)	
6													
7	31	1.04	21	33.87	71.61	63.71	7.90	19.58	40.34%	26.47%	29.84	1.52	42.50%
8	B1-S1	disturbed	69	15.72	35.52	33.46	2.06			11.61%	17.74		
9	B1-S2	1.95	22	34.15	98.82	95.17	3.65	36.58	9.98%	5.98%	61.02	1.67	37.05%
10	B1-S3	1.94	23	31.70	101.21	96.21	5.00	36.46	13.71%	7.75%	64.51	1.77	33.24%
11	B1-S4	1.88	24	33.88	104.54	101.19	3.35	35.30	9.49%	4.98%	67.31	1.91	28.05%
12	B1-S5	1.21	30	34.60	78.68	74.18	4.50	22.72	19.81%	11.37%	39.58	1.74	34.26%
13	B1-S6	2.00	31	34.74	103.69	99.17	4.52	37.55	12.04%	7.02%	64.43	1.72	35.26%
14	B1-S7	1.60	33	35.01	89.70	87.89	1.81	30.04	6.02%	3.42%	52.88	1.76	33.58%
15	B1-S8	1.75	35	34.86	99.10	90.59	8.51	32.77	25.97%	15.27%	55.73	1.70	35.82%
16	B2-S1	2.00	36	34.08	92.80	81.09	11.71	37.55	31.18%	24.91%	47.01	1.25	52.76%
17	B2-S2	1.82	38	34.05	102.95	95.32	7.63	34.17	22.33%	12.45%	61.27	1.79	32.34%
18	B2-S3	1.85	42	34.16	102.18	99.5	2.68	34.74	7.72%	4.10%	65.34	1.88	29.02%
19	B2-S4	2.00	82	31.92	109.83	100.47	9.36	37.55	24.92%	13.65%	68.55	1.83	31.12%
20	B2-S5	1.92	83	32.13	108.03	98.25	9.78	36.05	27.13%	14.79%	66.12	1.83	30.79%
21	B2-S6	1.92	89	37.23	98.46	86.91	11.55	36.05	32.04%	23.25%	49.68	1.38	48.00%
22	B2-S7	1.85	84	32.02	95.02	82.9	12.12	34.77	34.85%	23.82%	50.88	1.46	44.79%
23	B2-S8	1.84	86	32.05	98.88	na	na						
24	B2-S9	1.90	88	37.38	104.71	93.34	11.37	35.68	31.87%	20.32%	55.96	1.57	40.81%
25	B2-S10	disturbed	8	15.91	44.97	43.35	1.62			5.90%	27.44		
26	B2-S11	disturbed	72	15.90	50.65	45.48	5.17			17.48%	29.58		
27													
28													
29													
30	*: based on particle specific gravity of 2.65 g/cc												

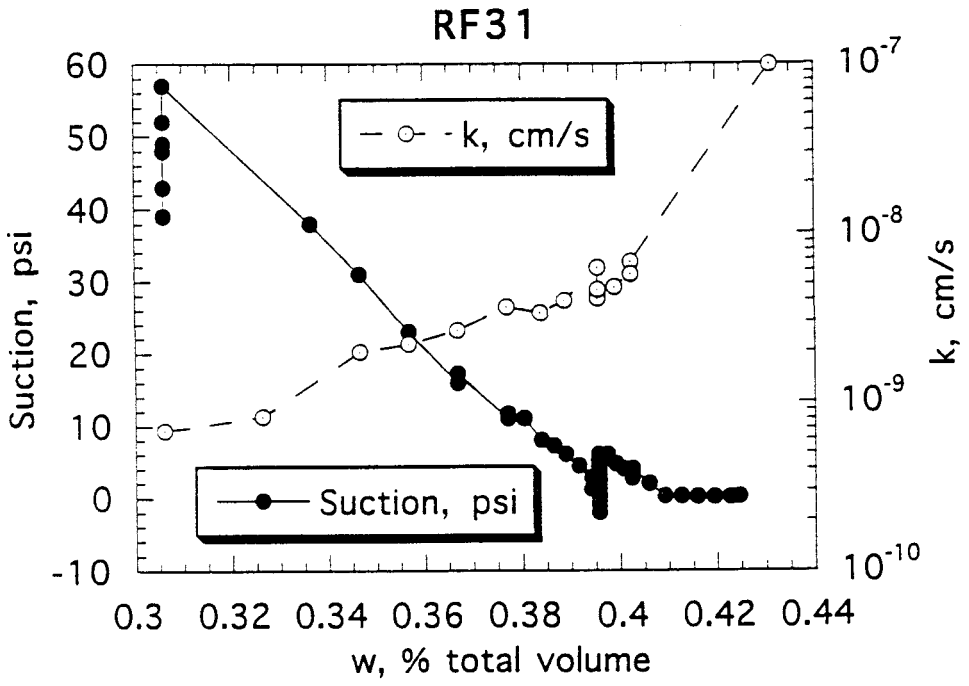
Sample RF31

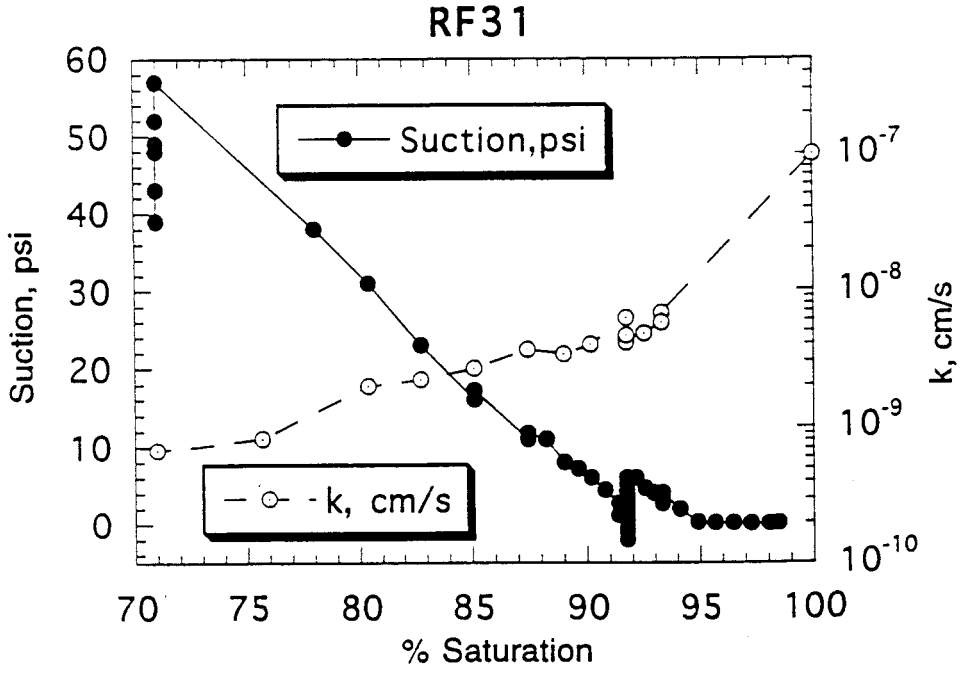
Elapsed Time hours	Cumulative extracted volume (cc)	w, % dry soil wt Ww/Ws (decimal)	w % total volume	Degree of Saturation x 100	Capillary Pressure PSI	k = (L/A)/(Q/delta h) (cm/s)
0		0.2860	0.4311	100.00		9.86E-08
5	0.6647	0.2815	0.4244	98.43		
10	0.6647	0.2815	0.4244	98.43	0.2	
12	0.8308	0.2804	0.4227	98.04		
14	0.8308	0.2804	0.4227	98.04	0.1	
16	1.1632	0.2781	0.4193	97.25		
18	1.1632	0.2781	0.4193	97.25	0.1	
20	1.4955	0.2759	0.4159	96.47		
22	1.4955	0.2759	0.4159	96.47	0.15	
24	1.8279	0.2736	0.4125	95.68		
26	1.8279	0.2736	0.4125	95.68	0.2	
28	2.1602	0.2714	0.4091	94.90		
30	2.1602	0.2714	0.4091	94.90	0.25	
32	2.4925	0.2692	0.4058	94.11		
34	2.4925	0.2692	0.4058	94.11	1.9	
35	2.8249	0.2669	0.4024	93.33		
38	2.8249	0.2669	0.4024	93.33	4	
40	2.8249	0.2669	0.4024	93.33	3.6	
45	2.8249	0.2669	0.4024	93.33	3.2	
50	2.8249	0.2669	0.4024	93.33	2.7	
55	2.8249	0.2669	0.4024	93.33		6.75E-09
58	2.8249	0.2669	0.4024	93.33		5.73E-09
59	2.9910	0.2658	0.4007	92.94		
62	2.9910	0.2658	0.4007	92.94	4	
63	3.1572	0.2647	0.3990	92.55		
67	3.1572	0.2647	0.3990	92.55	4.7	
70	3.1572	0.2647	0.3990	92.55		4.78E-09
73	3.3234	0.2635	0.3973	92.15		
75	3.3234	0.2635	0.3973	92.15	6	
77	3.4895	0.2624	0.3956	91.76		
80	3.4895	0.2624	0.3956	91.76	6	
85	3.4895	0.2624	0.3956	91.76	5.3	
87	3.4895	0.2624	0.3956	91.76		4.41E-09
90	3.4895	0.2624	0.3956	91.76	4.3	
95	3.4895	0.2624	0.3956	91.76	4.2	
100	3.4895	0.2624	0.3956	91.76	3.8	
105	3.4895	0.2624	0.3956	91.76	3.4	
110	3.4895	0.2624	0.3956	91.76	3.3	4.10E-09
115	3.4895	0.2624	0.3956	91.76	2.5	
120	3.4895	0.2624	0.3956	91.76	2.2	
125	3.4895	0.2624	0.3956	91.76	1.9	
130	3.4895	0.2624	0.3956	91.76	1.5	
135	3.4895	0.2624	0.3956	91.76	1.3	4.62E-09
140	3.4895	0.2624	0.3956	91.76	0.6	
145	3.4895	0.2624	0.3956	91.76	0	

150	3.4895	0.2624	0.3956	91.76	-0.6	
155	3.4895	0.2624	0.3956	91.76	-1	
160	3.4895	0.2624	0.3956	91.76		6.23E-09
165	3.4895	0.2624	0.3956	91.76	-2	
170	3.4895	0.2624	0.3956	91.76	-2	
172	3.4895	0.2624	0.3956	91.76	-0.3	
174	3.6557	0.2613	0.3939	91.37		
177	3.6557	0.2613	0.3939	91.37	1.2	
181	3.6557	0.2613	0.3939	91.37	2.8	
184	3.9050	0.2596	0.3914	90.78		
188	3.9050	0.2596	0.3914	90.78	4.4	
190	4.1542	0.2579	0.3888	90.19		
195	4.1542	0.2579	0.3888	90.19	6	
200	4.1542	0.2579	0.3888	90.19		3.98E-09
208	4.4035	0.2562	0.3863	89.60		
212	4.4035	0.2562	0.3863	89.60	7.2	
214	4.6527	0.2546	0.3838	89.01		
220	4.6527	0.2546	0.3838	89.01	8	
224	4.6527	0.2546	0.3838	89.01		3.37E-09
227	4.6527	0.2546	0.3838	89.01	8	
230	4.9851	0.2523	0.3804	88.23		
235	4.9851	0.2523	0.3804	88.23	11	
239	5.3174	0.2501	0.3770	87.44		
245	5.3174	0.2501	0.3770	87.44	11.7	
249	5.3174	0.2501	0.3770	87.44		3.63E-09
252	5.3174	0.2501	0.3770	87.44	11	
260	6.3144	0.2433	0.3668	85.09		
268	6.3144	0.2433	0.3668	85.09	17.2	2.65E-09
275	6.3144	0.2433	0.3668	85.09	16	
285	7.3114	0.2366	0.3567	82.74		
295	7.3114	0.2366	0.3567	82.74	23	
300	7.3114	0.2366	0.3567	82.74		2.21E-09
310	8.3084	0.2299	0.3465	80.38		
320	8.3084	0.2299	0.3465	80.38	31	
325	8.3084	0.2299	0.3465	80.38		1.98E-09
335	9.3055	0.2231	0.3364	78.03		
345	9.3055	0.2231	0.3364	78.03	38	
360	10.3025	0.2164	0.3262	75.67		
380	10.3025	0.2164	0.3262	75.67		8.19E-10
400	12.2965	0.2029	0.3060	70.97		
415	12.2965	0.2029	0.3060	70.97	57	
430	12.2965	0.2029	0.3060	70.97	52	
450	12.2965	0.2029	0.3060	70.97	49	
460	12.2965	0.2029	0.3060	70.97	48	
500	12.2965	0.2029	0.3060	70.97		6.75E-10
525	12.2965	0.2029	0.3060	70.97	43	
550	12.2965	0.2029	0.3060	70.97	39	


RF31
% Saturation
Suction,psi
% Saturation
Suction, psi
Time, hours
100
95
90
85
80
75
70
60
50
40
30
20
10
0
-10
0
100
200
300
400
500
600


RF31
k, cm/s
% Saturation
% Saturation
k, cm/s
Time, hours
100
95
90
85
80
75
70
10^{-7}
10^{-8}
10^{-9}
10^{-10}
0
100
200
300
400
500
600

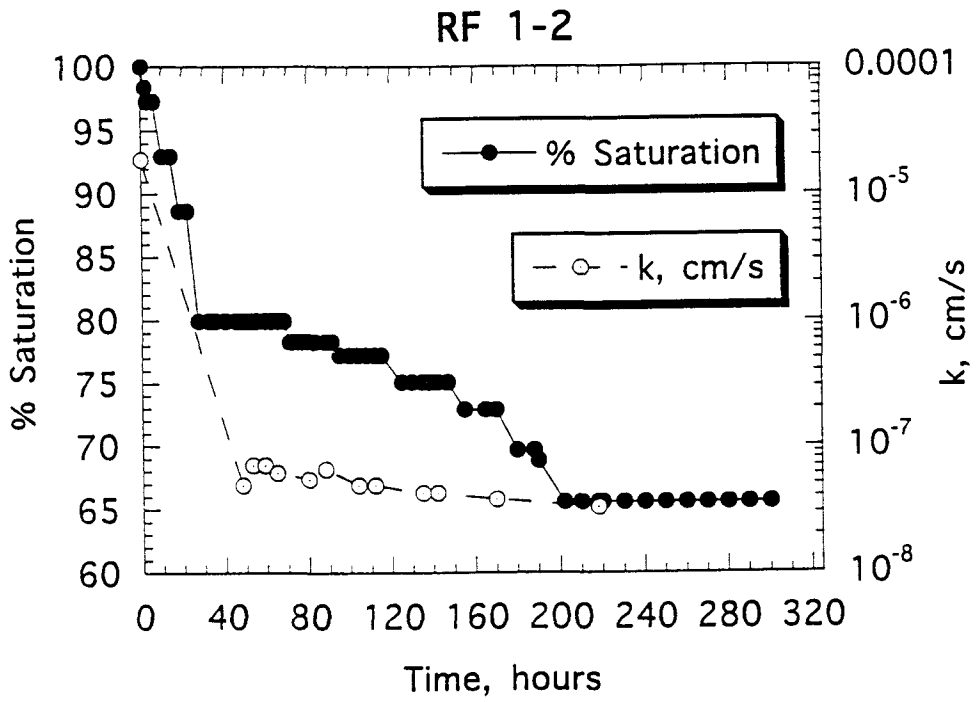

RF31
k, cm/s
Suction, psi
Suction, psi
k, cm/s
w, % total volume
60
50
40
30
20
10
0
-10
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
10^{-7}
10^{-8}
10^{-9}
10^{-10}

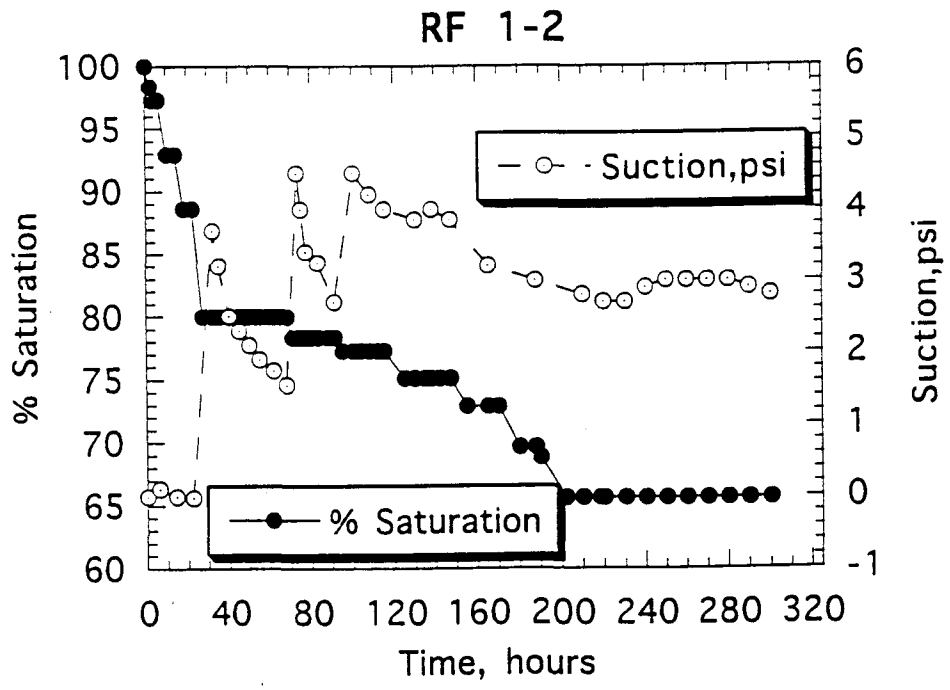

RF31
Suction,psi
k, cm/s
Suction, psi
k, cm/s
% Saturation
60
50
40
30
20
10
0
70
75
80
85
90
95
100
10^{-7}
10^{-8}
10^{-9}
10^{-10}

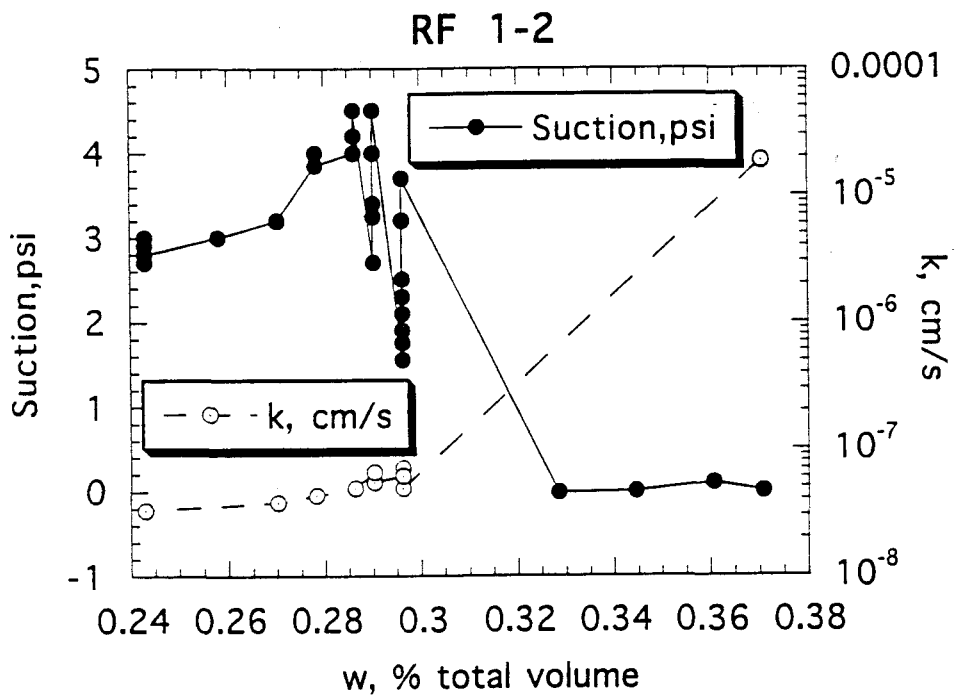
Sample RF 1-2

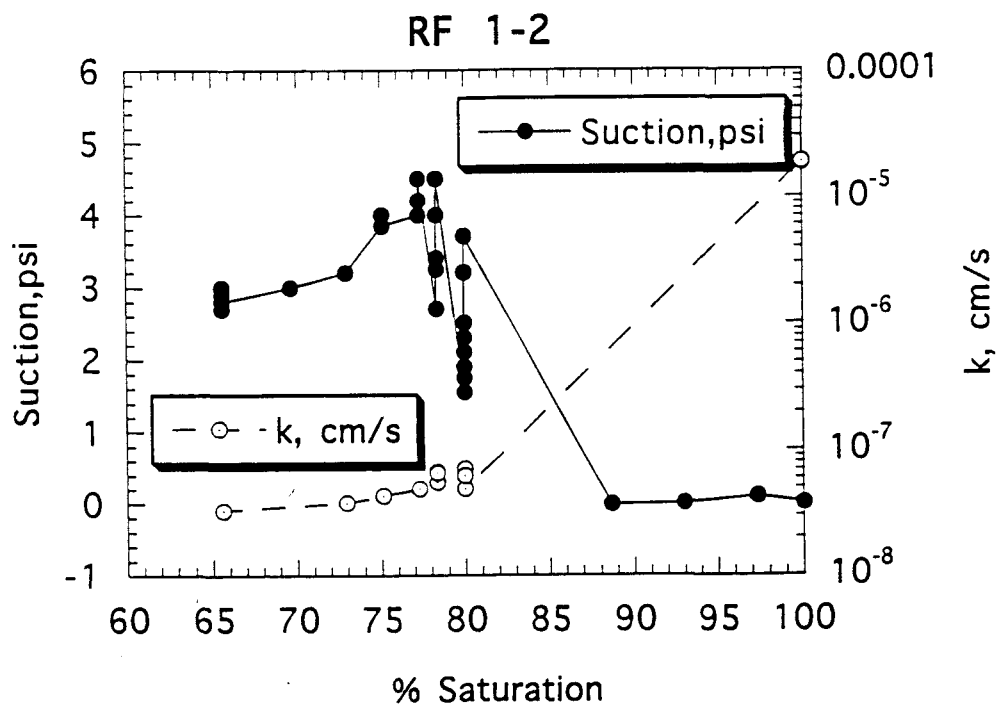
Elapsed Time hours	Cumulative extracted volume (cc)	w % dry soil wt x 100	w % total volume	Degree of Saturation x 100	Capillary Pressure PSI	k = (L/A)/(Q/delta h) (cm/s)
0	0.0000	22.2099	0.3705	100.00	0	1.87E-05
2	0.4985	21.8488	0.3645	98.37		
3	0.8308	21.6080	0.3605	97.29		
6	0.8308	21.6080	0.3605	97.29	0.1	
10	2.1602	20.6450	0.3444	92.95		
14	2.1602	20.6450	0.3444	92.95	0	
18	3.4895	19.6819	0.3283	88.62		
22	3.4895	19.6819	0.3283	88.62	-0.02	
27	6.1482	17.7558	0.2962	79.95		
32	6.1482	17.7558	0.2962	79.95	3.7	
35	6.1482	17.7558	0.2962	79.95	3.2	
40	6.1482	17.7558	0.2962	79.95	2.5	
45	6.1482	17.7558	0.2962	79.95	2.3	
48	6.1482	17.7558	0.2962	79.95		4.92E-08
50	6.1482	17.7558	0.2962	79.95	2.1	
53	6.1482	17.7558	0.2962	79.95		7.03E-08
55	6.1482	17.7558	0.2962	79.95	1.9	
59	6.1482	17.7558	0.2962	79.95		7.03E-08
62	6.1482	17.7558	0.2962	79.95	1.75	
65	6.1482	17.7558	0.2962	79.95		6.15E-08
68	6.1482	17.7558	0.2962	79.95	1.55	
71	6.6468	17.3947	0.2902	78.32		
73	6.6468	17.3947	0.2902	78.32	4.5	
75	6.6468	17.3947	0.2902	78.32	4	
77	6.6468	17.3947	0.2902	78.32	3.4	
80	6.6468	17.3947	0.2902	78.32		5.47E-08
83	6.6468	17.3947	0.2902	78.32	3.25	
88	6.6468	17.3947	0.2902	78.32		6.57E-08
91	6.6468	17.3947	0.2902	78.32	2.7	
95	6.9791	17.1539	0.2862	77.24		
100	6.9791	17.1539	0.2862	77.24	4.5	
104	6.9791	17.1539	0.2862	77.24		4.92E-08
108	6.9791	17.1539	0.2862	77.24	4.2	
112	6.9791	17.1539	0.2862	77.24		4.92E-08
115	6.9791	17.1539	0.2862	77.24	4	
125	7.6438	16.6724	0.2781	75.07		
130	7.6438	16.6724	0.2781	75.07	3.85	
135	7.6438	16.6724	0.2781	75.07		4.28E-08
138	7.6438	16.6724	0.2781	75.07	4	
142	7.6438	16.6724	0.2781	75.07		4.28E-08
147	7.6438	16.6724	0.2781	75.07	3.85	
155	8.3084	16.1909	0.2701	72.90		
165	8.3084	16.1909	0.2701	72.90	3.2	
170	8.3084	16.1909	0.2701	72.90		3.79E-08
180	9.3055	15.4686	0.2580	69.65		

188	9.3055	15.4686	0.2580	69.65	3	
190	9.5547	15.2880	0.2550	68.83		
202	10.5517	14.5658	0.2430	65.58		
210	10.5517	14.5658	0.2430	65.58	2.8	
218	10.5517	14.5658	0.2430	65.58		3.28E-08
220	10.5517	14.5658	0.2430	65.58	2.7	
230	10.5517	14.5658	0.2430	65.58	2.7	
240	10.5517	14.5658	0.2430	65.58	2.9	
250	10.5517	14.5658	0.2430	65.58	3	
260	10.5517	14.5658	0.2430	65.58	3	
270	10.5517	14.5658	0.2430	65.58	3	
280	10.5517	14.5658	0.2430	65.58	3	
290	10.5517	14.5658	0.2430	65.58	2.9	
300	10.5517	14.5658	0.2430	65.58	2.8	


RF 1-2
% Saturation
k, cm/s
Time, hours
100
95
90
85
80
75
70
65
60
0.0001
10^{-5}
10^{-6}
10^{-7}
10^{-8}
0
40
80
120
160
200
240
280
320


RF 1-2
% Saturation
Suction,psi
Time, hours
100
95
90
85
80
75
70
65
60
6
5
4
3
2
1
0
-1
0
40
80
120
160
200
240
280
320


RF 1-2
Suction,psi
k, cm/s
Suction,psi
k, cm/s
w, % total volume
5
4
3
2
1
0
-1
0.0001
10-5
10-6
10-7
10-8
0.24
0.26
0.28
0.3
0.32
0.34
0.36
0.38


RF 1-2
Suction,psi
k, cm/s
Suction,psi
k, cm/s
% Saturation
6
5
4
3
2
1
0
-1
0.0001
10-5
10-6
10-7
10-8
60
65
70
75
80
85
90
95
100

Appendix C-3

Advanced Terra Testing Laboratory Results

TABLE C-2

Soil Moisture Laboratory Data for Hydroprobe Calibration
Advanced Terra Testing Data

Sample Number	Dry Bulk Density (pcf)	Dry Bulk Density (g/cm^3)	Moisture Content (% dry soil wt.)	Wet Density (pcf)	Moisture Content (% volume)
ATT-1			8.3		
ATT-2	119.8	1.92	5.0	125.8	9.59
ATT-2	121.4	1.94	6.7	129.5	13.03
ATT-3	111.2	1.78	13.8	126.5	24.58
ATT-4			5.6		
ATT-5			19.3		
ATT-6	95.9	1.54	23.4	118.4	35.95
ATT-6	92.7	1.48	26.9	117.6	39.94

TABLE C-5

ATT. INC., LABORATORY MOISTURE-CHARACTERISTIC CURVE RESULTS AND VAN GENUCHTEN INPUT DATA

Sample Number	Sat. MC Bruce-Klute	Vol. Frac. of CF	Pressure / Head	Vol. MC % Sat. (0 cm)	Vol. MC % 0.3 Bar (309.9 cm)	Vol. MC % 0.5 Bar (516.5 cm)	Vol. MC % 1.0 Bar (1033 cm)	Vol. MC % 2.0 Bar (2066 cm)	Vol. MC % 4.0 Bar (4133 cm)	COMMENTS
ATT-1	31.25	0.386		19.19	13.92	13.99	12.71	11.63	10.60	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				31.25	22.67	22.78	20.69	18.95	17.26	Bruce-Klute Correction (31.25/40.23 * 40.23)
				40.23	29.19	29.33	26.64	24.39	22.22	Lab Results (Uncorrected)
ATT-1R				19.93	14.17	14.12	12.91	11.83	10.79	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				32.45	23.08	22.99	21.02	19.26	17.57	Bruce-Klute Correction
				41.78	29.71	29.60	27.06	24.80	22.62	Lab Results (Uncorrected)
ATT-2	36.07	0.363		22.98	18.48	18.53	16.95	15.58	13.89	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				36.07	29.01	29.08	26.61	24.46	21.81	Bruce-Klute Correction
				42.29	34.01	34.10	31.20	28.68	25.57	Lab Results (Uncorrected)
ATT-2R				22.72	18.29	18.30	16.81	16.65	13.71	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				35.66	28.72	28.73	26.39	26.14	21.52	Bruce-Klute Correction
				41.81	33.67	33.69	30.94	30.65	25.23	Lab Results (Uncorrected)
ATT-4	35.53	0.294		25.08	11.13	10.84	9.32	8.25	7.29	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				35.53	15.77	15.35	13.20	11.69	10.33	Bruce-Klute Correction
				48.00	21.30	20.74	17.83	15.79	13.95	Lab Results (Uncorrected)
ATT-4R				25.72	10.98	10.76	9.27	8.19	7.31	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				36.43	15.55	15.24	13.13	11.61	10.36	Bruce-Klute Correction
				49.21	21.01	20.59	17.74	15.68	13.99	Lab Results (Uncorrected)
ATT-5	40.06	0.015		39.46	30.04	30.28	28.52	27.09	25.25	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				40.06	30.50	30.74	28.95	27.50	25.64	Bruce-Klute Correction
				44.00	33.50	33.76	31.80	30.21	28.16	Lab Results (Uncorrected)
ATT-5R				39.77	30.01	30.21	28.40	27.03	25.27	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				40.38	30.46	30.67	28.83	27.44	25.66	Bruce-Klute Correction
				44.35	33.46	33.69	31.67	30.14	28.18	Lab Results (Uncorrected)
ATT-6	43.29	0.018		42.51	37.76	37.89	36.04	34.55	32.46	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				43.29	38.45	38.58	36.70	35.18	33.05	Bruce-Klute Correction
				51.30	45.57	45.72	43.49	41.69	39.17	Lab Results (Uncorrected)
ATT-6R				46.02	38.51	38.69	36.58	34.95	32.62	Corrected for Coarse Fract. (CF = (1-Vr) * Vol. MC %)
				46.86	39.21	39.40	37.25	35.59	33.22	Bruce-Klute Correction
				55.53	46.47	46.69	44.14	42.18	39.37	Lab Results (Uncorrected)

ADVANCED TERRA TESTING, INC.

833 Parfet Street
Lakewood, Colorado 80215
(303) 232-8308

MINUS #10 SIEVE ANALYSES

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#10 SIEVE ONLY

CLIENT ASI

JOB NO. 20810-08

BORING NO.	ATT-1	SAMPLED	
DEPTH	2-4'	DATE TESTED	7-28-93 SR
SAMPLE NO.		WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

MOISTURE/DENSITY DATA

Wt. Soil & Ring(s) (g)	
Wt. Ring(s) (g)	
Wt. Soil (g)	
Wet Density PCF	
Wt. Wet Soil & Pan (g)	
Wt. Dry Soil & Pan (g)	
Wt. Lost Moisture (g)	
Wt. of Pan Only (g)	
Wt. of Dry Soil (g)	
Moisture Content %	
Dry Density PCF	

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	1035.8
Wt. Dry Soil & Pan Before Washing (g)	1035.8
Weight of Pan (g)	0.0
Wt. of Dry Soil Before Washing	1035.8
Wt. Dry Soil & Pan After Washing (g)	558.0
Wt. of Dry Soil After Washing (g)	558.0
-#10 Wash. Out %	46.1

ADVANCED TERRA TESTING, INC.

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#10 SIEVE ONLY

CLIENT ASI

JOB NO. 20810-08

BORING NO.	ATT-2	SAMPLED	
DEPTH	Comb.	DATE TESTED	7-28-93 SR
SAMPLE NO.	4.4-4.9'	WASH SIEVE	Yes
SOIL DESCR.	4.9-5.4'	DRY SIEVE	No

MOISTURE/DENSITY DATA

Wt. Soil & Ring(s) (g)	
Wt. Ring(s) (g)	
Wt. Soil (g)	
Wet Density PCF	
Wt. Wet Soil & Pan (g)	
Wt. Dry Soil & Pan (g)	
Wt. Lost Moisture (g)	
Wt. of Pan Only (g)	
Wt. of Dry Soil (g)	
Moisture Content %	
Dry Density PCF	

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	898.0
Wt. Dry Soil & Pan Before Washing (g)	898.0
Weight of Pan (g)	0.0
Wt. of Dry Soil Before Washing	898.0
Wt. Dry Soil & Pan After Washing (g)	466.7
Wt. of Dry Soil After Washing (g)	466.7
-#10 Wash. Out %	48.0

ADVANCED TERRA TESTING, INC.

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#10 SIEVE ONLY

CLIENT ASI

JOB NO. 20810-08

BORING NO.	ATT-4	SAMPLED	
DEPTH	7.9-9.9'	DATE TESTED	7-28-93 SR
SAMPLE NO.		WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

MOISTURE/DENSITY DATA

Wt. Soil & Ring(s) (g)	
Wt. Ring(s) (g)	
Wt. Soil (g)	
Wet Density PCF	
Wt. Wet Soil & Pan (g)	
Wt. Dry Soil & Pan (g)	
Wt. Lost Moisture (g)	
Wt. of Pan Only (g)	
Wt. of Dry Soil (g)	
Moisture Content %	
Dry Density PCF	

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	1060.1
Wt. Dry Soil & Pan Before Washing (g)	1060.1
Weight of Pan (g)	0.0
Wt. of Dry Soil Before Washing	1060.1
Wt. Dry Soil & Pan After Washing (g)	553.1
Wt. of Dry Soil After Washing (g)	553.1
-#10 Wash. Out %	47.8

ADVANCED TERRA TESTING, INC.

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#10 SIEVE ONLY

CLIENT ASI

JOB NO. 20810-08

BORING NO.	ATT-5	SAMPLED	
DEPTH	19.4-21.5'	DATE TESTED	7-28-93 SR
SAMPLE NO.		WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

MOISTURE/DENSITY DATA

Wt. Soil & Ring(s) (g)	
Wt. Ring(s) (g)	
Wt. Soil (g)	
Wet Density PCF	
Wt. Wet Soil & Pan (g)	
Wt. Dry Soil & Pan (g)	
Wt. Lost Moisture (g)	
Wt. of Pan Only (g)	
Wt. of Dry Soil (g)	
Moisture Content %	
Dry Density PCF	

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	797.4
Wt. Dry Soil & Pan Before Washing (g)	797.4
Weight of Pan (g)	0.0
Wt. of Dry Soil Before Washing	797.4
Wt. Dry Soil & Pan After Washing (g)	21.0
Wt. of Dry Soil After Washing (g)	21.0
-#10 Wash. Out %	97.4

ADVANCED TERRA TESTING, INC.

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#10 SIEVE ONLY

CLIENT ASI

JOB NO. 20810-08

BORING NO.	ATT-6	SAMPLED	
DEPTH	Comb.	DATE TESTED	7-28-93 SR
SAMPLE NO.	Liner 39+40	WASH SIEVE	Yes
SOIL DESCR.		DRY SIEVE	No

MOISTURE/DENSITY DATA

Wt. Soil & Ring(s) (g)	
Wt. Ring(s) (g)	
Wt. Soil (g)	
Wet Density PCF	
Wt. Wet Soil & Pan (g)	
Wt. Dry Soil & Pan (g)	
Wt. Lost Moisture (g)	
Wt. of Pan Only (g)	
Wt. of Dry Soil (g)	
Moisture Content %	
Dry Density PCF	

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	844.8
Wt. Dry Soil & Pan Before Washing (g)	844.8
Weight of Pan (g)	0.0
Wt. of Dry Soil Before Washing	844.8
Wt. Dry Soil & Pan After Washing (g)	28.1
Wt. of Dry Soil After Washing (g)	28.1
-#10 Wash. Out %	96.7

ADVANCED TERRA TESTING, INC.

CAPILLARY MOISTURE RETENTION

CAPILLARY MOISTURE RETENTION TEST

CLIENT	ASI	JOB NO.	2081-08
LOCATION		TEST STARTED	7-30-93 SR
SAMPLED		TEST FINISHED	9-2-93

Mass Data

Sample Description	Ring Mass g	As Rec. Mass g	Sat. Mass g	0.3 Bar Mass g	0.5 Bar Mass g	1 Bar Mass g	2 Bar Mass g	4 Bar Mass g	Dry Mass Filter Ring & Dish	Dish Wt. g
Filter Mass g			0.686	0.637	0.349	0.327	0.312	0.308		
ATT-1	10.652	50.175	55.378	53.228	52.965	52.432	51.988	51.571	48.804	1.560
ATT-1R	10.496	50.065	55.552	53.203	52.895	52.389	51.943	51.524	48.692	1.571
ATT-2	10.611	49.242	54.442	52.816	52.545	51.971	51.476	50.879	47.463	1.549
ATT-2R	10.639	49.282	54.448	52.849	52.565	52.019	51.949	50.913	47.582	1.569
ATT-4	10.537	40.729	49.005	43.872	43.476	42.900	42.498	42.143	40.967	1.576
ATT-4R	10.738	40.885	49.452	44.032	43.663	43.099	42.691	42.365	41.174	1.568
ATT-5	10.779	44.883	48.570	46.521	46.283	45.888	45.570	45.176	41.292	1.575
ATT-5R	10.569	44.660	48.431	46.309	46.065	45.657	45.352	44.974	41.085	1.573
ATT-6	10.798	46.547	49.764	48.624	48.365	47.918	47.560	47.076	41.090	1.569
ATT-6R	10.662	46.468	50.553	48.779	48.532	48.024	47.637	47.097	41.060	1.556

ADVANCED TERRA TESTING, INC.

CAPILLARY MOISTURE RETENTION TEST

CLIENT	ASI	JOB NO.	2081-08
LOCATION		TEST STARTED	7-30-93 SR
SAMPLED		TEST FINISHED	9-2-93

Moisture Content Data - % DM = By Dry Mass, % Vol. = By Volume

Sample Description	Dry Mass g	Unit Wt. g/cc	Sat. Mass g	Total H2O g	Sat. MC % DM	Sat. MC % Vol.	Ret H2O	0.3 Bar % DM	0.3 Bar % Vol.	Ret H2O	0.5 Bar % DM	0.5 Bar % Vol.
ATT-1	36.379	1.910	44.040	7.661	21.06	40.23	5.56	15.28	29.19	5.59	15.35	29.33
ATT-1R	36.412	1.912	44.370	7.958	21.86	41.78	5.66	15.54	29.71	5.64	15.48	29.60
ATT-2	35.090	1.842	43.145	8.055	22.96	42.29	6.48	18.46	34.01	6.50	18.51	34.10
ATT-2R	35.161	1.846	43.123	7.962	22.65	41.81	6.41	18.24	33.67	6.42	18.25	33.69
ATT-4	28.641	1.504	37.782	9.141	31.92	48.00	4.057	14.17	21.30	3.949	13.79	20.74
ATT-4R	28.655	1.505	38.028	9.373	32.71	49.21	4.002	13.97	21.01	3.921	13.68	20.59
ATT-5	28.725	1.508	37.105	8.380	29.17	44.00	6.380	22.21	33.50	6.430	22.39	33.76
ATT-5R	28.730	1.508	37.176	8.446	29.40	44.35	6.373	22.18	33.46	6.417	22.34	33.69
ATT-6	28.510	1.497	38.280	9.770	34.27	51.30	8.68	30.44	45.57	8.71	30.54	45.72
ATT-6R	28.629	1.503	39.205	10.576	36.94	55.53	8.85	30.92	46.47	8.89	31.06	46.69

ADVANCED TERRA TESTING, INC.

CAPILLARY MOISTURE RETENTION TES

CLIENT	ASI	JOB NO.	2081-08
LOCATION		TEST STARTED	7-30-93 SR
SAMPLED		TEST FINISHED	9-2-93

Moisture Content Data - % DM = By Dry Mass, % Vol. = By Volume

Sample Description	1 Bar Ret H2O	1 Bar % DM	1 Bar % Vol.	2 Bar Ret H2O	2 Bar % DM	2 Bar % Vol.	4 Bar Ret H2O	4 Bar % DM	4 Bar % Vol.
ATT-1	5.074	13.95	26.64	4.65	12.77	24.39	4.232	11.63	22.22
ATT-1R	5.154	14.16	27.06	4.723	12.97	24.80	4.308	11.83	22.62
ATT-2	5.943	16.94	31.20	5.46	15.57	28.68	4.87	13.88	25.57
ATT-2R	5.892	16.76	30.94	5.84	16.60	30.65	4.81	13.67	25.23
ATT-4	3.395	11.85	17.83	3.008	10.50	15.79	2.657	9.28	13.95
ATT-4R	3.379	11.79	17.74	2.986	10.42	15.68	2.664	9.30	13.99
ATT-5	6.057	21.09	31.80	5.754	20.03	30.21	5.364	18.67	28.16
ATT-5R	6.031	20.99	31.67	5.741	19.98	30.14	5.367	18.68	28.18
ATT-6	8.283	29.05	43.49	7.94	27.85	41.69	7.460	26.17	39.17
ATT-6R	8.406	29.36	44.14	8.034	28.06	42.18	7.498	26.19	39.37

ADVANCED TERRA TESTING, INC.

CAPILLARY MOISTURE RETENTION TEST

CLIENT ASI

LOCATION

SAMPLED

JOB NO. 2081-08

TEST STARTED 7-30-93 SR

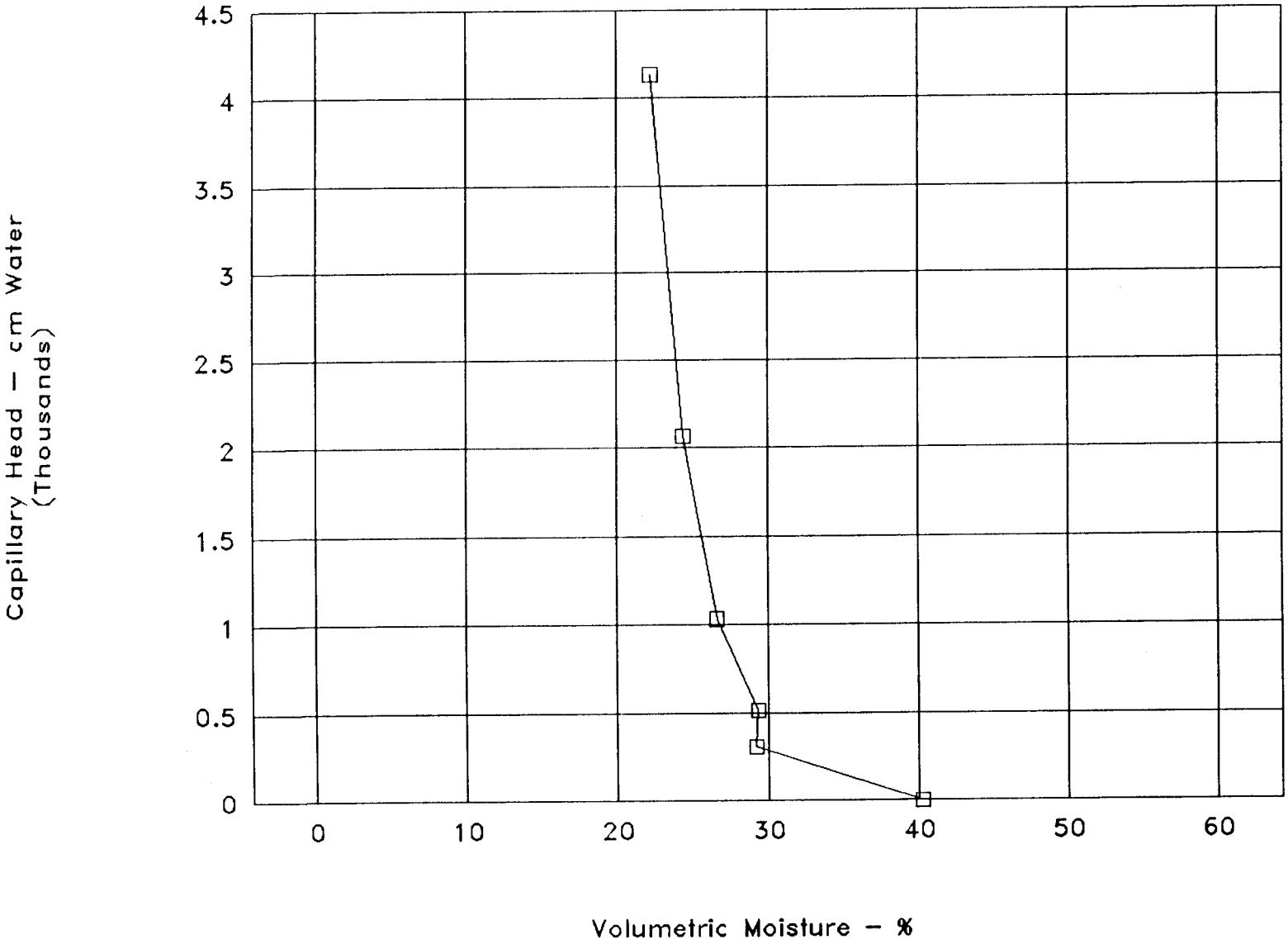
TEST FINISHED 9-2-93

	Vol. Mc % Sat.	Vol. MC % 0.3 Bar	Vol. MC % 0.5 Bar	Vol. MC % 1 Bar	Vol. MC % 2 Bar	Vol. MC % 4 Bar
ATT-1	40.23	29.19	29.33	26.64	24.39	22.22
ATT-1R	41.78	29.71	29.60	27.06	24.80	22.62
ATT-2	42.29	34.01	34.10	31.20	28.68	25.57
ATT-2R	41.81	33.67	33.69	30.94	30.65	25.23
ATT-4	48.00	21.30	20.74	17.83	15.79	13.95
ATT-4R	49.21	21.01	20.59	17.74	15.68	13.99
ATT-5	44.00	33.50	33.76	31.80	30.21	28.16
ATT-5R	44.35	33.46	33.69	31.67	30.14	28.18
ATT-6	51.30	45.57	45.72	43.49	41.69	39.17
ATT-6R	55.53	46.47	46.69	44.14	42.18	39.37
Heads Used	0	309.9	516.5	1033	2066	4133

ADVANCED TERRA TESTING, INC.

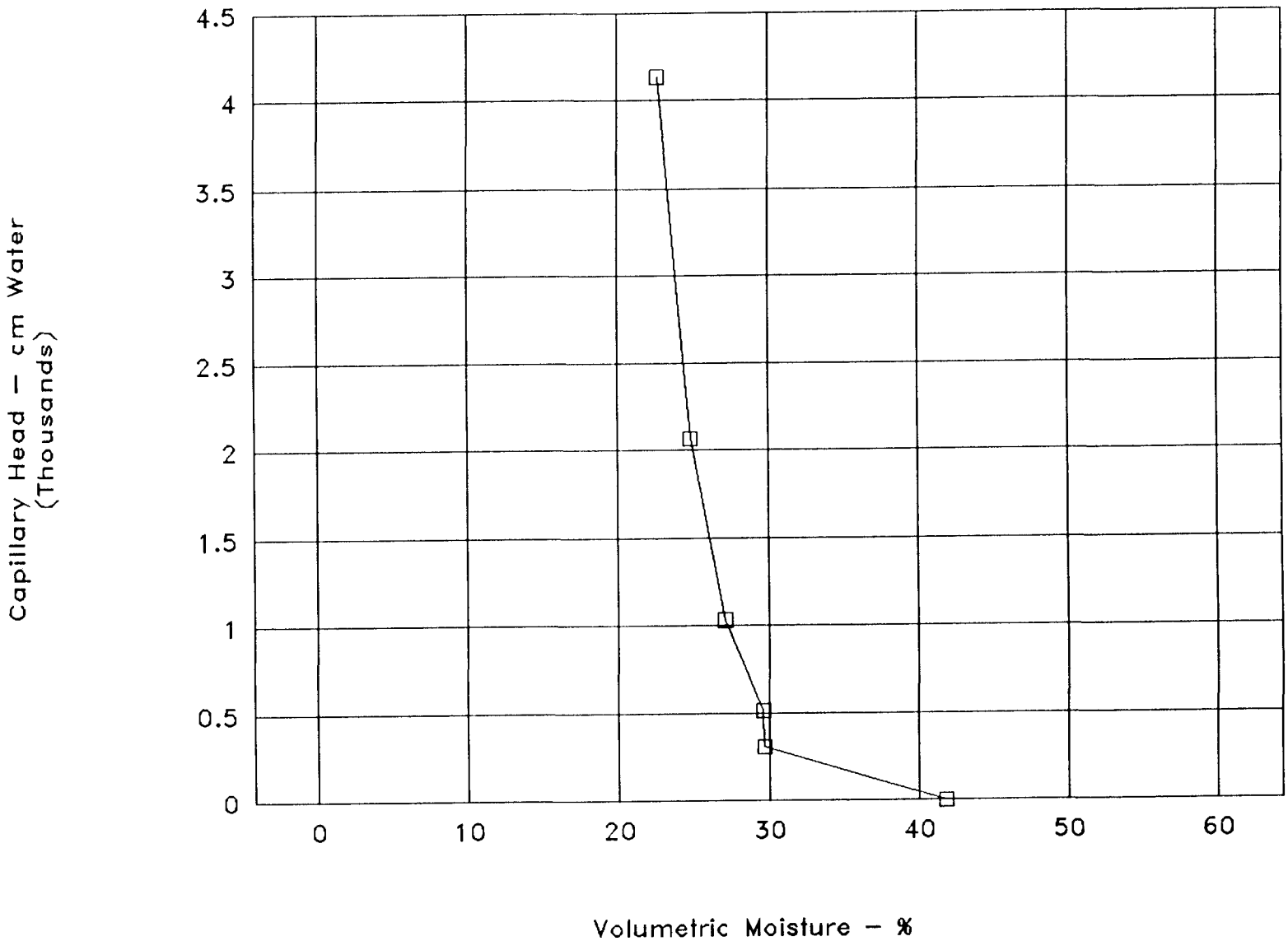
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-1 @2-4.0'



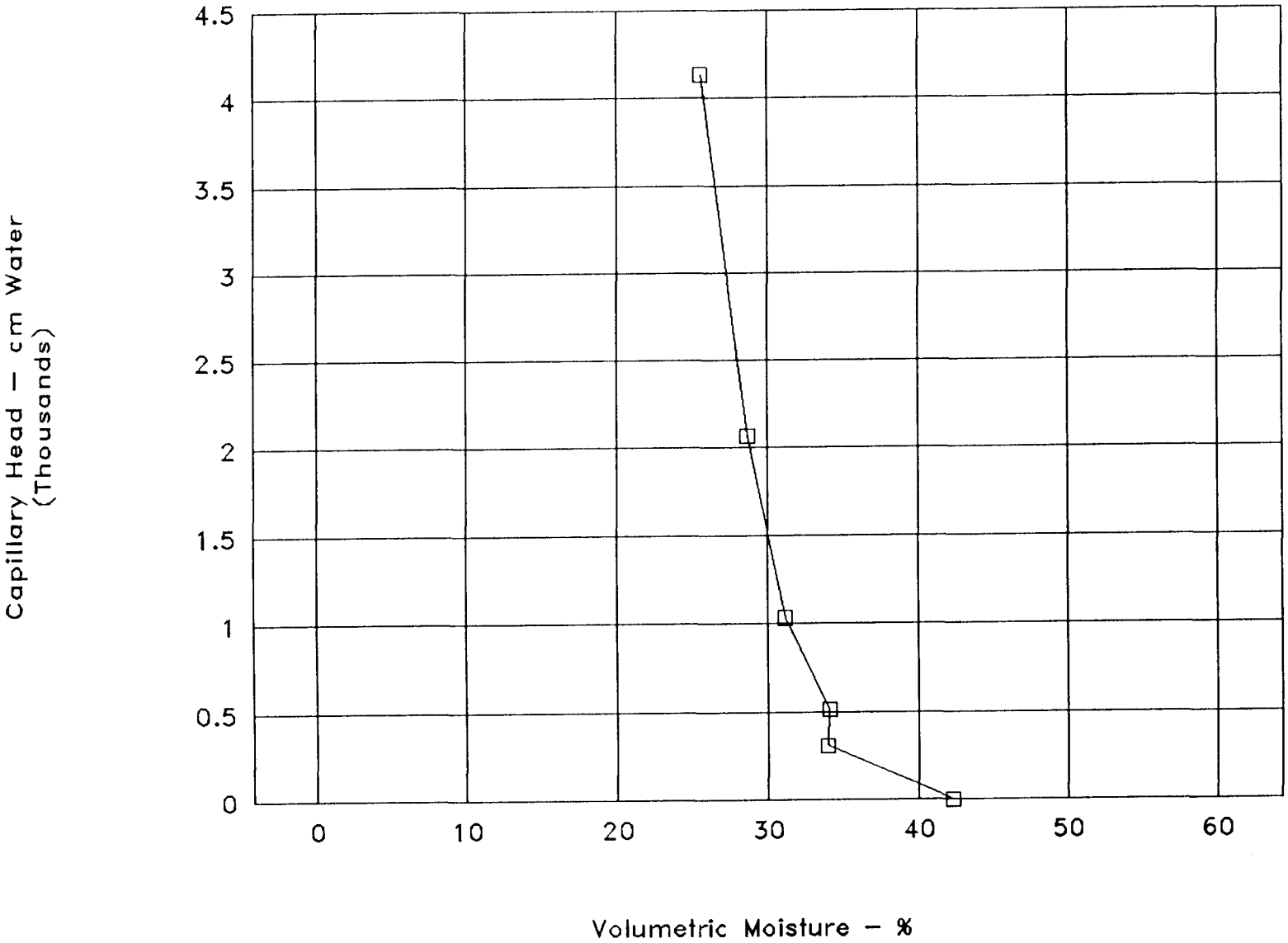
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-1 @2-4.0'(R)



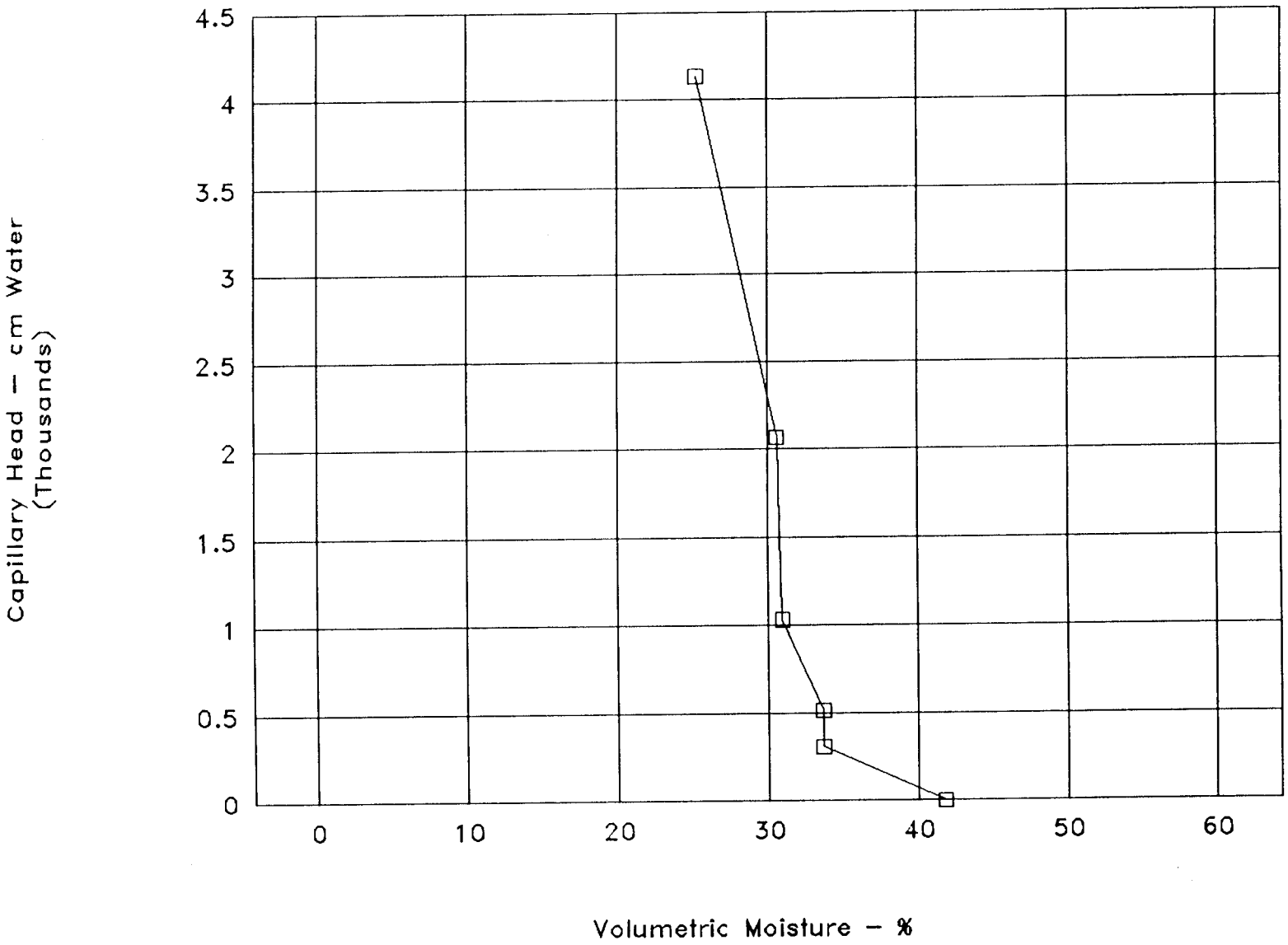
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-2 @4.9-5.4',4.4-4.9'



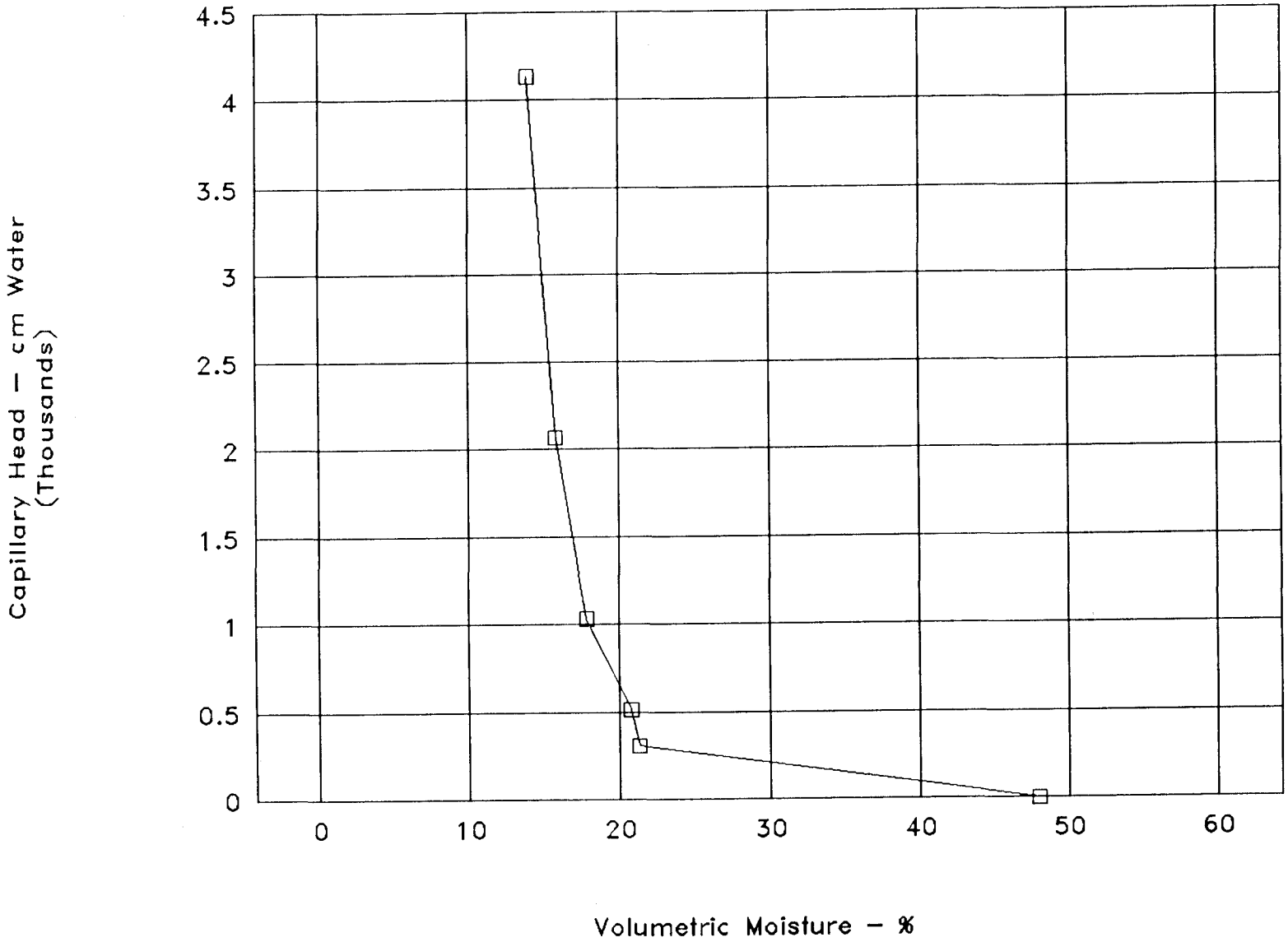
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-2 @4.9-5.4',4.4-4.9'(R)



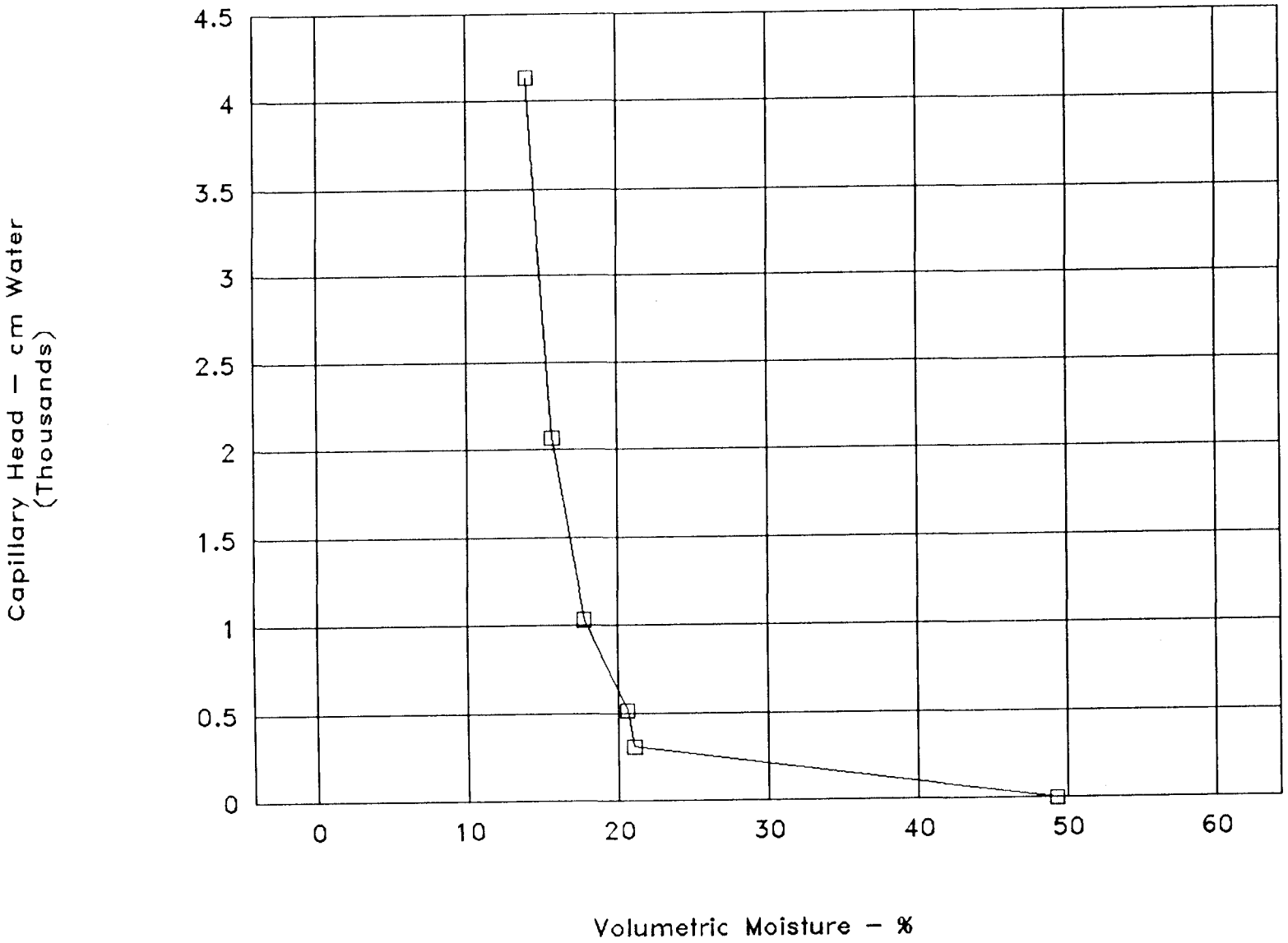
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-4 @7.9-9.9'



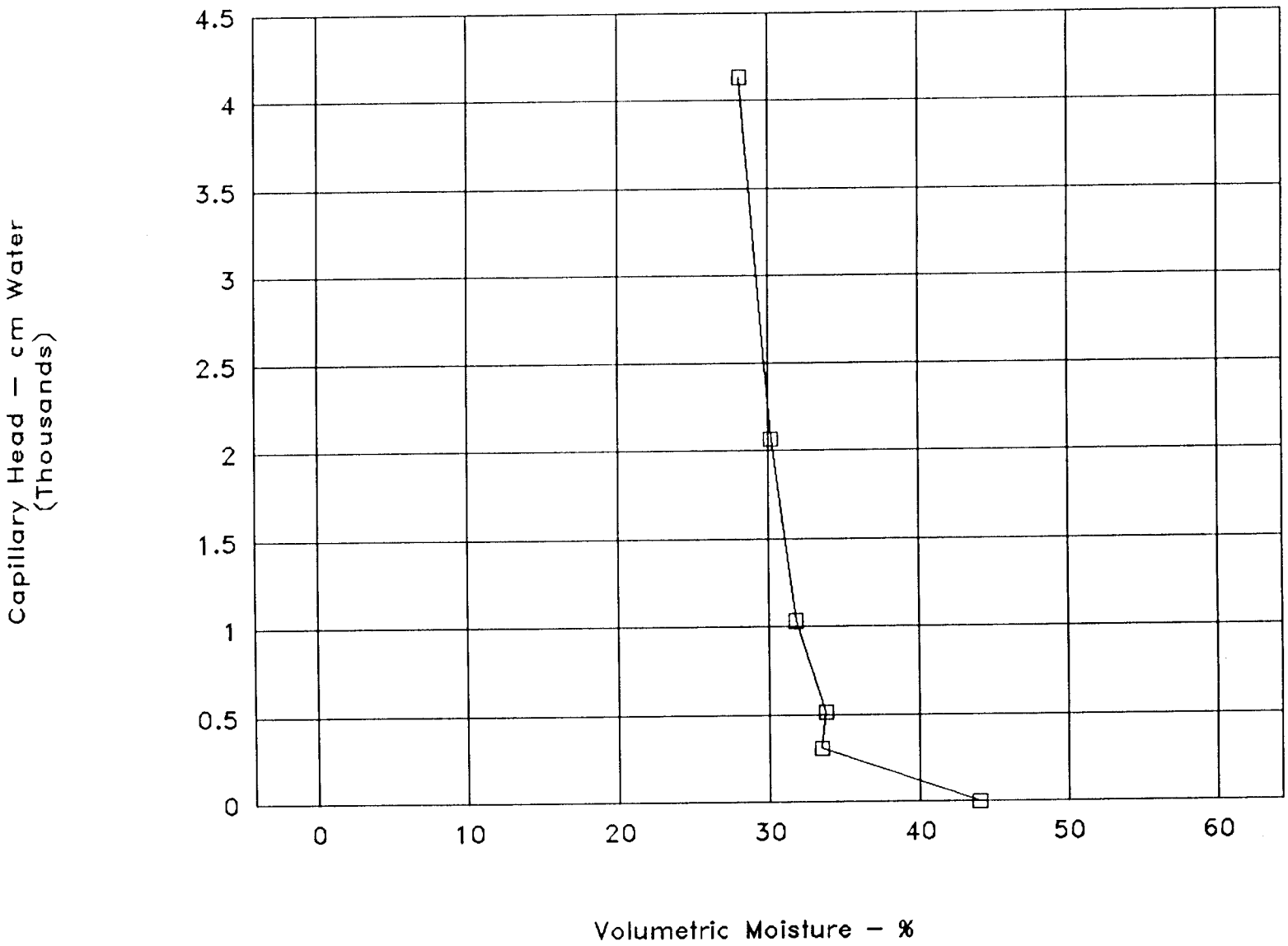
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-4 @7.9-9.9'(R)



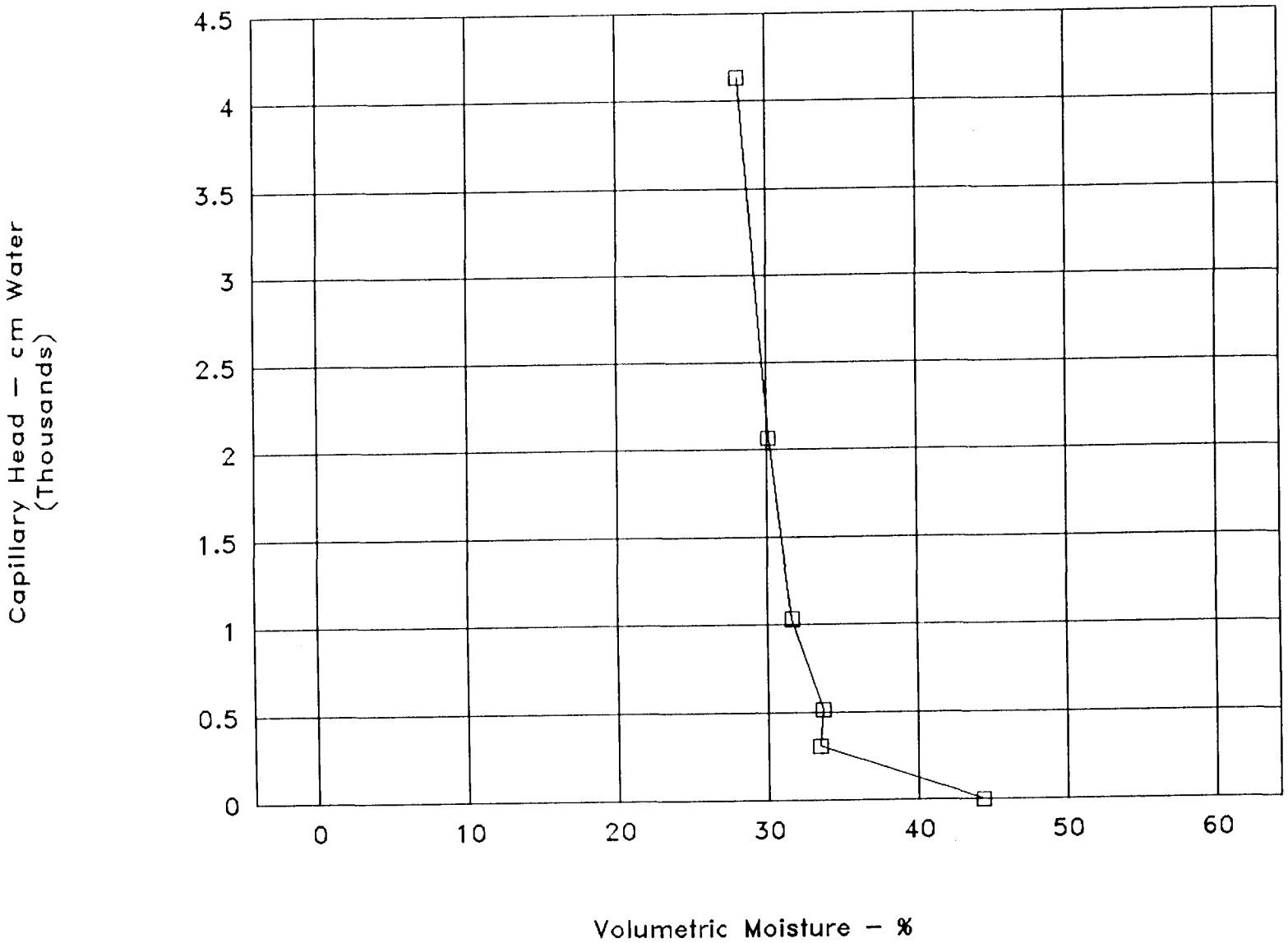
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-5 @19.4-21.5'



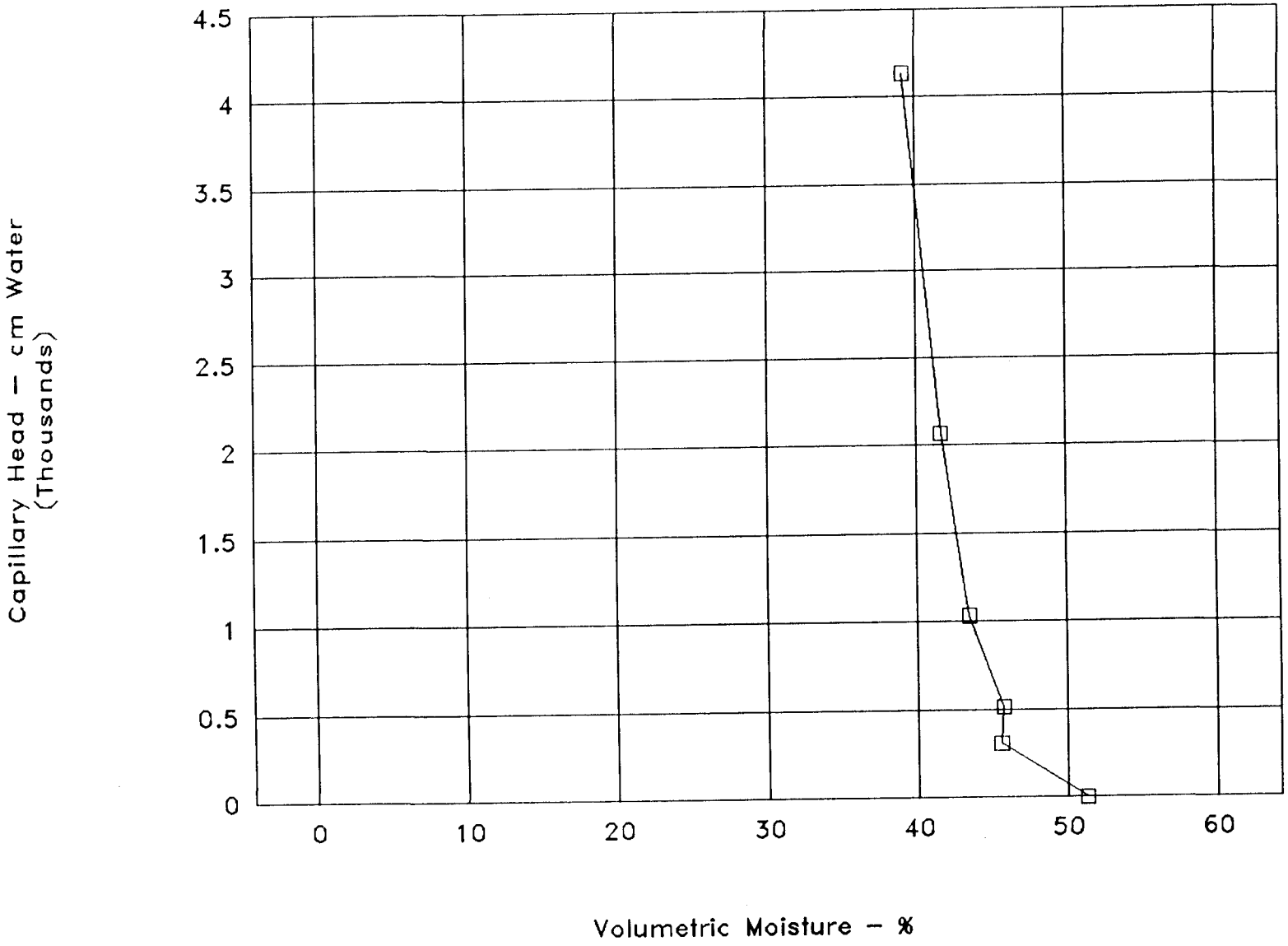
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-5 @19.4-21.5'(R)



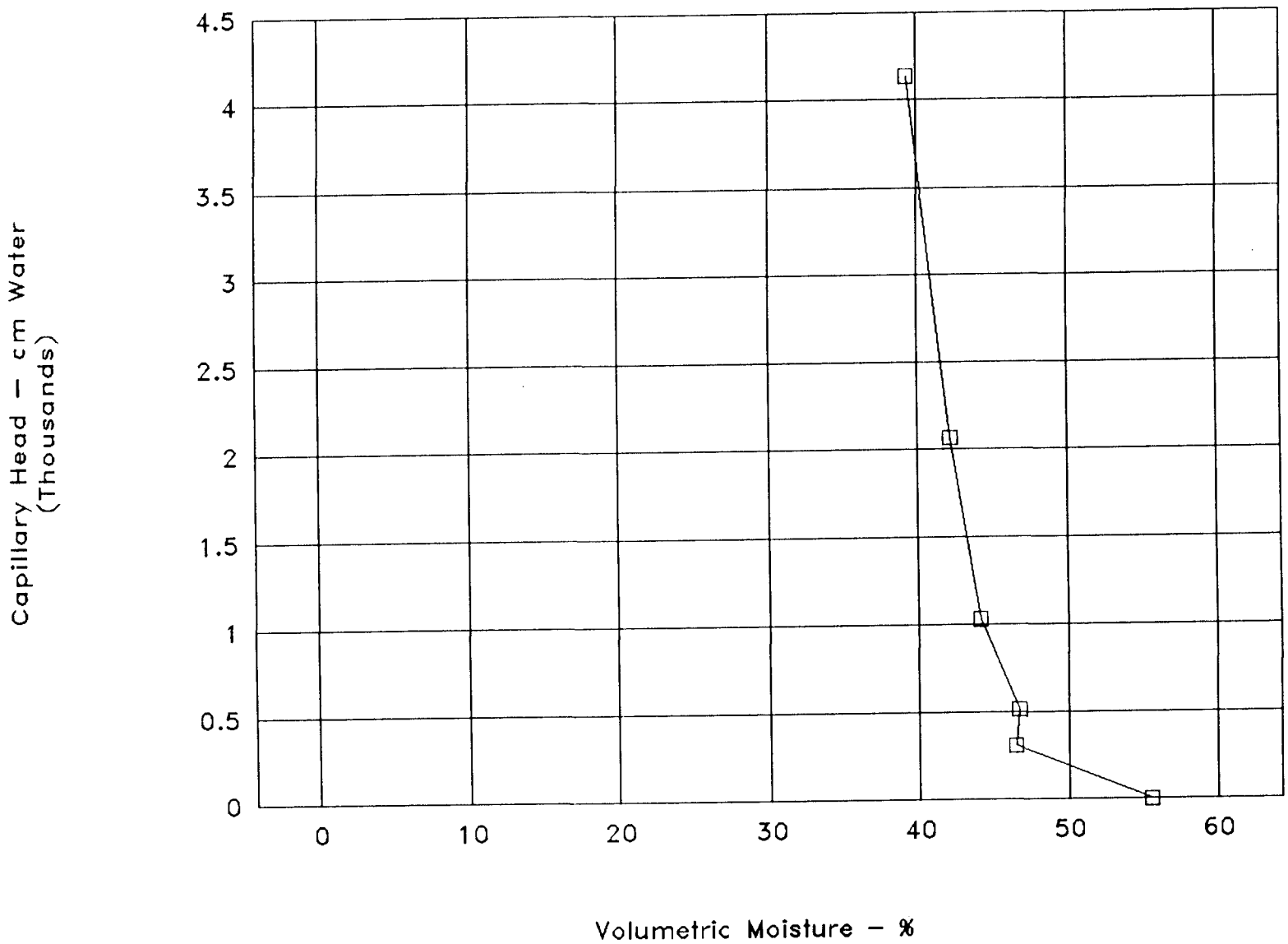
CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-6 @17.5-18.0',17-17.5'



CAPILLARY MOISTURE CHARACTERISTIC CURVE

Sample ATT-6 @17.5-18.0',17-17.5'(R)



Desorption Test Data

Client: ASI

Job #: 2081-08

Date: 7-30-93

Filter @ 4.0 Bar = .308g

ASKØATT

45

Specimen ID				Core Case Parameters During Casing					Core Case Parameters After Perforating						
Hole No.	Depth Ft.	Ring #	Date Measured	Ring Mass gm	Filter Mass gm	As Recieved Mass gm	Saturated Mass w/Ring + Filter	.637 Bulk Volume cm3 0.5	.349 0.5	.327 1.0	.312 2.0	4.0	Dry wt Soil filter Pan+Ring	Pan #	Pan wt
ATT-1	2.0-4.0'	52		10.652		50.175	55.378	53.228	52.965	52.432	51.988	51.571	48.804	37P	1.524
ATT-1(R)	2.0-4.0'	19		10.496		50.065	55.552	53.203	52.895	52.389	51.943	51.524	48.692	11P	1.574
Comb.	4.9-5.4'														
ATT-2	4.4-4.9'	58		10.611		49.242	54.442	52.816	52.545	51.971	51.476	50.879	47.463	11S	1.54
Comb.	4.9-5.4'														
ATT-2(R)	4.4-4.9'	59		10.639		49.282	54.448	52.849	52.565	52.019	51.494	50.913	47.582	21P	1.569
ATT-4	7.9-9.9'	16		10.537		40.729	49.005	43.872	43.476	42.900	42.498	42.143	40.967	5O	1.57
ATT-4(R)	7.9-9.9'	62		10.738		40.885	49.452	44.032	43.663	43.099	42.691	42.365	41.174	3P	1.568
ATT-5	19.4-21.5'	86		10.779		44.883	48.570	46.621	46.283	45.888	45.570	45.176	41.292	2P	1.572
ATT-5(R)	19.4-21.5'	65		10.569		44.660	48.431	46.309	46.045	45.657	45.352	44.974	41.085	26P	1.572
Comb.	17.5-18.0'														
ATT-6	17.0-17.5'	70		10.798		46.547	49.764	48.624	48.345	47.918	47.560	47.076	41.090	4P	1.569
Comb.	17.5-18.0'														
ATT-6(R)	17.0-17.5'	73		10.662		46.468	50.553	48.779	48.532	48.024	47.637	47.097	41.060	31P	1.550

ASKØATI

" " R

ASKØAT2

" " R

ASKØAT4

" " R

ASKØAT5

" " R

ASKØAT6

" " R

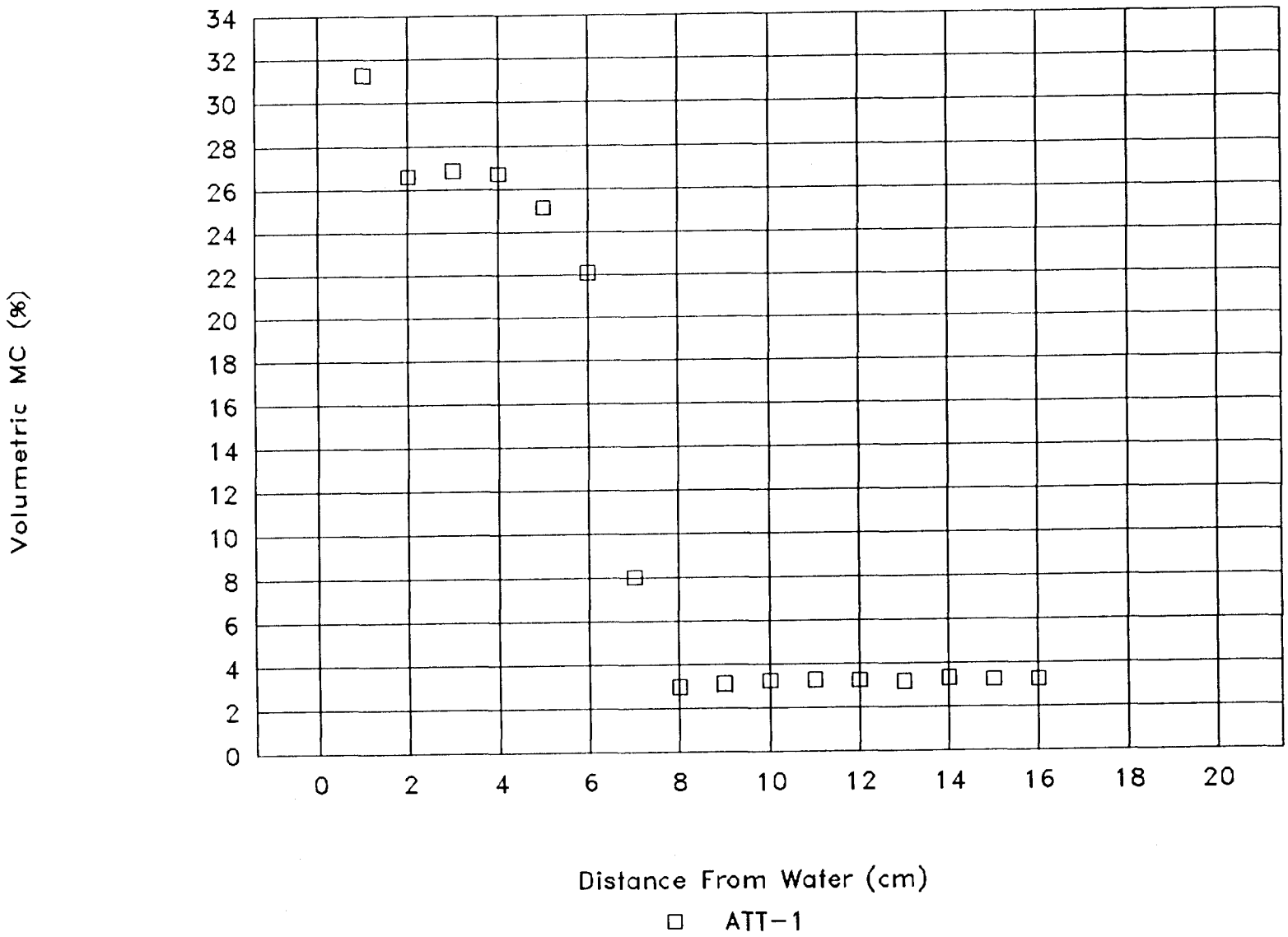
BRUCE-KLUTE DIFFUSIVITY

BRUCE/KLUTE DIFFUSIVITY ANALYSIS

Dist. From Water (cm)	ATT-1 Vol. MC (%)	ATT-2 Vol. MC (%)	ATT-4 Vol. MC (%)	ATT-5 Vol. MC (%)	ATT-6 Vol. MC (%)
1.00	31.25	36.07	35.53	40.06	43.29
2.00	26.57	33.15	34.26	35.82	38.86
3.00	26.85	31.12	33.35	23.82	11.56
4.00	26.72	29.81	35.12	2.71	3.06
5.00	25.12	29.84	33.63	3.38	2.93
6.00	22.09	29.15	31.43	2.31	2.97
7.00	8.03	28.48	31.43	2.43	2.96
8.00	3.00	27.08	15.17	2.35	3.02
9.00	3.15	25.61	2.48	2.40	3.18
10.00	3.25	21.11	2.39	2.43	3.15
11.00	3.30	4.32	2.56	2.40	3.03
12.00	3.25	2.62	2.44	2.19	3.02
13.00	3.19	2.65	2.58	2.29	3.02
14.00	3.34	2.73	2.44	2.46	3.00
15.00	3.27		2.58	2.25	3.02
16.00	3.27		2.58	2.65	3.40

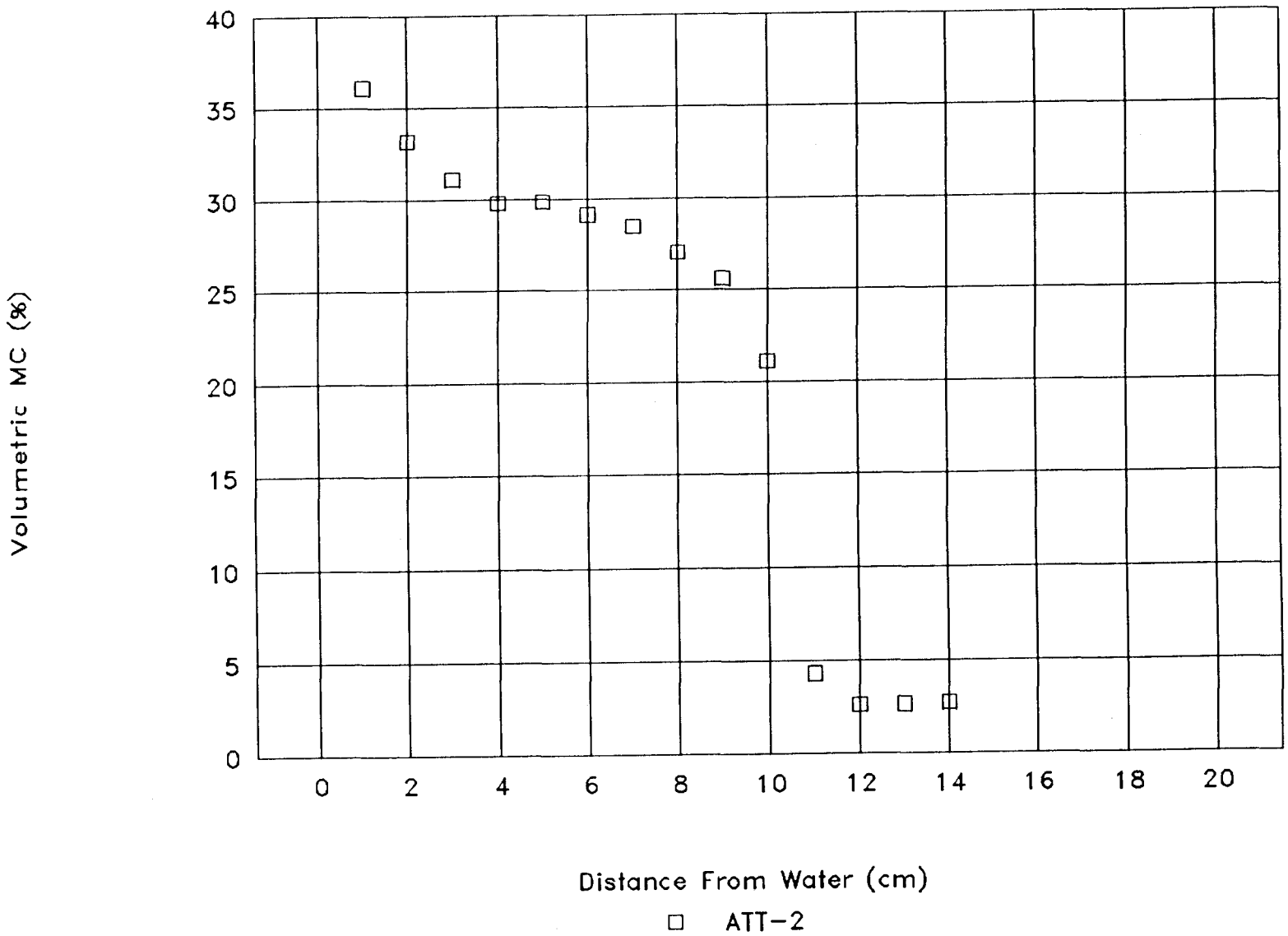
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



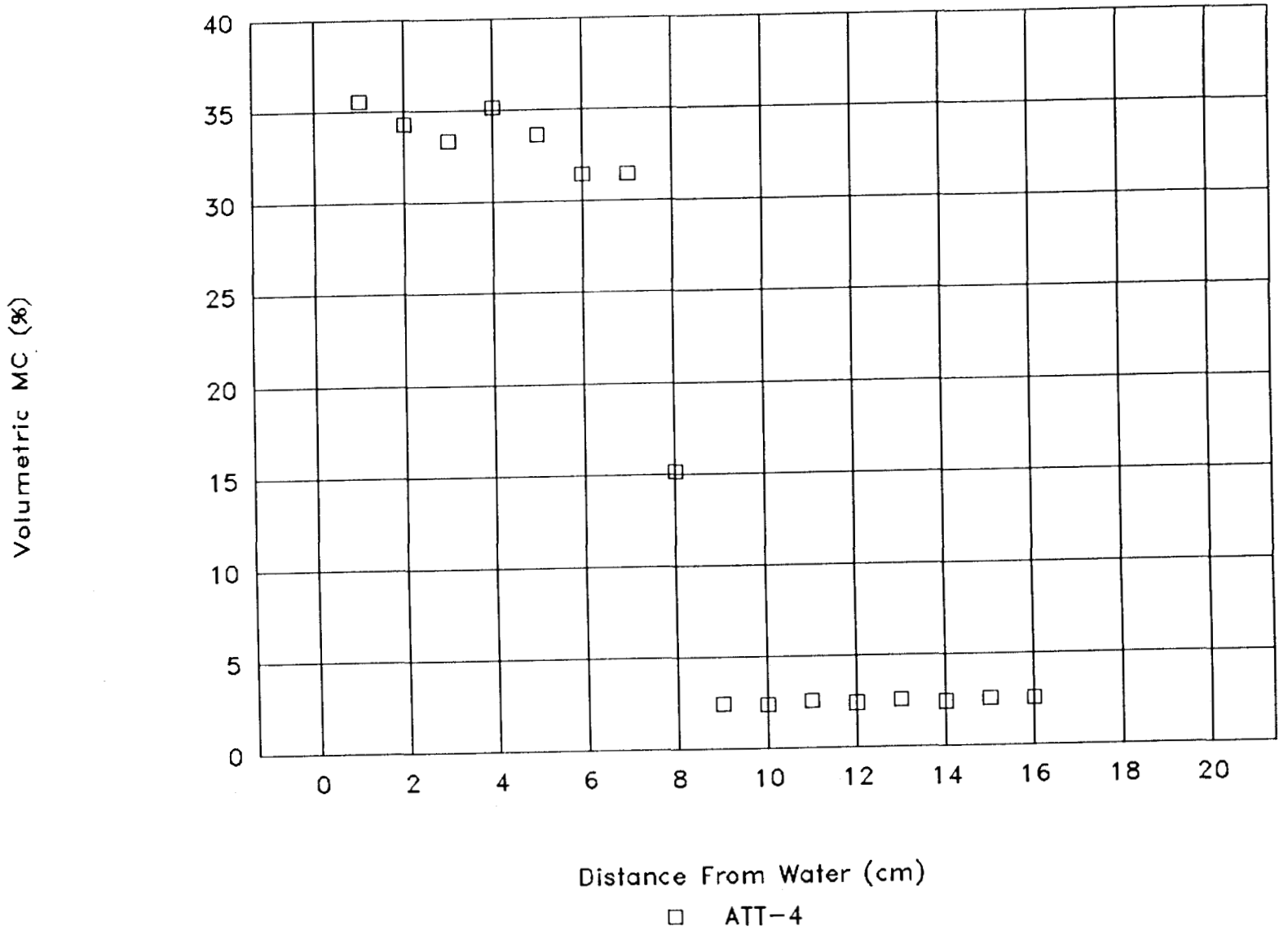
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



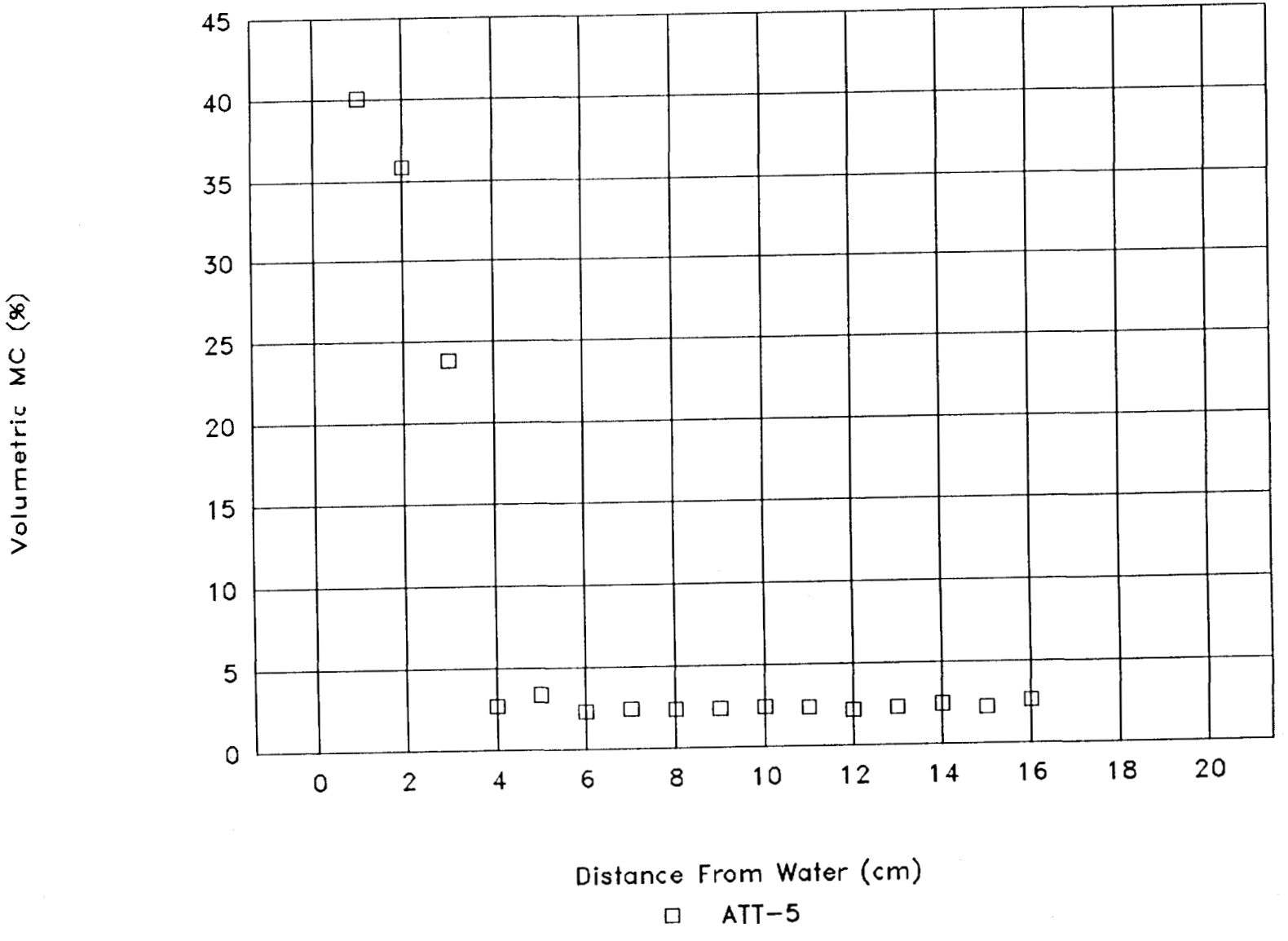
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



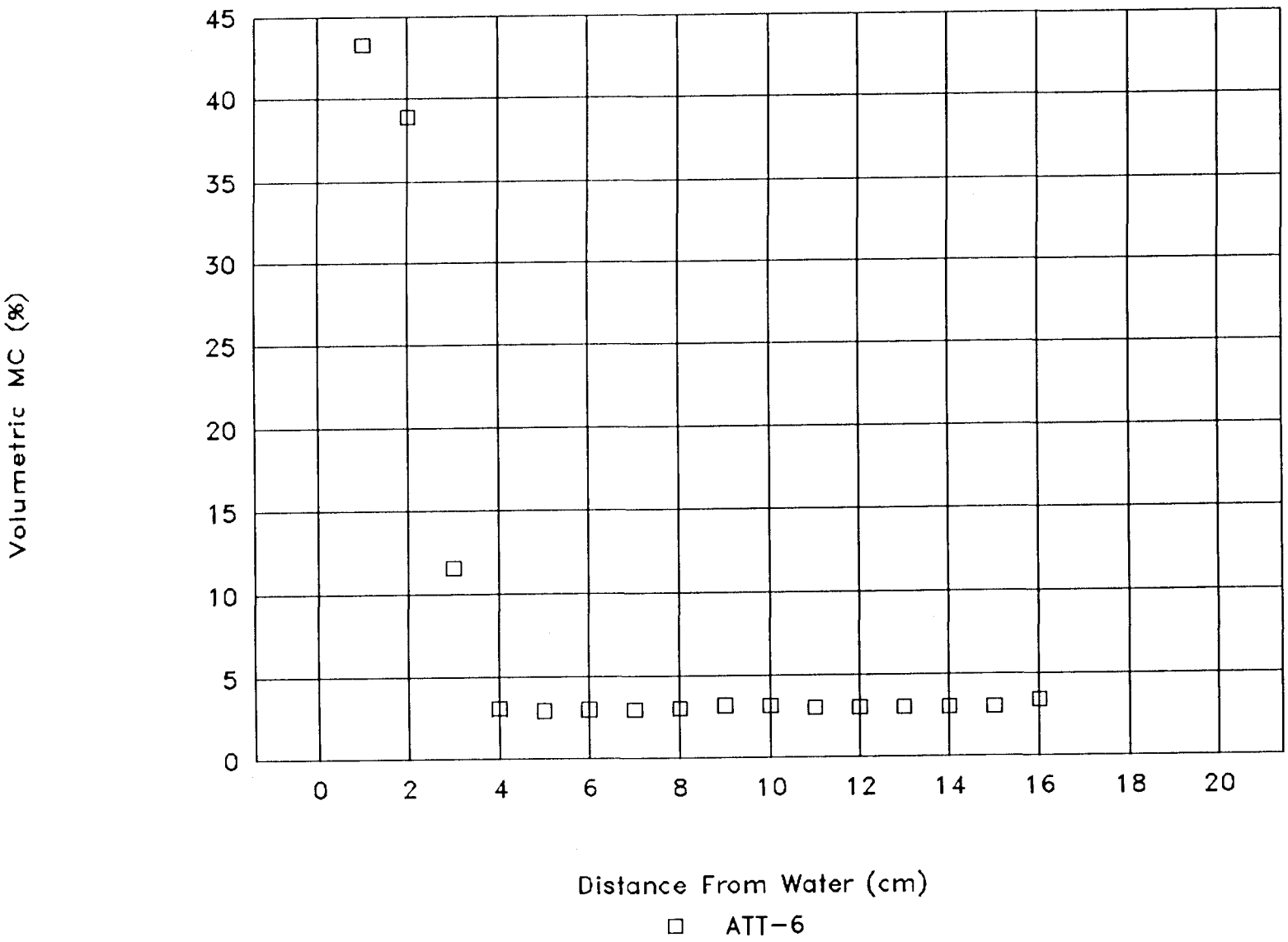
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



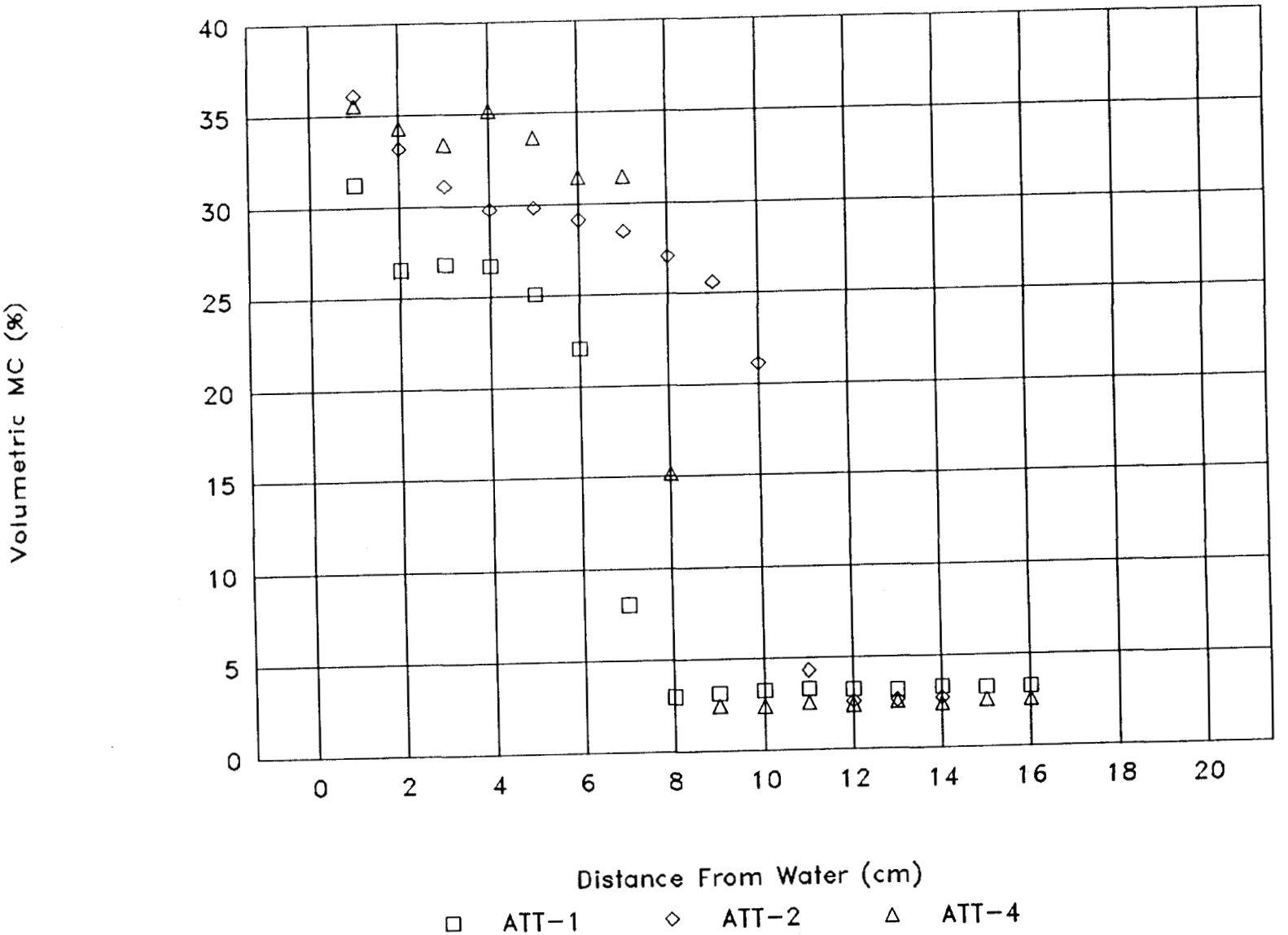
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



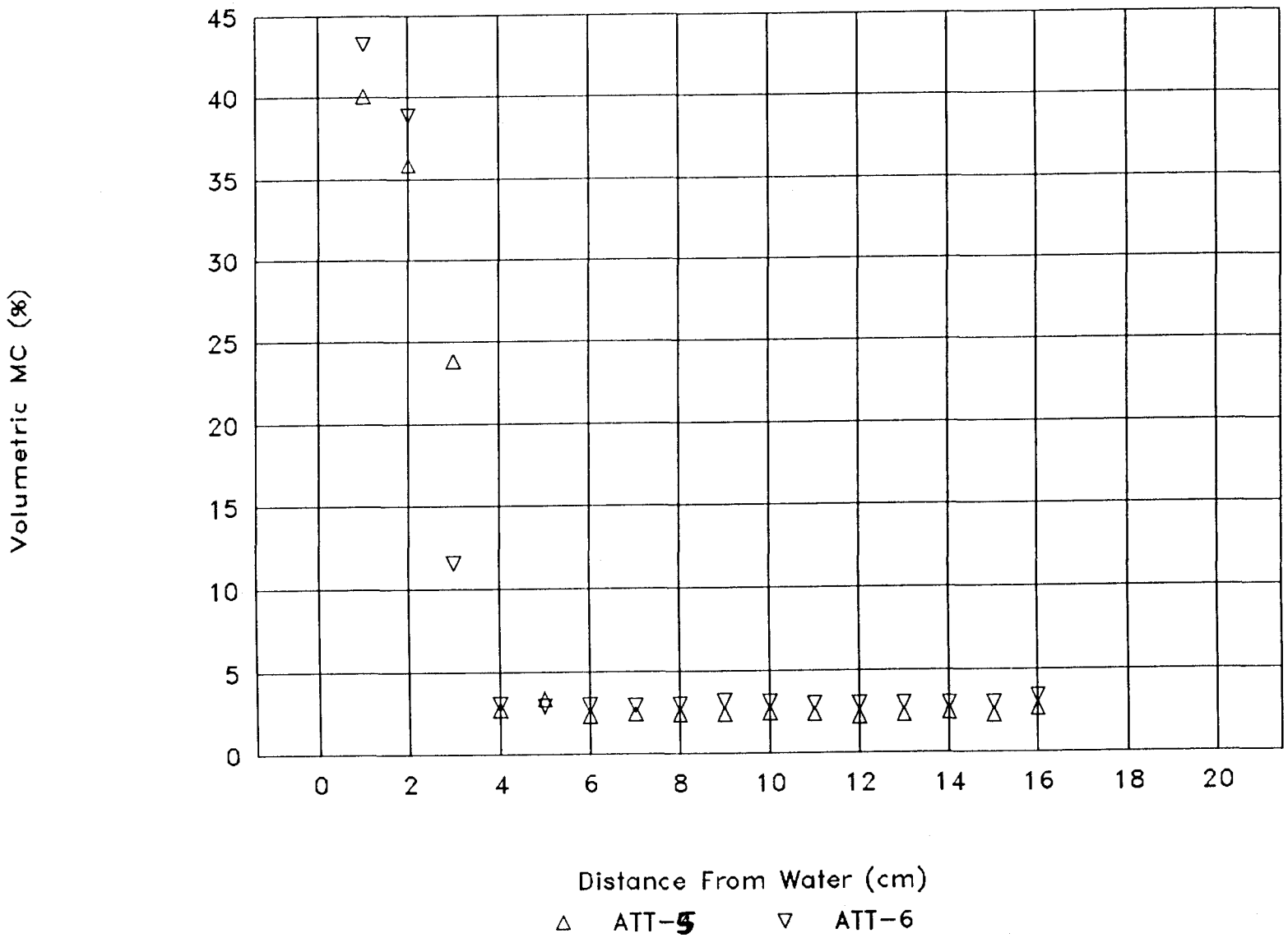
BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



BRUCE/KLUTE DIFFUSIVITY

Volumetric MC vs. Dist. From Water



ASBKATT1.PIC
ASBKATT.WK1

BEG PSI = 51.0
START TIME = 1339
TERMINATE TIME = 2339
TOTAL TIME ELAPSED = 10 HR 0.0 MIN = 600 MIN
BRUCE KLUTE

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT As1
LOCATION
JOB NO. 2281.08
PAGE 1 OF 2

SAMPLE & SOIL TYPE	BORING	ATT-1	→	→	→	→	→	→	→
	SAMPLE NO		FLOW DIRECTION						
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION (DISTANCE FROM FREE WATER, CM)	1	2	3	4	5	6	7	8
DENSITY	NO OF RINGS	75	78	66	61	73	69	72	54
	WT OF WET SOIL & RINGS g								
	WT OF RINGS g	7.900	8.000	7.925	7.967	7.968	7.926	7.967	7.985
	WT OF WET SOIL								
	WET DENSITY (LBS/CU.FT.)								
	DRY DENSITY (LBS/CU.FT.) PCF	118.56							
	g/cc	1.899							
MOISTURE CONTENT	AVG SAMPLE MC = 1.72% DISH NO	050P	39	64B	15	6P	70P	75B	X6
	WT OF WET SOIL & DISH g	19.059	19.469	17.729	17.836	17.828	18.099	16.362	16.439
	WT OF DRY SOIL & DISH g	16.586	17.271	15.695	15.829	15.929	16.331	16.135	16.208
	NET LOSS OF MOISTURE g	2.473	2.198	2.034	2.007	1.899	1.718	.627	.231
	WT OF DISH g	1.560	1.561	1.314	1.566	1.574	1.561	1.317	1.562
	WT OF DRY SOIL g	15.026	15.710	14.381	14.263	14.355	14.770	14.818	14.646
	MOISTURE CONTENT (% DRY WT.)	16.46	13.99	14.14	14.07	13.23	11.63	4.23	1.58
	VOLUMETRIC	31.25	26.57	26.85	26.72	25.12	22.09	8.03	3.00

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING INC.

CLIENT ASI

LOCATION

JOB NO. 2081-08

PAGE 2 OF 2

SAMPLE & SOIL TYPE	BORING	ATT-1	→	→	→	→	→	→	→
	SAMPLE NO.			FLOW	DIRECTION				
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION Distance From Well, cm	9	10	11	12	13	14	15	16
DENSITY	NO. OF RINGS	55	53	52	59	65	63	60	56
	WT. OF WET SOIL & RINGS g								~~23.083~~
	WT. OF RINGS g	7.934	8.024	7.882	8.068	7.902	8.039	7.880	7.965
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF g/cc	→							
MOISTURE CONTENT	DISH NO.	135	26	82P	18P	X8	38P	108	36P
	WT. OF WET SOIL & DISH g	16.542	16.297	16.694	16.759	16.733	17.121	15.522	16.588
	WT. OF DRY SOIL & DISH g	16.297	16.050	16.435	16.504 ~~495~~	16.482	16.852	15.283	16.334
	NET LOSS OF MOISTURE g	.245	.247	.259	.255	.251	.269	.239	.254
	WT. OF DISH g	1.563	1.579	1.562	1.575	1.566	1.561	1.314	1.552
	WT. OF DRY SOIL g	14.734	14.471	14.873	14.929	14.916	15.291	13.969	14.782
	MOISTURE CONTENT (% DRY WT.)	1.66	1.71	1.74	1.71	1.68	1.76	1.71	1.72
	VOLUMETRIC	3.15	3.25	3.30	3.25	3.19	3.34	3.27	3.27

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASL

LOCATION

JOB NO. 2081-08

PAGE 1 OF 2

10-6-93 2P-1 1243

[illegible] 0303 19 HR 20 MIN = 1160 MIN

ASBKATT2

BRUCE KLUTE

SAMPLE & SOIL TYPE	BORING	ATT-2	→	→	→	→	→	→	→
	SAMPLE NO.								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION DISTANCE FROM FREEWATER, Cm	1	2	3	4	5	6	7	8
DENSITY	NO. OF RINGS	55 ~~79~~ *	62	76	75	67	77	51	64
	WT. OF WET SOIL & RINGS g								
	WT. OF RINGS g	7.952 ~~7.948~~	7.899	7.903	7.913 ~~8.010~~	7.925	7.966	7.916	8.000
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF	~~111.96~~	116.33	115.33					
	g/cc	~~[illegible]~~	~~1.794~~	1.847					
MOISTURE CONTENT	AVG STARTING MC = 1.45% DISH NO.	22P	36	47P	84P	32P	48P	60P	06
	WT. OF WET SOIL & DISH g	27.22	18.31 ~~17.96~~	18.46	18.25	18.24	18.20	18.23	18.11
	WT. OF DRY SOIL & DISH g	23.029	15.762	16.023	15.931	15.918	15.934	16.002	15.995
	NET LOSS OF MOISTURE g	4.191	2.548	2.437	2.319	2.322	2.266	2.228	2.115
	WT. OF DISH g	1.57	1.57	1.56	1.56	1.55	1.57	1.55	1.57
	WT. OF DRY SOIL g	21.459	14.192	14.463	14.371	14.368	14.364	14.452	14.425
	MOISTURE CONTENT (% DRY WT.)	19.53	17.95	16.85	16.14	16.16	15.78	15.42	14.66
	VOLUMETRIC	~~35.04~~ 36.07	~~32.20~~ 33.15	~~30.23~~ 31.12	~~28.96~~ 29.81	~~28.99~~ 29.84	~~26.31~~ 29.15	~~27.66~~ 28.48	~~26.30~~ 27.08

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASI

LOCATION

JOB NO. 2081-28

PAGE 2 OF 2

BRUCE KLUTE

SAMPLE & SOIL TYPE	BORING	ATT-2	→	→	→	→	→	→	→
	SAMPLE NO.								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION DISTANCE FROM FREE WATER, Cm	9	10	11	12	13	14	15	16
DENSITY	NO. OF RINGS	58	70	68	50	57	78 ~~81~~	71	80
	WT. OF WET SOIL & RINGS g								
	WT. OF RINGS g	7.920	8.018	7.932	7.969	8.022	8.06 ~~7.960~~	7.992	7.988
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF	111.96							→
	DRY DENSITY (LBS./CU.FT.) g/cc	1.794							
MOISTURE CONTENT	DISH NO.	19A	79P	134	X2	09	23P		
	WT. OF WET SOIL & DISH g	17.70	17.61	15.92	16.11	16.19	17.35		
	WT. OF DRY SOIL & DISH g	15.704	15.907	15.568	15.904	15.983	14.163		
	NET LOSS OF MOISTURE g	1.996	1.64	.334	.204	.207	.187		
	WT. OF DISH g	1.31	1.56	1.30	1.56	1.57	1.57		
	WT. OF DRY SOIL g	14.394	14.347	14.268	14.346	14.41	12.593		
	MOISTURE CONTENT (% DRY WT.)	13.87	11.43	2.34	1.42	1.44	1.48		
	VOLUMETRIC	~~31.88~~ 25.61	~~20.50~~ 21.11	~~4.20~~ 4.32	~~2.55~~ 2.62	~~2.78~~ 2.65	~~2.66~~ 2.73		

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASI

LOCATION

JOB NO. 2081-02

PAGE 1 OF 2

1 PSI 0.27 START
0.36 END 9.0 MIN. ASBKATIA

BRUCE - KLUTE

SAMPLE & SOIL TYPE	BORING	ATT-4	→	→	→	→	→	→	→
	SAMPLE NO								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY	10-18-93 SR	→	→	→	→	→	→	→
	SOIL TYPE								
	LABORATORY IDENTIFICATION DISTANCE FROM FREE WATER, cm	1	2	3	4	5	6	7	8
DENSITY	NO OF RINGS	63	50	67	80	56	69	78	62
	WT. OF WET SOIL & RINGS								
	WT. OF RINGS g	8.036	7.981	7.938	8.004	7.472	7.923	8.009	7.915
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF	92.735							→
	g/cc	1.486							
MOISTURE CONTENT	AVG STARTING MC = 1.688% DISH NO	47	20P	45	42	34P	29P	15P	10P
	WT OF WET SOIL & DISH g	23.342	15.873	14.961	15.770	15.684	15.880	15.853	14.033
	WT OF DRY SOIL & DISH g	19.139	13.192	12.505	13.054	13.223	13.379	13.556	12.878
	NET LOSS OF MOISTURE g	9.203	2.681	2.456	2.716	2.641	2.501	2.297	1.155
	WT. OF DISH g	1.568	1.568	1.567	1.565	1.557	1.560	1.585	1.564
	WT. OF DRY SOIL g	17.571	11.624	10.99	11.489	11.666	11.819	11.981	11.314
	MOISTURE CONTENT (% DRY WT.)	23.92	23.06	22.45	23.64	22.64	21.16	19.17	10.21
	VOLUMETRIC	35.53	34.26	33.35	35.12	33.63	31.43	31.43	15.17

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASI

LOCATION

JOB NO. 2081-08

PAGE 2 OF 2

BRUCE KLUTE

SAMPLE & SOIL TYPE	BORING	ATT-4	→	→	→	→	→	→	→
	SAMPLE NO								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY	10-18-93 →	→	→	→	→	→	→	→
	SOIL TYPE								
	LABORATORY IDENTIFICATION Distance From Free Water Cm	9	10	11	12	13	14	15	16
DENSITY	NO OF RINGS	77	71	58	53	70	55	66	57
	WT. OF WET SOIL & RINGS								
	WT OF RINGS g	7.983	7.942	7.935	8.034	8.032	7.944	7.924	8.040
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU FT.) PCF	92.735							
	g/cc	1.486							
MOISTURE CONTENT	DISH NO	34	41	40P	71P	10S	19	12S	72P
	WT OF WET SOIL & DISH g	13.441	13.035	13.280	13.089	13.160	13.224	13.062	13.290
	WT OF DRY SOIL & DISH g	13.246	12.851	13.082	12.903	12.961	13.038	12.865	13.089
	NET LOSS OF MOISTURE g	.195	.182	.198	.186	1.1990	.188	.197	.201
	WT. OF DISH g	1.568	1.556	1.555	1.557	1.538	1.569	1.558	1.558
	WT. OF DRY SOIL g	11.678	11.295	11.527	11.346	11.423	11.469	11.301	11.531
	MOISTURE CONTENT (% DRY WT.)	1.67	1.61	1.72	1.69	1.74	1.64	1.74	1.74
	VOLUMETRIC	2.48	2.39	2.56	2.436	2.58	2.436	2.58	2.58

START TIME = 1473
END TIME = 1458 15.0 MIN
1 PSI

ASBK ATT 5

BRUCE - KLUTE

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASI

LOCATION

JOB NO. 2081-08

PAGE 1 OF 2

SAMPLE & SOIL TYPE	BORING	ATT-5	→	→	→	→	→	→	→
	SAMPLE NO								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY	SR	→	→	→	→	→	→	→
	SOIL TYPE								
	LABORATORY IDENTIFICATION Distance From Free Water, cm	1	2	3	4	5	6	7	8
DENSITY	NO OF RINGS	52	75	61	65	63	72	60	66
	WT. OF WET SOIL & RINGS	19.723							
	WT. OF RINGS g	7.873	7.893	7.963	7.898	8.034	7.958	7.877	7.920
	WT. OF WET SOIL	11.85							→
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) pcf	92.82							→
	g/cc	1.488							
MOISTURE CONTENT	AVG MC = 1.60 STARTING DISH NO	08	9P	57P	1X	86P	21P	115	50
	WT. OF WET SOIL & DISH g	23.345	15.057	13.674	13.155	13.291	13.260	13.175	13.425
	WT. OF DRY SOIL & DISH g	18.743	12.441	12.002	12.948	13.106	13.081	12.989	13.241
	NET LOSS OF MOISTURE g	4.602	2.616	1.672	.207	.185	.179	.186	.184
	WT. OF DISH g	1.572	1.573	1.559	1.558	1.548	1.568	1.551	1.576
	WT. OF DRY SOIL g	17.171	10.868	10.443	11.390	11.558	11.513	11.438	11.665
	MOISTURE CONTENT (% DRY WT.)	26.92	24.07	16.01	1.82	1.60	1.55	1.63	1.58
	VOLUMETRIC	40.06	35.82	23.82	2.71	2.38	2.31	2.43	2.35

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASL

LOCATION

JOB NO. 2081-08

PAGE 2 OF 2

SAMPLE & SOIL TYPE	BORING	ATT-5	→	→	→	→	→	→	→
	SAMPLE NO								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY	SR	→	→	→	→	→	→	→
	SOIL TYPE								
	LABORATORY IDENTIFICATION (DISTANCE FROM FREE WATER, Cm)	9	10	11	12	13	14	15	16
DENSITY	NO OF RINGS	49	59	73	54	56	51	50	48
	WT OF WET SOIL & RINGS								
	WT OF RINGS (g)	7.919	8.060	7.976	7.971	7.961	7.937	7.981	7.945
	WT OF WET SOIL	11.85							→
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF	92.82							→
	g/cc	1.488							
MOISTURE CONTENT	DISH NO	3P	25P	2P	4P	31P	11P	37P	07
	WT OF WET SOIL & DISH (g)	13.375	13.257	13.245	13.264	13.360	13.547	13.313	13.187
	WT OF DRY SOIL & DISH (g)	13.188	13.070	13.060	13.094	13.181	13.353 ~~13.700~~	13.138	12.984
	NET LOSS OF MOISTURE (g)	.187	.187	.185 ~~.224~~	.170	.179	.194	.175	.203
	WT. OF DISH (g)	1.570	1.572	1.572	1.563	1.556	1.570	1.559	1.579
	WT. OF DRY SOIL (g)	11.618	11.498	11.488	11.531	11.625	11.783	11.579	11.405
	MOISTURE CONTENT (% DRY WT.)	1.61	1.63	1.61	1.47	1.54	1.65	1.51	1.78
		2.70	2.43	2.70	2.19	2.29	2.46	2.25	2.65

START TIME 1638
FINISH TIME 1938 3 HR 0 MIN = 180 MIN

ASBKATTG

BRUCE - KLOTE

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT A.S.I.

LOCATION

JOB NO. 2081-08

PAGE 1 OF 2

SAMPLE & SOIL TYPE	BORING	ATT-C	→	→	→	→	→	→	→
	SAMPLE NO.								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION (DISTANCE FROM FREE WATER, cm)	1	2	3	4	5	6	7	8
DENSITY	NO OF RINGS	56	50	69	78	69	77	70	55
	WT. OF WET SOIL & RINGS								
	WT. OF RINGS g	7.965	7.983	7.918	8.008	7.916	7.982	8.033	7.944
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU FT.)								
	DRY DENSITY (LBS./CU FT.) PCF	92.30							
	g/cc	1.480							
MOISTURE CONTENT	AVG STARTING MC = 2.10% DISH NO	59P	30	01	50P	41P	76P	73P	28P
	WT OF WET SOIL & DISH g	16.861	16.000	14.012	13.372	13.313	13.210	13.217	13.091
	WT OF DRY SOIL & DISH g	13.398	13.000	13.111	13.133	13.085	12.981	12.988	12.812
	NET LOSS OF MOISTURE g	3.463	3.00	.901	.239	.228	.229	.229	.229
	WT. OF DISH g	1.560	1.574	1.575	1.561	1.559	1.564	1.555	1.576
	WT. OF DRY SOIL g	11.838	11.426	11.536	11.572	11.526	11.417	11.433	11.326
	MOISTURE CONTENT (% DRY WT.)	29.25	26.26	7.81	2.07	1.98	2.01	2.00	2.04
	VOLUMETRIC	93.29	38.86	11.56	3.06	2.93	2.97	2.96	3.02

MOISTURE AND DENSITY DETERMINATIONS

ADVANCED TERRA TESTING

CLIENT ASI

LOCATION

JOB NO. 2281.08

PAGE 2 OF 2

BRUCE - KLUTE

SAMPLE & SOIL TYPE	BORING	ATT-6	→	→	→	→	→	→	→
	SAMPLE NO.								
	SAMPLE DEPTH								
	DATE SAMPLED BY								
	DATE TESTED BY								
	SOIL TYPE								
	LABORATORY IDENTIFICATION (DISTANCE FROM FREE WATER, Cm)	9	10	11	12	13	14	15	16
DENSITY	NO. OF RINGS	67	80	71	58	53	66	73	63
	WT. OF WET SOIL & RINGS								
	WT. OF RINGS g	7.943	8.004	7.986	7.935	8.033	7.920	7.966	8.035
	WT. OF WET SOIL								
	WET DENSITY (LBS./CU.FT.)								
	DRY DENSITY (LBS./CU.FT.) PCF	92.36	—	—	—	—	—	—	→
	g/cc	1.480							
MOISTURE CONTENT	DISH NO.	51	28	16P	37	20	05	46P	43P
	WT. OF WET SOIL & DISH g	12.945	12.990	13.283	13.269	13.264	13.345	13.175	13.218
	WT. OF DRY SOIL & DISH g	12.700	12.746	13.048	13.035	13.030	13.111	12.943	12.956
	NET LOSS OF MOISTURE g	.245	.244	.235	.24	.234	.234	.232	.262
	WT. OF DISH g	1.289	1.304	1.572	1.569	1.573	1.573	1.558	1.556
	WT. OF DRY SOIL g	11.411	11.442	11.476	11.466	11.457	11.538	11.395	11.400
	MOISTURE CONTENT (% DRY WT.)	2.15	2.13	2.05	2.09	2.09	2.03	2.09	2.30
	VOLUMETRIC	3.18	3.15	3.03	3.02	3.02	3.00	3.02	3.40

Appendix C-4

Laboratory Data Analysis

TABLE C-4

RECHARGE STUDY, ROCKY FLATS PLANT SITE PRELIMINARY RESULTS OF UNSATURATED SOIL HYDROLOGIC PROPERTY MEASUREMENTS BY CSM BOREHOLE 02793, 14.4-14.9 FT.

Moisture Content (cm^3/cm^3)	Soil Suction (psi)	Matric Potential (cm)	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity
0.3060	57.0	-4008.1		
0.3262			8.19E-10	8.31E-03
0.3364	38.0	-2672.0		
0.3465	31.0	-2179.8	1.98E-09	2.01E-02
0.3567	23.0	-1617.3	2.21E-09	2.24E-02
0.3668	16.6 1)	-1167.3	2.65E-09	2.69E-02
0.3770	11.4 1)	-801.6	3.63E-09	3.68E-02
0.3804	11.0	-773.5		
0.3838	8.0	-562.5	3.37E-09	3.42E-02
0.3863	7.2	-506.3		
0.3888	6.0	-421.9	3.98E-09	4.04E-02
0.3914	4.4	-309.4		
0.3939	2.0	-140.6		
0.3956	2.9 1)	-201.8	4.38E-09 1)	4.44E-02
0.3990	4.7	-330.5	4.78E-09	4.85E-02
0.4007	4.0	-281.3		
0.4024	3.4 1)	-237.7	6.24E-09 1)	6.33E-02
0.4058	1.9	-133.6		
0.4091	0.3	-17.6		
0.4159	0.2	-10.5		
0.4193	0.1	-7.0		
0.4227	0.1	-7.0		
0.4244	0.2	-14.1		
0.4311	0.0	0.0	9.86E-08	1.00E+00

1) Average of two or more data points.

TABLE C-5

RECHARGE STUDY, ROCKY FLATS PLANT SITE PRELIMINARY RESULTS OF UNSATURATED SOIL HYDROLOGIC PROPERTY MEASUREMENTS BY CSM BOREHOLE 02293, 2.9-3.4 FT.

Moisture Content (cm^3/cm^3)	Soil Suction (psi)	Matric Potential (cm)	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity
0.2430	2.9 1)	-202.5	3.28E-08	1.75E-03
0.2580	3.0	-211.0		
0.2701	3.2	-225.0	3.79E-08	2.03E-03
0.2781	3.9 1)	-274.2	4.28E-08 1)	2.29E-03
0.2862	4.2 1)	-297.4	4.92E-08 1)	2.63E-03
0.2902	3.6 1)	-251.0	6.02E-08 1)	3.22E-03
0.2962	2.4 1)	-167.4	6.28E-08 1)	3.36E-03
0.3605	0.1	-7.0		
0.3705	0.0	0.0	1.87E-05	1.00E+00

1) Average of two or more data points.

TABLE C-7

RECHARGE STUDY, ROCKY FLATS PLANT SITE
ANALYSIS OF BRUCE-KLUTE TEST DATA
BOREHOLE 02393, 4.4-5.4 FT.

	Diffusivity Calculations						Hydraulic Conductivity Calculations				
Moisture Content (cm^3/cm^3)	Boltzmann ($cm/min^{1/2}$)	Area at Point	Cumulative Area Under Curve	Slope of Curve at Point	Diffusivity (cm^2/min)	Moisture Content (cm^3/cm^3)	Matric Potential (cm)	Slope of Curve at Point	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity	Corrected Moisture Content (cm^3/cm^3)
0.03	0.3390	--	--	--	--	0.03	-6.7E+10	--	--	--	0.01911
0.04	0.3240	0.003315	0.003315	-0.66667	0.002486	0.04	-6.2E+09	6.1E+12	6.83E-18	1.7E-13	0.02548
0.05	0.3190	0.003215	0.006530	-2.00000	0.001632	0.05	-9.8E+08	5.2E+11	5.21E-17	1.3E-12	0.03185
0.06	0.3170	0.003180	0.009710	-5.00000	0.000971	0.06	-2.2E+08	7.6E+10	2.12E-16	5.3E-12	0.03822
0.07	0.3160	0.003165	0.012875	-10.00000	0.000644	0.07	-6.1E+07	1.6E+10	6.87E-16	1.7E-11	0.04459
0.08	0.3150	0.003155	0.016030	-10.00000	0.000801	0.08	-2.0E+07	4.1E+09	3.30E-15	8.3E-11	0.05096
0.09	0.3140	0.003145	0.019175	-10.00000	0.000959	0.09	-7584644	1.3E+09	1.28E-14	3.2E-10	0.05733
0.10	0.3130	0.003135	0.022310	-10.00000	0.001115	0.10	-3173619	4.4E+08	4.21E-14	1.1E-09	0.0637
0.11	0.3120	0.003125	0.025435	-10.00000	0.001272	0.11	-1442998	1.7E+08	1.22E-13	3.1E-09	0.07007
0.12	0.3100	0.003110	0.028545	-5.00000	0.002854	0.12	-702710	7.4E+07	6.43E-13	1.6E-08	0.07644
0.13	0.3090	0.003095	0.031640	-10.00000	0.001582	0.13	-362497	3.4E+07	7.75E-13	1.9E-08	0.08281
0.14	0.3080	0.003085	0.034725	-10.00000	0.001736	0.14	-196396	1.7E+07	1.74E-12	4.4E-08	0.08918
0.15	0.3070	0.003075	0.037800	-10.00000	0.001890	0.15	-110995	8540029.91	3.69E-12	9.2E-08	0.09555
0.16	0.3060	0.003065	0.040865	-10.00000	0.002043	0.16	-65078.1	4591731.42	7.42E-12	1.9E-07	0.10192
0.17	0.3045	0.003053	0.043918	-6.66667	0.003294	0.17	-39405.5	2567261.05	2.14E-11	5.4E-07	0.10829
0.18	0.3030	0.003037	0.046955	-6.66667	0.003522	0.18	-24548.6	1485684.32	3.95E-11	9.9E-07	0.11466
0.19	0.3000	0.003015	0.049970	-3.33333	0.007495	0.19	-15683.7	886491.26	1.41E-10	3.5E-06	0.12103
0.20	0.2970	0.002985	0.052955	-3.33333	0.007943	0.20	-10247.3	543640.94	2.44E-10	6.1E-06	0.1274
0.21	0.2930	0.002950	0.055905	-2.50000	0.011181	0.21	-6830.23	341707.46	5.45E-10	1.4E-05	0.13377
0.22	0.2880	0.002905	0.058810	-2.00000	0.014702	0.22	-4633.93	219630.47	1.12E-09	2.8E-05	0.14014
0.23	0.2840	0.002860	0.061670	-2.50000	0.012334	0.23	-3193.26	144066.76	1.43E-09	3.6E-05	0.14651
0.24	0.2770	0.002805	0.064475	-1.42857	0.022566	0.24	-2230.48	96278.33	3.91E-09	9.8E-05	0.15288
0.25	0.2700	0.002735	0.067210	-1.42857	0.023523	0.25	-1575.91	65456.57	5.99E-09	1.5E-04	0.15925
0.26	0.2540	0.002620	0.069830	-0.62500	0.055864	0.26	-1123.75	45216.65	2.06E-08	5.2E-04	0.16562
0.27	0.2400	0.002470	0.072300	-0.71429	0.050610	0.27	-806.708	31703.76	2.66E-08	6.7E-04	0.17199
0.28	0.2220	0.002310	0.074610	-0.55556	0.067149	0.28	-581.273	22543.47	4.96E-08	1.2E-03	0.17836
0.29	0.2050	0.002135	0.076745	-0.58824	0.065233	0.29	-418.813	16245.99	6.69E-08	1.7E-03	0.18473
0.30	0.1800	0.001925	0.078670	-0.40000	0.098337	0.30	-300.207	11860.59	1.38E-07	3.5E-03	0.1911
0.31	0.1630	0.001715	0.080385	-0.58824	0.068327	0.31	-194.989	10521.88	1.08E-07	2.7E-03	0.19747
0.32	0.1380	0.001505	0.081890	-0.40000	0.102363	0.32	-146.77	4821.89	3.54E-07	8.9E-03	0.20384
0.33	0.1200	0.001290	0.083180	-0.55556	0.074862	0.33	-96.7992	4997.05	2.50E-07	6.3E-03	0.21021
0.34	0.0920	0.001060	0.084240	-0.35714	0.117936	0.34	-58.1304	3866.88	5.08E-07	1.3E-02	0.21658
0.35	0.0650	0.000785	0.085025	-0.37037	0.114784	0.35	-27.3814	3074.90	6.22E-07	1.6E-02	0.22295
0.36	0.0294	0.000472	0.085497	-0.28090	0.152185	0.36	-0.52607	2685.53	9.44E-07	2.4E-02	0.22932
0.36	0.0000	0.000147	0.085644	-0.02381	1.798524	0.36	0.000	751.52	3.99E-05	1.0E+00	0.229766

TABLE C-6

RECHARGE STUDY, ROCKY FLATS PLANT SITE
ANALYSIS OF BRUCE-KLUTE TEST DATA
BOREHOLE 02393, 2.0-4.0 FT.

	Diffusivity Calculations						Hydraulic Conductivity Calculations				
Moisture Content (cm^3/cm^3)	Boltzmann ($cm/min^{1/2}$)	Area at Point	Cumulative Area Under Curve	Slope of Curve at Point	Diffusivity (cm^2/min)	Moisture Content (cm^3/cm^3)	Matric Potential (cm)	Slope of Curve at Point	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity	Corrected Moisture Content (cm^3/cm^3)
0.03	0.3266	--	--	--	--	0.03	-2.7E+10	--	--	--	0.01842
0.04	0.3025	0.003146	0.003146	-0.41494	0.003790	0.04	-2.1E+09	2.5E+12	2.52E-17	2.52E-12	0.02456
0.05	0.2905	0.002965	0.006111	-0.83333	0.003666	0.05	-2.9E+08	1.8E+11	3.37E-16	3.37E-11	0.0307
0.06	0.2900	0.002903	0.009013	-20.00000	0.000225	0.06	-5.7E+07	2.3E+10	1.62E-16	1.62E-11	0.03684
0.07	0.2865	0.002883	0.011896	-2.85714	0.002082	0.07	-1.5E+07	4.3E+09	8.13E-15	8.13E-10	0.04298
0.08	0.2858	0.002862	0.014757	-14.28571	0.000516	0.08	-4429780	1.0E+09	8.53E-15	8.53E-10	0.04912
0.09	0.2800	0.002829	0.017586	-1.72414	0.005100	0.09	-1554405	2.9E+08	2.96E-13	2.96E-08	0.05526
0.10	0.2785	0.002793	0.020379	-6.66667	0.001528	0.10	-609135	9.5E+07	2.69E-13	2.69E-08	0.0614
0.11	0.2765	0.002775	0.023154	-5.00000	0.002315	0.11	-261016	3.5E+07	1.11E-12	1.11E-07	0.06754
0.12	0.2740	0.002753	0.025906	-4.00000	0.003238	0.12	-120409	1.4E+07	3.84E-12	3.84E-07	0.07368
0.13	0.2720	0.002730	0.028636	-5.00000	0.002864	0.13	-59093.2	6131534.52	7.78E-12	7.78E-07	0.07982
0.14	0.2690	0.002705	0.031341	-3.33333	0.004701	0.14	-30570.2	2852296.05	2.75E-11	2.75E-06	0.08596
0.15	0.2675	0.002683	0.034024	-6.66667	0.002552	0.15	-16548.1	1402214.02	3.03E-11	3.03E-06	0.0921
0.16	0.2650	0.002663	0.036686	-4.00000	0.004586	0.16	-9317.24	723084.71	1.06E-10	1.06E-05	0.09824
0.17	0.2630	0.002640	0.039326	-5.00000	0.003933	0.17	-5429.47	388777.18	1.69E-10	1.69E-05	0.10438
0.18	0.2600	0.002615	0.041941	-3.33333	0.006291	0.18	-3260.74	216872.39	4.83E-10	4.83E-05	0.11052
0.19	0.2575	0.002588	0.044529	-4.00000	0.005566	0.19	-2010.7	125004.05	7.42E-10	7.42E-05	0.11666
0.20	0.2540	0.002558	0.047086	-2.85714	0.008240	0.20	-1268.75	74195.63	1.85E-09	1.85E-04	0.1228
0.21	0.2500	0.002520	0.049606	-2.50000	0.009921	0.21	-816.554	45219.33	3.66E-09	3.66E-04	0.12894
0.22	0.2449	0.002475	0.052081	-1.96078	0.013281	0.22	-534.249	28230.49	7.84E-09	7.84E-04	0.13508
0.23	0.2390	0.002420	0.054500	-1.69492	0.016077	0.23	-354.075	18017.35	1.49E-08	1.49E-03	0.14122
0.24	0.2300	0.002345	0.056845	-1.11111	0.025580	0.24	-236.713	11736.21	3.63E-08	3.63E-03	0.14736
0.25	0.2200	0.002250	0.059095	-1.00000	0.029548	0.25	-158.789	7792.38	6.32E-08	6.32E-03	0.1535
0.26	0.2100	0.002150	0.061245	-1.00000	0.030623	0.26	-106.1	5268.97	9.69E-08	9.69E-03	0.15964
0.27	0.2000	0.002050	0.063295	-1.00000	0.031647	0.27	-69.832	3626.76	1.45E-07	1.45E-02	0.16578
0.28	0.1800	0.001900	0.065195	-0.50000	0.065195	0.28	-44.4099	2542.21	4.27E-07	4.27E-02	0.17192
0.29	0.1570	0.001685	0.066880	-0.43478	0.076912	0.29	-26.2275	1818.24	7.05E-07	7.05E-02	0.17806
0.30	0.1200	0.001385	0.068265	-0.27027	0.126290	0.30	-12.8738	1335.37	1.58E-06	1.58E-01	0.1842
0.31	0.0600	0.000900	0.069165	-0.16667	0.207495	0.31	-3.47	940.38	3.68E-06	3.68E-01	0.19034
0.3125	0.0000	0.000300	0.069465	-0.04167	0.833580	0.31	0	1388.00	1.00E-05	1.00E+00	0.191875

TABLE C-8

RECHARGE STUDY, ROCKY FLATS PLANT SITE
ANALYSIS OF BRUCE-KLUTE TEST DATA
BOREHOLE 02993, 7.9-9.9 FT.

	Diffusivity Calculations						Hydraulic Conductivity Calculations				
Moisture Content (cm^3/cm^3)	Boltzmann ($cm/min^{1/2}$)	Area at Point	Cumulative Area Under Curve	Slope of Curve at Point	Diffusivity (cm^2/min)	Moisture Content (cm^3/cm^3)	Matric Potential (cm)	Slope of Curve at Point	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity	Corrected Moisture Content (cm^3/cm^3)
0.03	0.9300	--	--	--	--	0.03	-2586555	--	--	--	0.02118
0.04	0.9120	0.009210	0.009210	-0.55556	0.008289	0.04	-535597	2.1E+08	6.74E-13	6.5E-10	0.02824
0.05	0.9020	0.009070	0.018280	-1.00000	0.009140	0.05	-157898	3.8E+07	4.03E-12	3.9E-09	0.0353
0.06	0.8930	0.008975	0.027255	-1.11111	0.012265	0.06	-58204.3	1.0E+07	2.05E-11	2.0E-08	0.04236
0.07	0.8870	0.008900	0.036155	-1.66667	0.010847	0.07	-25032.2	3.3E+06	5.45E-11	5.3E-08	0.04942
0.08	0.8800	0.008835	0.044990	-1.42857	0.015746	0.08	-12051.8	1.3E+06	2.02E-10	2.0E-07	0.05648
0.09	0.8750	0.008775	0.053765	-2.00000	0.013441	0.09	-6324.54	5.7E+05	3.91E-10	3.8E-07	0.06354
0.10	0.8700	0.008725	0.062490	-2.00000	0.015622	0.10	-3552.34	2.8E+05	9.39E-10	9.1E-07	0.0706
0.11	0.8650	0.008675	0.071165	-2.00000	0.017791	0.11	-2107.93	1.4E+05	2.05E-09	2.0E-06	0.07766
0.12	0.8600	0.008625	0.079790	-2.00000	0.019947	0.12	-1308.79	8.0E+04	4.16E-09	4.0E-06	0.08472
0.13	0.8550	0.008575	0.088365	-2.00000	0.022091	0.13	-844.052	4.6E+04	7.92E-09	7.7E-06	0.09178
0.14	0.8490	0.008520	0.096885	-1.66667	0.029066	0.14	-562.161	2.8E+04	1.72E-08	1.7E-05	0.09884
0.15	0.8410	0.008450	0.105335	-1.25000	0.042134	0.15	-384.902	17725.91	3.96E-08	3.8E-05	0.1059
0.16	0.8380	0.008395	0.113730	-3.33333	0.017060	0.16	-269.903	11499.90	2.47E-08	2.4E-05	0.11296
0.17	0.8360	0.008370	0.122100	-5.00000	0.012210	0.17	-193.23	7667.34	2.65E-08	2.6E-05	0.12002
0.18	0.8300	0.008330	0.130430	-1.66667	0.039129	0.18	-140.861	5236.90	1.25E-07	1.2E-04	0.12708
0.19	0.8260	0.008280	0.138710	-2.50000	0.027742	0.19	-104.315	3654.58	1.27E-07	1.2E-04	0.13414
0.20	0.8200	0.008230	0.146940	-1.66667	0.044082	0.20	-78.3148	2600.02	2.83E-07	2.7E-04	0.1412
0.21	0.8150	0.008175	0.155115	-2.00000	0.038779	0.21	-59.4917	1882.31	3.43E-07	3.3E-04	0.14826
0.22	0.8100	0.008125	0.163240	-2.00000	0.040810	0.22	-45.6463	1384.54	4.91E-07	4.8E-04	0.15532
0.23	0.8050	0.008075	0.171315	-2.00000	0.042829	0.23	-35.3127	1033.36	6.91E-07	6.7E-04	0.16238
0.24	0.7980	0.008015	0.179330	-1.42857	0.062765	0.24	-27.4954	781.72	1.34E-06	1.3E-03	0.16944
0.25	0.7900	0.007940	0.187270	-1.25000	0.074908	0.25	-21.507	598.84	2.08E-06	2.0E-03	0.1765
0.26	0.7830	0.007865	0.195135	-1.42857	0.068297	0.26	-16.8649	464.21	2.45E-06	2.4E-03	0.18356
0.27	0.7760	0.007795	0.202930	-1.42857	0.071025	0.27	-13.2256	363.93	3.25E-06	3.2E-03	0.19062
0.28	0.7680	0.007720	0.210650	-1.25000	0.084260	0.28	-10.3412	288.45	4.87E-06	4.7E-03	0.19768
0.29	0.7590	0.007635	0.218285	-1.11111	0.098228	0.29	-8.03017	231.10	7.08E-06	6.9E-03	0.20474
0.30	0.7480	0.007535	0.225820	-0.90909	0.124201	0.30	-6.15827	187.19	1.11E-05	1.1E-02	0.2118
0.31	0.7320	0.007400	0.233220	-0.62500	0.186576	0.31	-4.29749	186.08	1.67E-05	1.6E-02	0.21886
0.32	0.6950	0.007135	0.240355	-0.27027	0.444657	0.32	-3.35084	94.67	7.83E-05	7.6E-02	0.22592
0.33	0.6200	0.006575	0.246930	-0.13333	0.925987	0.33	-2.27615	107.47	1.44E-04	1.4E-01	0.23298
0.34	0.4600	0.005400	0.252330	-0.06250	2.018640	0.34	-1.34695	92.92	3.62E-04	3.5E-01	0.24004
0.35	0.2400	0.003500	0.255830	-0.04545	2.814130	0.35	-0.50027	84.67	5.54E-04	5.4E-01	0.2471
0.36	0.0000	0.001200	0.257030	-0.04167	3.084360	0.36	0	50.03	1.03E-03	1.0E+00	0.25416

TABLE C-9

RECHARGE STUDY, ROCKY FLATS PLANT SITE
ANALYSIS OF BRUCE-KLUTE TEST DATA
BOREHOLE 02993, 19.4-21.5 FT.

	Diffusivity Calculations						Hydraulic Conductivity Calculations				
Moisture Content (cm^3/cm^3)	Boltzmann ($cm/min^{1/2}$)	Area at Point	Cumulative Area Under Curve	Slope of Curve at Point	Diffusivity (cm^2/min)	Moisture Content (cm^3/cm^3)	Matric Potential (cm)	Slope of Curve at Point	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity	Corrected Moisture Content (cm^3/cm^3)
0.03	1.0000	--	--	--	--	0.03	--	--	--	--	0.02955
0.04	0.9670	0.009835	0.009835	-0.30303	0.016228	0.04	--	--	--	--	0.0394
0.05	0.9370	0.009520	0.019355	-0.33333	0.029033	0.05	--	--	--	--	0.04925
0.06	0.9200	0.009285	0.028640	-0.58824	0.024344	0.06	-7.8E+23	--	--	--	0.0591
0.07	0.9060	0.009130	0.037770	-0.71429	0.026439	0.07	-1.5E+17	7.8E+25	5.64E-30	2.7E-27	0.06895
0.08	0.8950	0.009005	0.046775	-0.90909	0.025726	0.08	-2.5E+14	1.5E+19	2.94E-23	1.4E-20	0.0788
0.09	0.8850	0.008900	0.055675	-1.00000	0.027837	0.09	-4.3E+12	2.5E+16	1.87E-20	9.0E-18	0.08865
0.10	0.8800	0.008825	0.064500	-2.00000	0.016125	0.10	-2.1E+11	4.1E+14	6.57E-19	3.2E-16	0.0985
0.11	0.8750	0.008775	0.073275	-2.00000	0.018319	0.11	-2.0E+10	1.9E+13	1.57E-17	7.5E-15	0.10835
0.12	0.8710	0.008730	0.082005	-2.50000	0.016401	0.12	-2.8E+09	1.7E+12	1.59E-16	7.6E-14	0.1182
0.13	0.8670	0.008690	0.090695	-2.50000	0.018139	0.13	-5.2E+08	2.3E+11	1.33E-15	6.4E-13	0.12805
0.14	0.8610	0.008640	0.099335	-1.66667	0.029801	0.14	-1.2E+08	4.0E+10	1.24E-14	6.0E-12	0.1379
0.15	0.8550	0.008580	0.107915	-1.66667	0.032374	0.15	-3.3E+07	8.8E+09	6.15E-14	3.0E-11	0.14775
0.16	0.8490	0.008520	0.116435	-1.66667	0.034931	0.16	-1.0E+07	2.3E+09	2.57E-13	1.2E-10	0.1576
0.17	0.8410	0.008450	0.124885	-1.25000	0.049954	0.17	-3562509	6.7E+08	1.24E-12	6.0E-10	0.16745
0.18	0.8330	0.008370	0.133255	-1.25000	0.053302	0.18	-1351694	2.2E+08	4.02E-12	1.9E-09	0.1773
0.19	0.8250	0.008290	0.141545	-1.25000	0.056618	0.19	-553079	8.0E+07	1.18E-11	5.7E-09	0.18715
0.20	0.8150	0.008200	0.149745	-1.00000	0.074872	0.20	-241401	3.1E+07	4.00E-11	1.9E-08	0.197
0.21	0.8050	0.008100	0.157845	-1.00000	0.078923	0.21	-111417	1.3E+07	1.01E-10	4.9E-08	0.20685
0.22	0.7950	0.008000	0.165845	-1.00000	0.082922	0.22	-53994.7	5742219.10	2.41E-10	1.2E-07	0.2167
0.23	0.7810	0.007880	0.173725	-0.71429	0.121608	0.23	-27315.7	2667906.62	7.60E-10	3.7E-07	0.22655
0.24	0.7700	0.007755	0.181480	-0.90909	0.099814	0.24	-14355.6	1296011.25	1.28E-09	6.2E-07	0.2364
0.25	0.7550	0.007625	0.189105	-0.66667	0.141829	0.25	-7805.21	655034.62	3.61E-09	1.7E-06	0.24625
0.26	0.7400	0.007475	0.196580	-0.66667	0.147435	0.26	-4374.82	343039.02	7.16E-09	3.4E-06	0.2561
0.27	0.7250	0.007325	0.203905	-0.66667	0.152929	0.27	-2519.91	185491.23	1.37E-08	6.6E-06	0.26595
0.28	0.7090	0.007170	0.211075	-0.62500	0.168860	0.28	-1487.38	103252.67	2.73E-08	1.3E-05	0.2758
0.29	0.6900	0.006995	0.218070	-0.52632	0.207167	0.29	-897.236	59014.37	5.85E-08	2.8E-05	0.28565
0.30	0.6690	0.006795	0.224865	-0.47619	0.236108	0.30	-551.672	34556.40	1.14E-07	5.5E-05	0.2955
0.31	0.6430	0.006560	0.231425	-0.38462	0.300853	0.31	-308.618	24305.47	2.06E-07	9.9E-05	0.30535
0.32	0.6200	0.006315	0.237740	-0.43478	0.273401	0.32	-218.284	9033.39	5.04E-07	2.4E-04	0.3152
0.33	0.5950	0.006075	0.243815	-0.40000	0.304769	0.33	-139.466	7881.81	6.44E-07	3.1E-04	0.32505
0.34	0.5700	0.005825	0.249640	-0.40000	0.312050	0.34	-89.4457	5002.01	1.04E-06	5.0E-04	0.3349
0.35	0.5350	0.005525	0.255165	-0.28571	0.446539	0.35	-57.1438	3230.19	2.30E-06	1.1E-03	0.34475
0.36	0.5030	0.005190	0.260355	-0.31250	0.416568	0.36	-35.9251	2121.87	3.27E-06	1.6E-03	0.3546
0.37	0.4700	0.004865	0.265220	-0.30303	0.437613	0.37	-21.7423	1418.28	5.14E-06	2.5E-03	0.36445
0.38	0.4150	0.004425	0.269645	-0.18182	0.741524	0.38	-12.0788	966.35	1.28E-05	6.1E-03	0.3743
0.39	0.3600	0.003875	0.273520	-0.18182	0.752180	0.39	-5.32494	675.39	1.86E-05	8.9E-03	0.38415
0.40	0.2580	0.003090	0.276610	-0.09804	1.410711	0.40	-0.2866	503.83	4.67E-05	2.2E-02	0.394
0.4006	0.0000	0.001290	0.277900	-0.00233	59.748500	0.4006	0	477.67	2.08E-03	1.0E+00	

TABLE C-10

RECHARGE STUDY, ROCKY FLATS PLANT SITE
ANALYSIS OF BRUCE-KLUTE TEST DATA
BOREHOLE 02993, 17.0-18.0 FT.

	Diffusivity Calculations						Hydraulic Conductivity Calculations				
Moisture Content (cm^3/cm^3)	Boltzmann ($cm/min^{1/2}$)	Area at Point	Cumulative Area Under Curve	Slope of Curve at Point	Diffusivity (cm^2/min)	Moisture Content (cm^3/cm^3)	Matric Potential (cm)	Slope of Curve at Point	Hydraulic Conductivity (cm/sec)	Relative Hydraulic Conductivity	Corrected Moisture Content (cm^3/cm^3)
0.03	0.2970	--	--	--	--	0.03	-2.8E+19	--	--	--	0.02946
0.04	0.2780	0.002875	0.002875	-0.52632	0.002731	0.04	-3.7E+17	2.8E+21	1.63E-26	3.0E-21	0.03928
0.05	0.2610	0.002695	0.005570	-0.58824	0.004734	0.05	-1.3E+16	3.5E+19	2.23E-24	4.2E-19	0.0491
0.06	0.2540	0.002575	0.008145	-1.42857	0.002851	0.06	-7.9E+14	1.2E+18	4.05E-23	7.5E-18	0.05892
0.07	0.2470	0.002505	0.010650	-1.42857	0.003727	0.07	-7.7E+13	7.2E+16	8.66E-22	1.6E-16	0.06874
0.08	0.2410	0.002440	0.013090	-1.66667	0.003927	0.08	-1.0E+13	6.7E+15	9.78E-21	1.8E-15	0.07856
0.09	0.2350	0.002380	0.015470	-1.66667	0.004641	0.09	-1.7E+12	8.5E+14	9.08E-20	1.7E-14	0.08838
0.10	0.2300	0.002325	0.017795	-2.00000	0.004449	0.10	-3.5E+11	1.4E+14	5.39E-19	1.0E-13	0.0982
0.11	0.2260	0.002280	0.020075	-2.50000	0.004015	0.11	-8.3E+10	2.7E+13	2.50E-18	4.6E-13	0.10802
0.12	0.2220	0.002240	0.022315	-2.50000	0.004463	0.12	-2.2E+10	6.1E+12	1.23E-17	2.3E-12	0.11784
0.13	0.2200	0.002210	0.024525	-5.00000	0.002453	0.13	-6.6E+09	1.6E+12	2.62E-17	4.9E-12	0.12766
0.14	0.2185	0.002193	0.026718	-6.66667	0.002004	0.14	-2.2E+09	4.5E+11	7.47E-17	1.4E-11	0.13748
0.15	0.2165	0.002175	0.028893	-5.00000	0.002889	0.15	-7.6E+08	1.4E+11	3.44E-16	6.4E-11	0.1473
0.16	0.2150	0.002158	0.031050	-6.66667	0.002329	0.16	-2.9E+08	4.7E+10	8.18E-16	1.5E-10	0.15712
0.17	0.2130	0.002140	0.033190	-5.00000	0.003319	0.17	-1.1E+08	1.7E+10	3.21E-15	6.0E-10	0.16694
0.18	0.2115	0.002123	0.035313	-6.66667	0.002648	0.18	-4.8E+07	6.6E+09	6.65E-15	1.2E-09	0.17676
0.19	0.2090	0.002103	0.037415	-4.00000	0.004677	0.19	-2.1E+07	2.7E+09	2.89E-14	5.4E-09	0.18658
0.20	0.2070	0.002080	0.039495	-5.00000	0.003950	0.20	-9817094	1.2E+09	5.72E-14	1.1E-08	0.1964
0.21	0.2055	0.002063	0.041558	-6.66667	0.003117	0.21	-4693666	5.1E+08	1.01E-13	1.9E-08	0.20622
0.22	0.2035	0.002045	0.043603	-5.00000	0.004360	0.22	-2322472	2.4E+08	3.06E-13	5.7E-08	0.21604
0.23	0.2015	0.002025	0.045628	-5.00000	0.004563	0.23	-1185686	1.1E+08	6.69E-13	1.2E-07	0.22586
0.24	0.1990	0.002003	0.047630	-4.00000	0.005954	0.24	-622888	5.6E+07	1.76E-12	3.3E-07	0.23568
0.25	0.1965	0.001978	0.049608	-4.00000	0.006201	0.25	-335931	2.9E+07	3.60E-12	6.7E-07	0.2455
0.26	0.1945	0.001955	0.051563	-5.00000	0.005156	0.26	-185602	1.5E+07	5.72E-12	1.1E-06	0.25532
0.27	0.1910	0.001928	0.053490	-2.85714	0.009361	0.27	-104858	8.1E+06	1.93E-11	3.6E-06	0.26514
0.28	0.1890	0.001900	0.055390	-5.00000	0.005539	0.28	-60473.1	4.4E+06	2.08E-11	3.9E-06	0.27496
0.29	0.1860	0.001875	0.057265	-3.33333	0.008590	0.29	-35546	2.5E+06	5.74E-11	1.1E-05	0.28478
0.30	0.1830	0.001845	0.059110	-3.33333	0.008866	0.30	-21263.8	1.4E+06	1.03E-10	1.9E-05	0.2946
0.31	0.1800	0.001815	0.060925	-3.33333	0.009139	0.31	-11496.7	9.8E+05	1.56E-10	2.9E-05	0.30442
0.32	0.1770	0.001785	0.062710	-3.33333	0.009407	0.32	-7973.81	3.5E+05	4.45E-10	8.3E-05	0.31424
0.33	0.1735	0.001753	0.064463	-2.85714	0.011281	0.33	-4982.94	3.0E+05	6.29E-10	1.2E-04	0.32406
0.34	0.1700	0.001718	0.066180	-2.85714	0.011582	0.34	-3148.62	1.8E+05	1.05E-09	2.0E-04	0.33388
0.35	0.1670	0.001685	0.067865	-3.33333	0.010180	0.35	-2007.01	1.1E+05	1.49E-09	2.8E-04	0.3437
0.36	0.1625	0.001648	0.069513	-2.22222	0.015640	0.36	-1286.53	7.2E+04	3.62E-09	6.7E-04	0.35352
0.37	0.1580	0.001603	0.071115	-2.22222	0.016001	0.37	-825.694	4.6E+04	5.79E-09	1.1E-03	0.36334
0.38	0.1540	0.001560	0.072675	-2.50000	0.014535	0.38	-527.079	3.0E+04	8.11E-09	1.5E-03	0.37316
0.39	0.1470	0.001505	0.074180	-1.42857	0.025963	0.39	-331.07	2.0E+04	2.21E-08	4.1E-03	0.38298
0.40	0.1400	0.001435	0.075615	-1.42857	0.026465	0.40	-200.704	1.3E+04	3.38E-08	6.3E-03	0.3928
0.41	0.1300	0.001350	0.076965	-1.00000	0.038483	0.41	-112.737	8.8E+03	7.29E-08	1.4E-02	0.40262
0.42	0.1150	0.001225	0.078190	-0.66667	0.058643	0.42	-52.2792	6.0E+03	1.62E-07	3.0E-02	0.41244
0.43	0.0745	0.000948	0.079138	-0.24691	0.160253	0.43	-9.16928	4.3E+03	6.20E-07	1.2E-01	0.42226
0.4329	0.0000	0.000373	0.079510	-0.03893	1.021292	0.4329	0	3.2E+03	5.38E-06	1.0E+00	0.425108

APPENDIX D

HYDROPROBE CALIBRATION RESULTS

Appendix D-1

Site 1 - PVC Casing and Aluminum Casing

TABLE D - 1

Hydroprobe Calibration at Site 1 - with Outliers

Site 1 All Casing Types							
Sample No.	Liner No.	Hole No./ Casing Type	Sample Interval (ft.)	Probe Notch No.	Probe Notch Lct'n. (ft.)	Volumetric Moisture Content %	Initial Hydroprobe Count
1-1	na	02393/pvc	1.9-3.9	na			
ATT-1	na	02393/pvc	2.0-4.0				
1-3	9	02393/pvc	3.9-4.4	7	4.2	13.71	4768
ATT-2		02393/pvc	4.4-4.9		4.6	13.03	4592
ATT-2		02393/pvc	4.9-5.4		5.1	24.58	4262
1-4	12	02393/pvc	5.4-5.9	10	5.6	9.49	4538
ATT-3		02693/pvc	8.4-8.9		8.8	24.58	6002
1-5	24	02393/pvc	9.4-9.9	18		19.81	
1-2	7	02293/alum	2.9-3.4	5	3	9.98	6933
1-6	11	02493/alum	4.9-5.4	6	5.2	12.04	7201
1-7	15	02493/alum	5.9-6.4	8	6.2	6.02	6672
1-8	20	02493/alum	8.9-9.4	13/14	8.8	25.97	10047

Regression Output: Site 1 PVC Casing	
Constant	-3.6983
Std Err of Y Est	7.3896
R Squared	0.1721
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	0.004299
Std Err of Coef.	0.005445

Regression Output: Site 1 Alum. Casing	
Constant	-28.5817
Std Err of Y Est	1.6778
R Squared	0.9751
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	0.0054561
Std Err of Coef.	0.0006167

C:\RFP\RECHARGE\ANALYSIS\CALBDATA.WK3 (worksheet B:)

TABLE D - 2

Hydroprobe Calibration at Site 1 - without Outliers

Site 1							
PVC (3.5 in. O.D.)							
Sample No.	Liner No.	Hole No./ Casing Type	Sample Interval (ft.)	Probe Notch No.	Probe Notch Lct'n. (ft.)	Volumetric Moisture Content %	Init. Probe Count
1-1	na	02393/pvc	1.9-3.9	na			
ATT-1	na	02393/pvc	2.0-4.0				
1-3	9	02393/pvc	3.9-4.4	7	4.2	13.71	4768
ATT-2		02393/pvc	4.4-4.9		4.6	13.03	4592
1-4	12	02393/pvc	5.4-5.9	10	5.6	9.49	4538
ATT-3		02693/pvc	8.4-8.9		8.8	24.58	6002
1-5	24	02393/pvc	9.4-9.9	18		19.81	

Regression Output:		
Constant		-30.78899
Std Err of Y Est		1.5589287
R Squared		0.9618835
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	0.009245	
Std Err of Coef.	0.001301	

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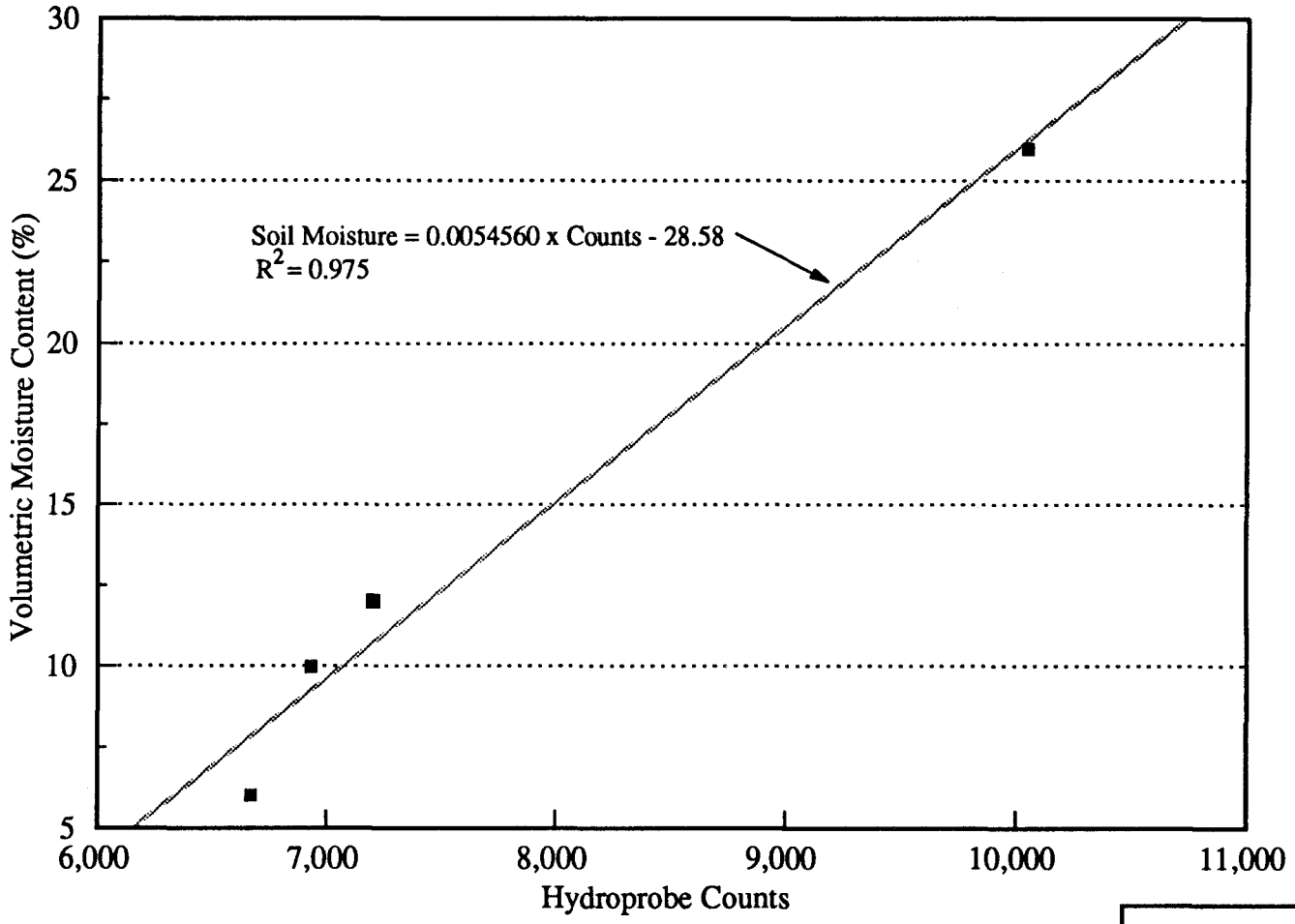

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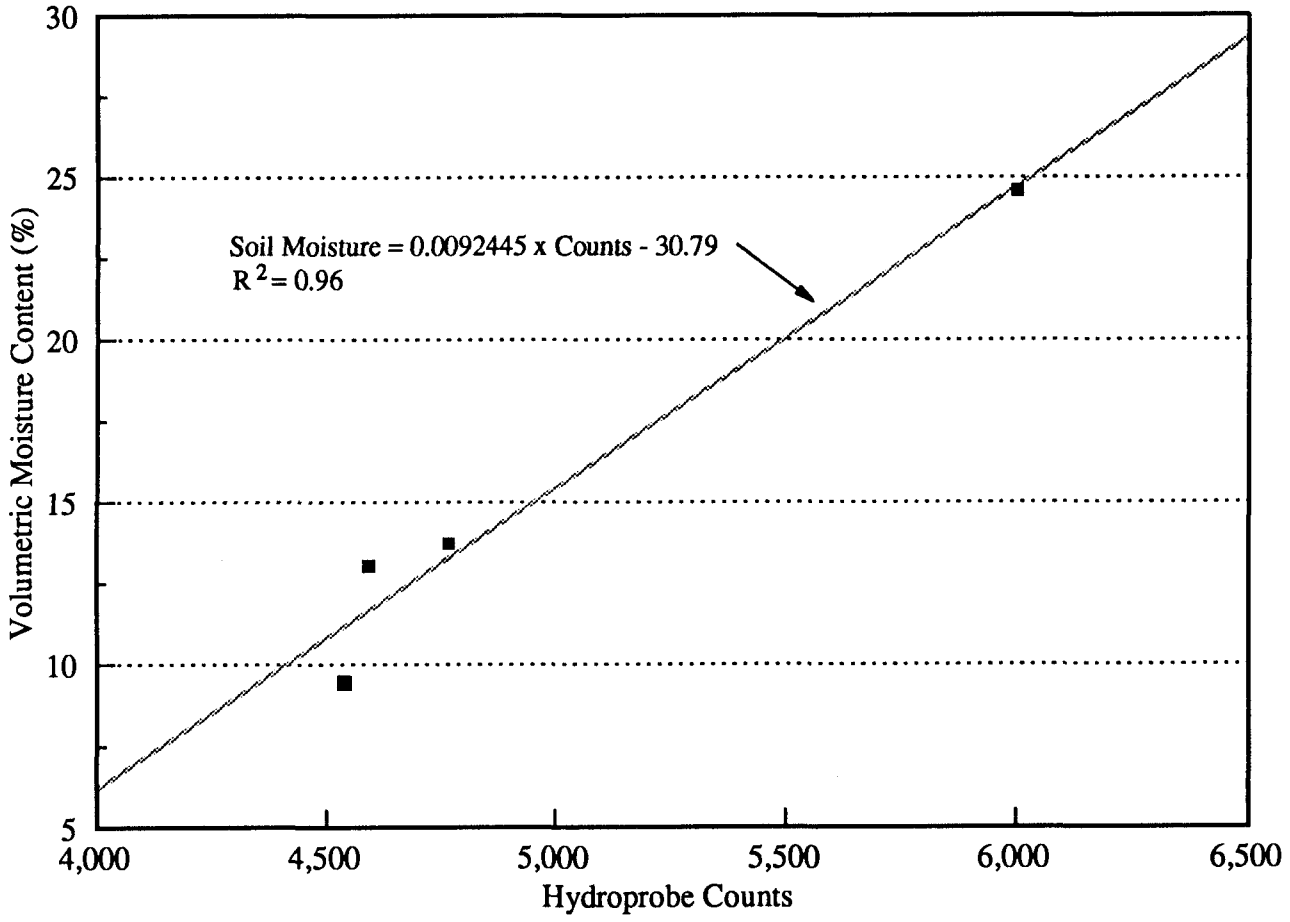
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Hydroprobe Calibration
Site 1 - Aluminum Casing
No Outliers Deleted

FIGURE D-1 OCTOBER 1993

ALCALCV1.DRW

Status: 10/27/93



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GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Hydroprobe Calibration
Site 1 - PVC Casing
Without Outlier

FIGURE D-2 OCTOBER 1993

PVCALCV1.DRW

Status: 10/27/93

Appendix D-2

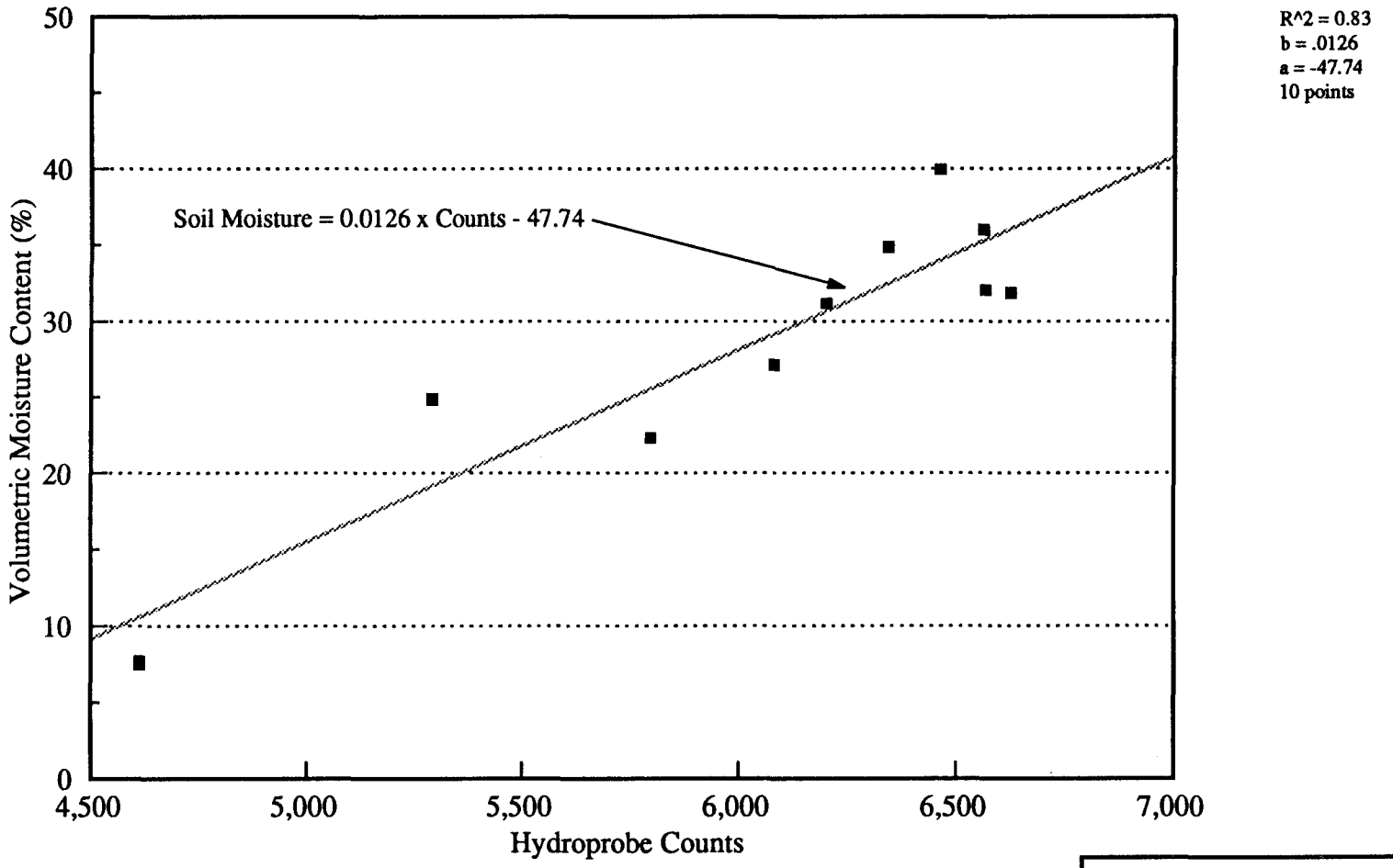
Site 2 - PVC Casing

TABLE D - 3

Hydroprobe Calibration at Borehole 02993 with Outliers

Site 2 PVC (3 O.D.)						
Sample No.	Liner Number	Sample Interval (ft.)	Probe Notch Number	Probe Notch Lct'n. (ft.)	Volumetric Moisture Content %	Hydrorobe Count 6/28 (avg.)
02993						
2-1	3	1.0-1.5	3	1.3	31.18	6200
2-2	10	4.4-4.9	10	4.7	22.33	5797
2-3	28	11.4-11.9	22&23	11.2/12.2	7.72	4614
2-4	32	13.4-13.9	24&25	13.2/14.2	24.92	5289
2-5	34	14.4-14.9	25&26	14.2/15.2	27.13	6080
2-6	38	16.5-17.0	27&28	16.2/17.2	32.04	6568
ATT-6		17.0-17.5		17.1	35.95	6562
ATT-6		17.5-18.0		18.2	39.94	6461
2-7	42	18.4-18.9	29&30	18.3/19.3	34.85	6342
2-9	51	22.9-23.4	34	23.3	31.87	6627

Regression Output: All data (incl. ATT)	
Constant	-47.7441
Std Err of Y Est	3.9807
R Squared	0.8290
No. of Observations	10
Degrees of Freedom	8
X Coefficient(s)	0.012642
Std Err of Coef.	0.00203



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GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Hydroprobe Calibration
Site 2 - 02993
With Outliers

FIGURE D-3 OCTOBER 1993

CALC2ALL.DRW

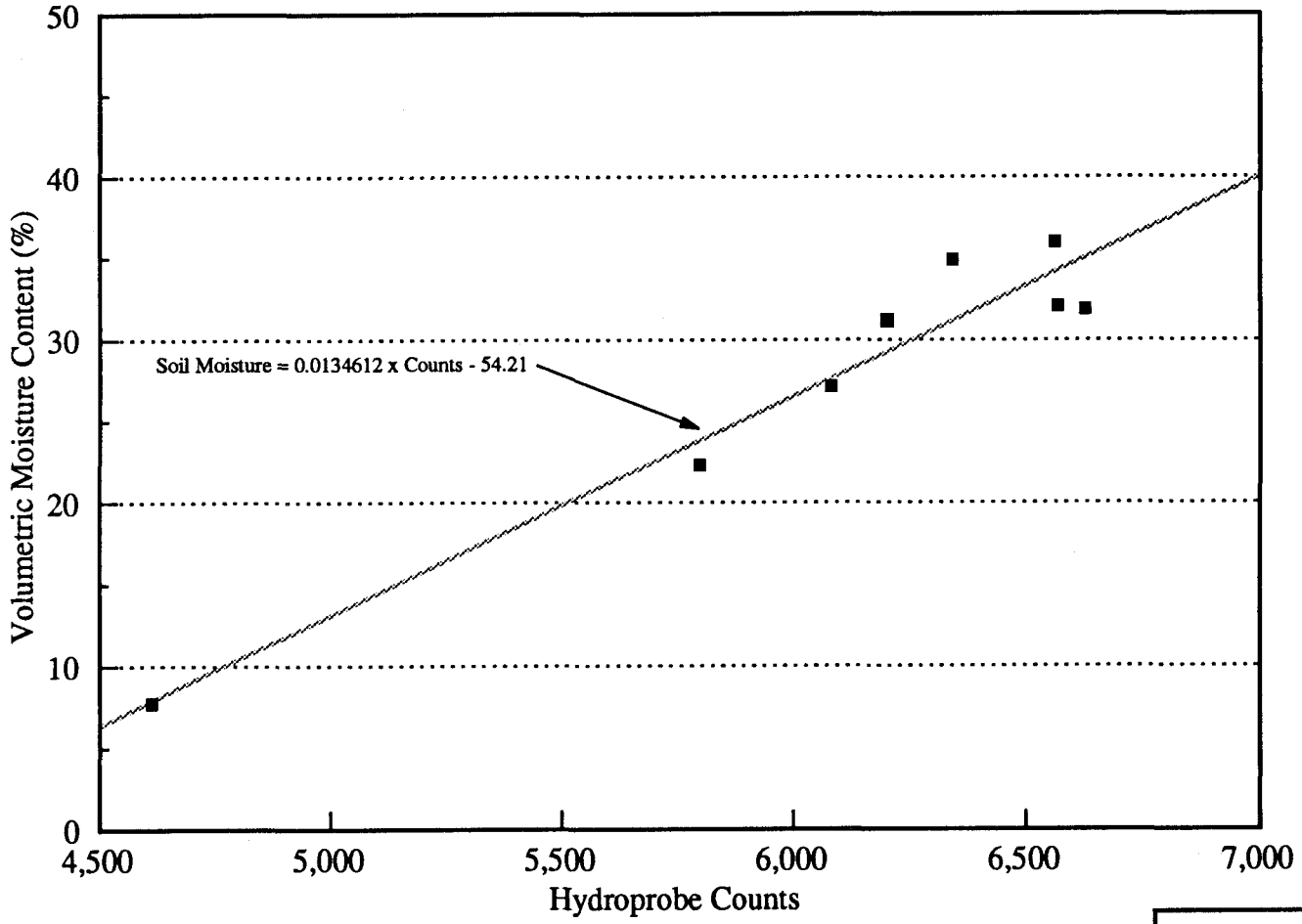
Status: 10/27/93

TABLE D - 4

Hydroprobe Calibration at Borehole 02993 without Outliers

Site 2 PVC (3 O.D.)						
Sample No.	Liner Number	Sample Interval (ft.)	Probe Notch Number	Probe Notch Lct'n. (ft.)	Volumetric Moisture Content %	Hydrorobe Count 6/28 (avg.)
02993						
2-1	3	1.0-1.5	3	1.3	31.18	6200
2-2	10	4.4-4.9	10	4.7	22.33	5797
2-3	28	11.4-11.9	22&23	11.2/12.2	7.72	4614
2-5	34	14.4-14.9	25&26	14.2/15.2	27.13	6080
2-6	38	16.5-17.0	27&28	16.2/17.2	32.04	6568
ATT-6		17.0-17.5		17.1	35.95	6562
2-7	42	18.4-18.9	29&30	18.3/19.3	34.85	6342
2-9	51	22.9-23.4	34	23.3	31.87	6627

Regression Output:		
Constant		-54.2128
Std Err of Y Est		2.5052
R Squared		0.9368
No. of Observations		8
Degrees of Freedom		6
X Coefficient(s)	0.013461	
Std Err of Coef.	0.001428	



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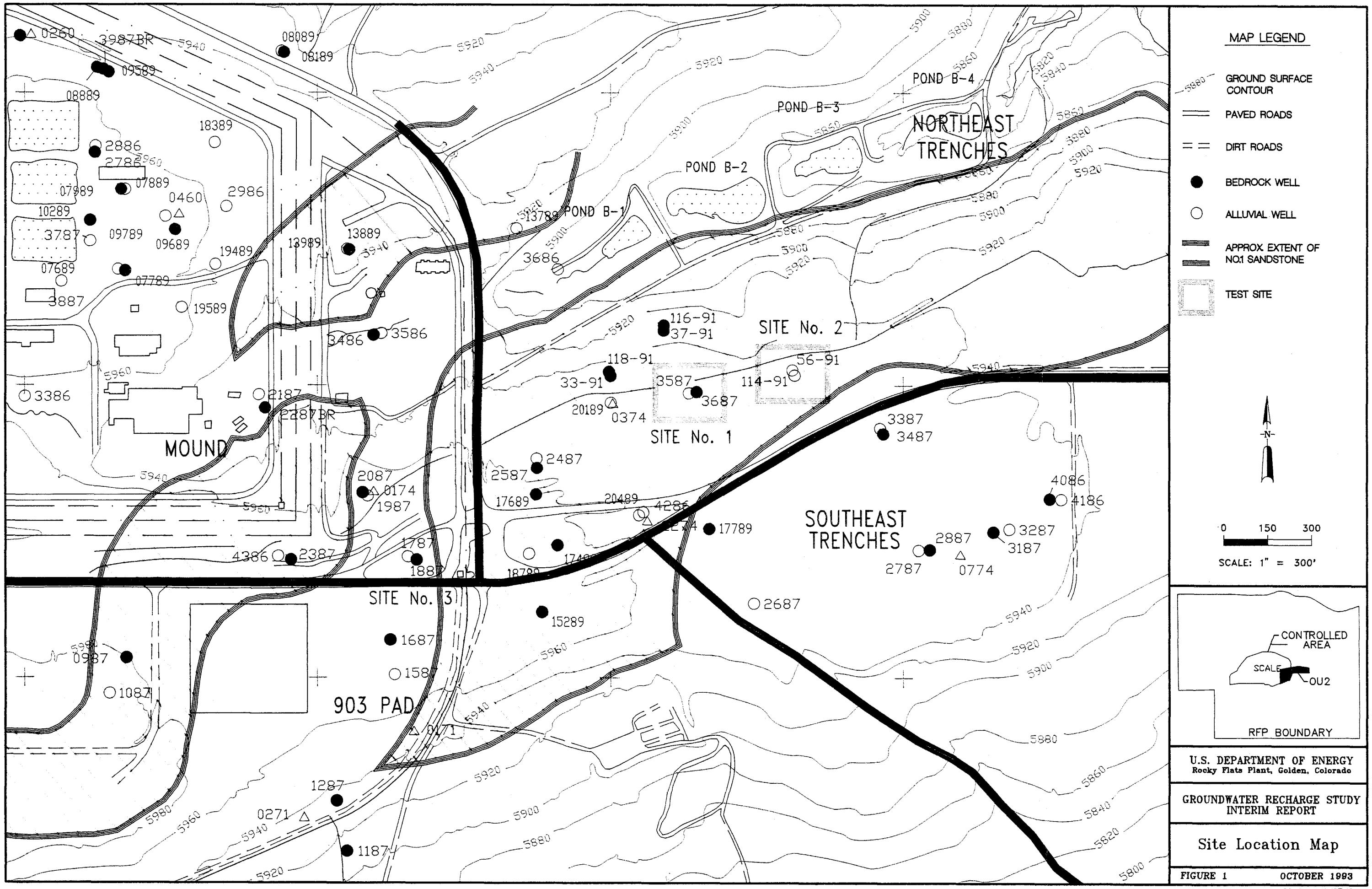
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Hydroprobe Calibration
Site 2 - 02993
Without Outliers

FIGURE D-4 OCTOBER 1993

CALCURV2.DRW

Status: 10/27/93



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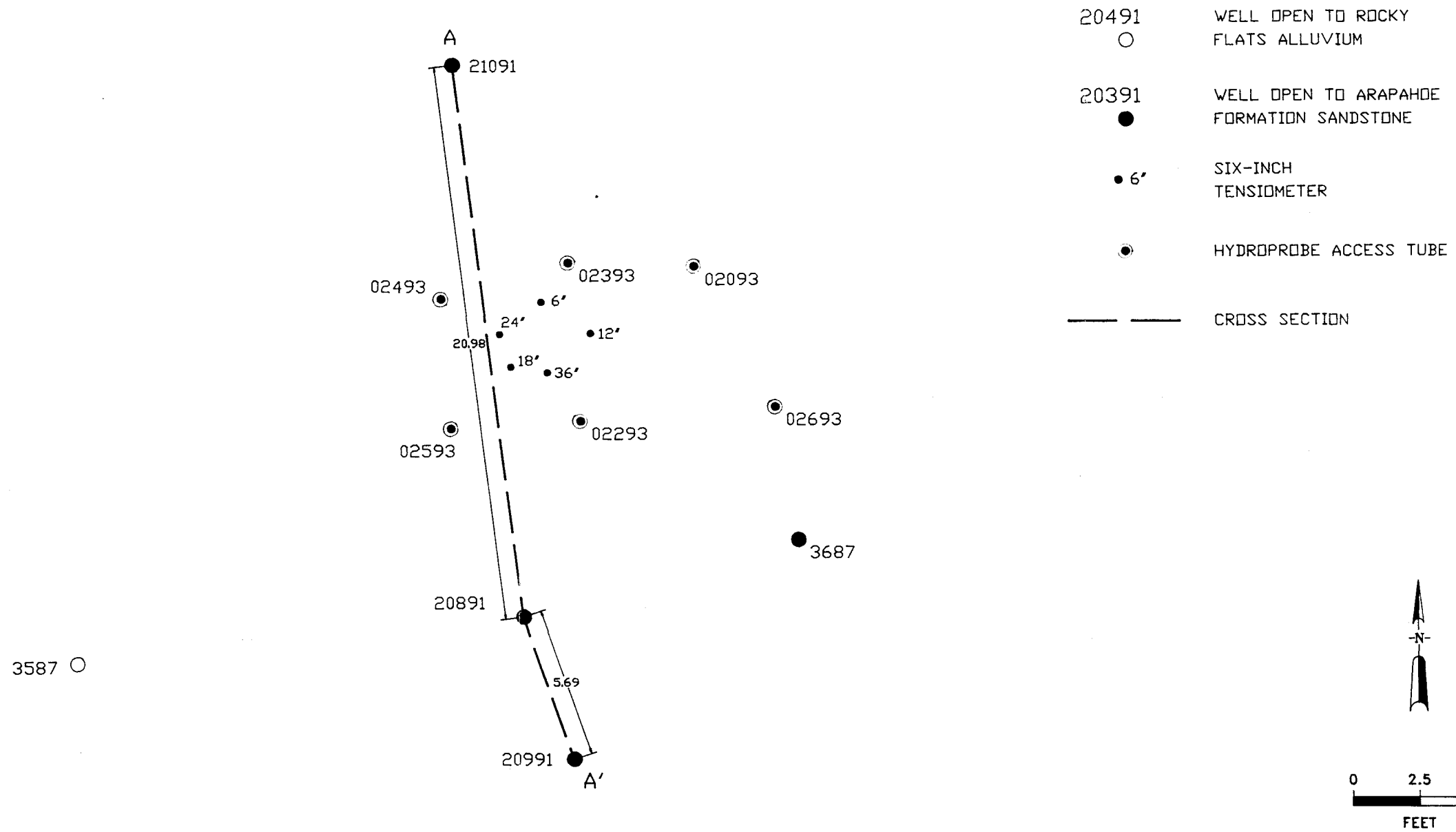
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Site Location Map

FIGURE 1 OCTOBER 1993

Status: 10/27/93



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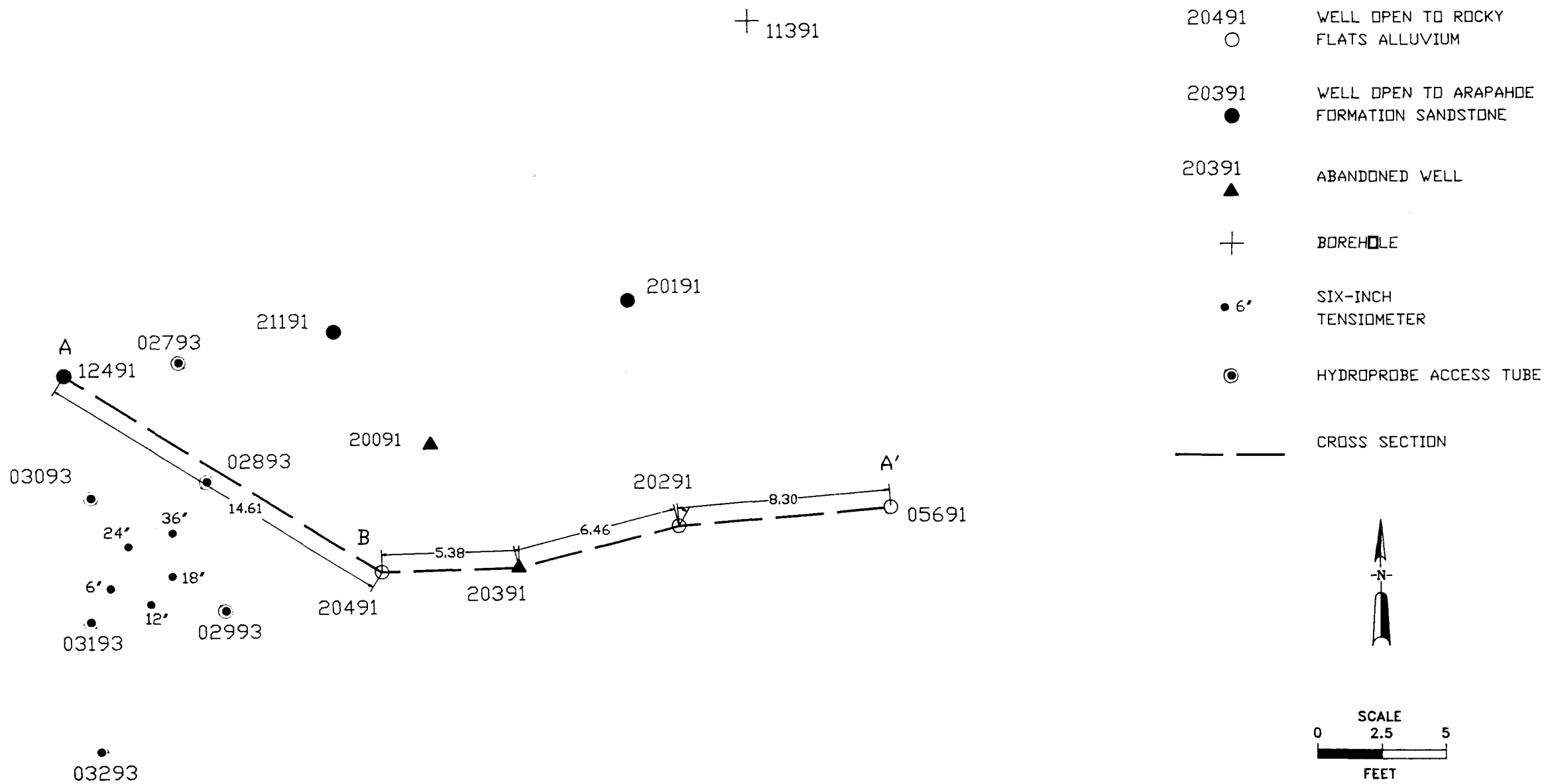
GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Site 1 Location Map

FIGURE 2 OCTOBER 1993

GRS-2.DWG

Status: 10/28/93



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GROUNDWATER RECHARGE STUDY
INTERIM REPORT

Site 2 Location Map

FIGURE 4 OCTOBER 1993

GRS-4.DWG

Status: 10/28/93