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Characterization Report

Operational Closure Covers for the Area 5 Radioactive Waste Management Site at the Nevada Test Site

Prepared by

Bechtel Nevada
Geotechnical Sciences
Las Vegas, Nevada

Prepared for

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Under Contract No. DE-AC08-96NV11718

June 2005

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ACRONYMS and ABBREVIATIONS

AES	Alternative Evaluation Study
ASER	Annual Site Environmental Report
BN	Bechtel Nevada
Bq/l	Bequerel per liter
$Bq/m^2/s$	Bequerel per square meter per second
C	Celsius
CA	Composite Analysis
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
cm	Centimeter
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
DOE/HQ	U.S. Department of Energy/Headquarters
DOE/NV	U.S. Department of Energy/Nevada Operations Office
DQO	Data Quality Objectives
E	Evaporation
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division (NNSA/NSO)
ET	Evapotranspiration
F	Fahrenheit
ft	Feet/foot
FY	fiscal year
gal	gallon
GCD	Greater Confinement Disposal
HDP	Heat Dissipation Probe
ICMP	Integrated Closure and Monitoring Plan
IHI	Inadvertent Human Intrusion
in.	Inch/inches
km	kilometer(s)
km^2	square kilometers
LANL	Los Alamos National Laboratory
LLW	Low-Level Waste
LLWMU	Low-Level Waste Management Unit
m	meter(s)
mGy	milliGray
mi	miles
mi^2	square miles
MLLW	Mixed Low-Level Waste
mrem	milliroentgen equivalent man

ACRONYMS and ABBREVIATIONS

mSv	milliSievert
MTRU	Mixed Transuranic (waste)
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NESHAP	National Emissions Standard for Hazardous Air Pollutants
NNSA/NSO	National Nuclear Security Administration Nevada Site Office
NNSA/NV	National Nuclear Security Administration Nevada Operations Office (Previous name for NNSA/NSO)
NTS	Nevada Test Site
OP	Organization Procedure
PA	Performance Assessment
pCi/L	picocurie(s) per liter
$pCi/m^2/s$	picocurie(s) per square meter per second
PET	Potential Evapotranspiration
RCRA	Resource Conservation and Recovery Act
RREMP	Routine Radiological Environmental Monitoring Plan
RWMS	Radioactive Waste Management Site
SME	Subject Matter Expert
SNL	Sandia National Laboratories
Sv	Sievert
TDR	Time-Domain Reflectometry
TEDE	Total Effective Dose Equivalent
TRU	Transuranic
UGTA	Underground Test Area
WAC	Waste Acceptance Criteria
WMD	Waste Management Division (NNSA/NSO)
yr	year

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EXECUTIVE SUMMARY

Bechtel Nevada (BN) manages two low-level Radioactive Waste Management Sites (RWMSs) (one site is in Area 3 and the other is in Area 5) at the Nevada Test Site for the U.S. Department of Energy (DOE) National Nuclear Security Administration Nevada Site Office (NNSA/NSO). The current DOE Order governing management of radioactive waste is Order 435.1. Associated with DOE Order 435.1 are a Manual (DOE M 435.1-1) and Guidance (DOE G 435.1-1). The Manual and Guidance specify that preliminary closure and monitoring plans for a low-level waste management facility be developed and initially submitted with the Performance Assessment (PA) and Composite Analysis for that facility. The Manual and Guidance, and the Disposal Authorization Statement (DAS) issued for the Area 5 RWMS further specify that the preliminary closure and monitoring plans be updated within one year following issuance of a DAS. That requirement was fulfilled by the Integrated Closure and Monitoring Plan (ICMP) (BN, 2005a) and additional updates will be conducted every third year hereafter.

This characterization report for the Area 5 RWMS Operational Closure Covers summarizes recent data collected in support of pending closure documents. This report briefly identifies the regulatory requirements, describes the disposal sites and the physical environment where they are located, reviews the approach and schedule for closing, summarizes characterization studies and results, and presents conclusions and recommendations.

Over the next several decades, most waste disposal units at both the Area 3 and Area 5 RWMSs are anticipated to be closed. Closure of the Area 3 and Area 5 RWMSs will proceed through three phases: operational closure, final closure, and institutional control. Many waste disposal units at the Area 5 RWMS are operationally closed and final closure has been placed on one unit at the Area 3 RWMS (U-3ax/bl). Because of the similarities between the two sites (e.g., type of wastes, environmental factors, operational closure cover designs), many characterization studies and data collected at the Area 3 RWMS are relevant and applicable to the Area 5 RWMS. For this reason, data and closure strategies from the Area 3 RWMS are referred to as applicable.

Analyses of samples collected in fiscal year (FY) 2002 from the Area 5 RWMS operational covers have been conducted to document the current physical and hydrogeological conditions of the closure covers. A comparison of these new physical properties and hydrogeologic data to previous values obtained for alluvium under the Area 5 RWMS (REECo, 1993a, b; Blout et al., 1995; Levitt et al., 1996) indicates that both data sets are very similar.

A topographic survey was completed in FY 2002 to document the configuration of the Area 5 RWMS (92-acre area) prior to any changes that might be made to the closure covers and intervening areas, inclusive of the Greater Confinement Disposal boreholes, from the time of the survey through FY 2007.

Closure activities for waste disposal units in the 92-acre Area 5 RWMS, and for an expansion area to the north, follow a systematic process consisting of ten steps, itemized below:

- Preliminary assessment
- Initial planning
- Drafting of a characterization plan
- Implementation of the characterization plan
- Drafting of a characterization report
- Drafting of a closure plan
- Implementation of closure
- Drafting of a closure report
- Acknowledgment of completion
- Post-closure monitoring and maintenance (if required according to the closure plan)

The first two steps, preliminary assessment and initial planing, determine the depth to which each remaining activity or document have to be conducted or developed. Results of investigations conducted prior to the interim measure discussed above for the 92-acre site, and results of previous site characterization studies and ongoing measurements of water balance at the 92-acre site and elsewhere (and the recently collected data presented here) are believed to be sufficient that initial closure activities for the 92-acre site will be minimal. A closure plan for the 92-acre site is scheduled for FY 2009, followed by closure construction and a closure report in FY 2010. Responsibilities for closure and monitoring of the 92-acre site are shared between the NNSA/NSO Waste Management Division and the Environmental Restoration Division (ERD). Formal closure activities between FY 2008 and FY 2010, and monitoring related specifically to disposal units composing the Corrective Action Unit, will be conducted by the ERD. Closure activities for waste disposal units in the expansion area are scheduled over the time frame of FY 2019 through 2021.

The basic closure cover design for the various units will be of the vegetated monolayer evapotranspirative (ET) type. In some cases, such as when considering long-lived or high-activity radionuclides, or where burrowing by animals or intrusion of roots might be problematic, the basic design may require modest modification to ensure long-term containment. Such modifications will be dealt with on a case-by-case basis. The addition of native soil to the operational closure covers is recommended as an interim measure prior to final closure.

Monitoring at the Area 5 RWMS is required under a variety of regulatory drivers, including federal regulations and DOE Orders. Monitoring data are used to demonstrate compliance with regulatory drivers and performance objectives presented in the PAs, confirm assumptions about flux rates through upward and downward pathways, confirm assumptions about soil water contents and potentials, confirm conceptual models, provide input to PA maintenance, and evaluate radiation doses to the general public. Monitoring is also conducted to ensure the integrity of waste covers. In addition, the monitoring program is designed to sufficiently forewarn of any need for mitigative actions, and to record the utility of any mitigative actions. Environmental and operational monitoring data from the Area 5 RWMS indicate that this facility is performing as expected for long-term isolation of buried waste.

Characterization studies at the Area 5 RWMS, including recent characterization of the operational closure covers (planned through FY 2002), have been completed. Based on analyses of this data, no changes to the PA or closure cover design are needed.

Analysis of the compliance scenarios indicates that the waste disposal site is reasonably likely to meet all the performance objectives for 10,000 years (Shott, et al., 1998; Levitt et al., 1999). Site characterization studies and performance assessment have shown that the arid nature of the Area 5 RWMS, along with the large depth to groundwater and negligible recharge, offer unique performance-enhancing advantages. The limited transport pathways and limited land use potential of the site, coupled with operational procedures (e.g., Waste Acceptance Criteria) and closure plans (monolayer-ET cover), provide reasonable assurance that regulatory performance objectives can be met (Shott, et al., 1998; Becker et al., 2002).

Recommendations are:

- Continue with site monitoring activities and reporting.
- Proceed through the scheduled planned phases leading to final closure of the Area 5 RWMS and defined in the ICMP (BN, 2005a).
- Proceed with the plan to add native soil to operational covers as a preparatory measure to final closure.

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1.0 INTRODUCTION

Bechtel Nevada (BN) manages two low-level Radioactive Waste Management Sites (RWMSs) at the Nevada Test Site (NTS) for the U.S. Department of Energy (DOE) National Nuclear Security Administration Nevada Site Office (NNSA/NSO). The Area 3 RWMS is located in south-central Yucca Flat and the Area 5 RWMS is located about 15 miles south, in north-central Frenchman Flat (Figure1-1). Though located in two separate topographically closed basins, they are similar in climate and hydrogeologic setting. The Area 5 RWMS uses engineered shallow-land burial cells to dispose of packaged waste, while the Area 3 RWMS uses subsidence craters formed from underground testing of nuclear weapons for the disposal of packaged and unpackaged bulk waste (Becker et al., 1998).

Over the next several decades, most waste disposal units at both the Area 3 and Area 5 RWMSs are anticipated to be closed. Closure of the Area 3 and Area 5 RWMSs will proceed through three phases: operational closure, final closure, and institutional control. Many waste disposal units at the Area 5 RWMS are operationally closed and final closure has been placed on one unit at the Area 3 RWMS (U-3ax/bl). Because of the similarities between the two sites (e.g., type of wastes, environmental factors, operational closure cover designs, etc.), many characterization studies and data collected at the Area 3 RWMS are relevant and applicable to the Area 5 RWMS. For this reason, data and closure strategies from the Area 3 RWMS are referred to as applicable.

This document is an interim Characterization Report – Operational Closure Covers, for the Area 5 RWMS. The report briefly describes the Area 5 RWMS and the physical environment where it is located, identifies the regulatory requirements, reviews the approach and schedule for closing, summarizes the monitoring programs, summarizes characterization studies and results, and then presents conclusions and recommendations.

1.1 Purpose and Objective

This characterization report has been prepared to capture, in summary, the results of characterization studies conducted at the Area 5 RWMS that are relevant to final closure of the Area 5 RWMS waste disposal units.

The immediate objective of this report is to provide information that is sufficient in applicability and quality to meet the requirements of the Nevada Division of Environmental Protection (NDEP) for accepting the plan of NNSA/NSO and BN to add soil to existing operational closure covers for regulated units as an interim measure toward site closure.

A second objective is to provide sufficient characterization information so that final closure of the Area 5 RWMS 92-acre area can proceed. Near the time of final site closure, this document (and others) may be found by the NNSA/NSO and NDEP to be adequate for development of a Closure Plan or, if not, the document will serve as the base for a next-generation Characterization Report.

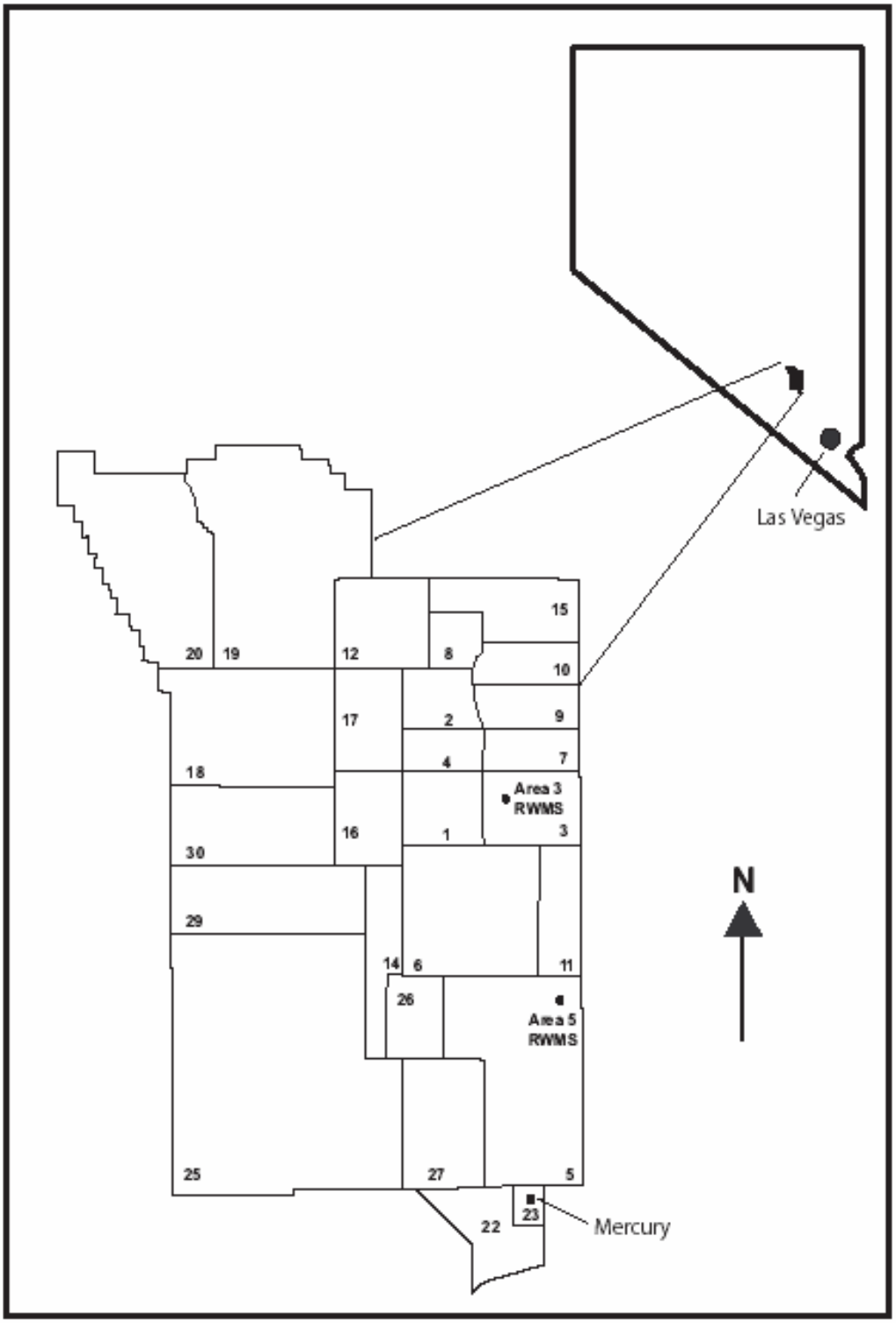

Figure 1-1 Location Map of the Area 3 and Area 5 Radioactive Waste Management Sites

1.2 Background Information

A brief description of the site is provided in this section, followed by information about the regulatory documents that govern the management of radioactive waste, and descriptions of various analyses, assessments, and plans applicable to this site.

1.2.1 Site Descriptions

The Area 3 and Area 5 RWMSs are designed and operated for disposal of low-level waste (LLW) from onsite, DOE offsite, and other approved offsite generators, and mixed waste from onsite. As mentioned above, waste disposal cells within the Area 3 RWMS are subsidence craters resulting from underground nuclear testing. At the time of formation, the seven craters ranged from 122 to 177 meters (m) (400 to 580 feet [ft]) in diameter and from 14 to 32 m (46 to 105 ft) in depth. Disposal in the craters began in the late 1960s, and waste interred there consisted primarily of contaminated soil and scrap metal, with some construction debris, equipment, and containerized waste. Craters U-3ax and U-3bl were combined to form the U-3ax/bl disposal unit, which is now covered with a vegetated native alluvium closure cover at least 2.4 m (8 ft) thick (BN, 2001a). For details of the final closure plan of U-3ax/bl disposal unit, refer to BN (2000). Disposal in the combined unit U-3ah/at began in 1988; this disposal cell is currently being used for disposal of bulk, low-level radioactive waste from the NTS and approved offsite generators. Crater U-3bh was originally used for disposal of contaminated soils from the Tonopah Test Range in 1997, and remains open for waste disposal from other approved generators. The remaining two craters are not in use. For a detailed description of the facilities at the Area 3 RWMS, refer to Shott et al. (1997).

Disposal of radioactive waste at the Area 5 RWMS has occurred since the early 1960s. Currently, the Area 5 RWMS consists of 31 excavated pits and trenches and 13 boreholes (Figure 1-2). The disposal cells were used to dispose classified and unclassified low-level radioactive waste (LLW), mixed LLW (MLLW), transuranic (TRU) waste, mixed TRU (MTRU) waste, and asbestiform waste. The 13 Greater Confinement Disposal (GCD) boreholes were used for the disposal of High Specific-Activity LLW (waste similar to Greater-than-Class C), TRU, and MTRU wastes. Currently, 21 of the cells and all 13 GCDs are operationally closed. For a detailed description of the facilities at the Area 5 RWMS, refer to Shott et al. (1998).

Table 1-1 shows the waste cells, type of waste in each, and activity status.

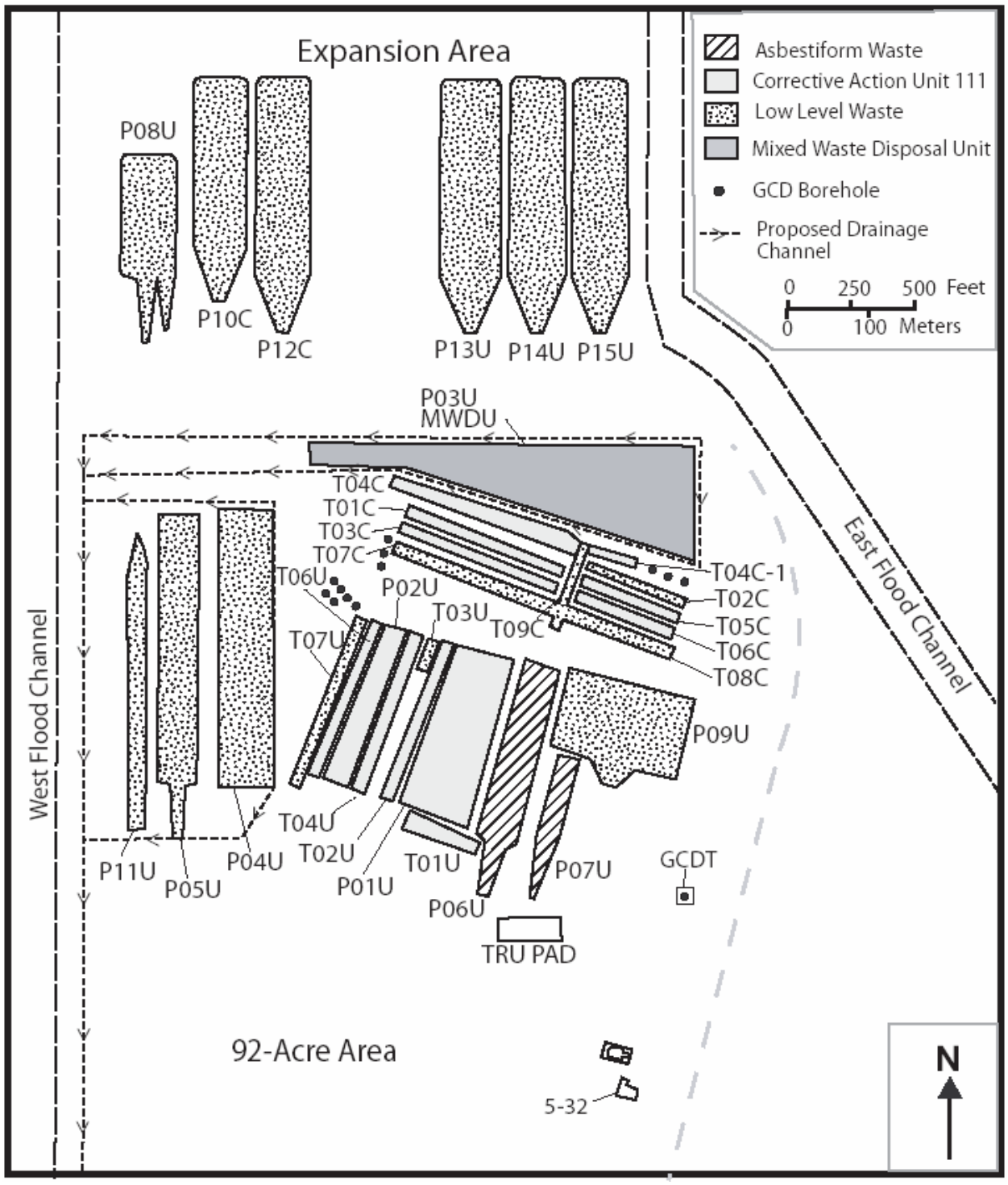

Figure 1-2 Waste Management Units Within the Area 5 RWMS

Table 1-1 - Area 5 RWMS Waste Unit Status

Units	Current Status	Waste Type/Material	Disposal Configuration
P08U, P09U, P13U, P14U, P15U, P10C, P12C	Active	LLW	Shallow Land Disposal
T02C, T07C, T08C, T09C, T07U, T03U P04U, P05U, P11U	Operationally Closed	LLW	Shallow Land Disposal
T01U, T02U, T04U, T06U, P01U, P02U, T01C, T03C, T05C, T06C, T04C, T04C-1	Operationally Closed (CAU 111)	MLLW	Shallow Land Disposal
GCDT, GCD-05U, GCD-06U, GCD-09U GCD-10U, GCD-11U, GCD-12U	Operationally Closed	LLW	GCD
GCD-07C, GCD-08C	Operationally Closed	MLLW	GCD
GCD-02C	Operationally Closed	TRU	GCD
GCD-01C, GCD-03C, GCD-04C	Operationally Closed	MTRU	GCD
P03U	Active (Pit 3)	MLLW	Shallow Land Disposal
P06U	Active	Asbestiform	Shallow Land Disposal
P07U	Operationally Closed	Asbestiform	Shallow Land Disposal

1.2.2 Regulatory Documents

The current DOE Order governing management of radioactive waste is 435.1 (DOE, 1999b). Associated with DOE Order 435.1 is Manual DOE M 435.1-1 and Guidance DOE G 435.1-1. The Manual and Guidance specify that preliminary closure and monitoring plans for a LLW management facility be developed and initially submitted with the Performance Assessment (PA) and Composite Analysis (CA) for that facility. Development of these plans is also a condition of the Disposal Authorization Statements (DASs) issued for the Area 3 and the Area 5 RWMSs. Key documents in place for the Area 5 RWMS include the following:

- Performance Assessment for the Area 5 RWMS at the NTS, Nye County, Nevada, Revision 2.1 (Shott et al., 1998).
- Composite Analysis for the Area 5 RWMS at the NTS, Nye County, Nevada (BN, 2001b).
- Consequences of Subsidence for the Area 3 and Area 5 RWMS's, Nevada Test Site (DOE, 1998a).
- Integrated Closure and Monitoring Plan for the Areas 3 and 5 RWMSs at the NTS (BN, 2005a).
- Disposal Authorization Statement for the DOE/NV NTS Area 5 RWMS (DOE, 2000).
- NTS Waste Acceptance Criteria (WAC), Revision 5 (NNSA/NSO, 2003).

Much of the background information provided in this report is extracted from these important documents, as well as from the cited reports listed in the Reference section (11.1) of this report.

1.2.3 Performance Assessment and Composite Analysis

A PA is a systematic analysis of potential risks, and includes a comparison of those risks to the established performance objectives. A PA is conducted to provide the NNSA/NSO with reasonable expectation that disposal of LLW will meet radiological performance objectives for long-term protection of the public and the environment, as established in DOE M 435.1-1. Composite Analyses are planning tools used by the NNSA/NSO to ensure that the combined effect of all sources of residual radioactive material that could contribute to the dose calculated from disposal facilities will not compromise requirements for future radiological protection of the public and environment. The PA and CA for a disposal facility are reviewed and updated as described in the Maintenance Plan for the PA and CA. The process of review and revision ensures that the analyses intended to ensure protection of the public and environment are conducted with the best data available at the time. Monitoring during operation of a facility, closure of that facility, and monitoring after closure are inextricably tied to the PA and CA. The PA and CA provide information useful for designing a monitoring plan and for determining the best method of closure to realize radiological protection of the public and environment. Conversely, results obtained through monitoring are part of the data needed to revise the PA and CA. Documents linked to the PA and CA and to the Integrated Closure and Monitoring Plan (ICMP) include the Auditable Safety Analysis, the NTSWAC (NNSA/NSO, 2003), and the Routine Radiological Environmental Monitoring Plan (RREMP) (BN, 2003).

A PA and a CA have been completed for both the Area 3 and Area 5 RWMSs (Shott et al., 1997, 1998; BN, 2001b). The combined PA and CA (under one cover) for the Area 3 RWMS was reviewed by DOE Headquarters (DOE/HQ) in 1999 and a conditional DAS was issued in October 1999. A revised PA/CA document addressing the DAS issues was prepared and submitted to DOE/HQ for review in 2000. The PA (under separate cover) for the Area 5 RWMS was reviewed and approved, with conditions, by DOE/HQ in 1996. A DAS (DOE, 2000a) was issued with conditions for the Area 5 RWMS in fiscal year (FY) 2001 following the review of the CA. A PA has been completed for the TRU waste in four GCD boreholes (Cochran et al., 2001).

In the PAs of the Area 3 and Area 5 RWMSs (Shott et al., 1997, 1998), the analyses assumed that the closure cover would consist of native alluvium, with its thickness corresponding to the thickness of the operational cover. The hydrogeologic properties of the cover material used in the models were based on results of field and laboratory tests. The assessments were done under closure conditions that were assumed to be more adverse than would likely occur. In the Area 3 RWMS PA/CA, a simple case was assumed where the closure cover subsides, but remains above grade. In the Area 5 RWMS PA, as a base case, the closure cover was assumed not to subside; as a worst case, the closure cover was assumed to thin, crack, and subside below grade. Performance objectives and results of modeling conducted for the Area 3 and Area 5 RWMS PAs are shown in Table 4.2 of the Integrated Closure and Monitoring Plan (BN 2005a). Based on these analyses, both the Area 3 and Area 5 RWMSs meet performance objectives by a wide margin. The dose from all interacting sources to a member of the public is calculated for the Area 3 and Area 5 RWMSs to be 2 milliroentgen equivalent man per year (mrem/yr) and 7 mrem/yr (0.02 and 0.07 milliSievert per year [mSv/yr]), respectively. The CA performance objective is 100 mrem/yr (1.00 mSv/yr) (BN, 2005a).

1.2.4 Integrated Closure and Monitoring Plan

An integrated plan for closing and monitoring both RWMSs was submitted in 2001 and revised in 2004 (BN, 2005a). The ICMP defines the approach and schedule for both closing and monitoring the sites. The closure and monitoring plans were integrated because much of the information that would be included in individual plans is the same, and integration provides efficient presentation and program management.

The conceptual closure approach consists of ensuring that the performance of the actual cover at least meets that modeled in the PAs. The actual cover will be of the vegetated monolayer-evapotranspirative (ET) type, with the monolayer comprising native alluvium properly screened to exclude cobbles coarser than about 9 centimeters (cm) (3.5 inches [in.]). Throughout a period of active institutional control, the cover will be maintained at its proper thickness by infilling subsided areas and cracks. Performance of the cover will be monitored at a frequency and for a period to be determined based on observed trends in monitoring data.

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2.0 PROJECT DESCRIPTION

This section contains brief descriptions of the NTS and the Area 5 RWMS. An overview of the Area 5 Waste Management facility and operations is also provided. For more detail regarding hydrogeology of the area, refer to Shott et al. (1998), IT (1998, 1999a, 1999b), and Laczniak et al. (1996). For more information about the Area 5 RWMS specifically, consult Shott et al. (1998) and BN (2005a).

2.1 Site Description

The NTS, located in Nye County, Nevada, 104 kilometers (km) (65 miles [mi]) northwest of Las Vegas, comprises approximately 3,561 square km (km^2) (1,375 square mi [mi^2]) of land reserved to the jurisdiction of the DOE under four land withdrawals (DOE, 1996). It is surrounded and further isolated on the north, east, and west by the Nevada Test and Training Range (Figure 1-1). The primary use of the NTS between 1952 and 1992 was testing of nuclear weapons. Since 1992, subcritical experiments and other defense-related and non-defense-related activities have been and continue to be conducted at the NTS. Mercury, in the southeast corner of the NTS, is the primary support facility for the NTS. Small communities, including Amargosa Valley, Lathrop Wells, and Indian Springs, are present within a few tens of kilometers (tens of miles) of the NTS, along the U.S. Highway 95 corridor. The primary valleys on the NTS are Yucca Flat, Frenchman Flat, and Jackass Flats. Yucca Flat is in the northeast part of the NTS, Frenchman Flat is in the southeast part of the NTS, and Jackass Flats is in the southwest part of the NTS.

Frenchman Flat is a closed intermontane basin located in the southeastern portion of the NTS. This roughly circular basin is bounded by Massachusetts Mountain on the north, the Buried Hills and Ranger Mountains on the east and southeast, Mount Salyer on the west, and Mercury Ridge and Red Mountain on the south (Figure 2-1). The sparsely vegetated valley floor slopes gently toward a central playa. Elevations range between 1,600 m (5,250 ft) in the surrounding mountains to 939 m (3,080 ft) at Frenchman Playa in the center of the basin. Frenchman Flat was one of several primary nuclear test areas. Atmospheric tests were conducted on the playa and a limited number of underground tests were conducted in the northern part of the basin (DOE, 2000b).

2.1.1 Area 5 RWMS Vicinity

The Area 5 RWMS is located in northern Frenchman Flat at the juncture of three coalescing alluvial fan piedmonts (Snyder et al., 1995). Ground-surface elevation at the Area 5 RWMS is 972 m (3,190 ft) above mean sea level.

The thickness of the unsaturated zone at the Area 5 RWMS is 235 m (770 ft) at the southeast corner of the RWMS (at Borehole Ue5PW-1), 256 m (840 ft) at the northeast corner of the RWMS (at Borehole Ue5PW-2), and 271 m (890 ft) to the northwest of the RWMS (at Borehole Ue5PW-3). Boreholes Ue5PW-1 and Ue5PW-2 penetrate only alluvium, while Borehole Ue5PW-3 encounters

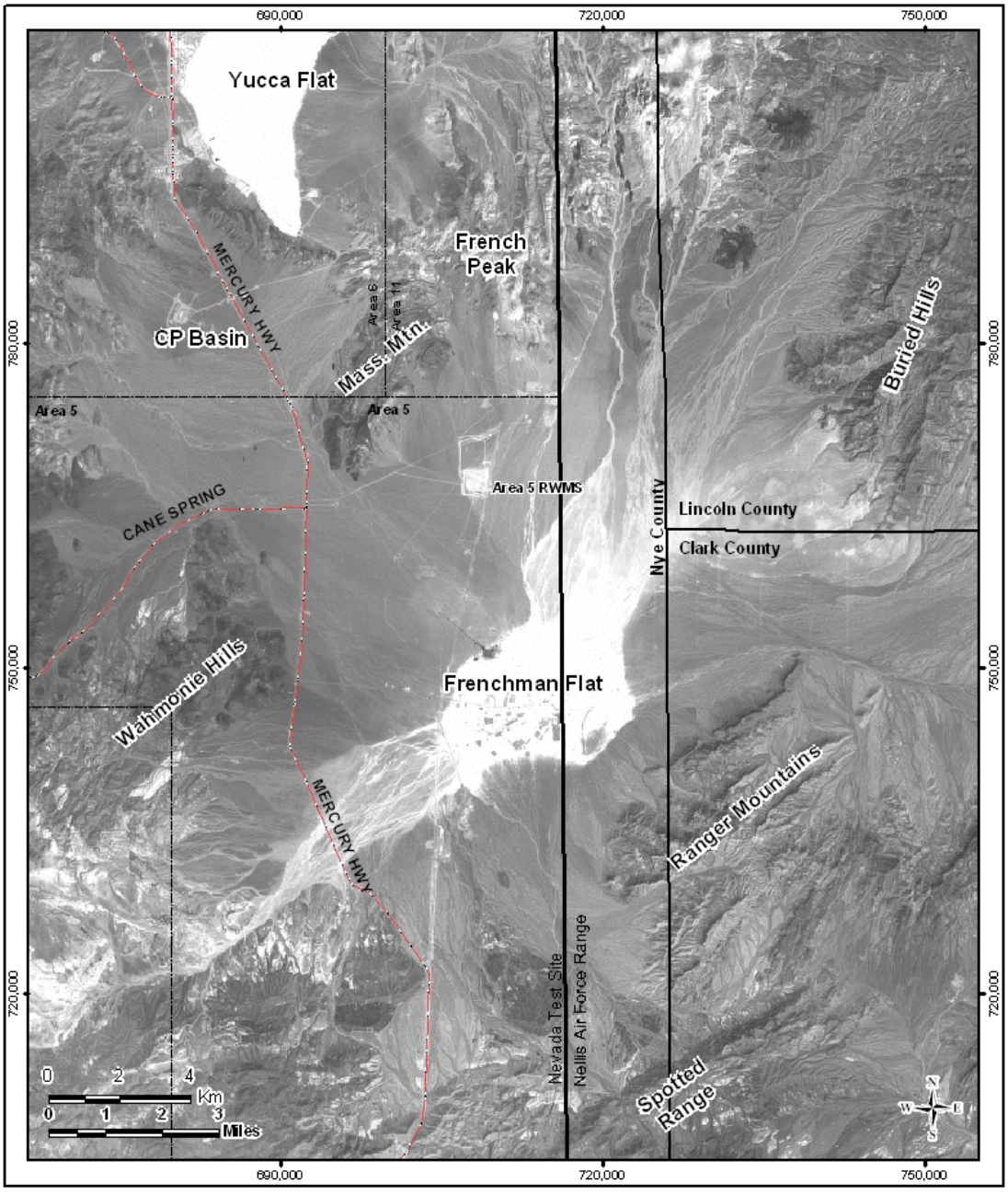

Figure 2-1 Map of Frenchman Flat

Tertiary tuff at a depth of approximately 189 m (620 ft) (REECo, 1994). The alluvium is estimated to be about 460 m (1,500 ft) thick at the Area 5 RWMS.

Air temperatures can vary from -15 degrees Celsius (°C; 5 degrees Fahrenheit [°F]) to 24°C (75°F) in winter and from 16 to 45°C (60 to 113°F) in summer. The climate of Frenchman Flat is arid. The average annual precipitation, based on a 38-year record (1963-2001) at a station located 6.4 km (4 mi) south of the RWMS, is 125 mm (4.9 in.). Precipitation is highly variable, with scant precipitation being recorded in some years. Average annual potential evapotranspiration (PET) at the Area 5 RWMS, calculated using local meteorology data, is approximately 13 times the annual average precipitation.

Areas 3 and 5 are similar, except for slight differences in air temperature, precipitation, and soil texture: Area 3 receives approximately 30 percent more rainfall than Area 5, the annual average temperature at Area 3 is about 2°C (4°F) cooler than at Area 5, and soils at Area 3 are slightly finer grained than at Area 5.

2.2 Area 5 RWMS Facility Description

The Area 5 RWMS is approximately 22 km (14 mi) north of Mercury in the northern part of Frenchman Flat (Figure 2-1). The Area 5 RWMS covers 293 hectares (732 acres) and is bounded by a buffer zone 300 m (1,000 ft) wide. A 37-hectare (92-acre) area in the southeast corner of the RWMS, referred to herein as the "92-acre area," has been actively used for disposal and storage of wastes since 1961. More recently the RWMS was expanded northward into an area referred to as the "expansion area."

Disposal consists of placing waste in various sealed containers in unlined pits and trenches. Soil backfill is pushed over the containers in a single lift, approximately 2.4 m (8 ft) thick, as rows of containers reach approximately 1.2 m (4 ft) below original grade. The following paragraphs provide brief, summarized descriptions of the excavations. For a detailed description of the facilities at the Area 5 RWMS, refer to Shott et al. (1998). Refer to Figure 1-2 for locations of pits and trenches at the Area 5 RWMS.

Packaged LLW and mixed low-level waste (MLLW) generated within Nevada under the purview of NNSA/NSO (formerly DOE/NV) are currently disposed in excavated pits. These disposal units, with exceptions, are typically 183 to 213 m (600 to 700 ft) long, over 30.5 m (100 ft) wide, and 6.1 to 9.1 m (20 to 30 ft) deep. All trenches in the RWMS are closed. The practice has been to designate an excavation as either a "trench" or "pit," the difference being that a truck could be turned around in a pit. (This equates to greater than 30.5 m [100 ft] wide for a pit and less than 30.5 m [100 ft] wide for a trench.) Trench designations are prefixed with a "T," whereas pit designations are prefixed with a "P." The designations are given the suffix "U" or "C" to indicate whether the waste is "unclassified" or "classified," respectively (as regards national security requirements). For further descriptions of pits, trenches, and GCD boreholes, refer to BN (2001b).

Currently, 10 of 31 disposal units are open for disposal of wastes; the others have been operationally closed with a cover of native alluvium approximately 2.4 m (8 ft) thick. (Trenches T04C and T04C-1

are herein considered to be discrete, resulting in 23 post-1978 disposal units at the RWMS rather than 22 as is sometimes referenced.) Pits P08U, P10C, P12C, P13U, P14U, and P15U were constructed north of the 92- acre main disposal area in the expansion area.

The GCD boreholes were used in the past to dispose of waste that was considered unsuitable for shallow land disposal. Thirteen such boreholes were drilled. A GCD borehole is typically 3 m (10 ft) in diameter and 36 m (120 ft) deep, and is unlined except for the top 3 m (10 ft), which is cased with corrugated steel culvert. Waste was remotely placed in a GCD borehole from the bottom up to a depth of 21 m (70 ft) below the ground surface, and backfilled with native alluvium. Seven of the GCD boreholes are filled and closed.

This characterization report addresses only the pit and trench disposal units within the Area 5 RWMS. More information regarding the GCD boreholes is presented in Shott et al. (1998) and in Cochran et al. (2001). A report that addresses regulations and issues associated with final closure of the GCD boreholes is being prepared (BN, 2002a).

2.2.1 Historical Development and Use of the Area 5 RWMS Facility

Disposal of radioactive waste at the Area 5 RWMS started in 1961 and, through 1978, eight disposal units were filled primarily with onsite-generated waste and operationally closed. The Area 5 RWMS began taking greater amounts of waste from offsite generators in 1978. Between 1978 and September 26, 1988 (the latter date being when DOE Order 5820.2A, "Radioactive Waste Management" [now replaced by DOE Order 435.1] was promulgated), two pits (P01U and P02U) and one trench (T07U) were filled and operationally closed. Thirteen pits (P03U, P04U, P05U, P06U, P07U, P08U, P09U, P10C, P11U, P12C, P13U, P14U, and P15U) and seven trenches (T03U, T02C, T04C, T04C-1, T07C, T08C, and T09C) have been active since promulgation of DOE Order 5820.2A. Four of these pits (P04U, P05U, P07U, and P11U) and all seven trenches are now operationally closed, leaving nine pits currently active (P03U, P06U, P08U, P09U, P10C, P12C, P13U, P14U, and P15U).

Most of the MLLW at the Area 5 RWMS was placed there before 1992; however, Pit 3 (P03U) has accepted small amounts of MLLW generated on site since that time. Pit 3 (P03U) is the only active mixed waste disposal unit. All other active units contain low-level radioactive waste. Pit 6 (P06U) is used for disposal of thorium (at the bottom tier), and Pit 7 (P07U) is used for disposal of asbestiform LLW.

2.3 Closure Strategy

Assumptions related to closure and monitoring of the Area 5 RWMS are given in the life cycle baseline documents of the NNSA/NSO Waste Management Division (WMD). Pertinent programmatic, scheduling, and funding assumptions from the WMD baseline are reproduced below, in addition to assumptions that relate more to the approach and responsibility for closure and monitoring described herein.

The following subsections were abstracted from BN (2005a).

2.3.1 Assumptions Related to Closure

- Funding will be available to complete closure-related activities at the scheduled times.
- Closure of all disposal units within the Area 3 and Area 5 RWMSs, regardless of waste type, will be included in the NNSA/NSO WMD baseline.
- Activities related to final closure of the Area 3 and Area 5 RWMSs will be under the management and technical direction of the NNSA/NSO WMD.
- The ICMP will address closure of all disposal units at the Area 3 and Area 5 RWMSs, including disposed LLW (asbestos, hydrocarbon-impacted, and regular LLW), disposed MLLW, and indefinitely stored classified materials.
- Individual closure plans will be drafted for the Pit 3 MWDU, Corrective Action Unit (CAU) 111, the asbestiform waste pits, the remaining LLW pits within the 92-acre area, and the GCD boreholes.
- The closure plans for disposal units containing hazardous constituents will incorporate conditions of Title 40 CFR 265.310, RCRA Permit NEV HW009, DOE O 435.1, the Area 5 RWMS DAS, and other applicable regulations as appropriate.
- The NDEP will approve adding excess soil on and between disposal units under their purview.
- Routine maintenance, including adding soil between and on operational closure covers, will continue until final closure.
- Soil backfill will be the engineered barrier for the GCD boreholes that contain waste or classified materials.
- GCD boreholes will be closed according to the regulations pertaining to the type of waste they contain, such as Title 40 CFR 191 for transuranic (TRU) waste.
- The NNSA/NSO will approve all documents required for final closure of all disposal units at the Area 3 and Area 5 RWMSs.
- The NDEP and the NNSA/NSO will approve all documents required for final closure of regulated disposal units at the Area 3 and Area 5 RWMSs.
- Activities related to final closure of the Area 5 RWMS 92-acre area will occur from fiscal year (FY) 2005 through FY 2008.
- Closure construction at the Area 5 RWMS 92-acre area will be completed in FY 2008 except for those units expected to still be operational.
- Final closure activities for the Area 5 RWMS expansion area will occur between FY 2019 and FY 2021.
- Closure construction at the Area 5 RWMS expansion area will be completed in FY 2021.
- Final closure activities at the Area 3 RWMS will occur between FY 2006 and FY 2008.
- No waste will be accepted in the current disposal areas after FY 2021.

2.3.2 Assumptions Related to Monitoring

- Environmental monitoring will continue through FY 2021 according to the ICMP (BN, 2005a). After FY 2021, environmental monitoring will continue under Long-Term Surveillance and Maintenance.
- RCRA groundwater monitoring will continue (unless an exemption is granted from NDEP) during the operational phase of the Pit 3 MWDU.
- Post-closure monitoring of the Area 5 RWMS 92-acre area will commence in FY 2008 and continue at least through FY 2021 according to RCRA requirements.

2.3.3 Assumptions Related to Long-Term Surveillance and Maintenance

- Active institutional control of the Area 5 RWMS 92-acre site will start after final closure in FY 2008 and continue for a period of 113 years (through FY 2121).
- An exemption from RCRA groundwater monitoring requirements will be obtained after final closure of the Pit 3 MWDU within the Area 5 RWMS 92-acre area.
- Active institutional control of the Area 5 RWMS expansion area will start after final closure in FY 2021 and continue for a period of 100 years (through FY 2121).
- Passive institutional control of closed sites will start after active institutional control and continue indefinitely.

3.0 REGULATORY REQUIREMENTS

The Area 3 and Area 5 RWMSs are primarily LLW disposal sites. The Area 3 RWMS includes LLW and MLLW, whereas the Area 5 RWMS includes LLW, MLLW, and small amounts of TRU waste and mixed TRU (MTRU) waste, and asbestiform waste. Waste with only a radioactive component is self-regulated by the DOE. The radioactive component of mixed waste is self-regulated by the DOE, whereas the hazardous component of mixed waste is regulated by RCRA under the authority of the U.S. Environmental Protection Agency (EPA). The NDEP has been granted the authority by the EPA to administer RCRA in Nevada. Nevada Administrative Code (NAC) 444.8632 incorporates the federal RCRA requirements by reference (Nevada Environmental Commission [NEC], 1987). A review of the regulatory requirements affecting the Areas 3 and 5 RWMSs was compiled for the ICMP (BN, 2005a) and is included in the following Subsections for convenient reference.

3.1 Closure Requirements

The following excerpts from the DOE Orders and other regulations for closure provide the basis for the Closure Program.

3.1.1 DOE Order 435.1

DOE Order 435.1 (DOE, 1999b) governs management of radioactive waste. Associated with the order are a manual (DOE M 435.1-1; DOE, 1999d) and a guidance (DOE G 435.1-1; DOE, 1999c). The DOE/NV M 435.1 provides the requirements, roles, and responsibilities for establishing the DOE/NV Radioactive Waste Management Program according to the Order. The DOE manual and guidance list the following requirements related to closure of LLW disposal cells.

- Chapter IV, Subpart Q (Closure) (1). A preliminary closure plan shall be developed and submitted to DOE/HQ for review with the Performance Assessment and Composite Analysis. The closure plan shall be updated within one year following issuance of the Disposal Authorization Statement to incorporate conditions specified in the Disposal Authorization Statement.

  - Subpart Q (1)(a). Closure plans shall be updated as required during the operational life of the facility.

  - Subpart Q (1)(b). Closure plans shall include a description of how the disposal facility will be closed to achieve long-term stability and minimize the need for active maintenance following closure and to ensure compliance with the requirements of DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (or 10 CFR 834, when promulgated).

  - Subpart Q (1)(c). Closure plans shall include the total expected inventory of wastes to be disposed of at the facility over the operational life of the facility.

  - Subpart Q (2). Closure of a disposal facility shall occur within a five-year period after it is filled to capacity, or after the facility is otherwise determined to be no longer needed.

- Subpart Q (2)(a). Prior to facility closure, the final inventory of the low-level waste disposed of in the facility shall be prepared and incorporated into the PA and CA which shall be updated to support closure of the facility.

- Subpart Q (2)(b). A final closure plan shall be prepared based on the inventory of waste disposed of in the facility and on the updated PA and CA prepared in support of the facility closure.

- Subpart Q (2)(c). Institutional control shall continue until the facility can be released pursuant to DOE Order 5400.5 (or 10 CFR 834, when promulgated).

- Subpart Q (2)(d). The location and use of the facility shall be filed with the local authorities responsible for land use and zoning.

3.1.2 Title 40 CFR 265

Performance objectives related to closure of a waste disposal cell containing only LLW are similar in principle to those specified in the RCRA Subpart N, Title 40 CFR 265.310(a) (CFR, 1996a) for waste disposal cells containing MLLW: At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfill,
- Function with minimum maintenance,
- Promote drainage and minimize erosion or abrasion of the cover,
- Accommodate settling and subsidence so that the cover's integrity is maintained, and
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

In addition to the above requirements, Title 40 CFR 265.310(b) specifies that after final closure, the owner or operator must comply with all post-closure requirements contained in Title 40 CFR 265.117 through 265.120, including maintenance and monitoring throughout the post-closure care period. The owner or operator must:

- Maintain the integrity and effectiveness of the final cover, including making repairs to the cover as necessary to correct the effects of settling, subsidence, erosion, or other events;
- Maintain and monitor the leak detection system according to Title 40 CFR 264.301(c)(3)(iv) and (4), and 265.304(b), and comply with all other applicable leak detection system requirements of this part;
- Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of Subpart F of this part;
- Prevent run-on and runoff from eroding or otherwise damaging the final cover; and
- Protect and maintain surveyed benchmarks used in complying with Title 40 CFR 265.309.

3.1.3 Title 40 CFR 191

Small amounts of TRU and MTRU wastes are disposed in GCD boreholes and in one shallow-land disposal unit at the Area 5 RWMS. According to DOE M 435.1-1 (DOE, 1999d), TRU waste is to be disposed according to Title 40 CFR 191 (CFR,1996b). With respect to the limited amounts of these wastes, the NNSA/NSO will assess the applicability of Title 40 CFR 191 to closure through the process of self regulation.

A compliance assessment document for TRU waste disposed in GCD boreholes, including a PA with respect to the requirements of Title 40 CFR 191, has been completed by Sandia National Laboratories (SNL) (Cochran et al., 2001). Title 40 CFR 191 includes both quantitative requirements and qualitative "assurance" requirements that must be met to demonstrate adequate protection of human health and the environment. The three quantitative requirements pertain to containment, individual protection, and groundwater protection. The six assurance requirements are imposed to provide additional confidence that the containment requirements will be met: (1) active institutional controls, (2) passive institutional controls, (3) monitoring, (4) engineered and natural barriers, (5) siting to avoid resources, and (6) future removal of waste. According to definitions in Title 40 CFR 191 for active and passive institutional controls, the assurance requirement of monitoring is considered to be an active control, and barriers are considered to be a passive control.

Comparison of the assurance requirements in Title 40 CFR 191 with closure and monitoring requirements of DOE O 435.1 and DOE M 435.1-1 indicates that measures taken to satisfy requirements of Title 40 CFR 191 will meet or exceed requirements of the radioactive waste management Orders. An assessment of the assurance requirements for TRU waste in the GCD boreholes is described in the GCD document (Brosseau, 2001). Closure and monitoring requirements of RCRA are also generally satisfied by these measures; specific requirements for closure and monitoring may be imposed by the NDEP for cells containing MTRU waste. These requirements are negotiated with the NDEP when drafting the specific closure plans.

3.1.4 NAC 444.743

Pits P06U and P07U are permitted Class III asbestiform low-level solid waste disposal units at the Area 5 RWMS. As such, it is regulated by NACs, as follows.

- NAC 444.743 (NAC, 1993a). Regulates final cover or closure; post-closure. A Class III site must comply with requirements set forth in NAC 444.6891 to 444.6894, inclusive, concerning closure and post-closure.
- NAC 444.6891 (NAC, 1993b). Sets requirements for design and construction of a system for final cover. The owner or operator of a Class I site shall install a system for a final cover which is designed to minimize infiltration and erosion. Except as otherwise provided in Subsection 2, the system must be designed and constructed to:

(a) Have a permeability that is less than or equal to the permeability of any system for a bottom liner or natural subsoils present, or have a permeability no greater than 0.00010 centimeters per second, whichever is less;
(b) Minimize infiltration through the closed municipal solid waste landfill unit by the use of an infiltration layer which contains at least 18 inches of earthen material; and
(c) Minimize erosion of the final cover by the use of an erosion layer which contains at least 6 inches of earthen material which is capable of sustaining the growth of native plants.

3.2 Monitoring Requirements

The following excerpts from the DOE Orders and other regulations for monitoring provide the basis for the Monitoring Program.

3.2.1 DOE Order 435.1

The DOE M 435.1-1 associated with DOE Order 435.1 provides requirements for air monitoring (including radon), vadose zone, meteorology, biota, direct radiation monitoring, and subsidence monitoring.

- **Chapter IV, Subpart P (1) (a)**. Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.

  – Subpart P (1) (b). Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny.

  – Subpart P (1) (c). Release of radon shall be less than an average flux of 20 picocurie(s) per square meter per second (pCi/m^2/s) (0.74 Bequerel per square meter per second [Bq/m^2/s]) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/liter (L) (0.0185 Bq/L) of air may be applied at the boundary of the facility.

  – Subpart R (3) (a). The site-specific performance assessment and composite analysis shall be used to determine the media, locations, radionuclides, and other substances to be monitored.

  – Subpart R (3) (b). The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters which may affect long-term performance.

  – Subpart R (3) (c). The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action prior to exceeding the performance objectives in this chapter.

3.2.2 DOE Order 450.1

DOE Order 450.1 (which replaced DOE O 5400.1) and Guidance Document DOE/EH-0173T (DOE, 1991) provide requirements for air monitoring (including radon), groundwater, vadose zone, meteorology, biota, and direct radiation monitoring.

- **Chapter IV, 5b. (1)**. Environmental surveillance shall be designed to satisfy one or more of the following program objectives:
  - 5b (1)(a). Verify compliance with applicable environmental laws and regulations;
  - 5b (1)(b). Verify compliance with environmental commitments made in Environmental Impact Statements, Environmental Assessments, Safety Analysis Reports, or other official DOE documents;
  - 5b (1)(c). Characterize and define trends in the physical, chemical and biological condition of environmental media;
  - 5b (1)(d). Establish baselines of environmental quality;
  - 5b (1)(e). Provide a continuing assessment of pollution abatement programs;
  - 5b (1)(f). Identify and quantify new or existing environmental quality problems.

3.2.3 Title 40 CFR 61

Title 40 CFR 61 (CFR, 1996c) provides requirements for radiological air monitoring (including radon) and direct radiation monitoring in Subparts H and Q of H, National Emission Standards for Emission of Radionuclides Other Than Radon from Department of Energy Facilities, Section 61.92 Standard.

- Subpart H. Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

- Subpart Q. No source at a Department of Energy facility shall emit more than 20 pCi/m2/s of radon-222 as an average for the entire source, into the air. This requirement will be part of any Federal Facilities Agreement reached between the EPA and the DOE. To date, neither the Area 3 or the Area 5 RWMSs contain 11.e.(2) waste (uranium mill tailings), so Subpart Q does not apply. However, Subpart Q is included in anticipation of receiving 11.e.(2) waste in the future.

3.2.4 Title 40 CFR 264

The Area 5 groundwater monitoring program is guided in part by the following sections of Title 40 CFR 264 (CFR, 1996d), Subpart F, unless as specified in the "Outline of a Comprehensive

Groundwater Monitoring Program" (BN, 1998a), and the Annual Groundwater Monitoring Data Report (e.g., BN, 2004a) in agreement between NNSA/NSO and NDEP:

- 264.97, General groundwater monitoring requirements
- 264.98, Detection monitoring program
- 264.99, Compliance monitoring program
- 264.100, Corrective action program
- 264.101, Corrective action for solid waste management units

3.2.5 Title 40 CFR 265

The Area 5 groundwater monitoring program is driven in part by the following sections of Title 40 CFR 265 (CFR, 1996a), Subpart F, unless as specified in the "Outline of a Comprehensive Groundwater Monitoring Program" (BN, 1998a), and the Annual Groundwater Monitoring Data Report (e.g., BN, 2004a) in agreement between NNSA/NSO and NDEP:

- 265.90, Applicability
- 265.91, Groundwater monitoring system
- 265.92, Sampling and analysis
- 265.93, Preparation, evaluation, and response
- 265.94, Record keeping and reporting

3.2.6 Title 40 CFR 191

Title 40 CFR 191 provides the following general monitoring requirement:

- Section 191.14 Assurance Requirements, (b). Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring.

4.0 WASTE DISPOSAL OPERATIONS

4.1 Introduction

This section summarizes the waste disposal operations at the Area 5 RWMS. The location, history of disposal, waste placement, waste container descriptions, and waste inventory are discussed briefly. For more detail, refer to the ICMP for the Area 3 and Area 5 RWMSs (BN, 2005a) and the Area 5 RWMS PA (Shott et al., 1998).

4.2 Location

The Area 5 RWMS covers 293 hectares (732 acres) and is bounded by a buffer zone 300 m (1,000 ft) wide. Waste disposal has occurred in a 37-hectare (92-acre) portion of the site, referred to as the LLWMU. More recently the RWMS was expanded northward into an area referred to as the "expansion area."

4.3 History

The LLWMU consists of 31 landfill cells (pits and trenches) and 13 GCD boreholes. Nine of the GCD boreholes were used to dispose TRU waste and MTRU waste. Seven of the GCD boreholes have been filled and operationally closed, two have received waste and remain open, and four are empty. Pit 3 (P03U) is the only active mixed waste disposal unit. All other active units contain low-level radioactive waste. Pit 6 (P06U) is used for disposal of thorium (at the bottom tier). Pits P06U and P07U are used for disposal of asbestiform LLW. Of the 31 landfill cells, 5 pits and 16 trenches have been closed. Ten pits (P03U, P06U, P08U, P09U, P10C, P11U, P12C, P13U, P14U and P15U) remain open.

4.3.1 Waste Acceptance Criteria

The NNSA/NSO has established waste acceptance criteria for its radioactive waste disposal sites at the NTS (NNSA, 2003). The WAC provides the requirements, terms, and conditions under which the NTS will accept low-level radioactive and mixed waste for disposal. Mixed waste generated within the state of Nevada by NNSA/NSO activities is accepted for disposal. The WAC includes requirements for the generator waste certification program, characterization, traceability, waste form, packaging, and transfer of material. Personnel of the Radioactive Waste Acceptance Program review each waste generator's program and documentation for compliance to the NTS WAC. Upon arrival at the NTS, the waste shipments/containers are inspected to verify placards, manifests, marking and labeling, and container integrity (Becker, 2002).

NNSA/NSO policies regarding the storage and disposal of radioactive waste are as follows:

- Ensure safe and compliant storage and disposal of radioactive waste; be consistent with the current revision of all applicable federal, state, and local regulations.

- Protect the environment, personnel, and public from chemical and radiological hazards according to Title 40 CFR, RCRA; Title 10 CFR 835, "Occupational Radiation Protection;" DOE Order 435.1, "Radioactive Waste Management;" and state of Nevada and applicable U.S. Department of Transportation regulations.
- Ensure that present and future radiation exposures are kept as low as reasonably achievable and do not exceed the radiation protection standards established in Title 10 CFR 835.
- Ensure that Quality Assurance programs are established and implemented to fulfill the requirements of DOE Order 435.1; Title 10 CFR 830.122, "Quality Assurance"; and DOE Order 414.1A, "Quality Assurance."

4.3.2 Waste Placement

Waste to be disposed at the Area 5 RWMS is transported there on trucks. On arrival, manifests are checked and trucks are inspected both visually and with instrumentation to ensure that there is no leakage of contaminated materials from the containers. After they are cleared, the containers are off-loaded and placed in the appropriate active pit or trench (Figure 4-1), depending on waste type or classification, or both. Unloaded trucks are released only after being surveyed for contamination and found to be clean.

Pits and trenches range in depth from 4.6 to 15 m (15 to 48 ft). Disposal consists of placing waste in various sealed containers in the unlined pits and trenches. As rows of containers reach approximately 1.2 m (4 ft) below original grade, screened native alluvium is pushed over the containers in a single lift, approximately 2.4 m (8 ft) thick, (Figure 4-2).

Eight "unclassified" pits (P03U, P06U, P08U, P09U, P11U, P13U, P14U and P15U), and two "classified" pits (P10C and P12C) are currently open for receipt of waste. Pit P03U is designated for disposal of MLLW under RCRA interim status; however, only a small amount of NTS-generated mixed waste has been disposed there since 1992. Pit P06U has been deepened for disposal of thorium waste.

The GCD units are 3-m (10-ft) diameter vertical boreholes, 36 m (118 ft) deep. The boreholes are cased from the surface to the depth of 3 m (10 ft). Waste packages were placed in the bottoms of the boreholes up to a depth of approximately 21 m (70 ft) below land surface. The holes were then backfilled with native soil.

For a detailed description of the facilities at the Area 5 RWMS, refer to Shott et al. (1998). For further descriptions of pits, trenches, and GCD boreholes, refer to Cochran et al. (2001).

Figure 4-1 **Waste Container Emplacement in a Typical Pit at the Area 5 Radioactive Waste Management Site**

Figure 4-2 Emplacement of Backfill Over Waste Containers

4.3.3 Waste Containers

The following description of waste containers that have been buried at the Area 5 RWMS was excerpted from the "Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site," prepared by Bechtel Nevada (BN, 2005a).

Containers disposed at the Area 5 RWMS are categorized as boxes, drums, or nonstandard. Cardboard, octagonal "tri-wall" boxes were commonly used prior to the mid-1980s. These cardboard boxes were 0.6 or 1.2 m (2 or 4 ft) high and banded to wooden pallets with steel strapping. Waste was contained in plastic bags inside the cardboard boxes. These boxes were stacked as close to each other as the underlying pallet allowed and were susceptible to crushing if stacked too high.

Plywood boxes came into wide use thereafter, and range in size from 0.6 m (2 ft) high, 1.2 m (4 ft) wide, and 2.1 m (7 ft) long to 1.2 m (4 ft) high, 1.2 m (4 ft) wide, and 2.1 m (7 ft) long. Runners are typically attached to the bottom of the boxes to facilitate handling with a forklift. More waste was received in steel boxes in the 1990s. The steel boxes come in standard sizes similar to those of plywood boxes, and steel

runners or slots for handling with a forklift are typically part of the box design. Both the cardboard and steel boxes are stacked as close to each other as practicable; typically, several inches separate adjacent boxes.

Waste has also been disposed in steel drums of various sizes at the Area 5 RWMS. Standard 209-L (55-gallon [gal]) drums and 315-L (83-gal) overpack drums are common; less commonly used are 6-drum overpack containers. Drums are stacked either vertically on pallets, horizontally in a square array, or horizontally in a nested array.

Containers other than standard-sized boxes and drums are considered nonstandard. Many nonstandard containers have been disposed at the Area 5 RWMS, including containers of unusual shapes or nonstandard-sized boxes or drums. Nonstandard containers are typically stacked to make best use of available pit volume.

4.4 Waste Inventory

Wastes have been disposed at the Area 5 RWMS since 1960. The inventory of radioactive materials placed in the Area 5 RWMS from 1960 through 1992 is documented in two databases that cover this period (1960 to 1978, and 1978 to 1992). These databases were indexed by shipment or by package number. After September 30, 1992, a new database, known as the LLW Information System, became operational. Data in this database are stored in a single record, indexed by package.

4.5 Future Inventory

The inventory anticipated to be disposed from September 1988 through 2028 was estimated in the Area 5 PA (Shott et al., 1998). The Area 5 RWMS PA is based on shipments of waste received between 1989 and 1993 (the last year that complete records were available for development of the PA). The probable inventory for the period between 1993 and 2028 was projected in the PA. The estimated inventories of radionuclides in pits and trenches at the Area 5 RWMS at closure (assumed in the PA to be FY 2028) are summarized in Table 3.7 of that report. The estimated inventories of radionuclides in GCD boreholes are also summarized in the PA.

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5.0 CONCEPTUAL MODELS

Various models have been developed that have application to the characterization and assessment of the Area 5 RWMS. Some are quite specific to address a single factor, and others are more complex, addressing numerous aspects of the total disposal system and environment. Examples include:

- Hydrogeologic (IT, 1998, 1999a,b; Blout, et al., 1995; Laczniak et al., 1996; Winograd and Thordarson, 1975)
- Unsaturated Flow (Dixon, 1999; BN, 1998b)
- Groundwater Recharge (Levitt and Yucel 2002,a,b; Hokett and French, 1998)
- Subsidence (DOE, 1998a; Obi et al., 1996)
- Source Term (Shott et al., 1998)
- Transport and Exposure (Cochran et al., 2001; Estrella, 1994)
- Inadvertent Human Intrusion (BN, 2001c; Black, 2001; Shott et al., 1998)
- Biological (Hansen and Ostler, 2003; Winkel et al., 1995; Wirth et al., 1999)
- General Performance Assessment (Shott et al., 1998; Levitt et al., 1999; Cochran et al., 2001)

Most scenarios for radionuclide release and transport ultimately involve some aspect of the hydrologic system. Additionally, the hydrologic environment affects monitoring, performance assessment, and closure cover design decisions. The hydrologic conceptual model for the Area 5 RWMS is described below.

5.1 Hydrologic Conceptual Model for the Area 5 RWMS

Climate and vegetation strongly control the movement of water in the upper few meters of the alluvium. The magnitude and direction of both liquid and vapor fluxes vary seasonally and often daily. Except for periods following precipitation events, the moisture content in this near-surface zone is quite low. Below the near-surface region is a region where relatively steady upward movement of water is occurring. In this zone of slow upward moisture movement, analyses of stable isotope compositions of soil pore water confirm that evaporation is the dominant process (Tyler et al., 1996). This zone extends to depths as great as 3 to 40 m (10 to 131 ft) in Area 5. Below this zone, water potential measurements indicate the existence of a static zone, the top of which is approximately 40 to 90 m (131 to 295 ft) below the ground surface in Area 5 (Shott et al., 1997; 1998). In this static zone, essentially no vertical liquid flow is currently occurring. Below this static zone, flow is steady and downward due to gravity. Stable isotope compositions of pore water from these depths indicate that infiltration into this zone occurred under cooler, past climatic conditions (Tyler et al., 1996). If water were to migrate below the currently static zone, movement to the aquifer would be extremely slow due to the low water content of the alluvium. Estimates of travel time to the water table (assuming zero upward flux), based on hydraulic characteristics of the alluvium and assuming current conditions would still apply, are in excess of 50,000 years in Area 5 (Shott et al., 1998). See Figure 5-1 for a diagram of the vadose zone hydrologic conceptual model at the Area 5 RWMS.

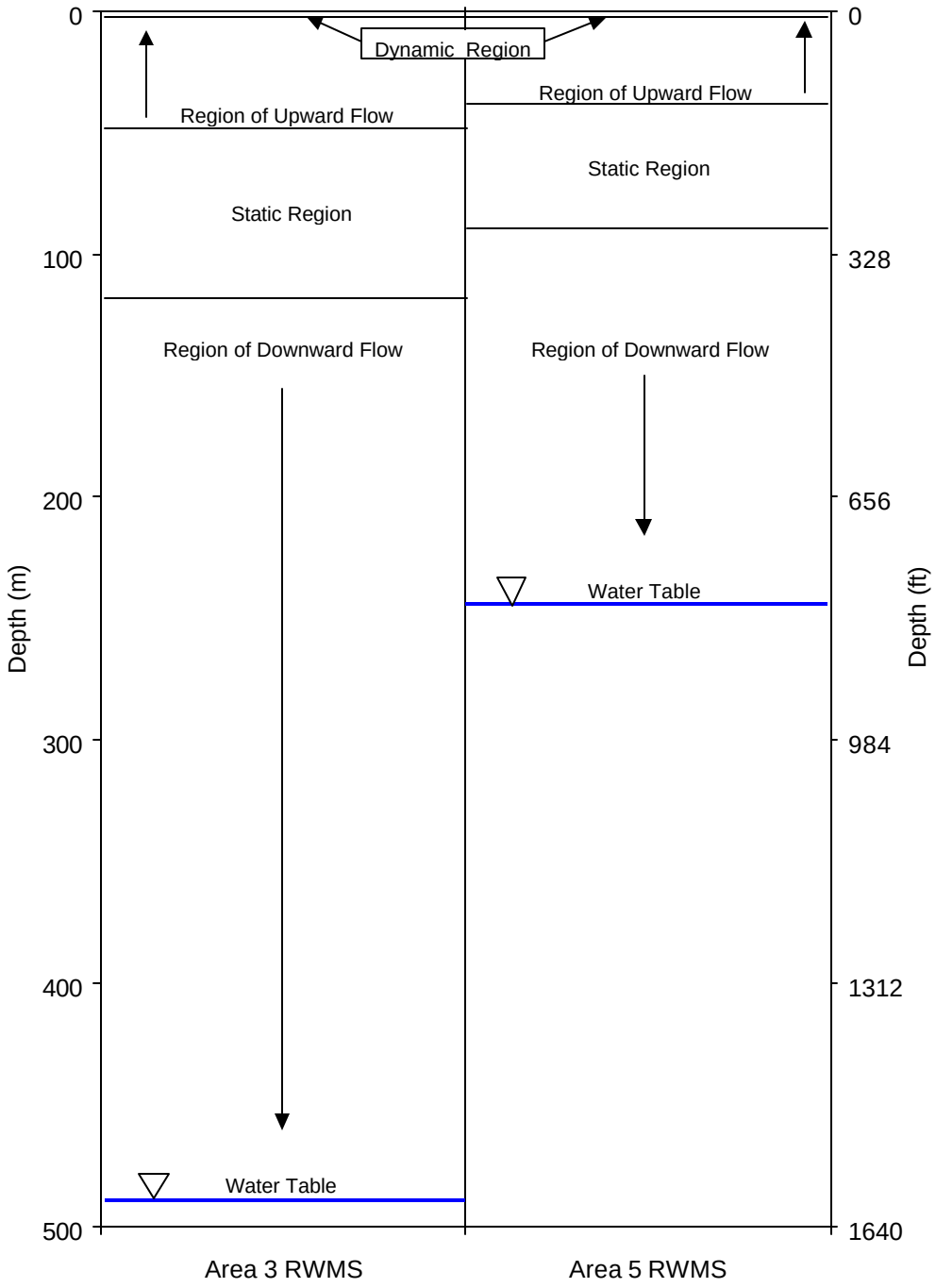

Figure 5-1 **Vadose Zone Hydrologic Conceptual Model of the Area 5 Radioactive Waste Management Site**

Based on the results of extensive research, field studies, modeling efforts, and monitoring data, which are summarized in the Area 5 Performance Assessment (Shott et al., 1998) and in Levitt et al. (2002a, 2002b, 1999, 1998), groundwater recharge is not occurring under current climatic conditions at the Area 5 RWMS. Studies indicate that under bare-soil conditions such as those found at the operational waste cell covers, some drainage may eventually occur through the waste covers into the waste zone. This drainage is estimated to be about 1 percent of the annual rainfall at Area 5, based on conservative one-dimensional modeling results (Levitt et al., 1998; 1999). In addition, monitoring data from a bare-soil weighing lysimeter located in Area 5 indicate that the soil water storage has increased slowly with time, although no drainage has been measured through the bottom of the lysimeter (Levitt et al., 1997)

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6.0 PERFORMANCE EVALUATION

The DOE waste management standards require operators of waste disposal sites to implement a site characterization program and to prepare a performance assessment. A PA is a systematic analysis of the potential risks posed by waste management systems to the public and the environment, and a comparison of those risks to the established performance objectives. Performance assessments identify the likely natural processes and events that affect the disposal system, examine the effects of these processes and events on the performance of the disposal system, and estimate potential exposures for a period of 10,000 years with consideration for the associated uncertainties.

6.1 Performance Objectives

Applicable performance objectives were identified in the Area 5 RWMS PA (Shott et al., 1998). In summary, current performance objectives are that offsite individuals shall not receive effective dose equivalents greater than 2.5×10^{-4} Sievert (Sv) per year from all pathways, 1.0×10^{-4} Sv per year from airborne emissions, and Radon-222 emissions must be less than 0.74 Bq m^{-2} per second. Groundwater resources must be protected as required by local governments, which usually require that doses from groundwater consumption be less than 0.4×10^{-4} Sv per year. Finally, the activity concentration of wastes disposed at the site must not exceed levels that would cause inadvertent human intruders to receive doses greater than 1.0×10^{-3} Sv (Shott et al., 1998).

6.2 Performance Evaluation Results

Analysis of the compliance scenarios indicates that the waste disposal site is reasonably likely to meet all the performance objectives for 10,000 years (Shott et al., 1998; Levitt et al., 1999). Site characterization studies and PAs have shown that the arid nature of the Area 5 RWMS offers unique performance-enhancing advantages. The limited transport pathways and limited land use potential of the site, coupled with operational procedures (e.g., WAC) and closure cover design, provide reasonable assurance that regulatory performance objectives can be met (Shott et al., 1998; Becker et al., 2002).

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7.0 CLOSURE COVERS

Closure of the Area 5 RWMS will proceed through three phases: operational closure, final closure, and institutional control. Many waste disposal units at the Area 5 RWMS are operationally closed. Over the latter part of the next decade, all waste disposal units at the Area 5 RWMS are anticipated to be closed.

Waste disposal units in the Area 5 RWMS expansion area, and possibly Pit P03U in the Area 5 RWMS 92-acre site will remain open for future waste disposal. Final closure of these units is anticipated in the period FY 2019 through FY 2021. Operational maintenance and monitoring will transition to post-closure maintenance and monitoring immediately after closure of the disposal units, and extend through the period of active institutional control. Any future release of the site will be according to the NTS Resource Management Plan (DOE, 1998b) and annual summaries, and with DOE Order 450.1, "Environmental Protection Program;" or, for mixed-waste units, according to conditions negotiated with the NDEP.

7.1 Closure Cover Design

Because performance objectives of the Area 5 PA are easily met, even with only an operational closure cover, the NNSA/NSO has considerable flexibility in designing the final closure covers. An approach will be taken for both closure and monitoring that emphasizes simplicity of design and maintenance. The basic closure cover design for all of the various units will be of the vegetated monolayer-ET type (Figure 7-1). A vegetated monolayer-ET closure cover was deployed in FY 2000 at the Central Nevada Test Area north of the NTS (BN, 2001d), and early in FY 2001 on U-3ax/bl at the Area 3 RWMS (BN, 2001a). In some cases, such as when considering long-lived or high-activity radionuclides, or where burrowing by termites or intrusion of roots might be problematic, the basic design may require modest modification to ensure long-term containment. Such modifications will be dealt with on a case-by-case basis. An instrumented drainage lysimeter facility near the Area 5 RWMS will collect data over at least the next several years that will be useful to optimize the design of the closure covers for specific units (see Section 8.3.1).

A monolayer-ET closure cover was selected as the preferred alternative design to a multilayered RCRA closure cover and other alternative designs only after a comprehensive evaluation of many alternatives. Evaluation of alternative designs included review of relevant literature, research on water balance in vegetated and unvegetated weighing lysimeters in Area 5 of the NTS, hydrogeologic modeling, site visits to closure cover test facilities at SNL and Los Alamos National Laboratory [LANL]), NNSA/NSO-sponsored workshops, and a conference on vadose zone monitoring. The various forums included representatives from industry, academia, and government, including SNL and LANL, and provided the opportunity to discuss closure and monitoring of waste disposal units. Multiple lines of evidence suggest that a monolayer-ET design will cost considerably less than a multilayer RCRA design, be much easier to install and maintain and, in an arid environment, perform according to performance criteria over long periods of time even under conditions of subsidence. The monolayer-ET cover and natural

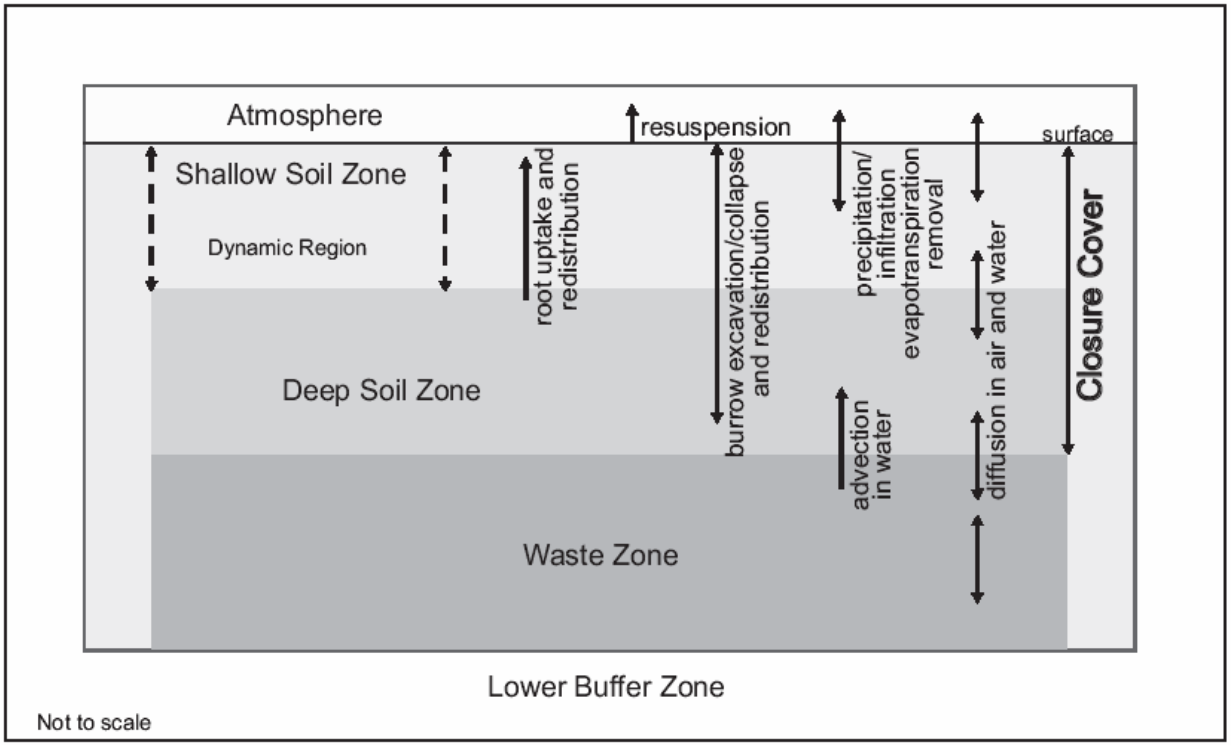

Figure 7-1 Diagram of a Monolayer-ET Closure Cover

conditions at the NTS will integrate and operate as a system. Natural conditions that optimize the system are extremely low precipitation and high evapotranspiration, large depth to groundwater, and negligible recharge to groundwater.

7.1.1 Water Infiltration

Measurement and modeling of water balance in test monolayer-ET covers at the Area 5 RWMS and at National Laboratories in arid regions of the United States show that the design will minimize infiltration of water (Levitt et al., 1998 and 1999; Dwyer, 1998; Levitt and Fitzmaurice 2001).

Water balance studies conducted at the Area 5 RWMS have shown that a monolayer-ET closure cover is most effective when vegetated (Levitt et al., 1999, 1997). Under the current climatic regime, any water that infiltrates into the soil is quickly extracted by evaporation and uptake by plant roots, even with a relatively low density of plant cover. Closure covers constructed over waste units at both the Area 3 and Area 5 RWMSs will be planted with species native to the area. Shallow-rooted, invasive plant species will also be allowed to vegetate the closure covers. Over the long term, a plant assemblage that will survive the ambient range of environmental conditions is anticipated to become established. Plants will also serve to maintain stability of the closure covers. The cover will have adequate slope to safely carry any precipitation runoff without significant erosion.

7.1.2 Disposal Unit Cover Integrity

The design of any closure cover must consider the potential for plant root intrusion into disposed waste, which would be a potential pathway for release of radionuclides. Cover designs will also have to consider the potential for animals burrowing into the closure cover or, less likely, into disposed waste. Burrowing by animals could degrade cover integrity, alter hydraulic properties of the cover, or transport radionuclides to the accessible environment (Hankonson et al., 1992). Mobile fauna could disperse contamination to distant sites, and animals could introduce contamination into trophic pathways, eventually leading to humans that consume wild game (O'Farrell and Gilbert, 1975). Design alternatives to mitigate these conditions will be included in closure plans specific to individual disposal units or groups of units.

7.1.3 Structural Stability

The structural stability of the closure cover could be affected by differential subsidence that might occur intermittently following infilling of void space around containers, and degradation and collapse of disposed waste containers (BN, 2005a; DOE, 1998a). Values of parameters affecting subsidence such as volume of void space, as well as estimates of subsidence, are described in Shott et al. (1998), Barker (1997), and Obi et al. (1996). During a period of active institutional control, any subsidence that might occur would immediately be mitigated by filling and grading the subsided spots with native alluvium, thus ensuring structural stability at all times. Any major damage to vegetation on the closure cover from maintenance activities will be corrected by replanting. Part of the total expected subsidence might take place by the end of the active institutional control period. The monolayer-ET cover design will be intrinsically structurally stable in that it does not include layers which, if displaced, would render the cover ineffective. The cover, however, will have to be of adequate thickness to accommodate some, but perhaps not all, subsidence over time. The cover itself is expected to erode; depressions will fill with sediment eroded from surrounding areas of the cover. The design of the closure cover will include proper surface and side slopes, and perhaps limited armoring, to permit drainage but not channelized erosion.

7.1.4 Inadvertent Intruder Barrier

The monolayer-ET closure cover design does not include a barrier against inadvertent human intrusion (IHI) (BN, 2005a). The thickness of the cover provides partial protection, but the greatest reliance is placed on a small probability of this occurrence, and on institutional control. The probability of IHI was the subject of an investigation of site-specific scenarios for inadvertent human intrusion into waste disposed at the Area 3 and Area 5 RWMSs. The intrusion scenarios focused on drilling for water in both Yucca Flat and Frenchman Flat, driven by an individual homesteader scenario and several community settlement scenarios (Black et al., 2001). A panel of Subject Matter Experts (SMEs), convened to elicit the probability of IHI into a waste unit, considered the effectiveness of management controls on reducing the probability of intrusion. Management controls, which include institutional control, site knowledge, placards and markers, and surface and subsurface barriers, were thought by the panel to be effective only for the first few centuries; some controls were considered to be more effective than others. For example, surface barriers could effectively control siting of a drill rig over a waste unit; whereas subsurface barriers and placards and markers were much less likely to control drilling.

Remoteness and harsh environmental conditions of both Yucca Flat and Frenchman Flat, and the presence of playas and subsidence craters, were thought by the panel to be the most important factors affecting the probability of drilling, and thus intrusion. One of several community scenarios (in which a community settlement that develops from an industrial-technological complex in a nearby, yet more accessible valley, and has commuter homesteaders living in Frenchman Flat) yielded the greatest probability of inadvertent intrusion; that is, about 10 percent.

7.2 Area 5 RWMS Operational Closure Cover Construction

Native alluvium excavated to form trenches at the Area 5 RWMS is typically stockpiled for later use in operational closure. Within a short time after disposal, this stockpiled alluvium is screened to remove rocks larger than 9 cm (3.5 in.) and then placed from the top of the unopen end of the disposal unit over the stacked packages. Final operational closures include placement of alluvium over the waste to a total thickness of about 2.4 m (8 ft), so that about 1.2 m (4 ft) of alluvium stand above grade (Figure 4-2). The front end of the waste is not covered, so that additional waste can be easily stacked. The alluvium is placed over the waste packages in one lift and is compacted by the process of placement and by heavy equipment running over the total thickness of alluvium. After a disposal unit is completely filled, the operational cover is graded to provide a smooth surface. Maintenance of the cover includes filling of fissures and depressions resulting from compaction and piping of alluvium between waste packages, and compaction of the surface with a roller and regrading. Operational closure covers are not vegetated because of the need for continued maintenance activities.

Two weighing lysimeters installed near the Area 5 RWMS, one vegetated and the other bare, serve as analogs for the operational closure covers. Data collected over the past five years show that alluvium in the unvegetated lysimeter stores more water than similar alluvium in the vegetated lysimeter. Over a period of approximately five years, the unvegetated area could have slight infiltration through the thickness of the alluvium column (approximately 1.8 m [6 ft]). Water that infiltrates into the vegetated lysimeter, however, is quickly removed by evapo-transpiration. To date, no water has drained through the bottom of either lysimeter (BN, 2004b). Modeling conducted for final closure of disposal unit U-3ax/bl shows that water is effectively removed from the alluvium column with as little as 20 percent vegetation cover (DOE, 2000c). Several instrumented drainage lysimeters have also been installed at the Area 3 RWMS.

7.3 Final Closure

Waste disposed at the Area 5 RWMS can be categorized on the basis of security requirements, waste type, and disposal configuration. The criteria defining the categories of disposed waste, along with the spatial distribution of waste cells at the RWMS, provide logical groups of waste cells when considering the activities, interactions, and documentation required to support closure.

Such grouping of disposal units will allow key differences that might require different interactions or engineering to be adequately addressed in final closure documentation. Disposal units that contain only LLW, or that contain LLW and TRU waste, will be closed according to regulations imposed by NNSA/NSO in the process of self-regulation. The atlas of disposal units in the Area 5 RWMS

(maintained by the management and operations contractor) shows several operationally closed LLW disposal units within the 92-acre site that may contain hazardous constituents. The basis for this determination is unknown because at the time of disposal, these wastes were not regulated or defined as mixed waste. Reviews of paper records of waste received from 1961 through 1976, and of electronic records of waste received from 1977 through 1988 were conducted to verify to the extent possible which disposal units contain hazardous constituents regulated under the RCRA. A CAU of "retired mixed waste cells" (citing from the RCRA Permit NEV HW009) is proposed on the basis of this evaluation. The "retired mixed waste cells" are within a group of waste disposal units that were opened, and generally operationally closed prior to January 1987, when P03U was opened for disposal of waste with hazardous constituents. The CAU will be closed in concert with the NDEP according to RCRA and regulations imposed by NNSA/NSO in the process of self-regulation.

7.3.1 Interim Closure Covers

Pending the approval of the NDEP as necessary, the NNSA/NSO will add native soil to disposal units composing the CAU and to all other operationally closed units within the 92-acre area. The addition of native soil is comparable to the approach taken to close U-3ax/bl (CAU 110) at the Area 3 RWMS in FY 2001. Characterization may be required to demonstrate that the action will not adversely impact the regulated disposal units. However, results of past characterization studies and ongoing measures of water balance at the Area 5 RWMS are believed to provide sufficient data to show that previous characterization is sufficient and additional characterization is not necessary.

7.3.2 Final Closure Schedule

Closure activities for waste disposal units in the 92-acre site, the expansion area north of the Area 5 RWMS, and the Area 3 RWMS follow a systematic process consisting of ten steps summarized below. These steps were followed for closure of U-3ax/bl (CAU 110). The first two steps, preliminary assessment and initial planning, determine the level of detail required to conduct each remaining activity or develop each remaining document. Results of investigations conducted prior to the emplacement of the interim closure cover for the 92-acre site, along with results of previous site characterization studies and ongoing measures of water balance at the 92-acre site and elsewhere, are believed to be sufficient to justify minimal initial closure activities for the 92-acre site. Development of a closure plan for the 92-acre site is scheduled for FY 2006, followed by closure construction and a closure report in FY 2008. Responsibilities for closure and monitoring of the 92-acre site are shared between the NNSA/NSO WMD and the BN Waste Management Project.

Closure activities for waste disposal units in the expansion area north of the Area 5 RWMS 92-acre site are scheduled for FY 2019 through FY 2021.

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8.0 MONITORING DURING OPERATIONAL CLOSURE

This section summarizes the environmental monitoring programs, as well as meteorology and subsidence monitoring data, collected for the Waste Management monitoring program for the Area 5 RWMS. Refer to the RWMS ICMP (BN, 2005a) for details of the RWMS monitoring program. Monitoring programs for radiation exposure, air, groundwater, meteorology, vadose zone, subsidence, and biota data are discussed in the following subsections.

8.1 Introduction

Environmental monitoring data, subsidence monitoring data, and meteorology monitoring data are routinely collected at and around the Area 3 and Area 5 RWMSs at the NTS. These monitoring data include radiation, air, groundwater, meteorology, vadose zone, subsidence, and biota data. Some of these data (radiation, air, and groundwater) are reported at various levels of detail in other BN reports. These include the Annual Site Environmental Report (ASER) (BN, 2003b), the National Emission Standards for Hazardous Air Pollutants (NESHAP) report (BN, 2002b), and the Annual Groundwater Monitoring Report (BN, 2003b).

Monitoring at the Area 5 RWMS is required under a variety of regulatory drivers, including federal regulations and DOE Orders (as discussed in Section 3.0). Monitoring data are used to demonstrate compliance with regulatory drivers and with performance objectives presented in the PAs, to confirm assumptions about flux rates through upward and downward pathways, to confirm assumptions about soil water contents and potentials, to confirm conceptual models, to provide input to PA maintenance, and to evaluate radiation doses to the general public. Monitoring is also conducted to ensure the integrity of waste covers. In addition, the monitoring program is designed to sufficiently forewarn of any need for mitigative actions and to record the utility of any mitigative actions.

The programs for monitoring direct radiation fields, air, vadose zone, biota, groundwater, meteorology, and subsidence during the operational closure period (current), and final closure and active institutional control periods are addressed in the ICMP (BN, 2005a). Monitoring data quality objectives are defined in the NTS RREMP (BN, 2003a).

Direct radiation monitoring is conducted to confirm that RWMS activities do not result in radiation levels significantly above background. Air monitoring is conducted to confirm that RWMS activities do not result in radionuclide concentrations significantly above background levels in air and to confirm compliance with NESHAP. Groundwater monitoring is conducted, as required by EPA regulations and DOE Orders, to assess the water quality of the aquifer beneath the RWMS and to confirm that RWMS activities are not affecting the aquifer. Vadose zone monitoring is conducted to assess the water balance of the RWMSs and to confirm the assumptions made in the PAs, including no downward pathway, and to evaluate the performance of the operational monolayer waste covers. Soil-gas monitoring for tritium is conducted to evaluate the upward and downward pathways, and biota monitoring for tritium is conducted to evaluate the upward pathway through the waste covers. Subsidence monitoring is conducted to ensure that subsidence features are repaired to prevent the development of preferential pathways through the covers.

Monitoring is also conducted to ensure the integrity of covers over waste disposal units. In addition, the monitoring program is designed to sufficiently forewarn management and regulators of any need for mitigative actions, and to record the utility of any mitigative actions.
Monitoring data are required for input to PA maintenance. The maintenance guide for DOE LLW disposal facility PAs and CAs (DOE, 1999a) states that the review of results of monitoring and research and development results will consist of several activities, including:

- Comparing facility monitoring results with expected performance and determining consistency with conceptual models;
- Evaluating monitoring results for consistency with CA and conceptual models;
- Evaluating other monitoring activities for significant results;
- Evaluating research and development results to determine impacts on PA results and conclusions and consistency with conceptual models;
- Evaluating research and development results to determine impacts on CA results and conclusions;
- Determining if better methodologies or technologies are available; and
- Evaluating the results of special studies.

Review of monitoring data for routine PA and CA maintenance is an iterative process that will ultimately dictate which monitoring data should continue to be collected, and which monitoring data are no longer required.

The ICMP (BN, 2005a) describes the program for monitoring direct radiation, air, vadose zone, biota, groundwater, meteorology, and subsidence at the Area 3 and Area 5 RWMSs during the operational closure period (current), and final closure/active institutional control periods.
At present, direct radiation is continuously monitored at ten locations at the Area 5 RWMS. Air monitoring for radionuclides other than radon is conducted at several locations at the RWMS using air samplers, whereas radon is passively monitored at six locations at the RWMS, and at several background locations. Radon flux through waste covers is monitored annually at various locations at each RWMS and at background locations. Vadose zone monitoring for soil water content and soil water potential is conducted continuously in waste covers, beneath waste units, and at lysimeter facilities. Surface water runoff is monitored at flumes. Tritium in soil-gas moisture is monitored annually in a deep borehole at the Area 5 RWMS (GCD-05U), which contains a large tritium source. Biota are monitored annually for tritium. Groundwater is monitored semiannually at three wells surrounding the Area 5 RWMS for radioactive and nonradioactive constituents. In addition, meteorological parameters are continuously monitored at the Area 5 RWMS, and monitoring of waste cover subsidence is conducted monthly (e.g., BN, 2004b).

8.1.1 Monitoring During Operational Closure

Based on applicable regulatory drivers and data needs, monitoring during operational closure includes environmental monitoring of direct radiation, air, vadose zone, biota, and groundwater. Additional monitoring includes meteorology monitoring, and subsidence monitoring of operational waste covers.

Water balance measurements activities include:

- Meteorological monitoring to measure precipitation (the driving force for downward flow), and to calculate PET (the driving force for upward flow).
- Lysimeters (weighing and drainage) to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.
- Neutron logging through access tubes to measure infiltration, soil water redistribution, and to monitor specific locations of interest (in some locations to depths of hundreds of feet) (discontinued and replaced by time-domain reflectometry [TDR]).
- Automated vadose zone monitoring systems with in situ sensors TDR probes, and heat dissipation probes[HDPs]) to measure soil water content and soil water potential over a large spatial area, but usually to a limited depth.
- Surface water runoff monitoring at flumes and at the floor of a nuclear subsidence crater.
- Soil-gas sampling for tritium to confirm PA assumptions and transport coefficients.

This strategy of incorporating a variety of moisture measurements provides an accurate estimate of the RWMS water balance, including any drainage through the RWMS waste covers and, therefore, potential recharge. Based on these data, as well as other work (Tyler et al., 1996), there is essentially no recharge to the groundwater under current conditions at the RWMSs, and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

A technical design process for development of a detailed Quality Assurance, Analysis, and Sampling Plan for vadose zone monitoring at the RWMSs, including guidance for action levels and corrective actions and styled after the EPA Data Quality Objectives (DQO) process (EPA, 1994), is included in the RREMP (BN, 2003a). The current vadose zone monitoring program is designed on the basis of a strong understanding of the vadose zone system through extensive vadose zone characterization studies (BN, 1998d; Blout et al., 1995; REECo, 1994, 1993a,b; Shott et al., 1998, 1997; and Tyler et al., 1996) and modeling studies (Crowe et al., 1998; and Levitt et al., 1999). In addition, the vadose zone monitoring program is designed in part from the results of an Alternative Evaluation Study (AES) on vadose zone monitoring (BN, 1998b) using an organized team approach, and in part from successful vadose zone monitoring field experience. Annual vadose zone monitoring data are reported in an annual monitoring report (e.g., BN 2004b). Details of the RWMS vadose zone monitoring activities can be found in the RWMS vadose zone monitoring Organizational Instructions OP-2154.106, "Neutron Moisture Logging;" OI-2154.111, "Instructions for Datalogger Monitoring Stations;" and OP-2154.113, "Soil Gas Sampling at GCD-05U."

8.2 Meteorological Monitoring

A meteorological monitoring program is maintained by operation of one two-level meteorology tower at each RWMS. The Area 5 RWMS meteorology station is located to the southeast of the Area 5 RWMS, about 100 m (328 ft) from Borehole Ue5PW-1 (Figure 8-1).

In addition to fulfilling basic regulatory requirements for meteorological monitoring in DOE Order 450.1, the RWMS meteorological monitoring program is designed to include measurements of components of the surface energy balance for calculation of PET. PET calculations are an important component of the water balance estimates of the RWMSs. Meteorological parameters monitored at the Area 5 RWMS include:

- Air temperature at two heights
- Relative humidity at two heights
- Wind speed at two heights
- Wind direction at two heights
- Barometric pressure
- Solar radiation
- Precipitation

8.2.1 Potential Evapotranspiration

The total calculated PET for Area 5 in 2001 was approximately 1,690 mm (66 in.). The PET was calculated using the radiation-based equation of Doorenbos and Pruitt (1977), which requires the following data inputs: net solar radiation, air temperature, relative humidity, wind speed, and barometric pressure. This method provides results similar to the previously used Penman Equation (Jensen et al., 1990), but with reduced data input needs and lower maintenance costs.

8.2.2 Precipitation Data

The annual average rainfall at the Area 5 RWMS is 12.2 cm (4.8 in). Notable rainfall may occur sporadically in winter or summer storms. Figure 8-2 depicts historical precipitation recorded at BJY station (located about 3 km northwest of the Area 3 RWMS) and Well 5B station (located about 5.5 km south of the Area 5 RWMS).

8.2.3 Wind Roses

Wind rose diagrams illustrate wind direction (direction of wind source) and the occurrence of wind speed groupings in each direction, using hourly wind data, measured at a height of 3.0 m (10 ft) above the ground surface. Wind roses from Area 5 RWMS meteorology station are presented in Figure 8-3. Note that in general, low wind speeds tend to originate from the north, whereas high wind speeds tend to originate from the south.

Figure 8-1 **Monitoring Stations at the Area 5 Radioactive Waste Management Site**

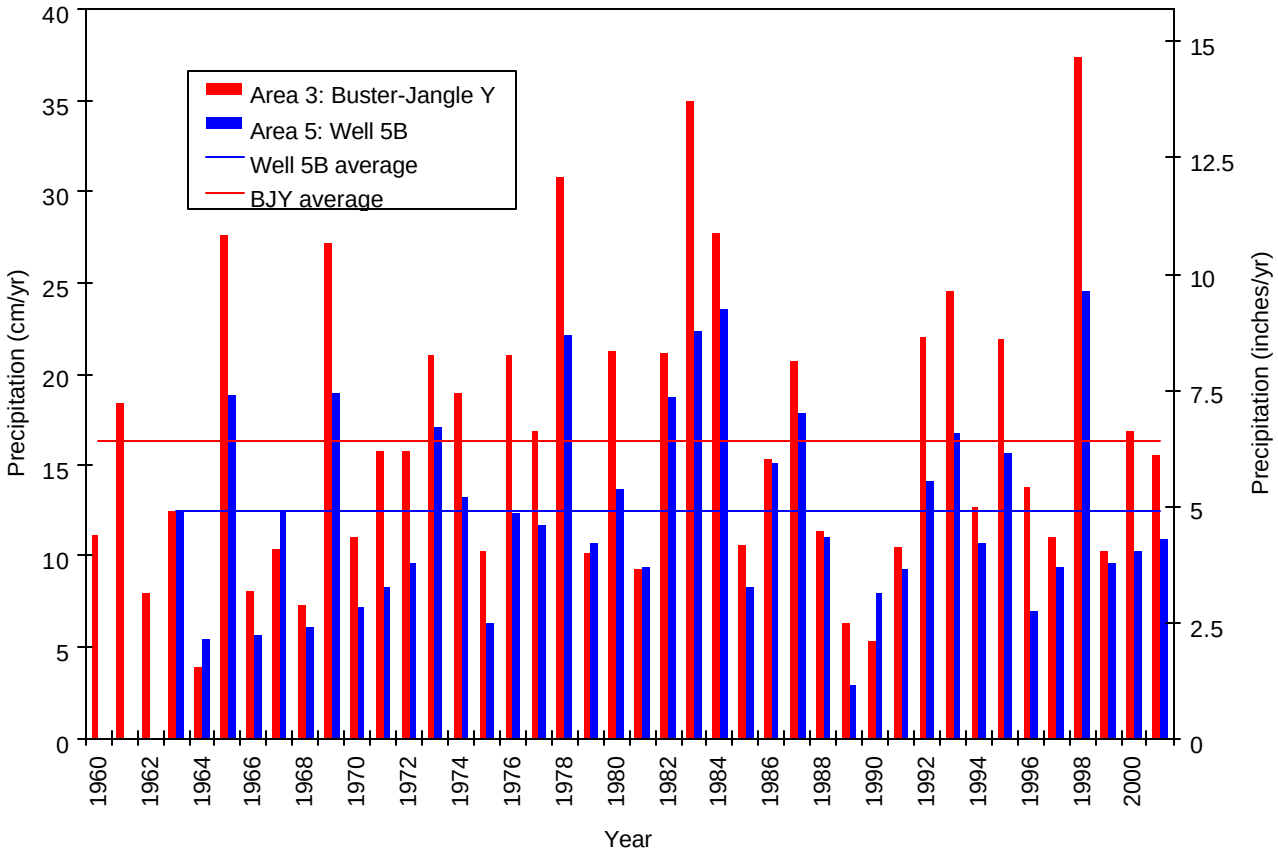

Figure 8-2 Historical Precipitation Records for Area 3 and Area 5

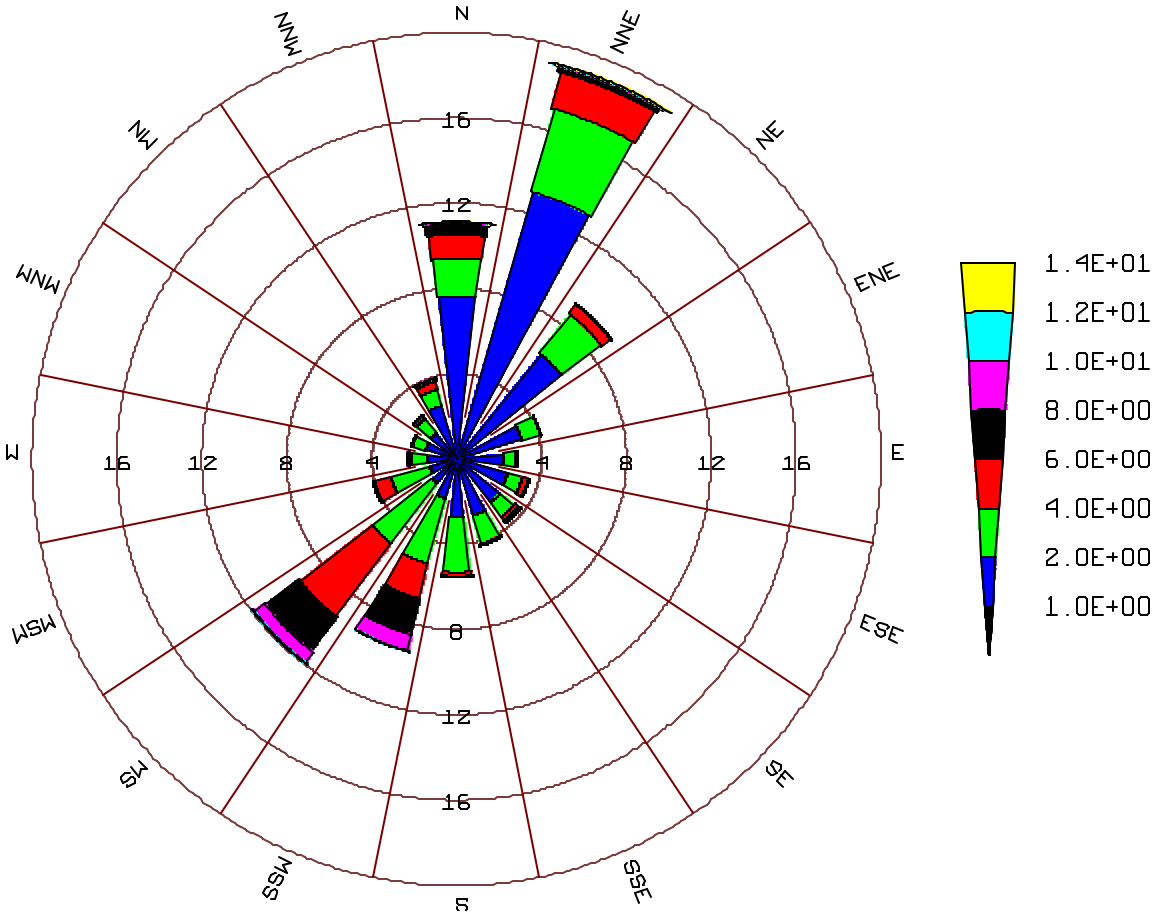

Figure 8-3 **Annual Wind Rose for Well 5B in Frenchman Flat for 1983 to 1993**

Meteorological monitoring data are reported in annual reports such as the Waste Management Monitoring Reports (e.g. BN, 2004b) and the NTS ASER (BN, 2003b). Details of the RWMS meteorology monitoring activities can be found in the RWMS meteorology monitoring OI-2154.111, "Instructions for Datalogger Monitoring Stations."

8.3 Vadose Zone Monitoring

Vadose zone monitoring is conducted at the Area 5 RWMS to demonstrate compliance with DOE Orders 450.1 and 435.1; to test PA assumptions regarding the hydrologic conceptual model including soil moisture content, upward and downward flux rates, and volatile radionuclide releases; to detect changing trends in performance; to provide added assurance to PA conclusions regarding facility performance; to evaluate the performance of the operational monolayer waste covers; and to confirm the PA performance objective of protecting groundwater resources.

Vadose zone monitoring is conducted at the Area 5 RWMS by measuring the water balance of the RWMS and by directly measuring tritium migration within the Area 5 RWMS. Water balance monitoring is accomplished by use of meteorology data to calculate PET, the driving force of upward flow; by measuring directly the actual evapotranspiration and bare-soil evaporation (Area 5 RWMS weighing lysimeter facility); and by measuring soil water content and soil water potential in waste cell covers and floors (automated waste cover monitoring systems). The RWMS vadose zone monitoring strategy also employs sampling of soil gas for tritium at GCD-05U near the center of the Area 5 RWMS to evaluate the subsurface migration of tritium.

The current vadose zone monitoring program is designed on the basis of a strong understanding of the vadose zone system from extensive vadose zone characterization studies (Blout et al., 1995; REECo, 1993a, 1993b, 1994; Shott et al., 1998, 1997; Tyler et al., 1996), and from modeling studies (Crowe et al., 1998; Levitt et al., 1999). The vadose zone monitoring program design also reflects the results of an AES on vadose zone monitoring using an organized team approach (BN, 1998b) and vadose zone monitoring field experience.

8.3.1 Gas-Phase Tritium Monitoring Data

Tritium monitoring of moisture in soil gas is conducted to evaluate the upward pathway for radionuclide transport. Tritium is a volatile radionuclide and therefore provides a conservative measure of the performance of the waste site and its ability to isolate buried waste.

Gas-phase tritium monitoring is conducted via soil-gas sampling at GCD-05U (see Figure 8-1 for location). Tritium sampling at GCD-05U has been conducted every year since 1990, providing an important data set for analyzing tritium migration from the Area 5 RWMS. This unit has a large tritium inventory (2.2 million Ci at time of disposal) and is instrumented with two strings of nine soil-gas sampling ports buried at depths ranging from 3 to 37 m (10 to 120 ft) below surface. Tritium sampling at GCD-05U provides a direct measure of tritium migration from waste packages with time due to degradation of waste containers and the natural transport processes of advection and diffusion. Results

indicate that while soil-gas tritium concentrations continue to increase at depths between 15 and 37 m (50 and 120 ft), vertical migration is extremely slow.

This ten-year data set could be used to calibrate a tritium vapor transport model to predict travel times to the ground surface (and atmosphere) and to validate the gaseous diffusion models in the PAs.

Soil-gas sampling ports are also located in various locations at the Area 5 RWMS, including several locations beneath pits P03U and P05U. The ports are not currently monitored, but if required, they may be monitored in the future to augment current studies of tritium migration.

8.3.2 Area 5 Weighing Lysimeter Facility Data

The Area 5 weighing lysimeter facility consists of two precision weighing lysimeters located about 400 m (1,312 ft) southwest of the Area 5 RWMS (Figure 8-4). Each lysimeter consists of a steel box 2 m (6.6 ft) deep, filled with soil and having a ground surface area of 2 by 4 m (6.6 by 13 ft) and a volume of 16 m^3 (565 ft^3). The top of the soil tank is flush with the ground surface, and access to the side of the soil tank is provided through an underground entry. Each lysimeter is mounted on a sensitive scale, which is continuously monitored using an electronic loadcell. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert. The other is kept bare (to simulate the bare operational waste covers at the Area 5 RWMS). Each of the weighing lysimeters is instrumented with TDR probes to measure volumetric soil water content at depths ranging from 10 to 170 cm (4 to 67 in.). The TDR probes are connected to automated datalogger systems that provide daily profiles of soil water content. The loadcells have been monitored continuously since March 1994 and provide an accurate dataset of the surface water balance at the Area 5 RWMS. This monitoring time period also includes the wet "El Nino" year of 1998, when rainfall was twice the annual average.

The Area 5 weighing lysimeter facility is managed by BN Environmental Technical Services. For more information on this facility, refer to Levitt et al. (1996). Weighing lysimeter data represent a simplified water balance: change in soil water storage is equal to precipitation minus evaporation (E) or evapotranspiration (ET), because no drainage has ever been measured through the bottoms of the lysimeters and because the one-inch high lip around the edge of the lysimeters prevents run-on or run-off. Total soil water storage is illustrated in Figure 8-5 for the period of March 30, 1994, through December 31, 2001. Daily precipitation totals also are illustrated in Figure 8-5. The soil water storage increases, recorded early in the data record for the vegetated lysimeter, were due to irrigations to ensure that transplanted vegetation survived. Note the steep decrease in soil water storage in the vegetated lysimeter following high-rainfall periods. Note also that the vegetated lysimeter is considerably drier than the bare-soil lysimeter, despite the paucity of plants in the vegetated lysimeter (about 15 percent cover). The increasing trend of soil water storage in the bare lysimeter may eventually lead to some drainage out the bottom of the lysimeter. Conservative modeling results also indicate that some slight drainage (1 percent of rainfall) will eventually leak from the bottom of the bare-soil lysimeter (Levitt et al., 1999).

Figure 8-4 **Locations of the Area 5 RWMS Pilot Wells and Weighing Lysimeter Facility**

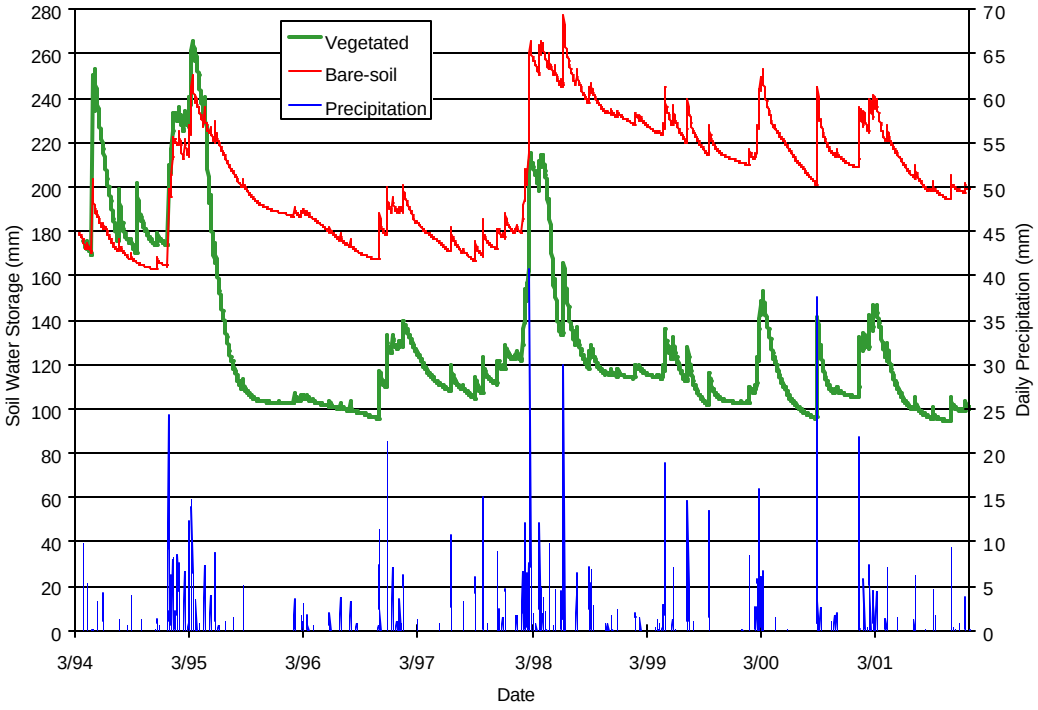

Figure 8-5 **Weighing Lysimeter and Precipitation Data from March 1994 to December 2001**

8.3.3 Automated Waste Cover Monitoring System Data

In 1998, TDR probes were buried 1.2 m (4 ft) beneath the open pit floors of pits 3 and 5 at the Area 5 RWMS. In 1999, TDR probes were installed in the operational cover of Pit 3 at two sites (north and south), at depths ranging from 10 to 180 cm (0.3 to 5.9 ft). In 2000, TDR probes were installed in the operational covers of Pits 4 and 5 at depths ranging from 20 to 180 cm (0.7 to 5.9 ft), and HDPs were installed in the operational cover of Pit P05U at those same depths. These sensors are connected to dataloggers that automatically collect and store data, which are downloaded by telephone links (at some locations) for immediate analysis. The datalogger station for the Pit P03U floor sensors is currently located in Pit P03U. This station will either be discontinued or moved (and some sensor cables may need to be lengthened) if enough waste arrives in Pit P03U to warrant the move.

An automated monitoring system was installed in Area 5 adjacent to Borehole Ue5PW-1, at the Neutron Probe Calibration Facility in 1998. This TDR system has 36 TDR probes buried at depths of 30, 60, and 90 cm (1, 2, and 3 ft) and has performed well for over three years.

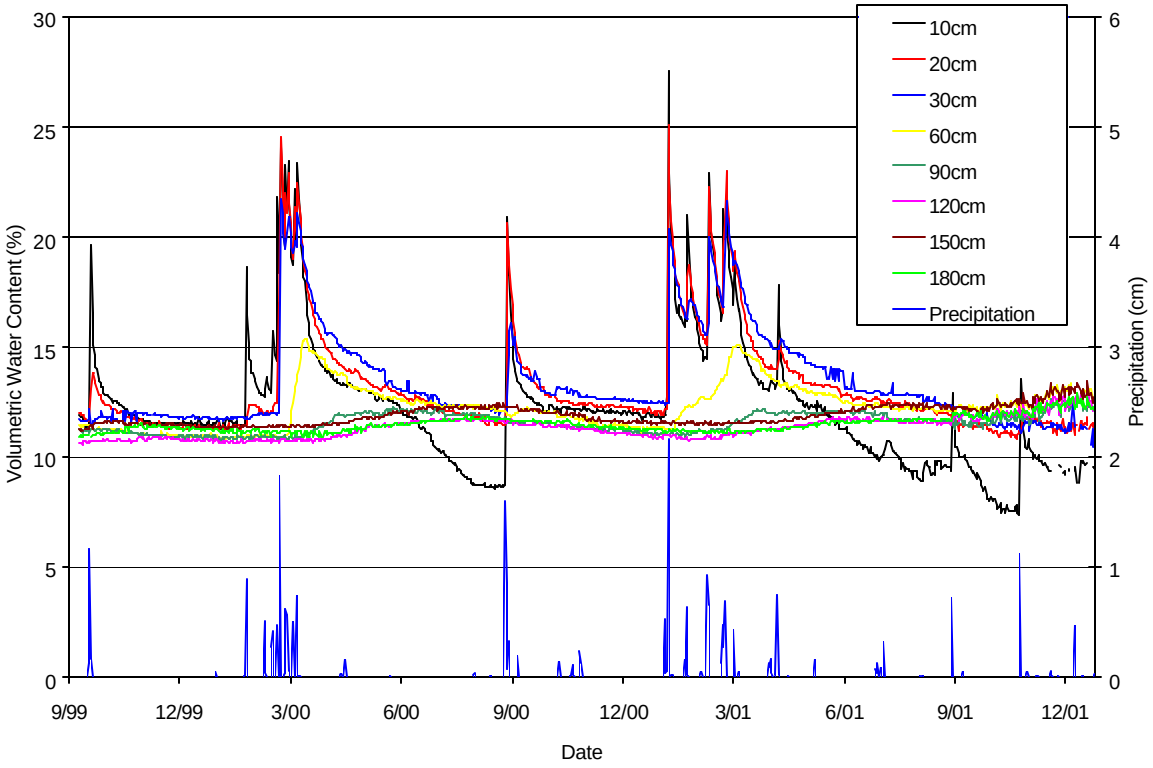

Figure 8-6 **Soil Water Content in Pit 3 Waste Cover (north Site) Using an Automated TDR System**

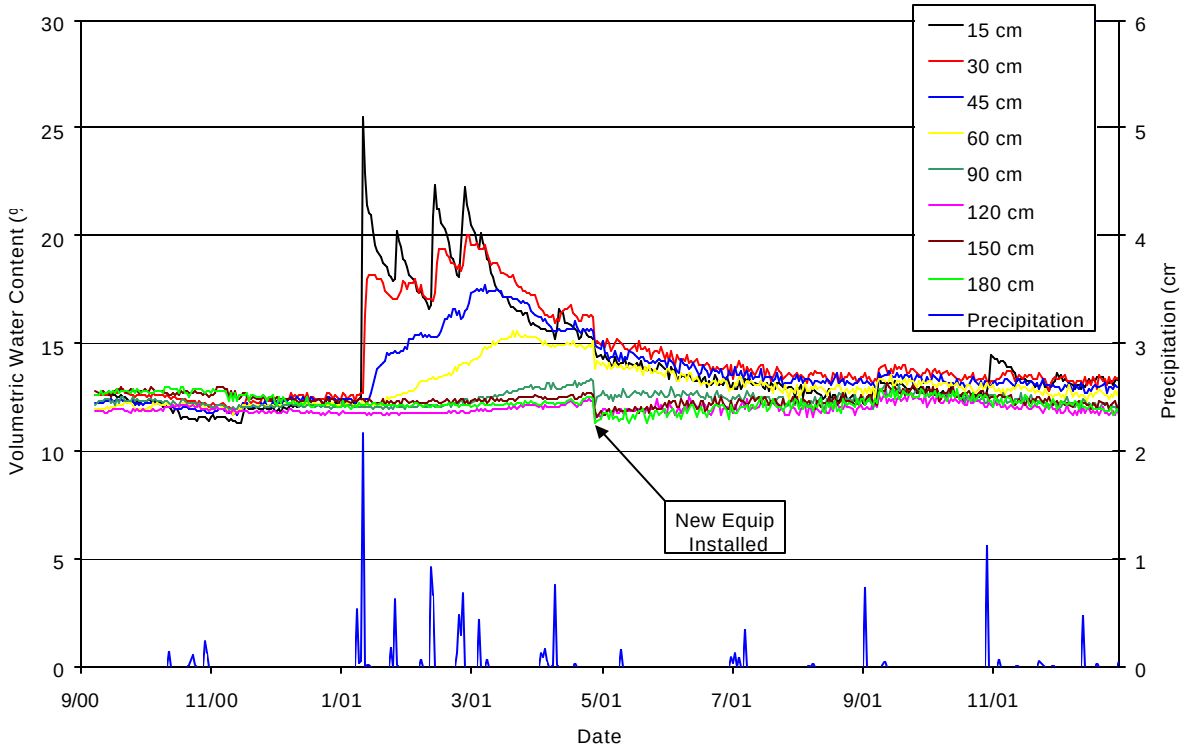

Figure 8-7 **Soil Water Content in Pit 4 Waste Cover Using an Automated TDR System**

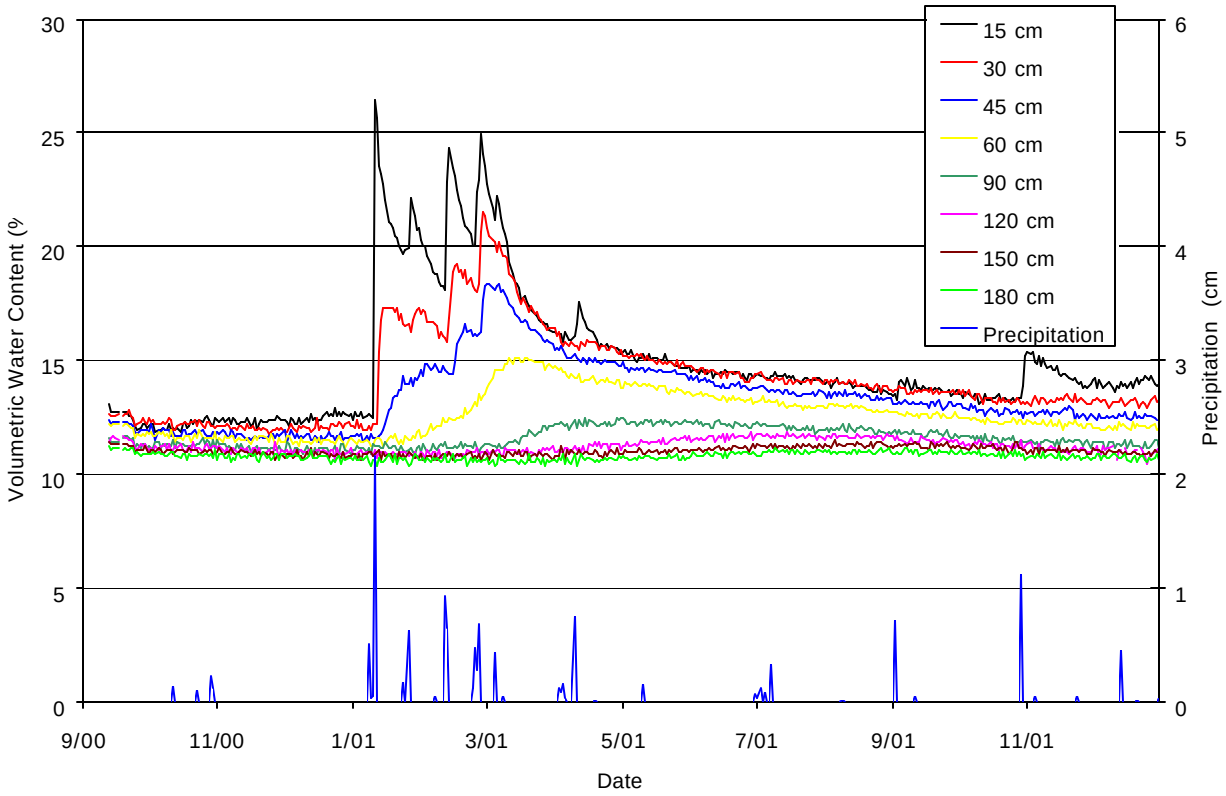

Figure 8-8 Soil Water Content in Pit 5 Waste Cover Using an Automated TDR System

Soil water content versus time, is illustrated in Figures 8-6 through 8-8 for TDR systems in the waste covers at Pits 3, 4, and 5, and for the TDR systems in the floors of Pits 3 and 5. In Figures 8-6 through 8-8, note that the depth of infiltration from 2001 precipitation never exceeded 60 cm (2 ft) before that water was returned to the atmosphere by evaporation. Slight increases in water contents are seen to greater depths, but these are likely the result of water vapor flow rather than liquid wetting fronts.

8.3.4 Neutron Logging

Monitoring of vadose zone moisture content by neutron logging has been discontinued. With the exception of disposal unit U-3bh crater, future moisture content monitoring at Areas 3 and 5 will be conducted using only the automated TDR systems described in Subsection 8.3.3 above. For a detailed history of the neutron logging monitoring program at Area 3 and Area 5 RWMSs, refer to BN (1997). The neutron access tubes are anticipated to remain in the covers.

8.4 Groundwater Monitoring

Groundwater monitoring is conducted at the three pilot wells surrounding the Area 5 RWMS (Figure 8-4) as required by Title 40 CFR 264 or 265. These wells were originally drilled in 1993 as characterization wells for determination of physical and chemical properties of drill core, for

determination of chemical properties of groundwater in the uppermost aquifer, and for determination of depths to the uppermost aquifer (REECo, 1994). In a letter from DOE/NV to NDEP dated December 12, 1993, DOE/NV requested that the pilot wells be accepted as RCRA monitoring wells. In a letter from NDEP to DOE/NV, dated February 24, 1994, NDEP stated that the pilot wells appear to meet the applicable design, construction, and development criteria for RCRA groundwater monitoring wells. A revised groundwater monitoring program outline was submitted to NDEP on March 1, 1998 (BN, 1998a). On March 31, 1998, NDEP transmitted a letter to DOE/NV stating concurrence with the sampling frequency, indicator parameters, and investigation levels submitted in the groundwater monitoring outline.

Groundwater from pilot wells are sampled semiannually for the following parameters (BN, 1998a):

Indicators of Contamination:

- pH
- Specific conductance
- Total organic carbon
- Total organic halogen
- Tritium

General Water Chemistry Parameters:

- Total Ca, Fe, Mg, Mn, K, Na, SiO_2
- Total SO , Cl, F 4
- Alkalinity

Investigation levels for these indicators of contamination can be found in BN (1998a). Details of pilot well construction can be found in REECo (1994).

Additional groundwater monitoring requirements driven by DOE Orders and independent of EPA requirements, were determined through a DQO-driven process and are detailed in the RREMP (BN, 2003a). The groundwater monitoring frequency identified in the RREMP is biennial. Groundwater monitoring analytes identified in the RREMP include:

- Tritium,
- Gross alpha,
- Gross beta,
- Gamma spectroscopy, and
- Plutonium-238, and plutonium-239+240.

All groundwater sampling data from the Area 5 RWMS pilot wells to date indicate that the groundwater in the uppermost aquifer is unaffected by RWMS or NNSA weapons testing activities. Tritium concentrations in the groundwater beneath the Area 5 RWMS have never exceeded the method detection limit for enriched tritium analysis (approximately 15 pCi/L). Groundwater elevation data

indicate that the water table beneath the Area 5 RWMS is nearly flat, with groundwater flowing in a northeastern direction at a horizontal velocity of approximately 23 cm (9 in) per year (BN, 2004a).

Groundwater monitoring data are presented in detail in the annual groundwater monitoring data report (e.g., BN, 2004a). Details of the Area 5 RWMS groundwater monitoring activities can be found in the Area 5 RWMS groundwater monitoring OI-2154.108, "Instructions for Area 5 RWMS Groundwater Well Preparation and Groundwater Sampling;" and OI-2154-104, "Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Groundwater Wells."

8.5 Surface Water Runoff Monitoring

Design of structures and closure covers that can best accommodate run-on from precipitation events over long periods of time must rely on historical precipitation and discharge data. Precipitation data have been collected at various locations around the NTS for several decades. However, until recently, the locations of data collection were not near the middle reaches of watersheds that potentially collect and discharge waters to the vicinities of facilities. To collect precipitation and discharge data relevant to performance assessment and eventual design activities, two each of precipitation gauges and flumes were installed in FY 2000 in watershed channels near the Area 5 RWMS. One precipitation gauge and flume are located in a watershed channel northwest of the Area 5 RWMS. The intent is to collect precipitation and discharge data at these locations through FY 2007, after which, activities associated with final closure of the currently active, 92-acre part of the Area 5 RWMS will be initiated.

8.7 Biota Monitoring

DOE Order 450.1, "Environmental Protection Program" includes specific requirements for the protection of natural resources including biota, and to evaluate the potential impacts to biota in the vicinity of DOE activities. A DOE technical standard, DOE-STD-1153-2002 "A Graded Approach to for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," was developed by the DOE's Biota Dose Assessment Committee. The standard describes a graded approach for evaluating radiation doses to biota and set the following dose limits, that based on current understanding, are protective of populations of biota:

- Dose limit to terrestrial plants = 1 rad/day (10 milliGray [mGy]/day)

- Dose limit to terrestrial animals = 0.1 rad/day (1 mGy/day)

At the RWMSs, biota monitoring consists of sampling vegetation for tritium. If tritium concentrations in vegetation are exceedingly high, wild game may be sampled. Vegetation sampling may be limited year to year, depending on rainfall and waste cover operations during operational closure. Annual biota monitoring data are reported in BN (2003b and 2004b). Details of the RWMS biota monitoring activities can be found in the RWMS biota monitoring OI-2154.110, "Biota Sampling and Sample Preparation for Animals and Vegetation."

The amount of tritium released into the atmosphere by plant transpiration is affected by several factors including plant size, species, and available moisture. Vegetation from on and near waste covers, as well as vegetation from control areas far from waste covers, is sampled in mid-summer each year and analyzed for tritium. Timing of the sampling is important because vegetation is forced to remove soil water from greater depths (closer to waste) as surface soils dry out in summer. Plant water is extracted from the vegetation samples by room temperature vacuum distillation and analyzed by liquid scintillation for tritium. Animals (and soil from animal burrows) will be monitored for tritium if warranted by increasing tritium trends in vegetation, or if animal burrows on or near waste covers are observed in significant numbers.

Slightly elevated tritium concentrations in air and vegetation at the Area 5 RWMS indicate that there is an upward pathway for tritium migration primarily because of the combined effects of diffusion and plant transpiration processes. Therefore, this pathway should continue to be monitored.

8.7 Subsidence Monitoring

A formal program to monitor subsidence of waste covers was initiated in October 2000, including coordination with waste operations personnel to facilitate timely repair of subsidence features. Subsidence monitoring consists of routine inspections of operational and final waste covers for subsidence features such as cracks and depressions, ponding, and erosion. When such features are observed, their locations are recorded using a Global Positioning System unit and digital camera, and operations personnel are informed to take corrective action.

Locations of any observed subsidence are presented in a report in (e.g., BN 2004b). Previously observed features were mostly in locations of recently covered waste and concentrated along the edges where compaction of the cover may be incomplete. In other locations within the Area 5 RWMS, only a few minor cracks and depressions required maintenance.

At the Area 5 RWMS, subsidence monitoring is conducted monthly at all operationally closed disposal units and at partially buried open disposal units. Details of the RWMS subsidence monitoring activities can be found in the RWMS subsidence monitoring OI-2154.112, "Subsidence Monitoring at the Radioactive Waste Management Sites." The effectiveness of subsidence monitoring will periodically be evaluated.

8.8 Air Monitoring Data

Air monitoring is conducted to confirm that RWMS activities do not result in significant radionuclide concentrations above background and to confirm compliance with NESHAP.

8.8.1 Tritium

Atmospheric moisture is collected at the Area 5 RWMS and analyzed for tritium. Tritium is a volatile radionuclide and is therefore a conservative indicator of waste disposal unit performance. Data from tritium sampling is presented in BN (2004a, 2004b, 2003a). Past data have shown slightly elevated tritium concentrations in air at the Area 5 RWMS northeast and west stations, but these are well below

any concentrations of concern (DOE Order 5400.5 [DOE, 1993] Derived Concentration Guide [DCG] level for the general public for tritium in air is 1E5 pCi/m^3). Note that most of the RWMS tritium concentrations were below the mean Minimum Detectable Concentration for tritium.

8.8.2 Particulates

Air particulate samples are collected at the RWMSs and are analyzed for gross alpha/beta radioactivity, gamma emitters, and americium and plutonium concentrations in air. Air particulate monitoring data indicate that radionuclide concentrations in air at the RWMSs are not above those of other nearby stations. The DOE Order 5400.5 DCG level for Pu-239+240 is 0.04 pCi/m^3. These data are presented in BN (2004b, 2003b).

8.8.3 Radon

Measurements of radon flux through operational waste covers are conducted at various locations every year using Electret-Passive Environmental Radon Monitors to determine if the fluxes are within a performance objective of 20 pCi/m^2/s given in the Area 3 and Area 5 PAs and DOE O 435.1. Radon flux is measured on the cover of U-3ax/bl because it is the only closed unit at the Area 3 RWMS. Radon flux monitoring is conducted at P01U because it has the highest radium inventory at the Area 5 RWMS. Monitoring data has shown that radon flux was well below the performance objective flux of 20 pCi/m^2/s, specified in DOE Order 435.1. Annual radon monitoring data are reported in the Annual Waste Management Monitoring Report (BN, 2004b).

8.9 Monitoring During Final Closure and Active Institutional Control

Monitoring activities during the final closure and active institutional control periods of the RWMSs are expected to be reduced and limited to:

- Air monitoring for radon-222 and atmospheric tritium
- Tritium monitoring of moisture in soil gas at GCD-05U
- Vadose zone monitoring of waste covers, waste disposal unit floors, and lysimeter facilities
- Groundwater monitoring
- Biota monitoring for tritium
- Subsidence monitoring.

Groundwater monitoring for compliance with Title 40 CFR 264 and 265 will be discontinued when a groundwater monitoring exemption is requested from, and approved by, NDEP. However, groundwater monitoring may continue at the Area 5 RWMS pilot wells under the RREMP program.

8.10 Summary

Environmental and operational monitoring data from the Area 3 and Area 5 RWMSs indicate that these facilities are performing as expected for long-term isolation of buried waste. Direct radiation exposure data indicate that exposure at and around the RWMSs is not above background levels. Air monitoring data indicate that tritium concentrations are slightly above background levels. Groundwater and vadose zone monitoring data indicate that the groundwater beneath the Area 5 RWMS is unaffected by waste disposal operations. Soil-gas monitoring at GCD-05U indicates that tritium is slowly migrating away from a large tritium inventory due to natural transport processes. Vadose zone monitoring data indicate that infiltrating precipitation reached a depth of about 1 m (3 ft) before returning to the atmosphere. Long-term vadose zone monitoring data from the weighing lysimeters indicate zero drainage through the bottoms of the lysimeters in the past nine years of their operation. Biota monitoring in Area 5 indicates that tritium continues to be detected in plant water and this upward pathway should continue to be monitored.

9.0 SITE CHARACTERIZATION STUDIES

9.1 Introduction

The intent of this section is to describe the site characterization studies conducted to date, with emphasis on the most recent studies at the Area 5 RWMS. Site characterization, monitoring, and modeling studies of the subsurface have been conducted at the Area 5 RWMS since the 1980s. Monitoring activities are described in Section 8.0, but monitoring information that contributes to characterization studies is summarized in the following paragraphs. A list of modeling studies that could apply to evaluation of the Area 5 RWMS, and closure cover design, is given in Section 5.0, and some are also described in the following paragraphs.

9.2 Meteorological Monitoring Data

The basic meteorological parameters required to quantify the exchange of water and heat between the soil and the atmosphere include: precipitation, air temperature, humidity, wind speed (and direction), barometric pressure, and solar radiation load. These data have been collected from a meteorology station near the Area 5 RWMS (its location is shown on Figure 8-1).

9.2.1 Potential Evapotranspiration

Potential evapotranspiration at Frenchman Flat is high because of the large incident solar radiation and high average wind speeds. The potential evaporation, calculated using the Penman equation (Doorenbos and Pruitt, 1977) and data collected from the Area 5 RWMS meteorology station, is approximately 157 cm (62 in.). The average annual precipitation at the Area 5 RWMS is 12.2 cm (4.8 in.) (BN, 2004b). The average ratio between potential evaporation and precipitation at the Area 5 RWMS is 12.4 (Levitt et al., 1996), indicating extreme evaporative conditions.

9.2.2 Precipitation Data

The average annual precipitation at Frenchman Flat is 12.2 cm (4.8 in.), based on records collected at Well 5B in Area 5 dating back to 1963 (Shott et al., 1998). Well 5B is approximately 6.0 km (3.7 mi) southwest of the Area 5 RWMS. This average is slightly lower than precipitation recorded at the Area 5 RWMS station noted in Section 9.2.1.

9.3 Vadose Zone Studies

Vadose zone monitoring is conducted at the Area 5 RWMS to support hydrogeologic characterization. Site characterization, monitoring, and modeling studies of the subsurface hydrology have been conducted since the 1980s. Vadose zone data has been gathered using lysimeters, neutron logging, and moisture sensors, as described in Section 8.3.

As described in Section 5.1, climate and vegetation strongly influence the movement of water in the near surface alluvium (upper 2.0 m [6.5 ft]). Except for periods following precipitation events, water content in the near-surface region is low. Below this region is a zone where steady upward movement of water is occurring, primarily via evaporation (Tyler et al., 1996). This zone extends to depths as great as 3 to 40 m (10 to 131 ft) in Area 5. Below this zone, water potential measurements indicate the existence of a

static zone, the top of which is approximately 40 to 90 m (131 to 295 ft) below the ground surface in Area 5 (Shott et al., 1997; 1998). In this static zone, essentially no vertical liquid flow is currently occurring. Below this static zone, flow is steady and downward due to gravity. Refer to Figure 5-1 for a diagram of the vadose zone hydrologic conceptual model at the Area 5 RWMS.

Monitoring and modeling data for Area 5 have indicated conditions of zero recharge (Levitt et al., 1996; Shott et al., 1998). Recent studies show that under bare-soil conditions such as those at the Area 5 operational waste cell covers, some drainage may occur through the covers and into the waste zone. The drainage is estimated to be 1 percent of the annual rainfall at Area 5 (Levitt et al., 1998, 1999). Also, monitoring data from the Area 5 bare-soil weighing lysimeter indicate that soil water content at depths of 1 to 2 m (3 to 7 ft) is slowly increasing. To date, no drainage has occurred through the bottom of the lysimeter.

9.3.1 Area 5 Weighing Lysimeter Facility Data

The Area 5 weighing lysimeter facility consists of two precision weighing lysimeters located about 400 m (1,312 ft) southwest of the Area 5 RWMS. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert, and the other is kept bare (to simulate the bare operational waste covers at the Area 5 RWMS). These stations have been monitored continuously since March 1994 and provide an accurate data set of the surface water balance at the Area 5 RWMS. This monitoring time period includes the wet El Nino year of 1998, when rainfall was twice the annual average. For details of the weighing lysimeters, refer to Levitt et al. (1996).

9.3.2 Neutron Logging

Neutron logging historically was conducted at selected neutron access tubes at the Area 5 RWMS to provide profiles of soil water content with depth and time (see Section 8.3.4 for description of the neutron logging program). Future plans for water content monitoring at the Area 5 RWMS include using only the automated vadose zone monitoring system described in Section 8.3.3 above and in the following section. For a detailed history of the neutron logging monitoring program at the Area 5 RWMS, refer to BN (1997).

9.3.3 Automated Waste Cover Monitoring Data

Since 1998, TDR data and soil temperature data have been gathered beneath the open pit floors of two pits at the Area 5 RWMS. Starting in 1999, water content sensors (TDR probes) and water potential/ temperature sensors (HDPs) were installed in the operational covers of specific pits at the Area 5 RWMS. Vadose zone monitoring data for the waste covers indicate that to date, infiltrating precipitation rarely exceeds 60 cm (2 ft) before that water is returned to the atmosphere by evaporation.

9.3.4 Soil Gas Moisture Monitoring for Tritium

Gas-phase tritium monitoring is conducted using soil-gas sampling at GCD-05U, GCD unit with a large tritium inventory, located near the center of the Area 5 RWMS. Tritium sampling has been conducted for over twelve years, providing a large data set for analysis of tritium migration from the Area 5 RWMS.

To date, results indicate that while soil-gas tritium concentrations continue to increase at depths between 15 and 37 m (50 and 120 ft), vertical migration is extremely slow (BN, 2004b).

9.4 Groundwater Monitoring

Groundwater monitoring has been conducted at three pilot wells around the Area 5 RWMS which were originally drilled in 1993 as characterization wells (REECo, 1994). Groundwater from these wells is sampled semiannually to determine pH, specific conductance, major cations/anions, metals, tritium, total organic carbon, and total organic halogen. All groundwater sampling data from the Area 5 RWMS pilot wells to date indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS. Also, there have been no major changes noted in the groundwater elevation. There continues to be an extremely small gradient to the northeast with a flow velocity of less than one foot per year (BN, 2004a).

Groundwater monitoring data are presented in detail in the annual groundwater monitoring data reports (e.g., BN, 2004a).

9.4.1 Hydrostratigraphic Model of Frenchman Flat

A three-dimensional framework model of the hydrostratigraphy of the Frenchman Flat CAU was completed in 2004 for the DOE Underground Test Areas (UGTA) Subproject of the Environmental Restoration Program (BN, 2005b). The framework model will be used in computer models to predict groundwater flow and contaminant migration within Frenchman Flat. Some studies conducted for development of the model that could contribute to the characterization of the Area 5 RWMS are described in the following paragraphs.

UGTA Program Exploratory Drilling. Two clusters of hydrogeologic investigation wells were drilled for the UGTA Program in 2000-2002. The first group of wells was drilled in northern Frenchman Flat. The deepest of those wells, Well ER-5-3#2, was drilled to total depth of 1,732 m (5,683 ft), and it penetrated the regional carbonate aquifer (known as the lower carbonate aquifer). A second cluster of wells was drilled in central Frenchman Flat. The deepest well in this group, Well ER-5-4#2, was drilled to a total depth of 2,134 m (7,000 ft) and does not penetrate the lower carbonate aquifer. These wells are located roughly 2,500 m (8,200 ft) to the northeast and 3,400 m (11,155 ft) to the southwest of the Area 5 RWMS.

UGTA Program Geophysical Studies. Two recent geophysical studies from the UGTA program have contributed to the understanding of the subsurface at Frenchman Flat. A three-dimensional seismic survey was conducted in Frenchman Flat in 2002 to help delineate the subsurface geologic units and to adjust the UGTA three-dimensional framework model (Prothro, written communication to P.K. Ortego [BN], August 8, 2002). The U.S. Geological Survey estimated the depth of the Frenchman Flat basin using a gravity inversion method (Phelps and Graham, 2002).

9.5 Biota Studies

Plant activity provides a potential pathway for the release of radionuclides to the accessible environment by direct transport of contaminants to the surface or indirectly by the decomposition of roots that create channels for water and vapor movement through a waste cover and by the modification of waste (Suter et al., 1993).

9.5.1 Floral Studies

Studies on floral communities occurring within Frenchman Flat (Romney et al., 1973; Hunter and Medica, 1989; Ostler et al., 2000; and Beatley, 1976) have classified the vicinity of the Area 5 RWMS as a *Larrea-Ambrosia* Mojave Desert community.

Direct release of radionuclides by vegetation begins with radionuclide absorption by plant roots, followed by radionuclide transport upwards past the ground surface to the leafy part of the plant. Three components associated with plant uptake are: root characteristics (root depth, density, and root activity); the ability of plants to concentrate radionuclides; and plant biomass production and turnover.

The ability of plants to take radionuclides from the soil is a very complex process that is affected by numerous factors such as soil type, climate, plant metabolism, rooting traits, and weather. Studies by Sheppard and Evenden (1988), Whicker (1978), and Dreesen and Marple (1979) document the variability in the ability of plants to take up radionuclides.

Root depth is one of the most important components associated with plant uptake. In an arid climate, the depth of infiltration tends to set the lower limit of rooting depths. Few studies have described the rooting depths of Mojave Desert plants and assessed their potential to penetrate waste cover caps at a LLW disposal site. A study in Rock Valley on the NTS by Wallace and Romney (1972) reported a maximum root depth of 168 cm (66 in.). Beatley (1969) stated that winter annuals root in the top 20 cm (8 in.) of soil. Foxx et al. (1984a) reported that Russian Thistle root systems extended to depths of up to 4 m (13 ft) at a site in New Mexico.

Data pertinent to the Area 5 RWMS on rooting depths of plants can be found in studies by Hansen and Ostler (2003), Foxx et al. (1984a and 1984b), and Tierney and Foxx (1987). These studies show that the roots of shrubland species that grow at the NTS are mostly confined within the top 5 m (16.4 ft) of soil. Hansen and Ostler (2003) indicate that root depth rarely exceeds 2 m (6.5 ft) based on visual examination of pit walls at the Area 5 RWMS .

Revegetation of the Area 5 RWMS waste covers, whether managed in the beginning, or left to occur naturally, will likely progress from bare soil to desert shrubland in less than 50 years (Suter et al., 1993). Under subsidence conditions, which may enhance infiltration, this process may take considerably less time.

At the Area 5 RWMS, biota monitoring consists of sampling vegetation for tritium. Slightly elevated tritium concentrations in air and vegetation at the Area 5 RWMS indicate that there is an upward

pathway for tritium migration primarily because of the combined effects of diffusion and plant transpiration processes. If tritium concentrations in vegetation are exceedingly high, wild game are sampled.

9.5.2 Faunal Studies

Fauna within the Mojave Desert plant communities at Frenchman Flat are diverse. Invertebrates, particularly insects, are the most abundant (O'Farrell and Emery, 1976), and burrowing insects are the most numerous insects on the NTS. This group includes both ants and termites. Allred et al. (1963) report 20 ant species for *Larrea-Ambrosia* Mojave Desert communities. Vertebrates are less numerous and diverse. They include game and fossorial (burrowing) species. For a summary on the NTS fauna see (Shott et al., 1998; Winkel et al., 1996; and Thompson, 1993).

The majority of animals at the NTS appear to confine burrowing activities to the upper 3m (10 ft) of soil. Termites, the exception, have been known to excavate burrows as deep as 6 m (20 ft) in the arid southwest (Thompson, 1993). Plant roots are a primary food source for termites and they will follow roots to their termination. Because termite burrow depths are constrained by the depth of plant roots, most burrows will terminate at around 5 m (16.4 ft). A few roots may reach the waste depth, and if termites penetrate the waste horizons, they could enhance the degradation of plant-derived waste products and wooden or cardboard containers.

9.6 Waste Cover Subsidence Monitoring and Studies

At the Area 5 RWMS, subsidence monitoring is conducted monthly at all operationally closed disposal units and at partially buried open disposal units. A formal program to monitor the subsidence of waste covers was initiated in October 2000. Subsidence monitoring is conducted to ensure that subsidence features are repaired, in a timely manner, to prevent the development of preferential pathways through the waste covers, and to ensure that vadose zone monitoring data are representative of the entire RWMS.

Analyses of waste forms presently interred in U-3ax/bl and U-3ah/at disposal units in the Area 3 RWMS have shown that subsidence will occur, due mainly to the decomposition of metal boxes (Obi et al., 1996). Obi et al. (1996) reported potential subsidence estimates as much as 4.3 m (14 ft) in U-3ax/bl, and up to 15 m (49 ft) in U-3ah/at. They also stated that collapse of the containers will occur sporadically, leading to localized subsidence features distributed over the surface of the cap until the maximum collapse is reached.

As part of the closure process, a final cap was designed for the U-3ax/bl disposal unit. This design was prepared assuming that subsidence of the buried waste under the cover would be minimal. However, concerns developed over the amount and effects of subsidence on potential radiological releases. Consequently, a working group of SMEs was convened to evaluate the consequences of subsidence at the Area 3 and Area 5 RWMSs.

The major observations and recommendations of that study (DOE/NV, 1998a) were:

- None of the regulations for disposal of low-level radioactive waste at the NTS include specific design requirements for closure caps.
- Performance assessment models should be used to optimize designs for closure of waste disposal sites.
- Closure cover designs should satisfy minimum engineering performance standards and dose-related performance assessment standards.
- The existing cover design would not perform as intended because of the effects of subsidence.
- An alternative closure cover design consisting of a thick layer of native alluvium should be developed for use at the RWMSs. The cover design should rely upon thickness and evapotranspiration to provide containment.
- The cover should be monitored during the Institutional Control period to monitor performance and allow modification and maintenance if necessary.
- Void spaces between and within the waste packaging should be minimized.

An AES was convened August 12-15, 1997, to address closure of Disposal Cell U-3ax/bl and other disposal cells, and mitigation/accommodation of waste subsidence at the RWMSs at the NTS. Some of the recommendations of the AES (Barker, 1997) were:

- Close all NTS waste cells with soft covers, possibly thicker than present operational covers.
- Do not grout or use deep dynamic compaction on any NTS waste cells.
- Encourage generators to minimize waste container void spaces.
- Create a database of waste container locations and observed waste subsidence.
- Whenever possible, consider bulk waste disposal.

9.7 Flood Studies

A flood assessment based on three watersheds that could contribute water to the Area 5 RWMS shows that only the southwest corner of the facility is within a 100-year flood hazard zone (Schmeltzer et al., 1993). The currently active part of the Area 5 RWMS is now protected from a 25-year, 24-hour flood event via a channel and berm system.

9.8 Physical and Hydrogeological Property Data for Closure Covers

Analyses of samples collected in FY 2002 from the Area 5 RWMS operational covers have been conducted to document the current physical and hydrogeological conditions of the closure covers. The addition of soil to operational closure covers could make collection of samples in the future more difficult and expensive. Table 9-1 summarizes some of these geotechnical properties. A complete set of all sample analyses obtained can be found in Appendix B.

A comparison of these new physical properties and hydrogeologic data to previous values obtained for alluvium under the Area 5 RWMS (REECo, 1993a, b; Blout et al., 1995; Levitt et al., 1996) indicates that both data sets are very similar.

9.9 Topographic Survey

A topographic survey was completed in FY 2002 to document the configuration of the Area 5 RWMS (92-acre area) prior to any changes that might be made to the closure covers and intervening areas, inclusive of the GCD boreholes, from the time of the survey through FY 2007. The process of final closure of the 92-acre area by the BN Waste Management Project is scheduled to start in FY 2005. The topographic map from this most recent survey of the Area 5 RWMS is provided as Figure C-1 in Appendix C of this document.

Table 9-1 Summary of Hydraulic Properties for Selected Samples from the Area 5 Radioactive Waste Management Site Closure Covers

Location of Sample	Depth [a] (feet)	Sample Date	Moisture Content (percent by weight)	Permeability (centimeters/second)	Bulk Density (grams/cc)	Specific Gravity [b] (grams/cc)
T01U/T07U [c]:						
Grid Pt. B8	1	07/03/02	3.6	7.65E-04	1.77	NA
	3	07/03/02	4.6	5.94E-04	1.61	NA
Grid Pt. B4	1	07/03/02	5.6	5.02E-04	1.71	NA
	3	07/03/02	6.8	9.12E-03	1.69	2.50
Grid Pt. D5	1	06/25/02	5.8	6.68E-04	1.75	NA
	3	06/25/02	5.9	8.39E-04	1.67	NA
Grid Pt. F4	1	06/19/02	5.1	1.33E-04	1.66	NA
	3	06/19/02	5.9	4.39E-04	1.70	2.38
Grid Pt. F7	1	06/25/02	NA	NA	NA	NA
	3	06/25/02	5.9	4.01E-04	1.69	NA
Pit 3 :						
Loc. 22	1	05/29/02	4.7	2.86E-03	1.69	NA
	3	05/29/02	4.7	3.26E-03	1.60	2.53
Pit 4 :						
Grid Pt. B4, Well-8	1	05/29/02	5.7	6.49E-03	1.62	NA
	3	05/29/02	6.7	3.12E-03	1.57	2.50
Grid Pt. C10	1	06/19/02	6.4	1.88E-04	1.70	2.45
	3	07/03/02	6.3	3.72E-05	1.78	2.37

[a] Depths are below ground level.

[b] Numbers reported are analyses done on material smaller than #4 sieve (0.187 in.).

[c] Trenches TO1U, TO2U, TO3U, TO4U, TO6U, and TO7U.

NA - No analyses done.

Note: See Appendix B for complete analyses.

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10.0 CONCLUSIONS And RECOMMENDATIONS

10.1 Conclusions

Analysis of the compliance scenarios indicates that the waste disposal site is reasonably likely to meet all the performance objectives for 10,000 years (Shott et al., 1998; Levitt et al., 1999). Site characterization studies and performance assessment have shown that the arid nature of the Area 5 RWMS, along with the large depth to groundwater and negligible recharge, offer unique performance enhancing advantages. The limited transport pathways and limited land use potential of the site, coupled with operational procedures (e.g., WAC) and closure plans (monolayer- ET cover), provide reasonable assurance that regulatory performance objectives can be met (Shott, et al., 1998; Becker et al., 2002).

Characterization studies at the Area 5 RWMS planned through FY 2002, including recent characterization of the operational closure covers, have been completed. Based on analyses of this data, no changes to the PA or closure cover design is needed.

10.2 Recommendations

- Continue with site monitoring activities and reporting.
- Proceed through the scheduled planned phases leading to final closure of the Area 5 RWMS and defined in the ICMP (BN, 2005a).
- Proceed with the recommendation to add native soil to operational covers as a preparatory measure to final closure.

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11.0 REFERENCES

This section is divided into "References Cited" in this report (Subsection 11.1) and "Other References Consulted" for background information (Subsection 11.2). An annotated bibliography of selected references (1994 - 2002) relevant to the Area 5 RWMS is provided in Appendix A.

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APPENDIX A

Annotated Bibliography of Selected References Relevant to the Area 5 Radioactive Waste Management Site 1994 through 2005

Appendix A

Annotated Bibliography of Selected References Relevant to the Area 5 Radioactive Waste Management Site (1994 through September 2002)

Albright, W., 1995. *Physical and Hydraulic Characteristics of Bentonite-Amended Soil from Area 5, Nevada Test Site.* Desert Research Institute Publication No. 45137, DOE/NV/11508--06. Las Vegas, NV.

This report details the characterization of a soil mixture intended for use as the low-permeability component of a radioactive waste disposal site. The addition of 6.5 percent bentonite to the sandy soils of the site reduced the value of saturated hydraulic conductivity by more than two orders of magnitude to 7.6x10-8 cm/sec. Characterization of the soil mixture included measurements of grain density, grain size distribution, compaction, porosity, dry bulk density, shear strength, desiccation shrinkage, Ks, the effect of alternating cycles of drying and restoration on Ks, the effect of water content at time of compaction on Ks, vapor conductivity, air permeability, the characteristic water retention function, and unsaturated hydraulic conductivity by both experimental and numerical estimation methods. Simulations were conducted using a one-dimensional model of the landfill cover.

Albright, W., S. Tyler, J. Chapman, M. Miller, R.Estrella, 1994. *Area 5 Site Characterization Project Report FY 1994.* U.S. Dept. of Energy Report DOE/NV/10845-T20. Desert Research Institute, Las Vegas, NV.

The Area 5 Site Characterization Project is designed to determine the suitability of the RWMS for disposal of LLW, MW and TRU waste. DRI characterized important properties of the upper vadose zone which influence infiltration and redistribution of water and transport of solutes as well as water quality and hydrologic conditions of the uppermost aquifer. This report describes methods and presents a summary of all data and results from laboratory physical and chemical testing from borehole samples through September 1994. DRI laboratories performed soil water content, soil water potential, soil bulk density, and soil water extract isotope analyses.

Barker, L., 1997. *Alternative Evaluation Study: Methods to Mitigate/Accommodate Subsidence for the Radioactive Waste Management Sites at the Nevada Test Site, Nye County, Nevada, with Special Focus on Disposal Unit U-3ax/bl.* Bechtel Nevada, September, 1997.

An Alternative Evaluation Study was convened August, 1997 to make recommendations concerning closure of Disposal Cell U-3ax/bl and to address waste subsidence at the RWMS at the NTS. Results of the study and recommendations are presented.

Barker, L.E., G.J. Shott, P.K. Black, B. A. Moore, and S. E. Rawlinson, 1998. *Performance Assessment of the Area 5 RWMS at the NTS, Nye County, Nevada: Update of Scenarios and Waste Acceptance Criteria Through the Performance Assessment Maintenance Program.* Bechtel Nevada. DOE/NV/11718--177. February 1998.

The Performance Assessment Maintenance Program is the mechanism to integrate additional information about the site. Through the PA Maintenance Program at DOE/NV, technical uncertainties in the initial PA are systematically reduced by data collection, further studies, and ongoing analyses to provide greater confidence in the results and to ensure long-tem protection of the public health and environment. This addendum is the first update to the Area 5 RWMS PA through the PA Maintenance Program.

Bechtel Nevada, 2005. *Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site.* DOE/NV/11718--449-REV-2. Report to U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Las Vegas, Nevada. June 2005.

This document is an integrated plan for closing and monitoring both RWMSs, and is based on guidance issued in 1999 by the DOE for developing closure plans. The closure and monitoring plans were integrated because much of the information is the same, and integration provides program efficiency. The ICMP identifies the regulatory requirements, describes the disposal sites and the physical environment, and defines the approach and schedule for both closing and monitoring the sites. Closure of the Area 3 and Area 5 RWMSs will proceed through three phases: operational closure, final closure, and institutional control. The basic closure cover design for all of the various units will be of the vegetated monolayer-evapotranspirative type. Closure activities for waste disposal units in the 92-acre site, an expansion area north of the Area 5 RWMS, and the Area 3 RWMS follow a systematic process consisting of ten steps, itemized below:

- preliminary assessment
- initial planning
- drafting of a characterization plan
- implementation of the characterization plan
- drafting of a characterization report
- drafting of a closure plan
- implementation of closure
- drafting of a closure report
- acknowledgment of completion
- post-closure monitoring and maintenance (if required according to closure plan).

Closure activities for waste disposal units in the expansion area and the Area 3 RWMS are scheduled over the time frame of FY 2019 through 2021. Active institutional controls, such as control of access, cover maintenance, and monitoring, will continue for 100 years.

Monitoring at the Area 3 and Area 5 RWMSs is required under a variety of regulatory drivers, including federal regulations and DOE Orders. Monitoring data are used to demonstrate compliance with regulatory drivers and performance objectives presented in the PAs, confirm assumptions about flux rates through upward and downward pathways, confirm assumptions about soil water contents and potentials, confirm conceptual models, provide input to PA maintenance, and evaluate radiation doses to the general public. Monitoring is also conducted to ensure the integrity of waste covers. In addition, the monitoring program is designed to sufficiently forewarn of any need for mitigative actions, and to record the utility of any mitigative actions. This ICMP describes the programs for monitoring direct radiation fields, air, vadose zone, biota, groundwater, meteorology, and subsidence during the operational closure period (current), and final closure/active institutional control periods.

Bechtel Nevada, 2002. *2001 Waste Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Sites, Nevada Test Site.* DOE/NV/11718–718.

This document summarizes the calendar year 2001 environmental, subsidence, and meteorology monitoring data collected at and around the Area 3 and Area 5 RWMSs at the NTS. These monitoring data include radiation exposure, air, groundwater, meteorology, vadose zone, subsidence, and biota data. All 2001 monitoring data indicate that the Area 3 and Area 5 RWMSs are preforming within expectations of the model and parameter assumtions for the facility performance assessments.

Bechtel Nevada, 2002. *2001 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site, Nevada Test Site.* DOE/NV/11718--694. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. February 2002.

This report is a compilation of the calendar year 2001 groundwater sampling results for the Area 5 RWMS at the NTS. Wells UE-5PW-1, UE-5PW-2 and UE-PW-3 were sampled semiannually for pH, specific conductance, major cations/anions, metal, tritium. total organic carbon, and total organic halogen. Results from all samples collected in 2001 were below ILs. These data indicate that there has been no measurable impact to the uppermost aquifer from the RCRA regulated unit within the Area 5 RWMS, and confirm that the detections of TOC and TOX in 2000 were false positives. There were no major changes noted in the groundwater elevation. There continues to be an extremely small gradient to the northeast with a flow velocity of less than one foot per year.

Bechtel Nevada, 2002. *Bechtel Nevada Facility-Level Facility Execution Plan for Areas 3 and 5 Radioactive Waste Management Sites.* Bechtel Nevada, FEP-NTS-FL-03-05 Rev. 2. Las Vegas, NV.

The following topics for the subject NTS facilities are defined: facility description, including capabilities, assets, interfaces, operating schedule, costs and funding sources, performance measures, hazard analysis, legal and regulatory obligations, and management tools.

Bechtel Nevada, 2002. *Bechtel Nevada Support Execution Plan for Areas 3 and 5 Radioactive Waste Management Sites.* Bechtel Nevada, SEP-2150-04 Rev. 2. Las Vegas, NV.

The following topics for the subject NTS facilities are defined: scope of work, organization and responsibilities, work schedule, costs and funding sources, hazard analysis, legal and regulatory obligations, and management tools.

Bechtel Nevada, 2002. *2001 Annual Summary Report for the Area 3 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada, Review of the Performance Assessment and Composite Analysis.* Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. March 2002.

This report presents the determinations of the adequacy of the PA/CA, as well as the supporting information and data from the FY 2001 review. The annual review for the PA includes operational factors, such as the waste form and containers, facility design parameters and closure, waste receipts and inventory estimate at closure, and the results of the monitoring and research and development activities. The annual review of the CA includes the environmental restoration activities at the NTS relevant to the sources of residual radioactive material that are considered in the CA, the land use planning, and the results of the environmental monitoring and R&D activities. Recent results of site monitoring and site research programs are compared with PA and assumptions, conceptual models, and results, and are found to be consistent. No revisions to the PA/CA are needed at this time.

Bechtel Nevada, 2001. *Alternative Closure Cover and Monitoring System Project Area 3 Drainage Lysimeter Facility, Nevada Test Site, Fiscal Year 2001 Data Report.* Bechtel Nevada. Las Vegas, NV.

A drainage lysimeter facility was constructed at the mixed waste disposal unit U-3ax/bl at the Area 3 RWMS at the NTS. Each of the eight lysimeters is instrumented with soil water content and soil water potential sensors at eight depths. The objective of the facility is to collect data to reduced the uncertainty associated with the performance of monolayer-evapotranspiration waste covers in arid regions. Data collection of daily water content and water potential measurements began in February 2001.

Bechtel Nevada, 2001. *Closure Report for Corrective Action Unit 110: Area 3 RWMS U-3ax/bl Disposal Site Nevada Test Site, Nevada.* DOE/NV–733. Report prepared for the U.S. DOE/NNSA/NV. Las Vegas, NV.

The NTS Area 3 U-3ax/bl Disposal Unit, CAU 110, was operationally closed in 1987 by installing a RCRA equivalent cover. Closure was completed using a NDEP approved Closure Plan (DOE, 2000, Rev 0). The U-3ax/bl Waste Disposal Unit was closed in place by installing a monolayer vegetative cover. Post-closure monitoring will consist of site inspections to determine the condition of the engineered cover and cover performance monitoring using Time-Domain Reflectometry arrays to monitor moisture migration in the cover. (www.osti.gov)

Bechtel Nevada, 2001. *Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site.* DOE/NV/11718–449, Revision 1. September 2001.

Bechtel Nevada, 2001. *2000 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Sites, Nevada Test Site.* DOE/NV/11718--514. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. February 2001.

This report is a compilation of the calendar year 2000 groundwater sampling results for the Area 5 RWMS at the NTS. Wells UE-5PW-1, UE-5PW-2 and UE-PW-3 were sampled semiannually for pH, specific conductance, major cations/anions, metal, tritium. total organic carbon, and total organic halogen. Although some indicator analytes have been reported above the IL, it is most likely that these results are a product of sample handling rather than being representative of aquifer conditions. There were no major changes noted in the groundwater elevation.

Bechtel Nevada, 2001. *Performance Assessment for the Area 5 Radioactive Waste Management Site. Addendum 1.* DOE/NV/11718–176-ADD1.

The Area 5 RWMS Disposal Authorization Statement issued by the U.S. Department of Energy/Headquarters on December 5, 2000, identifies two performance assessment issues and requires resolution of these issues in an addendum or a revision to the PA within one year. The two conditions for resolution affect: 1) Dose estimates for the post-drilling intrusion scenario for Pit 6, and 2) Performance objectives for the agricultural scenario.

Bechtel Nevada, 2001. *Composite Analysis Assessment for the Area 5 Radioactive Waste Management Site. Addendum 1.* DOE/NV/11718–594-ADD1.

The Area 5 RWMS Disposal Authorization Statement issued by the U.S. Department of Energy/Headquarters on December 5, 2000, requires that supplemental information generated during the DOE/HQ review of the CA be incorporated into the CA within one year. The supplemental information includes the following: Issues identified in the review team report, crosswalk presentation, and maintaining doses as-low-as-reasonably-achievable.

Bechtel Nevada, 2001. *2000 Waste Management Monitoring Report: Area 3 and Area 5 Radioactive Waste Management Sites, Nevada Test Site.* DOE/NV/11718--582. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. June 2001.

Environmental monitoring data, subsidence monitoring data, and meteorology monitoring data were collected at and around the Area 3 and Area 5 RWMSs at the NTS, and include radiation exposure, air, groundwater, meteorology, vadose zone, subsidence, and biota data. All 2000 monitoring data indicate that the Area 3 and Area 5 RWMSs are performing well at isolating buried waste.

Bechtel Nevada,, 2001. *Annual Site Environmental Report for Calendar Year - 1999, Nevada Test Site.* DOE/NV/11718--605. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. October 2001.

Monitoring and surveillance, on and around the NTS, by U.S. DOE/NNSA/NV contractors and NTS user organizations during 2000, indicated that operations on the NTS were conducted in compliance with applicable NNSA/NV, state, and federal regulations and guidelines. Results and explanations of environmental monitoring programs at the NTS and offsite locations, an overview of QA programs and a summary of environment compliance activities associated with each site are included. During 2000, no accidental or unplanned releases occurred on the NTS. No measurable radiological exposure occurred to the general public who reside outside these locations, and no federal or contractor employees working at theses sites received radiation exposure doses in excess of international standards, while most were far below allowable limits.

Bechtel Nevada, 2001. *Composite Analysis for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada.* DOE/NV--595-ADD1. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

The Area 5 RWMS Disposal Authorization Statement issued by the U.S. Department of Energy/Headquarters on December 5, 2000, requires that the supplemental information generated during the DOE/HQ review of the CA be incorporated into the CA within one year. This report fulfills that requirement. The supplemental information includes the following: Issues identified in the Review Team Report; crosswalk presentation; and maintaining doses as low as reasonably achievable.

Bechtel Nevada, 2000. *Performance Assessment/Composite Analysis for the Area 3 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada, Rev 2.0.* DOE/NV/11718--491.

This document describes the results of a Performance Assessment and Composite Analysis for the Area 3 RWMS at the NTS. The PA performance objectives adopted from DOE

Order 5820.2A contain standards for members of the public and inadvertent human intruders. Total effective dose equivalent limits are set and include exposure through all pathways. The results of the PA are less than all performance objectives for a period of 1,000 years after closure.

Bechtel Nevada, 2000. *Composite Analysis for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada*. DOE/NV--594. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. February 2000.

This report is prepared as an addendum to the PA for the Area 5 RWMS Rev 2.1 (Shott et al., 1997). The CA assesses the potential radiological dose from all radioactive waste projected to be disposed of at the Area 5 RWMS by closure and all other sources of residual radioactive contamination that may interact with the disposal site. The TEDE estimated for the Area 5 RWMS is 0.8 mrem/yr, much less than the 30-mrem/yr dose constraint, and is assumed to be ALARA. The CA provides reasonable assurance that continuing operation of the site does not pose an unacceptable risk to the public considering the effects of interaction sources of radioactive materials.

Bechtel Nevada, 2000. *1999 Waste Management Monitoring Report: Area 3 and Area 5 Radioactive Waste Management Sites, Nevada Test Site.* DOE/NV/11718–425. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. May 2000.

Environmental monitoring data, subsidence monitoring data, and meteorology monitoring data were collected at and around the Area 3 and Area 5 RWMS at the NTS. These data include radiation exposure, air, groundwater, meteorology, vadose zone, subsidence, and biota data. This document now includes data that were formerly reported in the annual Ecosystem Monitoring Report (radon and tritium monitoring data). All 1999 monitoring data indicate that the Area 3 and Area 5 RWMSs are performing well at isolating buried waste.

Bechtel Nevada, 2000. *1999 Annual Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Sites, Nevada Test Site.* DOE/NV/11718–401. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. March 2000.

This report is a compilation of the calendar year 1999 groundwater sampling results for the Area 5 RWMS at the NTS as required by Title 40 CFR 265. Wells UE-5PW-1, UE-5PW-2 and UE-5PW-3 were sampled semiannually to determine pH, specific conductance, major cations/anions, metal, tritium, total organic carbon, and total organic halogen. Information regarding site hydrogeology, well construction, and sample collection is also provided. There were no major changes noted in the groundwater elevation.

Bechtel Nevada, 1999. Written Communication Prepared for National Nuclear Security Administration, Nevada Operations Office. Subject: *1998 Annual Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Sites.* February 1999.

This report is a compilation of the calendar year 1998 groundwater sampling results for the Area 5 RWMS at the NTS. Wells UE-5PW-1, UE-5PW-2 and UE-5PW-3 were sampled semiannually to determine pH, specific conductance, major cations/anions, metal, tritium, total organic carbon, and total organic halogen. There were no major changes noted in the groundwater elevation.

Bechtel Nevada, 1999. Written Communication Prepared for National Nuclear Security Administration, Nevada Operations Office. Subject: *Watershed Report: Area 3 Radioactive Waste Management Site, DOE/Nevada Test Site, Nye County, Nevada.* September 1999.

Watershed studies were conducted near the Area 3 RWMS as part of a site characterization program designed to obtain input parameters required for a hybrid rainfall-runoff/transmission loss model developed by DRI. Field data from two high intensity precipitation events (February 1998, June 1998) were collected. This study also supports the long-term sediment modeling at nearby subsidence crater U-3db.

Bechtel Nevada, 1999. *Characterization Report for Corrective Action Unit 110: Area 3 U-3ax/bl Disposal Unit Nevada Test Site, Nevada.* DOE/NV--580. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. Environmental Restoration Division, Bechtel Nevada. Las Vegas, NV. November 1999.

The U-3ax/bl disposal unit was operationally closed in 1987. Hydrogeologic characterization included two angled boreholes beneath the U-3bl crater. Laboratory analysis showed physical and hydraulic properties typical of alluvial valleys on the NTS. A conceptual model of the disposal unit indicates that wastes have not migrated beneath the unit. An evaluation of the potential subsidence by a working group indicated that the operational cover will likely fail in the future. It is recommended to proceed with the development of a Closure Plan. The recommended closure strategy is closure in place with an engineered RCRA alternative cover.

Bechtel Nevada, 1999. *Bechtel Environmental Integrated Data Management System (BEIDMS)*

BEIDMS is an Oracle® based relational database management system developed by Bechtel for the comprehensive management and processing of environmental data. This database management system has been licensed and tailored to support both small and large environmental projects at BN. The use of BEIDMS will ensure consistency and promote advanced planning, while providing a central repository for all unclassified environmental data. BEIDMS is currently operational for environmental monitoring data from the NTS.

Bechtel Nevada, 1998. *Geology Report: Area 3 Radioactive Waste Management Site, Nye County, Nevada*. DOE/NV/11718--195. Report to U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada. January 1998.

This report presents a summary of geologic studies undertaken by BN during fiscal years 1996 and 1997 near the Area 3 RWMS at the DOE NTS, Nye County, in southern Nevada. These studies were conducted as part of a site characterization program designed to satisfy the LLW Performance Assessment required by DOE Order 5820.2A (DOE,1988); the LLW Composite Analysis required at DOE sites (DOE, 1996) in response to Recommendation 94-2 of the Defense Nuclear Facility Safety Board; and the RCRA closure requirements in response to 40 CFR 265.

Bechtel Nevada, 1998. *Nevada Test Site Routine Radiological Environmental Monitoring Plan.* DOE/NV/11718--244. Report to U. S. Department of Energy Nevada Operations Office. December, 1998.

The RREMP brings together site-wide environmental surveillance; site-specific effluent monitoring; and operational monitoring conducted by various missions, programs, and projects on the NTS. The plan provides an approach to identifying and conducting routine radiological monitoring at the NTS, based on integrated technical, scientific, and regulatory compliance data needs. The RREMP uses a decision-based approach to identify the environmental data that must be collected and provides QAASPs which ensure that defensible data are generated. The approach is based on a modification of the EPA's Data Quality Objective (DQO) process (EPA, 1994), a 7-step process that calls for identification of the decisions that data collection activities must support, and uses a logical structure to develop the plan for data collection and analysis. The detailed steps of the process for each media are presented in Appendix E of the RREMP. During the design process, existing and historical site information and regulatory requirements were reviewed. A summary of the site characteristics, transport and exposure pathways, regulatory requirements, and historical data were evaluated for each medium in the preparation of the RREMP to support the monitoring designs.

Becker, B.D., W.A. Clayton, and B.M. Crowe. 2002. *Waste Management at the Nevada Test Site Fiscal Year 2001, Current Status.* U.S. Department of Energy, DOE/NV11718–714. Las Vegas, NV.

The performance objectives of the NNSA/NV Low-level Radioactive Waste (LLW) disposal facilities located at the NTS transcend those of any other radioactive waste disposal site in the United States. Situated at the southern end of the Great Basin, 244 m (800 ft) above the water table, the design of the Area 5 RWMS incorporates a combination of engineered shallow land disposal cells and deep augured shafts to dispose a variety of waste streams. These include high volume low-activity waste, classified radioactive material, and

high-specific-activity special case waste. Fifteen miles north of Area 5 is the Area 3 RWMS. Here bulk LLW disposal takes place in subsidence craters formed from underground testing of nuclear weapons. Earliest records indicate that documented LLW disposal activities have occurred at the Area 5 and Area 3 RWMSs since 1961 and 1968, respectively. However, these activities have only been managed under a formal program since 1978. This paper describes the technical attributes of the facilities, present and future capacities and capabilities, and provides a description of the process from waste approval to final disposition. The paper also summarizes the current status of the waste disposal operations.

Becker, B.D., C.P. Gertz, W.A. Clayton, and B.M. Crowe. 1998. *Low-Level Radioactive Waste (LLW) Management at the Nevada Test Site (NTS).* U.S. Department of Energy, DOE/NV–520. Las Vegas, NV.

The two Low-Level Radioactive Waste Management Sites at the NTS are briefly described. The NTS Waste Acceptance Criteria establishes the standard and requirements that generator sites must meet in order to receive approval to ship radioactive waste to the NTS. Disposal process and present waste inventory are defined for these shallow-land disposal facilities. An estimate of future capacities is also included.

Blout, D. O., W. S. Birchfiel, D. P. Hammermeister, K. A. Zukosky, and K. D. Donnelson, 1995. *Site Characterization Data from Area 5 Science Boreholes, NTS, Nye County, Nevada.* DOE/NV/11432-170. Reynolds Electrical & Engineering Co., Inc. February 1995.

The Science Borehole Project consists of eight boreholes that were drilled (from 45.7 to 83.8 m depth) in Area 5 of the NTS, on behalf of the DOE. These boreholes are part of the Area 5 Site Characterization Program developed to meet data needs associated with regulatory requirements applicable to the disposal of LLW and MW at this site. This series of boreholes was specifically designed to characterize parameters controlling near-surface gas transport and to monitor changes in these and liquid flow-related parameters over time. These boreholes are located along the four sides of the approximately 2.6-sq km Area 5 RWMS. Material and hydrologic properties are reported (field and laboratory measurements). Four of the boreholes were instrumented and stemmed, and four were completed as neutron-moisture logging access boreholes.

BN, see Bechtel Nevada.

Cochran, J. R., W. E. Beyeler, D. A. Brosseau, L. H. Brush, T. J. Brown, S. H. Conrad, P. A. Davis, T. Ehrhorn, T. Feeney, B. Fogleman, D. P. Gallegos, R. Haaker, D. Kalinina, L. L. Price, D. P. Thomas, and S. Wirth, 2001. *Compliance Assessment for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Site. Volume 2: Performance Assessment (Version 2.0).* Sandia Report SAND2001-2977. Sandia National Laboratories. September 2001.

Intermediate depth disposal operations were conducted by the NNSA/NV at the NTS from 1984 through 1989. These operations emplaced high-specific activity low-level wastes (LLW) and limited quantities of classified, "special case" transuranic (TRU) wastes in 37-m (120-ft) deep, 3-m (10-ft) diameter Greater Confinement Disposal (GCD) boreholes. Four boreholes contain about 60,000 kg (132,000 lb.) of classified TRU waste packages, containing less than 330 curies of Plutonium-239. This report presents the performance assessment (PA) that was conducted to determine if disposal of TRU waste in the GCD boreholes complies with the EPA's 40 CFR 191 requirements. Sandia National Laboratories completed this PA. Topics addressed in this PA include:

- Regulatory analysis
- Explanation of the Iterative PA Methodology
- Quality assurance and software quality
- Analysis and screening of features, events, and processes
- Analysis of human intrusion
- Nuclear criticality assessment
- Geochemical studies, including sorption and solubility
- Vadose zone characterization, including moisture content, water balance, and advective flux
- Development of plant and animal bioturbation models
- Climate change studies
- Landfill subsidence analysis
- 10,000 year surface water flooding analysis under current and glacial climates
- Conceptual model development
- Development of Flow and transport
- Dose Assessment modeling.

The primary conclusions of this PA are that the disposal of TRU wastes in the GCD boreholes will, at most, result in minuscule doses to individuals, and that the GCD disposal system easily meets the EPA's 1985, 40 CFR 191 requirements for disposal of TRU waste.

Dixon, J. M., D. G. Levitt, and S. E. Rawlinson, 2001. "Alternative Site Technology Deployment-Monitoring System For the U-3ax/bl Disposal Unit at the Nevada Test Site." *36th Annual Engineering Geology and Geotechnical Engineering Symposium: Soil and Water Issues for the Arid West.* DOE/NV/11718–505.

In December 2000, a performance monitoring facility was constructed adjacent to the U-3ax/bl mixed waste disposal unit at the NTS. Recent studies conducted in the arid southwestern United States suggest that a vegetated monolayer evapotranspiration (ET) closure cover may be more effective at isolating waste than traditional RCRA multi-layered designs. The monitoring system deployed next to the U-3ax/bl disposal unit consists of eight drainage lysimeters with three surface treatments: two are left bare; two are revegetated with native species; two are being allowed to revegetate with invader species; and two are reserved for future studies. Closure of U-3ax/bl is unique in that it was one of the first mixed waste disposal units to receive regulatory approval for closure using the monolayer-ET cover.

This closure cover is a significant departure from the traditional RCRA subtitle C and D multi-layered systems. This paper describes the design and deployment of a monitoring facility using drainage lysimeters and the latest monitoring and data acquisition technology for demonstration of cover performance.

Dixon, J.M. 1999. *An Evaluation of Unsaturated Flow Models in an Arid Climate.* Univ. of Nevada, Las Vegas MS thesis, also as a report to the U.S. Department of Energy/NV, DOE/NV/11718--395. Las Vegas, NV.

The objective of this study was to evaluate the effectiveness of two unsaturated flow models (HYDRUS-1D and SHAW) in arid regions (the Area 5 RWMS at the NTS). The monitoring data collected included soil-water potential, moisture content, evaporation, storage and various meteorological data. These data made it possible to estimate soil water balance, and to calibrate unsaturated flow models that can be used to predict future performance of the site.

DOE, see U.S. Department of Energy.

Drellack, S. L., 1997. *Selected Stratigraphic Data for Drill Holes Located in Frenchman Flat, Nevada Test Site, Revision 1*. Bechtel Nevada Report: DOE/NV/11718--077. February 1997.

Stratigraphic data are presented for 72 holes drilled in Frenchman Flat between 1950 and 1993. Three pairs of data presentations are included for each hole: depth to formation tops, formation thicknesses, and formations elevations are presented in both field (English) and metric units. Also included for each hole are various construction data (hole depth, hole diameter, surface location coordinates) and certain information of hydrogeologic significance (depth to water-level, top of zeolitization). An extensive set of footnotes is included. Stratigraphic setting of Frenchman Flat, drill-hole naming conventions and database terminology, and other background and references are included.

Estrella, R., 1994. *Fate and Transport Proceses Controlling the Migration of Hazardous and Radioactive Materials from the Area 5 Radioactive Waste Management Site (RWMS).* Desert Research Institute Publication No. 45134, DOE/NV/19845--53, Las Vegas, NV.

This study summarizes the available data and investigates the fate and transport processes that govern the migration of contaminants from the RWMS in Area 5 of the NTS. The purpose of this effort is to define data availability and to better direct future data collection activities. An overview of relevant sorption processes is given first, followed by a discussion of results obtained to date. Fundamentals of chemical and biological transformation precesses are discussed subsequently, followed by a discussion of relevant results.

Estrella, R., Tyler, S., Chapman, J., Miller, M., 1993. *Area 5 Site Characterization Project: Report of hydraulic property analysis through August 1993.* University of Nevada, Las Vegas, NV. Desert Research Institute. DOE/NV/10845-41.

The purpose of DRI`s Area 5 Site Characterization Project is to characterize important properties of the upper vadose zone which influence infiltration and redistribution of water and transport of solutes as well as to characterize the water quality and hydrologic conditions of the uppermost aquifer. This report describes methods and presents a summary of all data and results from laboratory physical and chemical testing from Pilot Wells and Science Trench borehole samples through August 1993. DRI laboratories performed soil water content, soil water potential, soil bulk density, soil water extract isotope analyses and soil water chemistry analyses.

FFACO (Federal Facilities Agreement and Consent Order), 1996. Agreed to by the State of Nevada Division of Environmental Protection, the U.S. Department of Energy, and the U.S. Department of Defense.

This is an agreement among the State of Nevada Division of Environmental Protection, the U.S. Department of Energy, and the U.S. Department of Defense. The facilities addressed in this agreement are the NTS, parts of the Tonopah Test Range, parts of the Nellis Air Force Range, the Central Nevada Test Area, and the Project Shoal Area. The Yucca Mountain site is specifically excluded from this Agreement. The purpose of this agreement include: identifying contaminated sites and implementing proposed corrective actions, establishing sampling and monitoring requirements, providing all parties with sufficient information, ensuring that the parties work together, reducing the costs of cleanup through coordinated project activities, and satisfying applicable legal regulatory requirements.

Fitzmaurice, T. M. and D. G. Levitt, 2000. *Deployment of an Alternative Closure Cover and Monitoring System at the Mixed Waste Disposal Unit U-3ax/bl at the Nevada Test Site.*

Final closure of the Mixed Waste Disposal Unit U-3ax/bl at the NTS was achieved by the successful deployment of RCRA alternative cover design. This closure is unique in that a mono-layer closure cover, also known as an evapotranspiration (ET) cover, consisting of native alluvium, received regulatory approval instead of using a traditional RCRA multilayered cover. Recent studies indicate that in the arid southwestern United States, mono-layer covers may be more effective at isolating waste than layered covers because of the tendency of layered systems to fail over time.

Hokett, S. L. and R. H. French, 1998. *Evaluation of Recharge Potential at Crater U-5a.* Desert Research Institute Publication 45160, DOE/NV/11508--32. Las Vegas, NV.

On the NTS, subsidence craters resulting from testing underground nuclear weapons are numerous, and many intercept surface water flows. Consequently, these craters may provide a mechanism for surface water to recharge the groundwater aquifer system underlying the NTS. Crater U5a (WISHBONE test), located in Frenchman Flat, was selected for study because of its potentially large drainage area, and significant erosional features, which suggested that it has captured more runoff than other craters in the Frenchman Flat area. Recharge conditions were studied in subsidence crater U5a by first drilling boreholes and analyzing the collected soil cores to determine the soil properties and moisture conditions. This information, coupled with a 32-year precipitation record, was used to conduct surface and vadose zone modeling.

IT Corporation, 1998. *Underground Test Area Subproject Corrective Action Unit 98: Frenchman Flat Data Analysis Task , Vol. 1 - Hydrostratigraphic Model Documentation Package, Rev. 0.* Las Vegas, NV.

This report documents the development of a three-dimensional framework model of the hydrostratigraphy of the Frenchman Flat CAU, located on the southeast corner of the NTS. This hydrostratigraphic framework will be used in computer models to predict groundwater flow and contaminant migration within the Frenchman Flat CAU. The Frenchman Flat CAU, defined in the FFACO includes the sites of ten underground nuclear tests conducted between 1965 and 1971 which are potential sources of groundwater contaminants.

Kunerth, D. C., J. M. Svoboda, J. M. Slate, and J. E. Lee, 2002. *Monitoring Moisture Content in Surface Barriers Using a Passive Sensor Platform.* Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID.

Work is being performed to develop a versatile micro-power sensor platform for the purpose of periodic, remote sensing of environmental variables such as subsurface moisture or radiation. The key characteristics of the platform are passive components (no internal power source), communication with a "reader" via short-range telemetry (no wires need penetrate barrier structure), long service life, and compact size. Functionally, the sensor package is read by a short-range induction coil that both activates and powers the sensor platform and detects the sensor output via a radio frequency signal generated by the onboard programmable interface controller microchip. To date, a prototype of the platform has been constructed and tested with a commercial moisture sensor.

Laczniak, R. J., J. C. Cole, D. A. Sawyer, and D. A. Trudeau, 1996. *Summary of Hydrogeologic Controls on Ground-Water Flow at the Nevada Test Site, Nye County, Nevada.* U.S. Geological Survey Water-Resources Investigations Report 96-4109.

The underground testing of nuclear devices has generated substantial volumes of radioactive and other chemical contaminants below ground at the NTS. Ground-water flow is the

primary mechanism by which contaminants can be transported significant distances. The diversity and structural complexity of the rocks along these flow paths complicates the hydrology of the region. This report summarizes what is known and inferred about ground-water flow throughout the NTS region. Major controls on ground-water flow, uncertainties, and technical needs related to the Environmental Restoration Program are discussed.

Levitt, D. G., and V. Yucel, 2002. *Infiltration Modeling to Support the Design of Closure Covers at the Radioactive Waste Management Sites at the Nevada Test Site* (Abstract). Bechtel Nevada. Las Vegas, NV.

Two low-level-radioactive-waste, shallow-land disposal cells at the NTS, managed by BN for the NNSA, will be closed with monolayer covers of native alluvium. The cover thickness has been optimized for infiltration, subsidence, biointrusion, and radon emissions. Unsaturated zone modeling was performed using long-term continuous climatic data to assess the long-term performance of various cover geometries.

Levitt, D. G., and V. Yucel, 2002. *Potential Groundwater Recharge and the Effects of Soil Heterogeneity on Flow at Two Radioactive Waste Management Sites at the Nevada Test Site*. DOE/NV/11718--609. Bechtel Nevada. Las Vegas, NV.

Scenarios for potential groundwater recharge and associated radionuclide transport are modeled in support of the PAs for the two low-level RWMSs at the NTS. Radionuclide travel times through the vadose zone, and via a groundwater pathway are modeled to calculate radionuclide doses to the public using conservative assumptions. Recent studies indicate that under bare-soil conditions such as those found at the operational waste cell covers, some drainage may eventually occur through the waste covers into the waste horizon. The drainage is estimated to be about one percent of the annual rainfall at Area 5, and ten percent of annual rainfall at Area 3. Simulations and neutron logging data indicate that subtle layering of hydraulic properties cause water flow to be significantly less than if a single set of hydraulic properties are used.

Levitt, D. G., and T. M. Fitzmaurice, 2001. "Deployment of an Alternative Closure Cover and Monitoring System at the Mixed Waste Disposal Unit U-3ax/bl at the Nevada Test Site." *Proceedings of the Waste Management 2001 Conference*. Tucson, Arizona. DOE/NV/11718–462.

In October 2000, final closure was initiated at U-3ax/bl, a mixed waste disposal unit at the NTS. The application of approximately 30 cm of topsoil, composed of compacted native alluvium onto an operational cover, seeding of the topsoil, installation of soil water content sensors within the cover, and deployment of a drainage lysimeter facility immediately adjacent to the disposal unit initiated closure. This closure is unique in that it required the involvement of several DOE Environmental Management groups: Waste Management, Environmental

Restoration, and Technology Development. In addition, this closure is unique in that a monolayer closure cover, also known as an evapotranspiration cover, consisting of native alluvium, received regulatory approval instead of a traditional CRA multi-layered cover. Recent studies indicate that in the arid southwestern United States, monolayer covers may be more effective at isolating waste than layered covers because of the tendency of clay layers to desiccate and crack, and subsequently develop preferential pathways. The lysimeter facility deployed immediately adjacent to the closure cover consists of eight drainage lysimeters with three surface treatments: two were left bare; two were revegetated with native species; two were allowed to revegetate with invader species; and two are reserved for future studies. The lysimeters are constructed such that any drainage through the bottoms of the lysimeters can be measured.
(http://www.osti.gov/servlets/purl/783705-w3K3JP/webviewable/783705.pdf)

Levitt, D. G., M. J. Sully, B. L. Dozier and C. F. Lohrstorfer, 1999. "Determining the Performance of an Arid Zone Radioactive Waste Site Through Site Characterization, Modeling and Monitoring." *Proceedings of the Waste Management 1999 Conference*, Tucson, Arizona. DOE/NV/11718--307.

A strategy of site characterization, modeling and monitoring are used to evaluate the performance of an interim cover at a low-level radioactive waste management site. The soil water migration pathway must be evaluated to assure the long-term isolation of low-level radioactive waste. Water balance studies using precision weighing lysimeters have been conducted for five years near the radioactive waste site at the NTS. The numerical flow models UNSAT-H and HYDRUS-2D were tested using the weighing lysimeter data and then used to evaluate various cover design issues including cover thickness, presence of vegetation, and monitoring system design. The modeling was conducted to examine the expected behavior of a cover under realistic climate conditions by simulating flow over a 24-year period using site-specific historical data. Modeling results indicate that the current interim cover, a single layer of unvegetated recompacted native alluvium in excess of 2.4 m thick, adequately isolates the waste during the operational period. Total soil water storage never exceeded 17.6 cm per meter of soil, and total drainage through the bottom of the cover was 4.8 cm, or 1.6 percent of the total rainfall for that period. In addition, modeling results indicate that for a 3-m-thick unvegetated cover, total soil water storage never exceeded 16.3 cm per meter of soil, and total drainage through the bottom of the cover was 1.8 cm, or 0.6 percent of the total rainfall for that period. Therefore the potential for transport of radioactive and hazardous constituents through the soil water pathway to the uppermost aquifer (at a depth of 235 m), should be judged to be negligible. Results also indicate that any cover thickness in conjunction with partial vegetative cover completely eliminates drainage. The performance of instrumentation in the lysimeters and modeling of moisture profiles in the cover provided insight into instrument selection, instrument location, and monitoring frequency for the design of a cover monitoring system. This type of an evaluation strategy of cover performance and monitoring system design can be easily applied to other sites.

Levitt, D. G., M. J. Sully, and C. F. Lohrstorfer, 1997. *Annual Data Report for the Water Balance Monitoring Program at the Area 5 Radioactive Waste Management Site*. Bechtel Nevada report. September 30, 1997. Las Vegas, NV.

A summary of the water balance data collected as part of the Water Balance Monitoring Program at the Area 5 RWMS. Data collected from four rain gauges (precipitation) and from two weighing lysimeters (evapotranspiration and evaporation) are summarized.

Levitt, D. G., C. F. Lohrstorfer, M. J. Sully, and J. M. Ginanni, 1996. "An Arid Zone Lysimeter Facility for Performance Assessment and Closure Investigations at the Nevada Test Site." *Proceedings of Waste Management 1996 Conference*, Tucson, Arizona. DOE/NV/10833–34. Bechtel Nevada, Las Vegas, NV.

Two precision weighing lysimeters were installed near the Area 5 RWMS on the NTS to provide support for investigations of water, solute, and heat fluxes in the near-surface of the soil. The lysimeters consist of soil tanks with a volume of 16 m^3 mounted on a sensitive scale. One lysimeter was revegetated with native shrubs where as the other was kept bare to simulate a non-vegetated waste cover. Data consisting of physical and hydrological properties of the lysimeter soils, thermal and moisture conditions in the lysimeters and atmospheric boundary conditions are being collected for calibration and verifying computer models for simulating the flow of water and heat in the near surface alluvium at the Area 5 RWMS. Moisture and thermal conditions in the lysimeters are monitored daily using time domain reflectometry probes and thermocouple psychrometers. Daily evaporation and evapotranspiration are calculated from the lysimeter scales. Meteorological variables are monitored by sensors mounted on a 3-meter tower adjacent to the lysimeters. (http://www.osti.gov/gpo/servlets/purl/251140-GK42ip/webviewable/251140.pdf)

NAC, see Nevada Administrative Code.

Nevada Administrative Code. NAC 444.6894, "Program for postclosure for each municipal solid waste landfill unit within Class I site." September 2, 1992; amended November 8, 1993.

The postclosure program, to be conducted for 30 years, shall include several aspects including, "The integrity and effectiveness of any final cover must be maintained, including making repairs to the cover as necessary..."

Nevada Administrative Code. NAC 444.6891, "Requirements for Design and Construction of System for Final Cover." November 8, 1993.

The owner or operator of a Class I site shall install a system for a final cover which is designed to minimize infiltration and erosion.

Obi, C. M., G. J. Shott, C. J. Muller, and L. E. Barker, 1996. *Preliminary Estimates of Future Waste Subsidence, Hydrogeologic Impact, and Contaminant Concentrations for Area 3 RWMS Disposal Units at the NTS.* Bechtel Nevada. October 1996.

This study provides a preliminary assessment of subsidence resulting from degradation of waste and waste containers disposed at the Area 3 RWMS, and the implications toward compliance with the DOE (1988) performance objectives. Included are: 1) A conservative assessment of possible subsidence at the two waste disposal units U3ah/at and U3axbl. 2) A preliminary assessment of hydrogeologic consequences of subsidence. 3) An uncertainty assessment of the radionuclide concentration in both disposal units.

Shott, G. J., L. E. Barker, S. E. Rawlinson, M. J. Sully, and B. A. Moore, 1998. *Performance Assessment of the Area 5 RWMS at the NTS, Nye County, Nevada.* Bechtel Nevada. Revision 2.1. DOE/NV/11718--176. January 1998.

This is a revised and updated version of Shott et al., 1995 (Rev. 2.0). A systematic analysis of the potential risks posed by a waste management system to the public and to the environment and a comparison of those risks to established performance objectives was conducted. Performance objectives applied are contained in DOE Order 5820.2A. The purpose of this assessment is to provide reasonable assurance of compliance with the performance objectives for a period of 10,000 years after closure. See Shott et al., (1995) for Rev. 2.0.

Shott, G. J., C. J. Muller, L. E. Barker, D. E. Cawlfield, F. T. Lindstrom, D. G. Linkenheil, M. J. Sully, L. McDowell-Boyer, and D. J. Thorne, 1995. *Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada.* Rev. 2.0. DOE/NV/11432--196. June 1995.

A systematic analysis of the potential risks posed by a waste management system to the public and to the environment and a comparison of those risks to established performance objectives was conducted. Performance objectives applied are contained in DOE Order 5820.2A. The purpose of this assessment is to provide reasonable assurance of compliance with the performance objectives for a period of 10,000 years after closure. See Shott et al., (1998) for Rev. 2.1.

Shott, G. J., S.J. Sully, C. J. Muller, D.P. Hammermeister, J.M. Ginanni, 1995. *Site Characterization and Performance Assessment for a Low-Level Radioactive Waste Management Site in the American Southwest.* Reynolds Electrical & Engineering Co., Inc. DOE/NV/11432--192. November 1995.

Site characterization studies at the Area 5 RWMS, NTS, included the measurement of physical, hydrologic, and geochemical properties of core samples collected from 10 shallow

and 3 relatively deep boreholes. The extreme arid climatic conditions at the site reduce or eliminate many radionuclide release and transport mechanisms. Important radionuclide transport pathways appear to be limited to upward diffusion and advection of gases and biologically-mediated transport. Conceptual models of disposal site performance have been developed based on site characterizations studies.

Smith, J. and T.M. Fitzmaurice, 2001. *Regulatory Acceptance of Monolayer Vegetative Cover for the Mixed Waste Disposal Unit U-3ax/bl at the Nevada Test Site.* Bechtel Nevada. Las Vegas, Nevada.

The NTS has numerous low-level waste landfills that require closure by 2011. In 1997, a study was conducted on closure covers and subsidence. The study concluded that a monolayer vegetative cover accommodates subsidence better than a traditional multilayered cover. In 1999, planning for the closure of U-3ax/bl mixed waste disposal unit was started. It was decided that a monolayer vegetative cover design would be proposed to the Nevada Division of Environmental Protection (NDEP). Approval of the monolayer vegetative cover design by the NDEP was achieved by careful up front planning. The process was accelerated by anticipating NDEP concerns and preparing arguments and data that addressed these concerns during the planning process.

U.S. Department of Energy, Nevada Nuclear Security Administration/Nevada Operations Office, 2002. *Nevada Test Site Waste Acceptance Criteria.* DOE/NV-325, Rev. 4.

This document establishes the US DOE, NNSA/NV waste acceptance criteria for the two NTS RWMSs in Areas 3 and 5. The WAC provides the requirements, terms, and conditions under which the NTS will accept low-level radioactive and mixed waste for disposal. It includes requirements for the generator waste certification program, characterization, traceability, waste form, packaging, and transfer.

U.S. Department of Energy, 2001. *Closure Report for Corrective Action Unit 417: Central Nevada Test Area Surface, Nevada, Rev. 1.* DOE/NV–743.

This report provides documentation for closure of the Central Nevada Test Area surface Corrective Action Unit 417 located in Hot Creek Valley in Nye County Nevada. A nuclear device for Project Faultless was detonated at a depth of 975 m in emplacement boring UC-1. Site closure was completed using a NDEP-approved Corrective Action Plan (DOE/NV, 2000). The 34 Corrective Action Sites that comprise CAU 417 were closed in two phases. The Central Mud Pit cover was vegetated and instrumented with time-domain reflectometry sensors to monitor soil moisture in the cover. The UC-4 Mud Pit C cover was a non-vegetated cover system that used a geosynthetic clay liner to prevent infiltration from reaching the waste package. Site Closure was completed using NDEP approved CAP which was based on the recommendations presented in the NDEP-approved CADD.

U.S. Department of Energy, 2000. *Disposal Authorization Statement for the Department of Energy/Nevada Operations Office Nevada Test Site Area 5 Radioactive Waste Management Site*. December 5, 2000.

A disposal authorization statement (DAS) was issued by the U.S. Department of Energy/Headquarters (DOE/HQ) on December 5, 2000, authorizing the NNSA/NV to continue the operation of the Area 5 RWMS at the NTS for the disposal of low-level waste and mixed low-level waste. The Area 5 RWMS DAS identifies two performance assessment issues and requires that NNSA/NV provide to the Low-Level Waste Federal Review Group (LFRG) the resolution of these issues in an addendum or a revision to the Performance Assessment (PA) within one year of the signed DAS. The DAS cites the following two conditions for resolution:

- As a result of the post-drilling intruder scenario as stated in Section 5.1 of the 1998 PA, the specific radionuclide concentration or inventory limits shall be imposed on Pit 6 to ensure that performance objectives will not be exceeded. A quantitative dose estimate shall be calculated using the reduced inventory to demonstrate compliance with the performance objective.

- The closure plan shall require a closure cap thickness of at least 4 meters as stated in Section 5.1 of the 1998 PA to ensure that performance objectives for the agricultural scenario will not be exceeded. A quantitative dose estimate shall be calculated using the 4-meter cap to demonstrate compliance with the performance objective.

U.S. Department of Energy, 2000. *Closure Plan for Corrective Action Unit 110: Area 3 RWMS U-3ax/bl Disposal Site, Nevada Test Site, Nevada*. DOE/NV--647. Environmental Restoration. August 2000.

The U-3ax/bl disposal unit was operationally closed in 1987, and will be closed in place by installing a RCRA equivalent cover. Post-closure monitoring will consist of site inspections to determine the condition of the engineered cover and cover performance monitoring using Time-Domain Reflectometry arrays to monitor moisture migration in the cover.

U.S. Department of Energy, 2000. *United States Nuclear Tests, July 1945 through September 1992*. DOE/NV–209-Rev.15. Las Vegas, NV. December 2000.

This document lists chronologically and alphabetically by name all nuclear tests conducted by the United States from July 1945 through September 1992.

U.S. Department of Energy, 2000. *Corrective Action Plan for Corrective Action Unit 417: Central Nevada Test Area, Nevada*. DOE/NV--588. Environmental Restoration. April 2000.

This CAP provides methods for implementing the approved corrective action alternative as provided in the CADD for the CNTA, CAU 417. The CNTA is located in the Hot Creek Valley in Nye County, NV, approximately 137 km (85 mi) northeast of Tonopah, NV. A nuclear device for Project Faultless was detonated at a depth of 975 m in emplacement boring UC-1. Thirty four CASs were identified for investigation at the CNTA. Results of the investigation activities completed in 1998 indicate that the only constituent of concern at the CNTA is total petroleum hydrocarbons. A multi-layered cover using a Geosynthetec Clay Liner as an infiltration barrier was constructed over the UC-4 Mud Pit. An alternative cover design, a vegetated cover, is proposed for the UC-1 CMP. Closure activities are planned for completion by October 2000.

U.S. Department of Energy, 1999. Written Communication Prepared for the Nevada Division of Environmental Protection. Subject: *RCRA Part B Permit Application for Waste Management Activities at the Nevada Test Site, Pit 3 Mixed Waste Disposal Unit. Vol 3.* October 1999.

This document provides specific information as required for the RCRA Permit Application. Specifically, this permit application presents an alternative liner design and a waste verification program to allow for the disposal of 20,000 cubic meters of onsite- and off-site-generated LLMW at the NTS. In addition, it also includes details regarding the modification of the pit to accommodate the disposal capability and installation of additional soil moisture monitoring equipment.

U.S. Department of Energy, 1998. *Consequences of Subsidence for the Area 3 and Area 5 RWMS, Nevada Test Site* (Working Group Report). DOE/NV–502. Las Vegas, NV.

During review of the NTS Area 5 RWMS performance assessment, concern developed over the amount and effects of subsidence on potential radiological releases. This report presents the conclusions and recommendations of a Working Group of nine subject matter experts convened to evaluate the consequences of subsidence at the Area 3 and Area 5 RWMSs. Minimum requirements for a closure cap included: maintaining a minimum cover over the waste, reducing moisture infiltration, limiting gas migration, and minimizing plant and animal intrusion. The previous cap design contained soil-cement and soil-bentonite layers intended to function as barriers. However, the unit will not perform as intended under expected subsidence conditions. The working Group concluded the most practical option is to develop an alternative cover. The cap design proposed is based on a single thick layer of compacted native soil simulating the natural soil system at the NTS. Infiltration would be limited by enhancing evapotranspiration. The barrier would accommodate subsidence with limited fracturing. Layering, accomplished by differential compaction or sorting, would promote lateral dispersion of moisture and a reduction in plant-root penetration. Also, preliminary cost estimates indicate that the alternative design would be less expensive than the initial design.

U.S. Department of Energy, 1999. DOE Order 435.1, "Radioactive Waste Management." U.S. Department of Energy, Washington, D.C., July 9, 1999. (Changed 08/28/01)

The objective of this Order is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment.

U.S. Department of Energy, 1999. DOE M 435.1-1, "Radioactive Waste Management Manual." U.S. Department of Energy, Washington, D.C., July 9, 1999.

This manual establishes an integrated Site-Wide Radioactive Waste Management Program and basis for the management of radioactive waste (RW) under the responsibility of the DOE/NV Operations Office. In this Manual radioactive waste includes LLW, TRU, and MW.

U.S. Department of Energy, 1999. Implementation Guide for use with DOE M 435.1-1, U.S. Department of Energy, Washington, D.C., July 9, 1999.

This guide provides suggestions and acceptable ways of implementing DOE M 435.1-1 "Radioactive Waste Management Manual."

Young, M., C. Cooper, S. Sharpe, J. Miller, and D. Shafer, 2002. Written Communication Prepared for the National Nuclear Security Administration, Nevada Operations Office. Subject: *Upward Advection: Dynamic Simulation of Vadose Zone Moisture Flux.* Desert Research Institute. Las Vegas, NV.

The primary goal of this research was to simulate water and vapor transport through 250 m of unconsolidated sediment found at the Area 5 RWMS at the NTS. Previous studies yielded a large range in upward flux rates. The analysis was expanded to include laboratory conductivity data from samples taken from the three Pilot Wells and Science Trench boreholes, a 24,000-year climate sequence and a geothermal gradient. These data, along with measured soil water conditions were incorporated into the TOUGH2 code.

Yucel, V. and D. G. Levitt, 2002. *Estimation of Upward Advective Liquid Flux at the Nevada Test Site* (Abstract). Bechtel Nevada. Las Vegas, Nevada.

The conceptual model of release and transport of radionuclides from LLW disposal facilities at the NTS identifies upward liquid flux as one of the primary pathways. The probability distribution of the upward flux was developed through unsaturated zone flow modeling using parameter values partially derived from numerous core samples taken at the site. The paper also compares soil-physics based estimates and stable-isotope base estimates for upward liquid flux

Appendix B
Characterization Data

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Appendix B-1

Area 5 RWMS Operational Closure Cover
Soil Sample Location Information

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Area 5 RWMS Soil Core Samples

MTL Lab Number	Date of Sample	Operational Cover	Sample Location	Depth of Core	Comments
1746, 1747, 1748	05/29/02	P03U	Logging Tube 22	-1'	Sampling location is approximately 6" east of logging tube 22. Location was dug to -4'. Material appears loose, not well graded, with rocks to about 11" to 15". Soil appears slightly moist with some organic matter (plant roots). Using shovel, side wall was benched at -1'. One 3" and two 6" core samples were taken.
Lab # 1746, 1748 performed by MTL. Lab # 1747 performed by D.B. Stephens					
1746, 1750, 1751 **1794	05/29/02	P03U	Logging Tube 22	-3'	Sampling location is approximately 6" east to logging tube 22. Location was dug to -4'. Material appears loose, not well graded, with rocks to about 11" to 15". Soil appears slightly moist with some organic matter (plant roots). Using shovel, side wall was benched at -3'. One 3" and two 6" core samples were taken. **Two 5-gallon buckets were filled for proctor.
Lab # 1749, 1751 performed by MTL. Lab # 1750 performed by D.B. Stephens.					
1752, 1753, 1754	05/29/02	P04U	Grit Point #B4	-1'	Sampling location is by logging tube 8 and was dug to -1'. Ground is loose, sandy, very gravely, with some small rock, and slightly moist. One 3" and two 6" core samples were taken.
Lab # 1752, 1754 performed by MTL. Lab # 1753 performed by D.B. Stephens.					
1755, 1756, 1757 **1795	05/29/02	P04U	Grit Point #B4	-3'	Continued digging to -3'. Ground is loose, sandy gravel, with some small rock, and slightly moist at depth. One 3" and two 6" core samples were taken. **Two 5-gallon buckets were filled for proctor.
Lab # 1755, 1757 performed by MTL. Lab # 1756 performed by D.B. Stephens.					
1758, 1759, 1760	06/19/02	P04U	Grid Point #C10	-1'	Dug to -1'. Soil core samples were pounded. Ground was stiff, appears well compacted, and is moderately moist. Contains rock to approximately 8". One 3" and two 6" core samples were taken.
Lab # 1758, 1760 performed by MTL. Lab # 1759 performed by D.B. Stephens.					
1761, 1762, 1763 **1796	06/19/02	P04U	Grid Point #C10	-3'	Dug to -3'. Soil core samples were pounded. Ground was stiff, and is moderately moist. Contains rock to approximately 4"-5". One 3" and two 6" core samples were taken. **Collected two 5-gallon buckets of material for proctor.
Lab # 1761, 1763 performed by MTL. Lab # 1762 performed by D.B. Stephens.					
1764, 1765, 1766	06/19/02	T01U-T07U*	Grid Point #F4	-1'	Dug to -1'. Soil core samples were pounded. Ground was somewhat stiff (not hard), contains rock to 8", and is moderately moist. Contains rock to approximately 8". One 3" and two 6" core samples were taken.
Lab # 1764, 1766 performed by MTL. Lab # 1765 performed by D.B. Stephens.					
1767, 1768, 1769 **1797	06/19/02	T01U-T07U*	Grid Point #F4	-3'	Continued digging to -3'. Soil core samples were pounded. Ground was somewhat stiff (not hard), contains rock to 8", and is moderately moist. Contains rock to approximately 8". One 3" and two 6" core samples were taken. **Collected two 5-gallon buckets of material for proctor.
Lab # 1767, 1769 performed by MTL. Lab # 1768 performed by D.B. Stephens.					

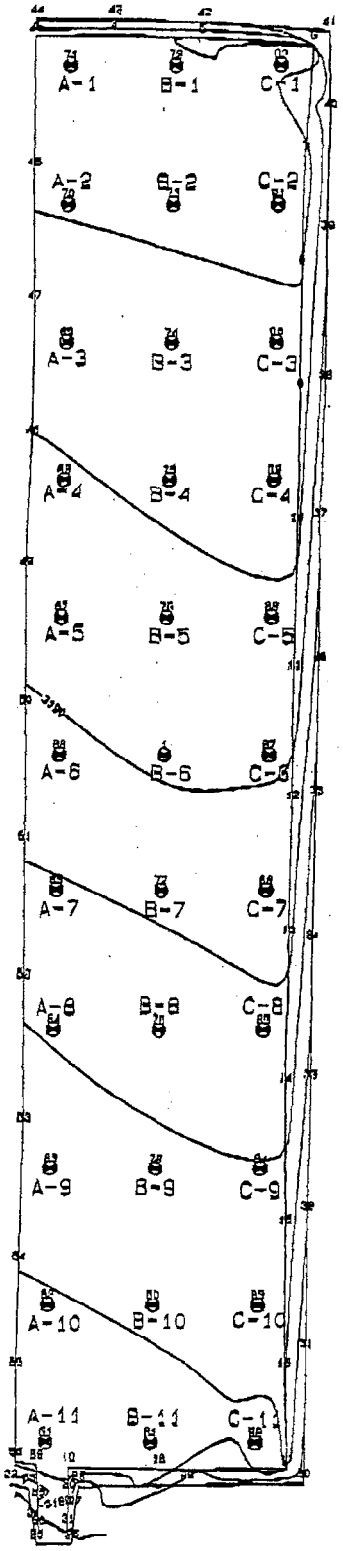
*Operational cover consists of the following pits and trenches: T01U, T02U, T03U, T04U, T06U, T07U, P01U, and P02U.

Area 5 RWMS Soil Core Samples

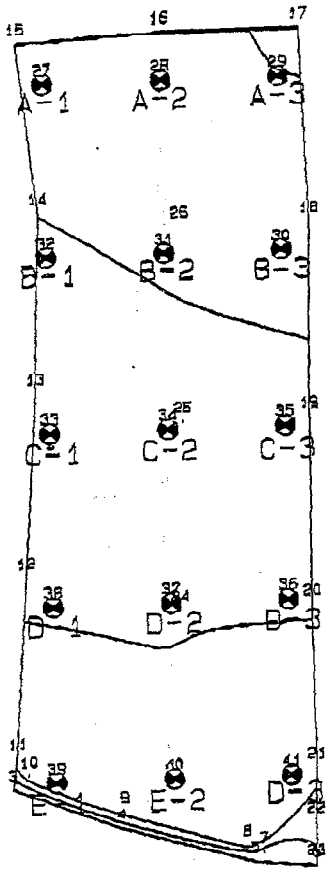
MTL Lab Number	Date of Sample	Operational Cover	Sample Location	Depth of Core	Comments
1770, 1771, 1772	06/25/02	T01U-T07U*	Grid Point #F7	-1'	Dug to -1'. Soil core samples were pounded. Ground was somewhat stiff, contains rock to 4"-5", is moderately moist, and appears loose while digging. One 3" and two 6" core samples were taken.
Lab # 1770, 1772 performed by MTL. Lab # 1771 performed by D.B. Stephens					
1773, 1774, 1775	06/25/02	T01U-T07U*	Grid Point #F7	-3'	Continued digging to -3'. Soil core samples were pounded. Soil was very loose and moderately moist. One 3" and two 6" core samples were taken.
Lab # 1773, 1775 performed by MTL. Lab # 1774 performed by D.B. Stephens.					
1776, 1777, 1778	06/25/02	T01U-T07U*	Grit Point #D5	-1'	Dug to -1'. Soil core samples were pounded. Ground is loose and rocky and contains rock 3.5"-5". Soil appears loose while digging and is slightly moist. One 3" and two 6" core samples were taken.
Lab # 1776, 1778 performed by MTL. Lab # 1777 performed by D.B. Stephens.					
1779, 1780, 1781	06/25/02	T01U-T07U*	Grit Point #D5	-3'	Continued digging to -3'. Soil core samples were pounded. Ground is loose and rocky and contains rock 3.5"-5". Soil appears loose while digging and is slightly moist. One 3" and two 6" core samples were taken.
Lab # 1779, 1781 performed by MTL. Lab # 1780 performed by D.B. Stephens.					
1782, 1783, 1784	07/03/02	T01U-T07U*	Grit Point #B4	-1'	Dug to -1'. Soil core samples were pounded. Ground is somewhat dense, sandy with some rock, and is slightly moist. One 3" and two 6" core samples were taken.
Lab # 1782, 1784 performed by MTL. Lab # 1783 performed by D.B. Stephens.					
1785, 1786, 1787 **1798	07/03/02	T01U-T07U*	Grit Point #B4	-3'	Continued digging to -3'. No change in material until around -2.5' where an approximately 1' layer of cobbles was encountered. Appears to be waste rock from the screening process. Soil core samples were pounded. One 3" and two 6" core samples were taken. **Two 5-gallon buckets were filled for proctor.
Lab # 1785, 1787 performed by MTL. Lab # 1786 performed by D.B. Stephens.					
1788, 1789, 1790	07/03/02	T01U-T07U*	Grid Point #B8	-1'	Dug to -1'. Soil core samples were pounded. Ground is loose, dry, rocky with sand, and contains rock to 3". One 3" and two 6" core samples were taken.
Lab # 1788, 1790 performed by MTL. Lab # 1789 performed by D.B. Stephens.					
1791, 1792, 1793	07/03/02	T01U-T07U*	Grid Point #B8	-3'	Continued digging to -3'. No change in material until around -2.5' (same depth as Grid Point #B4) where an approximately 1' layer of cobbles was encountered. Appears to be waste rock from the screening process. Soil core samples were pounded. One 3" and two 6" core samples were taken.
Lab # 1791, 1793 performed by MTL. Lab # 1792 performed by D.B. Stephens.					
1799	07/03/02	T01C- T06C	Grid Point #C10	-1'	Dug to -1'. Attempted to retrieve three soil cores. All three attempts failed due to bending or defacing leading edge of sampling core. Therefore no further attempts were made in this area. Material appeared to not have been screened and was extremely rocky. Collected two 5-gallon buckets of material for proctor.

*Operational cover consists of the following pits and trenches: T01U, T02U, T03U, T04U, T06U, T07U, P01U, and P02U.

P04U PIT COVER
& TEST HOLES

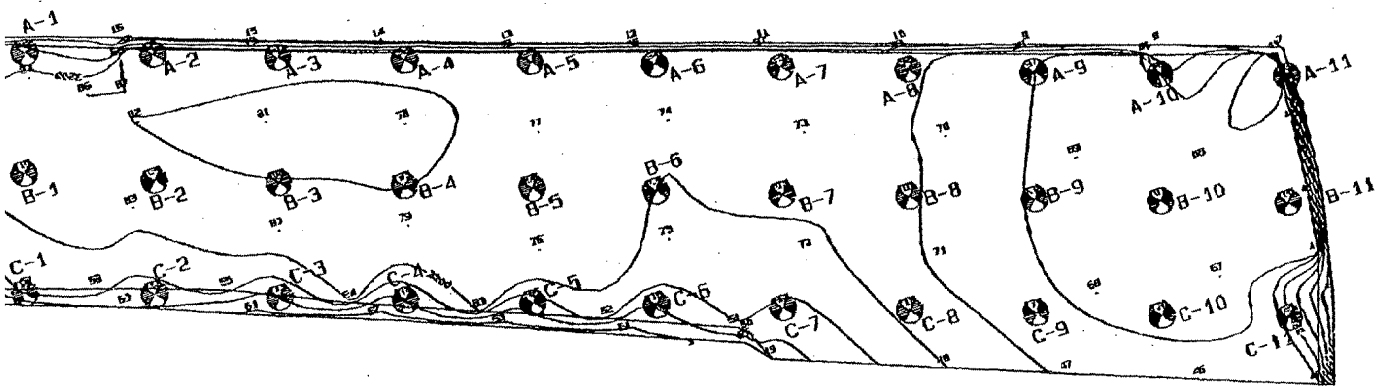


SURVEY DATE:
4/18/02



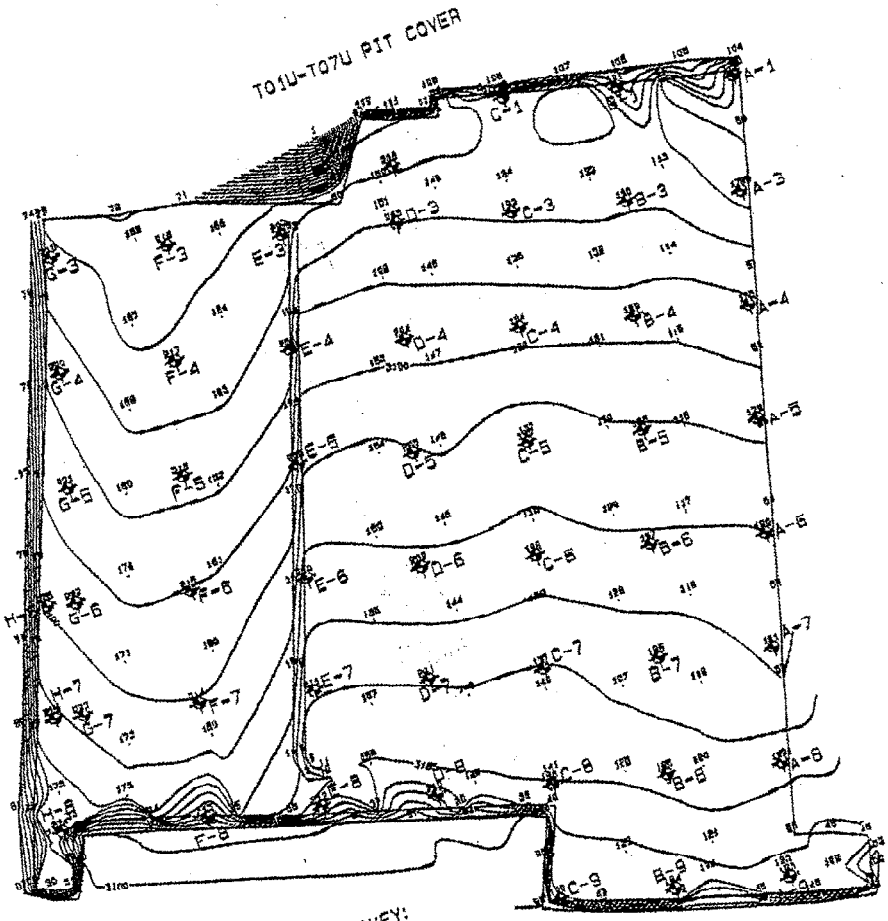
P-03U COVER & TEST PT.S

DATE OF SURVEY:
4/22/02



T01C - T06C PIT (S) COVER

TEST POINT


T01U-T07U PIT COVER
A-1
C-1
A-3
B-3
C-3
D-3
E-3
F-3
G-3
A-4
B-4
C-4
D-4
E-4
F-4
G-4
A-5
B-5
C-5
D-5
E-5
F-5
G-5
A-6
B-6
C-6
D-6
E-6
F-6
G-6
A-7
B-7
C-7
D-7
E-7
F-7
G-7
H-7
A-8
B-8
C-8
D-8
E-8
F-8
H-8
B-9
C-9
DATE OF SURVEY:
4/23/02
TEST POINT

Appendix B-2

Nuclear Density (field measurement)

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ASTM D2922-92 TROXLER 3440	MATERIALS TESTING LABORATORY *P.O. BOX 98521* *LAS VEGAS, NV 89193-8521*	Date Typed : 09/24/02 Page 1 of 1

Requested by: Stuart Rawlinson User / Agency: Bechtel Material: Soil / Fill

Project: A-5 RWMS Operational Cover Location of Tests: PO3U Cover (Pit 3), Next to Sampling Tube #22

Tested by: Johnny H. Denny Date Tested: 05/29/02 Checked By: V. Denny Checked Date: 09/25/02

Information transmitted to: By: How Date:

LABORATORY NO.	2100	2101	2102					
TEST NO.	1	2	3					
STATION NO.	By sampling tube # 22	By sampling tube # 22	By sampling tube # 22					
DEPTH OF PROBE in inches	B/S	B/S	B/S					
DEPTH OF TEST	-4'	-1'	-2'					
DRY DENSITY - PCF	85.8	102.9	95.3					
MOISTURE %	11.7	6.6	10.0					
MAX DENSITY PCF	110.1	110.1	110.1					
OPTIMUM MOISTURE %	10.8	10.8	10.8					
PERCENT COMPACTION	77.9	93.5	86.6					
REQUIRED COMPATCTION %	*N/A	*N/A	*N/A					
IN / OUT of SPECIFICATION	*N/A	*N/A	*N/A					

GAUGE NO. 23205 DATE OF STANDARDIZATION 05/29/02 VALUE OF M 639 VALUE OF D 2738

REMARKS:

CC:

ASTM D2922-92 TROXLER 3440	*P.O. BOX 98521* *LAS VEGAS, NV 89193-8521*	Date Typed : 09/26/02 Page 1 of 1

Requested by: Stuart Rawlinson User / Agency: Bechtel Material: Soil / Fill

Project: A-5 RWMS Operational Cover Location of Tests: PO3U Cover (Pit 3)

Tested by: Johnny H. Denny Date Tested: 08/19/02 Checked By: [signature] Checked Date: 09/25/02

Information transmitted to: _____ By: _____ How _____ Date: _____

LABORATORY NO.	2103	2104	2105	2106				
TEST NO.	4	5	6	7				
STATION NO.	A-1	A-2	A-3	By sampling tube # 22				
DEPTH OF PROBE in inches	0	6	12	12				
DEPTH OF TEST	GRADE	GRADE	GRADE	GRADE				
DRY DENSITY - PCF	*N/A	106.6	104.9	99.6				
MOISTURE %	*N/A	2.4	2.1	1.9				
MAX DENSITY PCF	*N/A	110.1	110.1	110.1				
OPTIMUM MOISTURE %	*N/A	10.8	10.8	10.8				
PERCENT COMPACTION	*N/A	96.8	95.3	90.5				
REQUIRED COMPATCTION %	*N/A	N/A	N/A	N/A				
IN / OUT of SPECIFICATION	*N/A	N/A	N/A	N/A				

GAUGE NO. 23205 DATE OF STANDARDIZATION 08/19/02 VALUE OF M 634 VALUE OF D 2717

REMARKS: * Due to the amount of course rock and cobles, as well as not being compated no test were completed at location A-1. Each test locations sample hole was driven to a depth of 12", due to the condition of the material it became difficult to maintain the 12" depth.

CC:

TROXLER 3440	P.O. BOX 98521 LAS VEGAS, NV 89193-8521	Page 1 of 2

Requested by: Stuart Rawlinson User / Agency: Bechtel Material: Soil / Fill

Project: A-5 RWMS Operational Cover Location of Tests: PO4U Cover (Pit 4)

Tested by: Johnny H. Denny Date Tested: 08/19/02 Checked By: [signature] Checked Date: 09/09/02

Information transmitted to: By: How Date:

LABORATORY NO.	2107	2108	2109	2110	2111	2112	2113	2114
TEST NO.	8	9	10	11	12	13	14	15
STATION NO.	A-1	C-1	B-2	A-3	C-3	B-4	A-5	C-5
DEPTH OF PROBE in inches	10	8	12	10	4	12	8	8
DEPTH OF TEST	GRADE	GRADE	GRADE	GRADE	GRADE	GRADE	GRADE	GRADE
DRY DENSITY - PCF	105.6	103.4	105.1	104.8	103.8	107.4	109.8	109.3
MOISTURE %	1.9	2.6	2.5	3.9	3.1	2.9	2.2	2.4
MAX DENSITY PCF	112.1	112.1	112.1	112.1	112.1	112.1	112.1	112.1
OPTIMUM MOISTURE %	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
PERCENT COMPACTION	94.2	92.2	93.8	93.5	92.6	95.8	97.9	97.5
REQUIRED COMPATCTION %	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A
IN / OUT of SPECIFICATION	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A	*N/A

GAUGE NO. 23205 DATE OF STANDARDIZATION 08/19/02 VALUE OF M 634 VALUE OF D 2717

REMARKS: Each test locations sample hole was driven to a depth of 12", due to the condition of the material it became difficult to maintain the 12" depth.

CC:

ASTM D2922-92 TROXLER 3440	MATERIALS TESTING LABORATORY *P.O. BOX 98521* *LAS VEGAS, NV 89193-8521*	Date Typed : 09/23/02 Page 2 of 2

Requested by: Stuart Rawlinson User / Agency: Bechtel Material: Soil / Fill

Project: A-5 RWMS Operational Cover Location of Tests: PO4U Cover (Pit 4)

Tested by: Johnny H. Denny Date Tested: 08/19/02 Checked By: V Denny Checked Date: 09/09/02

Information transmitted to: _____ By: _____ How _____ Date: _____

LABORATORY NO.	2115	2116	2117					
TEST NO.	16	17	18					
STATION NO.	B-6	A-7	C-7					
DEPTH OF PROBE in inches	8	8	12					
DEPTH OF TEST	GRADE	GRADE	GRADE					
DRY DENSITY - PCF	105.1	104.6	108.2					
MOISTURE %	2.1	2.5	2.5					
MAX DENSITY PCF	112.1	112.1	112.1					
OPTIMUM MOISTURE %	10.6	10.6	10.6					
PERCENT COMPACTION	93.8	93.3	96.5					
REQUIRED COMPATCTION %	N/A	N/A	N/A					
IN / OUT of SPECIFICATION	N/A	N/A	N/A					

GAUGE NO. 23205 DATE OF STANDARDIZATION 08/19/02 VALUE OF M 634 VALUE OF D 2717

REMARKS:

CC:

Appendix B-3

In-Place Bulk Density/Percent Compaction/Moisture Content

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PERCENT COMPACTION

P.O. BOX 98521
LAS VEGAS, NV 89193-8521

Date Typed : 08/13/02

PROJECT: Area 5 RWMS Cover Closure DATE RECEIVED: 7/3/2002

TESTED BY: Johnny H Denny DATE TESTED: 07/08/02 - 07/18/02

CHECKED BY: V. Thummala V. Thummala 9/30/02

Lab#	Sample Location	Date	Volume (in^3)	Volume (c.c)	Moisture %	In place Dry den. (g/cc)	In place As Received density (g/cc)	In place Dry den. (pcf)	Proctor Dry den. Pcf	% Compacti
1746	Pit 3 ,-1', *Loc. 22	05/29/02	26.25	430.10	4.7	1.561	1.690	97.4	110.1	88.5
1749	Pit 3, -3', *Loc. 22	05/29/02	26.47	433.75	5.2	1.507	1.600	94.1	110.1	85.5
1752	Pit 4, -1', Grid Pt. B4 *L.W #8	05/29/02	26.09	427.60	5.7	1.517	1.621	94.7	112.1	84.5
1755	Pit 4, -3', Grid Pt. B4 *L.W #8	05/29/02	26.29	430.86	6.7	1.461	1.568	91.2	112.1	81.4
1758	Pit 4, -1', Grid Pt. C10	06/19/02	26.14	428.28	6.4	1.578	1.702	98.5	109.8	89.7
1761	Pit 4, -3', Grid Pt. #C10	07/03/02	26.48	433.93	6.3	1.618	1.776	101.0	109.8	92.0
1764	TO1U / TO7U, -1', Grid Pt. F4	06/19/02	25.68	420.78	5.1	1.564	1.661	97.6	113.1	86.3
1767	TO1U / TO7U, -3', Grid Pt. F4	06/19/02	26.11	427.91	5.9	1.591	1.698	99.3	113.1	87.8
1770	TO1U / TO7U, -1', Grid Pt. F7	06/25/02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1773	TO1U / TO7U, -3', Grid Pt. F7	06/25/02	26.36	431.92	5.9	1.564	1.691	97.7	113.1	86.4
1776	TO1U / TO7U, -1', Grid Pt. F5	06/25/02	25.99	425.93	5.8	1.645	1.752	102.7	113.1	90.8
1779	TO1U / TO7U, -3', Grid Pt. F5	06/25/02	27.23	446.28	5.9	1.562	1.668	97.5	113.1	86.2
1782	TO1U / TO7U, -1', Grid Pt. B4	07/03/02	25.99	425.89	5.6	1.607	1.711	100.4	110.0	91.2
1785	TO1U / TO7U, -3', Grid Pt. B4	07/03/02	26.20	429.38	6.8	1.564	1.687	97.6	110.0	88.7
1788	TO1U / TO7U, -1', Grid Pt. B8	07/03/02	26.02	426.46	3.6	1.699	1.765	106.1	112.4	94.4
1791	TO1U / TO7U, -3', Grid Pt. B8	07/03/02	25.98	425.75	4.6	1.542	1.613	96.2	112.4	85.6

EQUIPMENT USED: Calibration Date:

Scale: Mettler PM 6100, ID# 301723 03/11/02

Thermometer: Omegasys, ID# 002875 12/19/01

REMARKS: Density was calculated by dividing the as received sample weight (minus wt. of core) by the volume of sampling core. * Location are next to existing neutron logging wells.

BULK DENSITY

MATERIALS TESTING LABORATORY
P.O. BOX 98521
LAS VEGAS, NV 89193-8521

Date Typed : 08/13/02

PROJECT: Area 5 RWMS Cover Closure

DATE RECEIVED: 7/3/2002

TESTED BY: Johnny H Denny

DATE TESTED: 07/08/02 - 07/18/02

CHECKED BY: V. Thummala V-Thummala 9/30/02

Lab#	Sample Location	Date	Length	Diameter	Volume (in^3)	Volume (c.c)	Moisture%	In place Sat. den.	In place Dry den.	In place As Received
1746	Pit 3 ,-1', *Loc. 22	05/29/02	6.00	2.36	26.25	430.10	4.7	1.874	1.561	1.690
1749	Pit 3, -3', *Loc. 22	05/29/02	6.00	2.37	26.47	433.75	5.2	1.918	1.507	1.600
1752	Pit 4, -1', Grid Pt. B4 *L.W #8	05/29/02	5.91	2.37	26.09	427.60	5.7	1.932	1.517	1.621
1755	Pit 4, -3', Grid Pt. B4 *L.W #8	05/29/02	5.95	2.37	26.29	430.86	6.7	1.827	1.461	1.568
1758	Pit 4, -1', Grid Pt. C10	06/19/02	6.00	2.36	26.14	428.28	6.4	1.934	1.578	1.702
1761	Pit 4, -3', Grid Pt. #C10	07/03/02	6.00	2.37	26.48	433.93	6.3	1.939	1.618	1.776
1764	TO1U / TO7U, -1', Grid Pt. F4	06/19/02	5.90	2.35	25.68	420.78	5.1	2.057	1.564	1.661
1767	TO1U / TO7U, -3', Grid Pt. F4	06/19/02	6.00	2.35	26.11	427.91	5.9	1.910	1.591	1.698
1770	TO1U / TO7U, -1', Grid Pt. F7	06/25/02	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1773	TO1U / TO7U, -3', Grid Pt. F7	06/25/02	6.00	2.37	26.36	431.92	5.9	1.879	1.564	1.691
1776	TO1U / TO7U, -1', Grid Pt. F5	06/25/02	5.99	2.35	25.99	425.93	5.8	1.991	1.645	1.752
1779	TO1U / TO7U, -3', Grid Pt. F5	06/25/02	6.02	2.40	27.23	446.28	5.9	1.868	1.562	1.668
1782	TO1U / TO7U, -1', Grid Pt. B4	07/03/02	5.99	2.35	25.99	425.89	5.6	1.933	1.607	1.711
1785	TO1U / TO7U, -3', Grid Pt. B4	07/03/02	5.99	2.36	26.20	429.38	6.8	1.956	1.564	1.687
1788	TO1U / TO7U, -1', Grid Pt. B8	07/03/02	6.00	2.35	26.02	426.46	3.6	2.079	1.699	1.765
1791	TO1U / TO7U, -3', Grid Pt. B8	07/03/02	5.99	2.35	25.98	425.75	4.6	1.900	1.542	1.613

EQUIPMENT USED:	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

REMARKS: Density was calculated by dividing the as received sample weight (minus wt. of core) by the volume of sampling core. * Location are next to existing neutron logging wells.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Initial Moisture Content		Dry Bulk Density	Wet Bulk Density	Calculated Porosity
	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	(g/cm^3)	(g/cm^3)	(%)
1747	5.6	8.8	1.58	1.67	40.4
1750	6.7	10.3	1.53	1.63	42.2
1753	6.0	9.5	1.59	1.69	39.8
1756	7.4	11.4	1.53	1.64	42.3
1759	7.0	10.9	1.55	1.66	41.6
1762	6.6	10.6	1.61	1.72	39.3
1765	5.8	9.0	1.53	1.62	42.1
1768	6.4	10.3	1.60	1.70	39.6
1771	6.7	10.5	1.56	1.67	41.0
1774	5.1	8.4	1.66	1.74	37.3
1777	6.1	9.2	1.51	1.61	42.9
1780	6.4	10.0	1.56	1.66	41.1
1783	5.9	8.8	1.49	1.57	43.9
1786	6.8	10.3	1.51	1.61	43.0
1789	3.8	5.8	1.54	1.60	42.0
1792	4.7	6.6	1.40	1.46	47.3

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Appendix B-4

Specific Gravity

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PECIFIC GRAVITY
ASTM D854-98

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Charge #: 5LDPCHA
Date Typed: 08/23/200

JECT: A/5 RWMS, OPERATIONAL COVER CLOSURES
DATE SAMPLED: 05/29/2002
IPLED BY: J. DENNY
TESTED BY: D. HERRINGTON
UESTOR: S. RAWLINSON
DATE TESTED: 08/15-23/2002
CKED BY: V. Perucchi
DATE CHECKED: 9/12/02

B .	SAMPLE MATERIAL	FLASK NO.	FLASK WT.	FLASK WT. + SOIL	SOIL WT.	FLASK WT. + SOIL + WATER	WATER WT (ML) 500	WT. DISP. WATER	REL. DENS. WATER	TEMP. (C)	SPECIFIC GRAVITY	DENSITY (PCF)
4	-#4	517	173.34	480.97	307.63	858.71	499.44	121.704	0.99889	16.5	2.528	157.7
5	-#4	516	171.90	437.62	265.72	830.48	499.31	106.451	0.99862	18.0	2.496	155.8
6	-#4	518	164.98	467.35	302.37	838.83	498.98	127.497	0.99795	21.3	2.372	148.0
7	-#4	519	174.04	474.32	300.28	847.26	498.98	126.037	0.99795	21.3	2.382	148.7
8	-#4	520	171.35	463.06	291.71	845.37	499.06	116.753	0.99813	20.5	2.499	155.9
9	-#4	557	179.97	460.04	280.07	844.64	499.04	114.442	0.99808	20.7	2.447	152.7

B	SAMPLE MATERIAL	WT. IN AIR	WT. IN WATER	DIFFERENCE	TEMP. (C)	SPECIFIC GRAVITY (g/cc)	DENSITY (PCF)
4	+#4	2786.8	1576.8	1210.0	21.1	2.303	143.8
5	+#4	2819.1	1599.4	1219.7	19.5	2.311	144.3
6	+#4	4450.4	2476.1	1974.3	19.2	2.254	140.7
7	+#4	4718.9	2583.8	2135.1	19.2	2.210	138.0
8	+#4	5183.7	2963.4	2220.3	19.1	2.335	145.7
9	+#4	4024.9	2334.7	1690.2	19	2.381	148.7

MENT USED: PJ3000, # 301737, Calibration Date: 05/07/2002 Calibration Due: 05/07/2003
METTLER PM16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

ARKS: NO SPECIFICATION, INFORMATION ONLY
THIS TEST WAS PERFORMED AS REQUESTED IN ASTM 1557-91.

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Appendix B-5

Proctor Test

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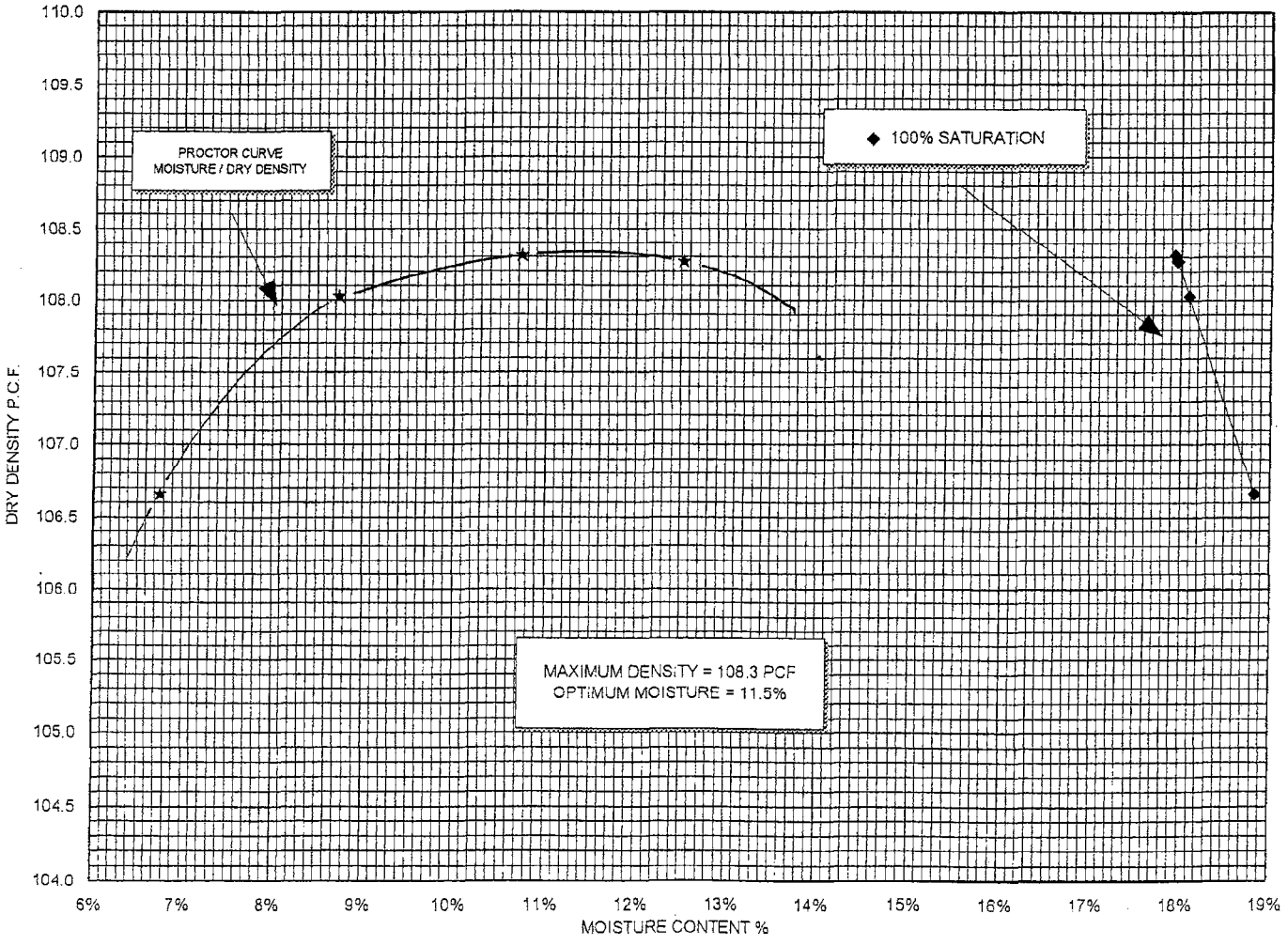
ASTM D 1557-2000 METHOD: C PREP. METHOD: MOIST	**MATERIALS TESTING LABORATORY** **P. O. BOX 98521** **LAS VEGAS, NV 89193-8521**	LAB # 1794 DATE 08/26/2002 RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN

Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: PO3U Sample Loc.: Logging Tube 22

Tested by: D. HERRINGTON Date tested: 08/15/2002 Checked by:

	TRIAL	1	2	3	4	5	6
1	Wt.mold + wet soil	6824.6	6908.8	6702.1	6973.3	N/A	N/A
2	Wt. mold	2828.7	2828.7	2828.7	2828.7	N/A	N/A
3	Wt. wet soil	3995.9	4080.1	3873.4	4144.6	N/A	N/A
4	Wet Density, PCF	117.5	119.9	113.9	121.8	N/A	N/A
5	Moisture Tare #	1	2	3	4.0	N/A	N/A
6	Wt wet soil + tare	1305.9	1269.0	1425.5	1553.9	N/A	N/A
7	Wt dry soil + tare	1202.4	1147.7	1336.4	1382.8	N/A	N/A
8	Wt moisture	103.5	121.3	89.1	171.1	N/A	N/A
9	Wt tare	17.3	17.2	16.9	17.0	N/A	N/A
10	Wt dry soil	1185.1	1130.5	1319.5	1365.8	N/A	N/A
11	**% Moisture**	**8.7**	**10.7**	**6.8**	**12.5**	**N/A**	**N/A**
12	**Dry Density, PCF**	108.0	108.3	106.7	108.3	N/A	N/A
13	**100% Saturation Moisture**	**18.1**	**17.9**	**18.8**	**18.0**	**N/A**	**N/A**



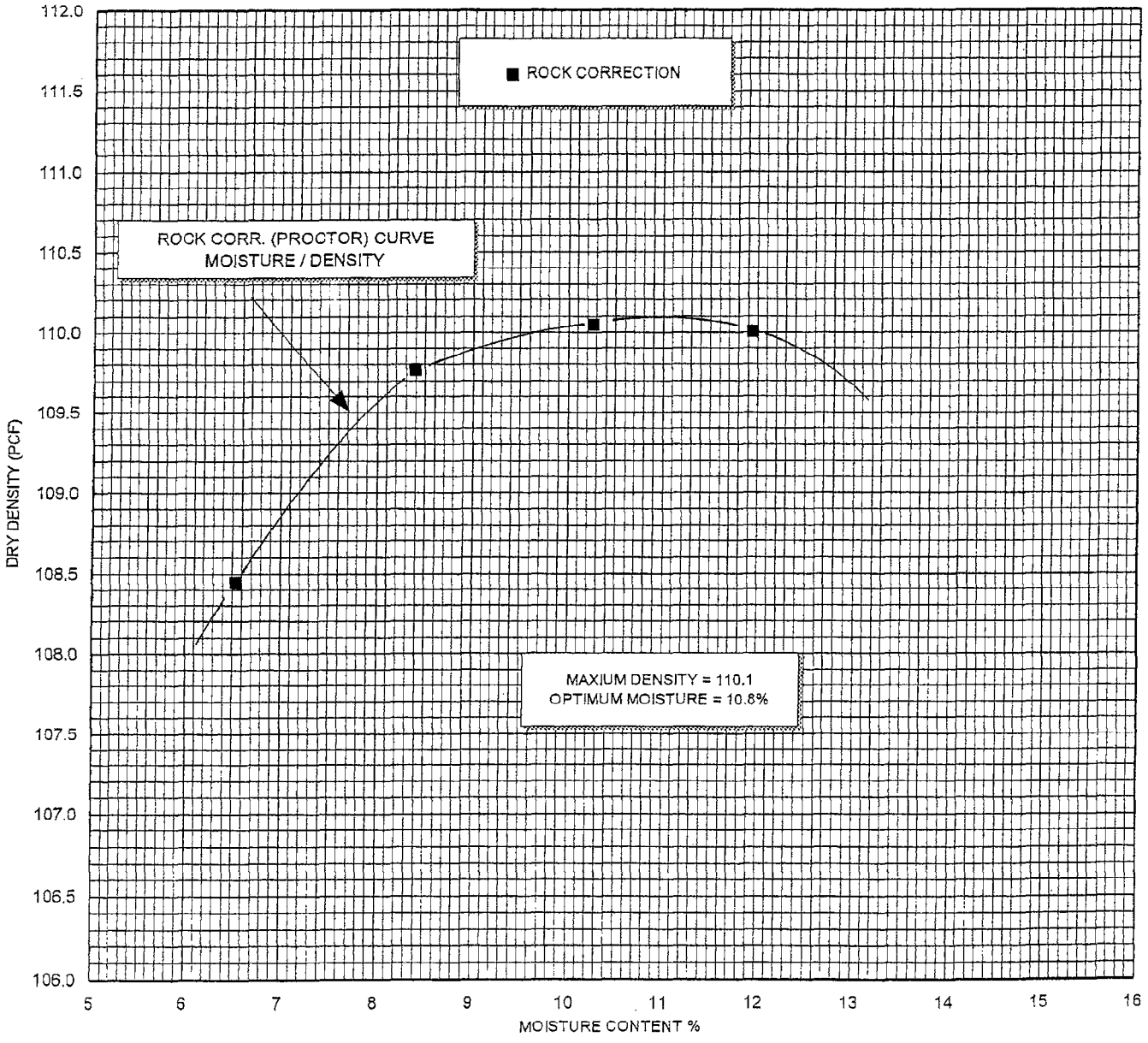
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # SLDPCHAR
LAB # 1794
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: PO3U Sample Loc.: Logging Tube 22
Tested by: D. HERRINGTON Date tested: 08/15/2002 Checked by:

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	6.4%	6.4%	6.4%	6.4%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.30	2.30	2.30	2.30	N/A	N/A
4	% Water Content of 3/4":	3.4%	3.4%	3.4%	3.4%	N/A	N/A
5	% Water Content of Fines:	8.7%	10.7%	6.8%	12.5%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	108.0	108.3	106.7	108.3	N/A	N/A
7	% Corrected Water Content:	8.4%	10.3%	6.5%	11.9%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	109.8	110.0	108.4	110.0	N/A	N/A



PROCTOR TEST
ASTM D 1557-2000
METHOD: C
PREP. METHOD: MOIST

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

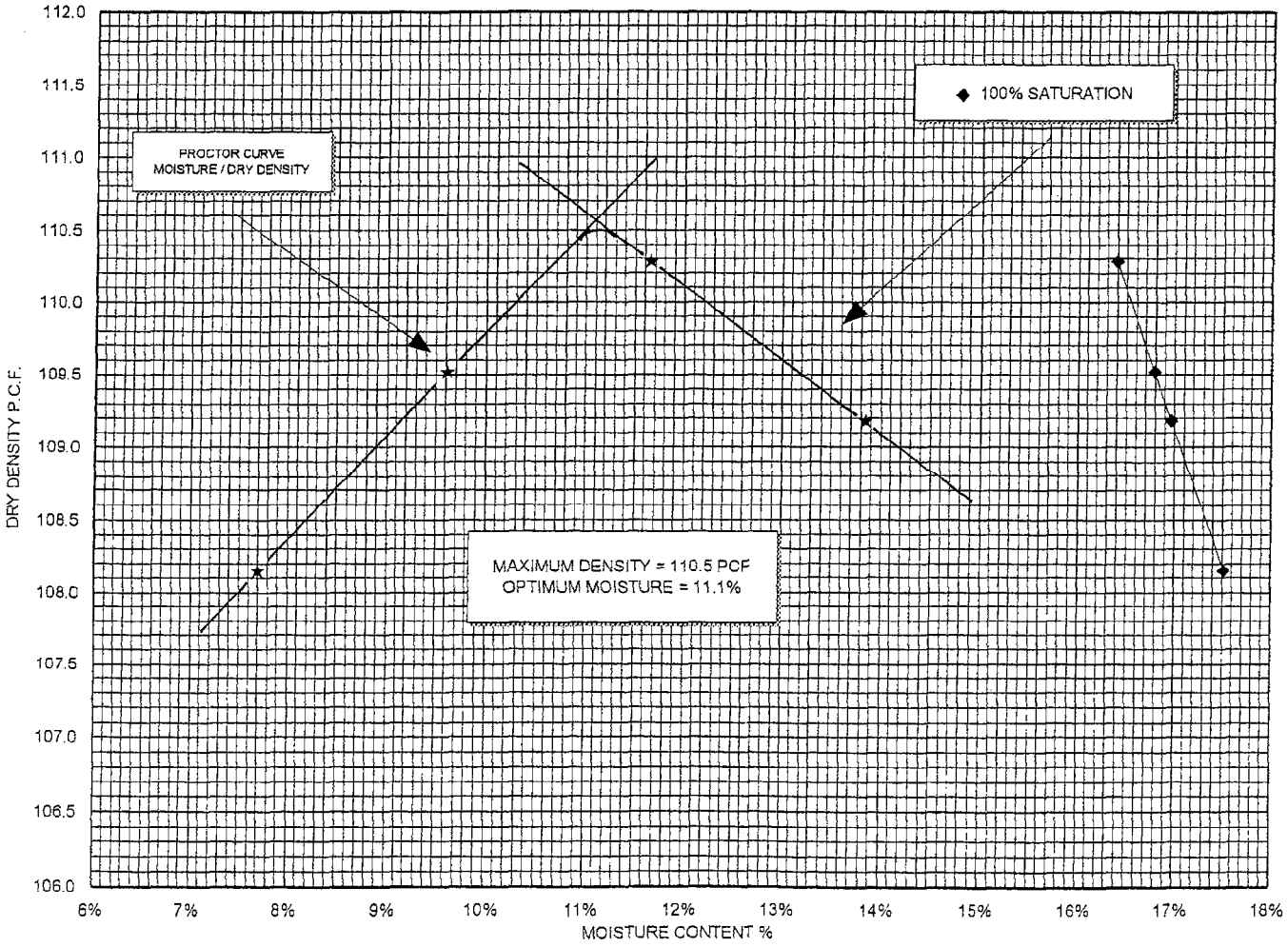
CHARGE #
LAB # 1795
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Requested by: S. RAWLINSON | User/Agency: BN

Sampled by: J. DENNY | Date sampled: 05/29/2002 | Operational Cover: PO4U | Sample Loc.: Grid Pt. # B4

Tested by: D. HERRINGTON | Date tested: 08/20/2002 | Checked by:

	TRIAL	1	2	3	4	5	6
1	Wt.mold + wet soil	6912.6	7017.7	7057.3	6791.3	N/A	N/A
2	Wt. mold	2828.8	2828.8	2828.8	2828.8	N/A	N/A
3	Wt. wet soil	4083.8	4188.9	4228.5	3962.5	N/A	N/A
4	Wet Density, PCF	120.0	123.1	124.3	116.5	N/A	N/A
5	Moisture Tare #	1	2	3	4.0	N/A	N/A
6	Wt wet soil + tare	1455.5	1405.4	1640.0	1486.9	N/A	N/A
7	Wt dry soil + tare	1329.4	1260.5	1442.6	1381.8	N/A	N/A
8	Wt moisture	126.1	144.9	197.4	105.1	N/A	N/A
9	Wt tare	17.3	17.2	16.8	17.1	N/A	N/A
10	Wt dry soil	1312.1	1243.3	1425.8	1364.7	N/A	N/A
11	**% Moisture**	**9.6**	**11.7**	**13.8**	**7.7**	**N/A**	**N/A**
12	Dry Density, PCF	109.5	110.3	109.2	108.1	N/A	N/A
13	**100% Saturation Moisture**	**16.8**	**16.4**	**17.0**	**17.5**	**N/A**	**N/A**



Equipment used: PM 16, #301667, Cal. date: 03/11/2002, Cal. due: 03/11/2003

CC: K. COOKE BECHTEL

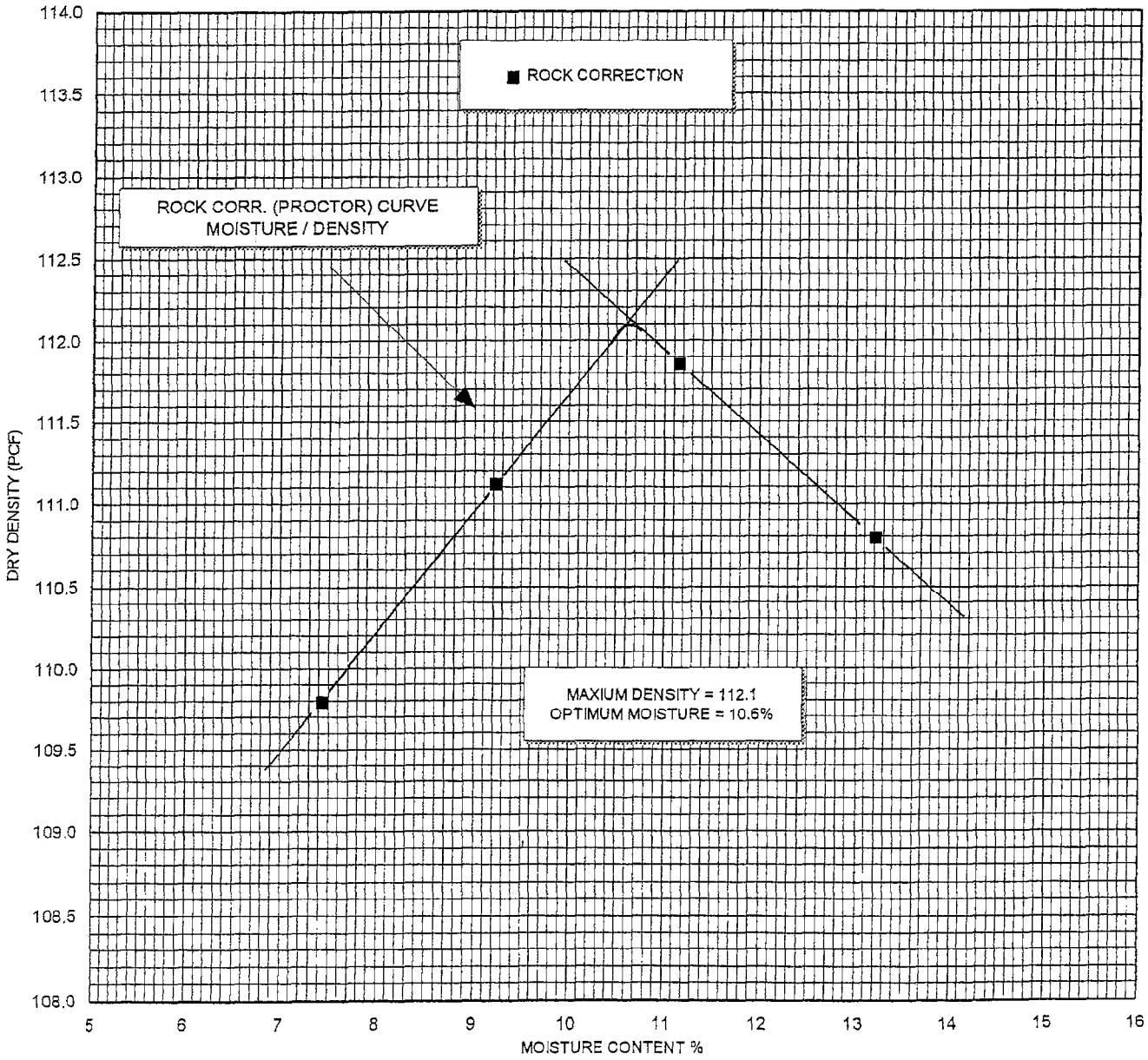
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

BECHTEL NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # SLDPCHAR
LAB # 1795
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: PO4U Sample Loc.: Grid Pt. # B4
Tested by: D. HERRINGTON Date tested: 08/20/2002 Checked by: W. Arnold

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	6.0%	6.0%	6.0%	6.0%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.31	2.31	2.31	2.31	N/A	N/A
4	% Water Content of 3/4":	3.3%	3.3%	3.3%	3.3%	N/A	N/A
5	% Water Content of Fines:	9.6%	11.7%	13.8%	7.7%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	109.5	110.3	109.2	108.1	N/A	N/A
7	% Corrected Water Content:	9.2%	11.2%	13.2%	7.4%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	111.1	111.9	110.8	109.8	N/A	N/A



PROCTOR TEST
ASTM D 1557-2000
METHOD: C
PREP. METHOD: MOIST

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

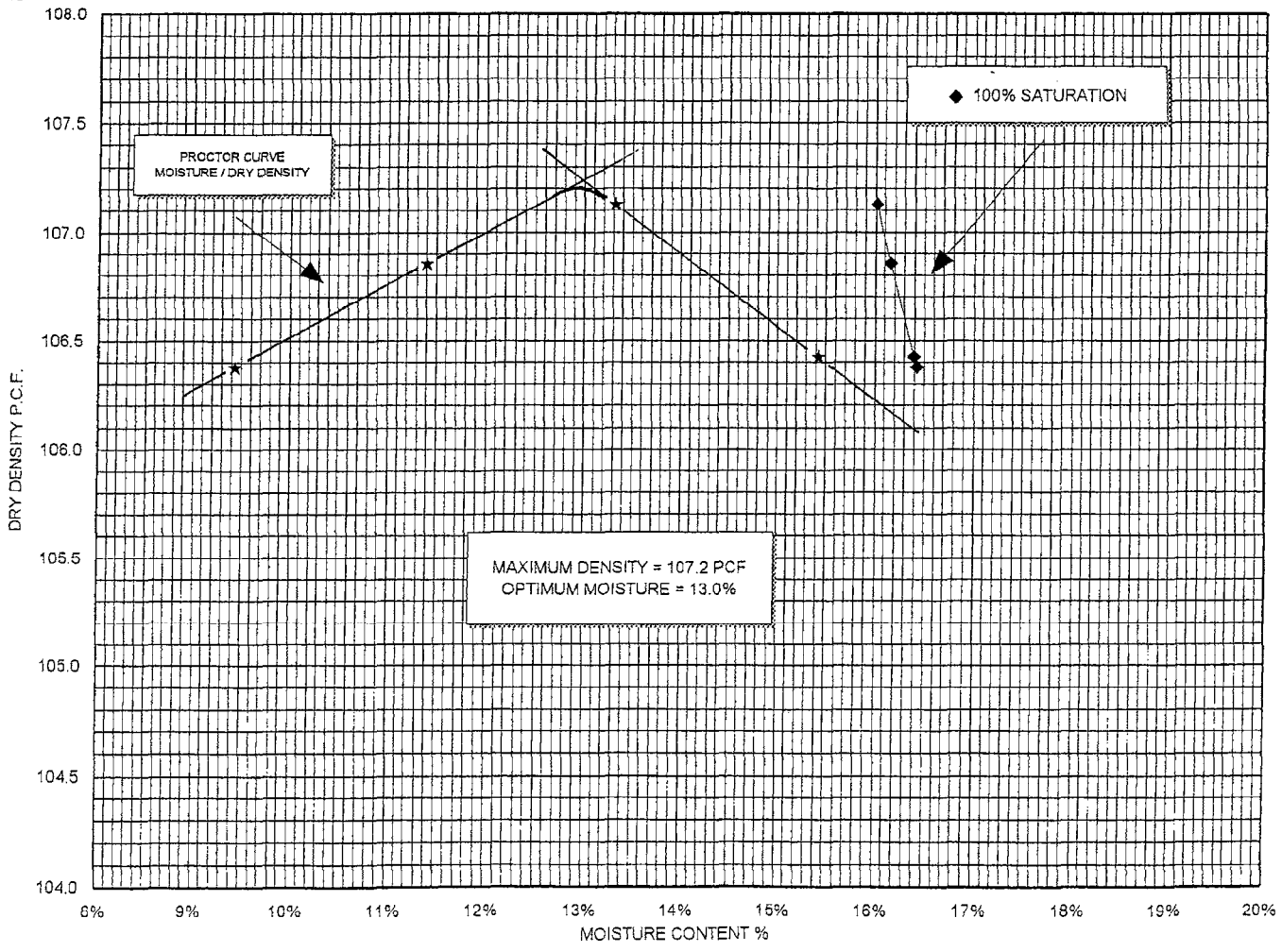
CHARGE #
LAB # 1796
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN

Sampled by: J. DENNY Date sampled: 06/19/2002 Operational Cover: PO4U Sample Loc.: Grid Pt. # C10

Tested by: D. HERRINGTON Date tested: 08/22/2002 Checked by:

	TRIAL	1	2	3	4	5	6
1	Wt.mold + wet soil	6878.4	6789.0	6958.8	7007.7	N/A	N/A
2	Wt. mold	2828.8	2828.8	2828.8	2828.8	N/A	N/A
3	Wt. wet soil	4049.6	3960.2	4130.0	4178.9	N/A	N/A
4	Wet Density, PCF	119.0	116.4	121.4	122.8	N/A	N/A
5	Moisture Tare #	1	2	3	4.0	N/A	N/A
6	Wt wet soil + tare	1417.1	1506.7	1724.6	1689.8	N/A	N/A
7	Wt dry soil + tare	1273.8	1378.3	1523.8	1466.3	N/A	N/A
8	Wt moisture	143.3	128.4	200.8	223.5	N/A	N/A
9	Wt tare	17.3	17.2	16.9	17.2	N/A	N/A
10	Wt dry soil	1256.5	1361.1	1506.9	1449.1	N/A	N/A
11	**% Moisture**	**11.4**	**9.4**	**13.3**	**15.4**	**N/A**	**N/A**
12	**Dry Density, PCF**	106.9	106.4	107.1	106.4	N/A	N/A
13	**100% Saturation Moisture**	**16.2**	**16.4**	**16.0**	**16.4**	**N/A**	**N/A**



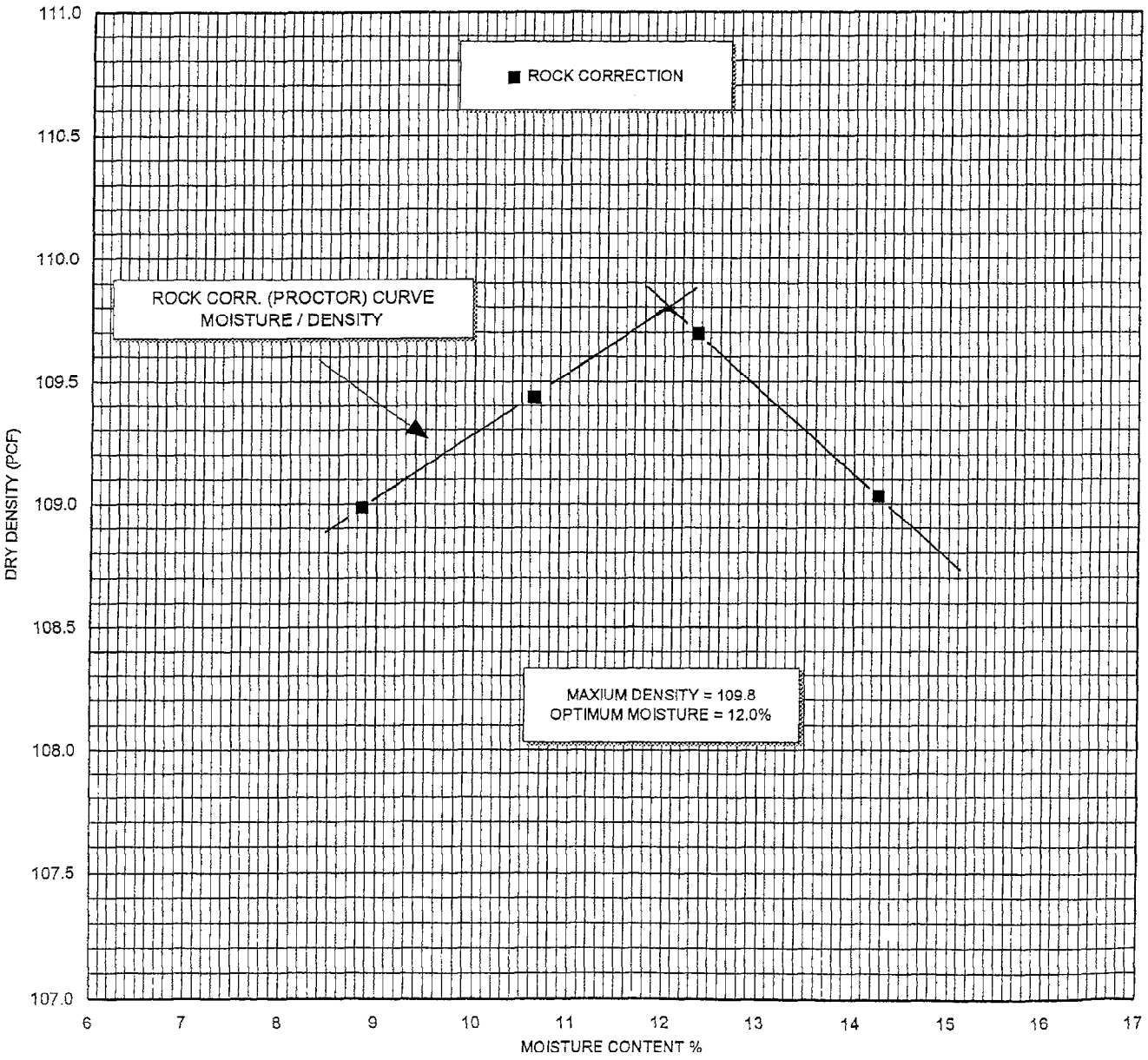
AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB # 1796
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 06/19/2002 Operational Cover: PO4U Sample Loc.: Grid Pt. # C10
Tested by: D. HERRINGTON Date tested: 08/22/2002 Checked by: V. Quinnan Ed

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	9.8%	9.8%	9.8%	9.8%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.25	2.25	2.25	2.25	N/A	N/A
4	% Water Content of 3/4":	3.5%	3.5%	3.5%	3.5%	N/A	N/A
5	% Water Content of Fines:	11.4%	9.4%	13.3%	15.4%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	106.9	106.4	107.1	106.4	N/A	N/A
7	% Corrected Water Content:	10.6%	8.9%	12.4%	14.3%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	109.4	109.0	109.7	109.0	N/A	N/A



Equipment used: PM 16 #301667 Cal. date: 03/11/2002 Cal. due: 03/11/2003

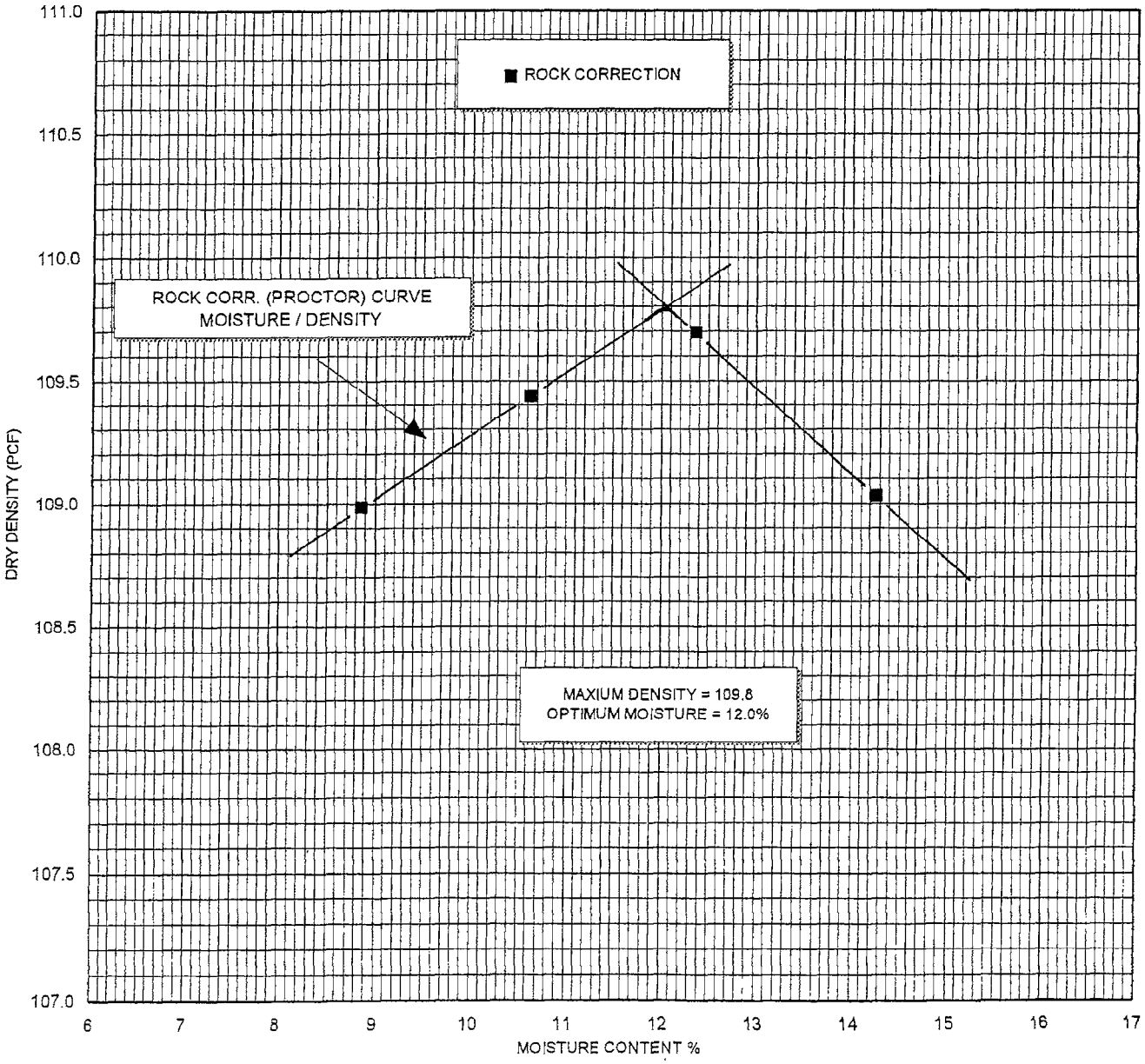
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # [illegible]
LAB # 1796
DATE 08/26/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Requested by: S. RAWLINSON | User/Agency BN
Sampled by: J. DENNY | Date sampled: 05/29/2002 | Operational Cover: PO4U | Sample Loc.: Grid Pt. # B4
Tested by: D. HERRINGTON | Date tested: 08/22/2002 | Checked by: V. [illegible]

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	9.8%	9.8%	9.8%	9.8%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.25	2.25	2.25	2.25	N/A	N/A
4	% Water Content of 3/4":	3.5%	3.5%	3.5%	3.5%	N/A	N/A
5	% Water Content of Fines:	11.4%	9.4%	13.3%	15.4%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	106.9	106.4	107.1	106.4	N/A	N/A
7	% Corrected Water Content:	10.6%	8.9%	12.4%	14.3%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	109.4	109.0	109.7	109.0	N/A	N/A



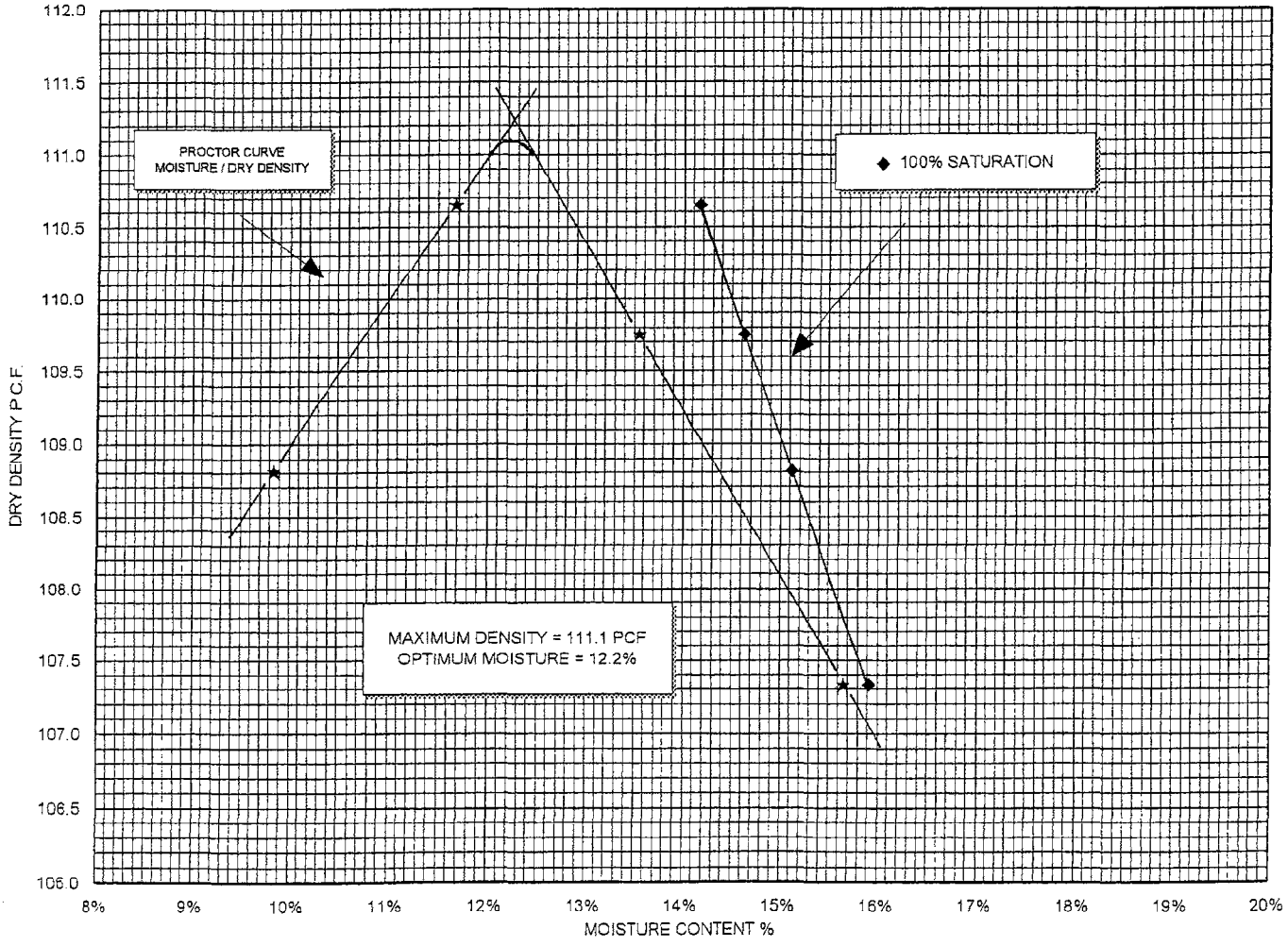
PROCTOR TEST
ASTM D 1557-2000
METHOD: C
PREP. METHOD: MOIST

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB # 1797
DATE 09/09/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Requested by: S. RAWLINSON | User/Agency: BN
Sampled by: J. DENNY | Date sampled: 06/19/2002 | Operational Cover: TO1U-TO7U | Sample Loc.: Grid Pt. # F4
Tested by: D. HERRINGTON | Date tested: 09/05/2002 | Checked by: V. Perrin

	TRIAL	1	2	3	4	5	6
1	Wt mold + wet soil	6894.9	7032.6	7068.3	7051.8	N/A	N/A
2	Wt. mold	2828.8	2828.8	2828.8	2828.8	N/A	N/A
3	Wt. wet soil	4066.1	4203.8	4239.5	4223.0	N/A	N/A
4	Wet Density, PCF	119.5	123.6	124.6	124.1	N/A	N/A
5	Moisture Tare #	1	2	3	4.0	N/A	N/A
6	Wt wet soil + tare	1374.9	1632.5	1744.0	1554.4	N/A	N/A
7	Wt dry soil + tare	1253.2	1463.6	1537.9	1346.3	N/A	N/A
8	Wt moisture	121.7	168.9	206.1	208.1	N/A	N/A
9	Wt tare	17.4	17.2	17.0	17.2	N/A	N/A
10	Wt dry soil	1235.8	1446.4	1520.9	1329.1	N/A	N/A
11	**% Moisture**	**9.8**	**11.7**	**13.6**	**15.7**	**N/A**	**N/A**
12	**Dry Density, PCF**	108.8	110.7	109.7	107.3	N/A	N/A
13	**100% Saturation Moisture**	**15.1**	**14.2**	**14.6**	**15.9**	**N/A**	**N/A**



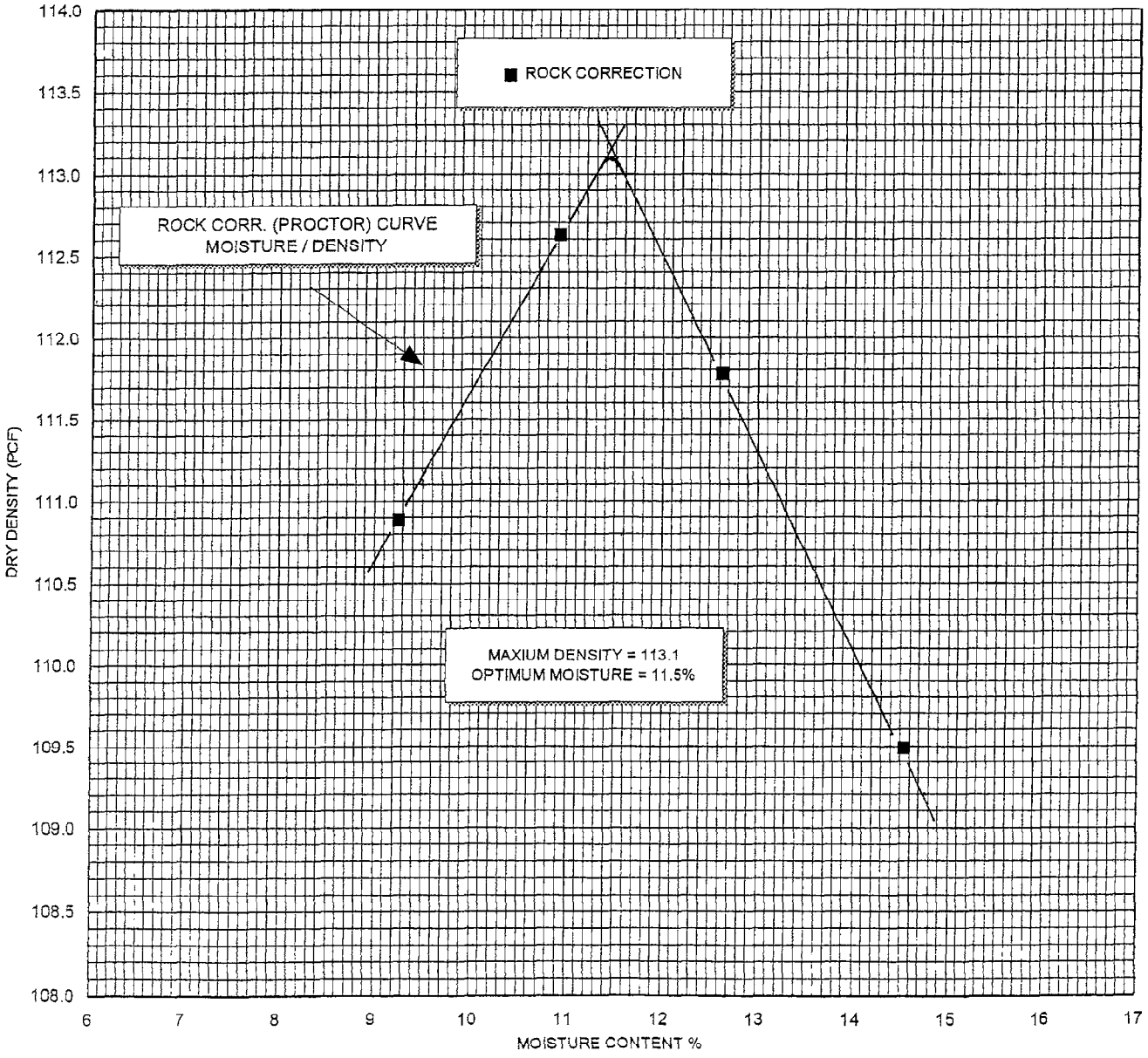
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB # 1797
DATE 09/09/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: TO1U-TO7U Sample Loc.: Grid Pt. # F4
Tested by: D. HERRINGTON Date tested: 09/05/2002 Checked by:

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	8.9%	8.9%	8.9%	8.9%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.21	2.21	2.21	2.21	N/A	N/A
4	% Water Content of 3/4":	3.1%	3.1%	3.1%	3.1%	N/A	N/A
5	% Water Content of Fines:	9.8%	11.7%	13.6%	15.7%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	108.8	110.7	109.7	107.3	N/A	N/A
7	% Corrected Water Content:	9.2%	10.9%	12.6%	14.5%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	110.9	112.6	111.8	109.5	N/A	N/A



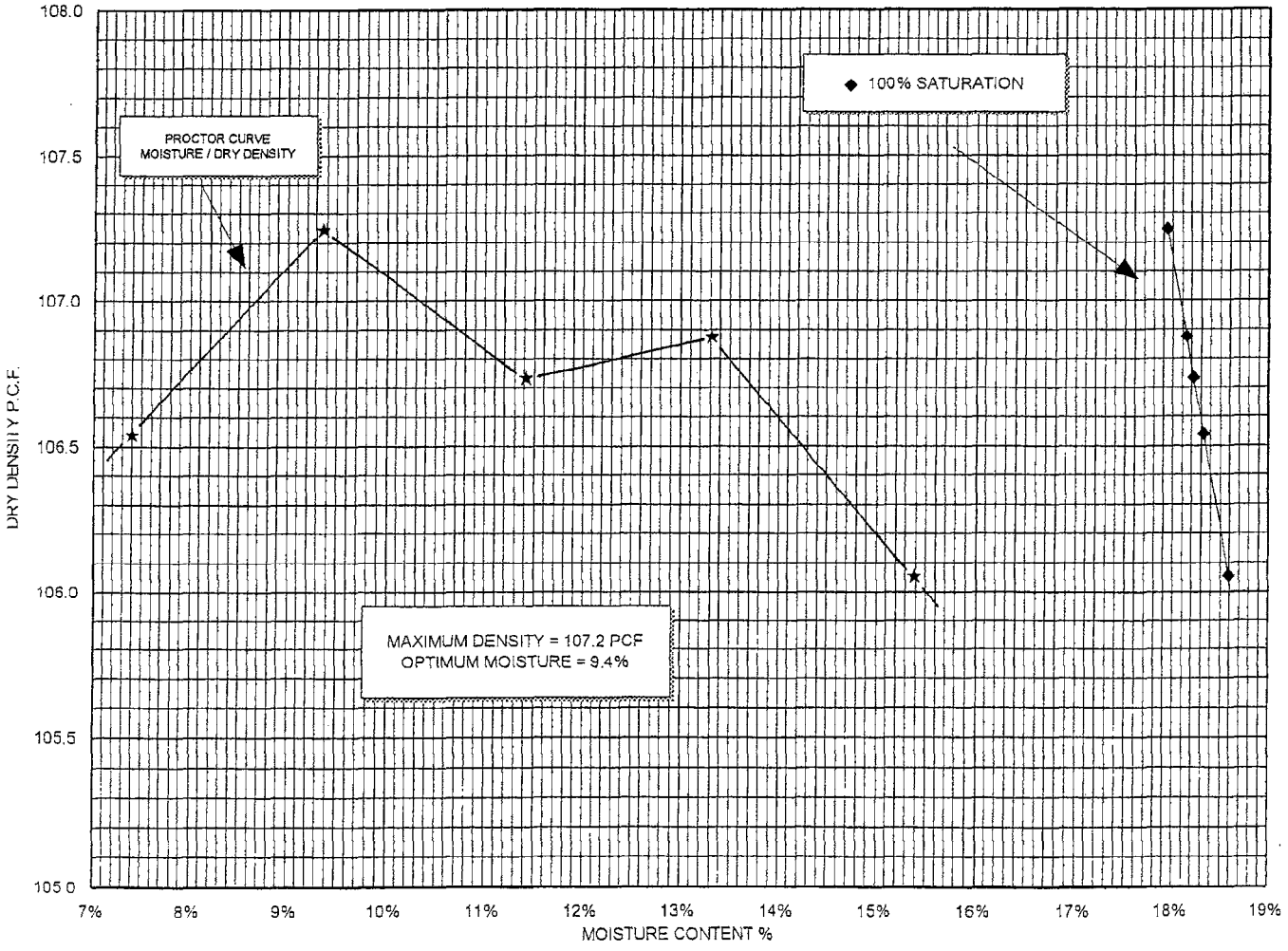
PROCTOR TEST
ASTM D 1557-2000
METHOD: C
PREP. METHOD: MOIST

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB # 1798
DATE 09/11/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Requested by: S. RAWLINSON | User/Agency BN
Sampled by: J. DENNY | Date sampled: 07/03/2002 | Operational Cover: TO1U-TO7U | Sample Loc.: Grid Pt. # B4
Tested by: D. HERRINGTON | Date tested: 09/09/2002 | Checked by: V. Quesada

	TRIAL	1	2	3	4	5	6
1	Wt.mold + wet soil	6721.6	6818.9	6874.3	6948.8	6991.9	N/A
2	Wt. mold	2828.8	2828.8	2828.8	2828.8	2828.8	N/A
3	Wt. wet soil	3892.8	3990.1	4045.5	4120.0	4163.1	N/A
4	Wet Density, PCF	114.4	117.3	118.9	121.1	122.4	N/A
5	Moisture Tare #	1	2	3	4.0	5	N/A
6	Wt wet soil + tare	1566.6	1562.1	1691.6	1672.9	1770.1	N/A
7	Wt dry soil + tare	1459.8	1429.8	1520.0	1478.3	1536.3	N/A
8	Wt moisture	106.8	132.3	171.6	194.6	233.8	N/A
9	Wt tare	17.3	17.2	17.0	17.2	17.2	N/A
10	Wt dry soil	1442.5	1412.6	1503.0	1461.1	1519.1	N/A
11	**% Moisture**	**7.4**	**9.4**	**11.4**	**13.3**	**15.4**	**N/A**
12	**Dry Density, PCF**	106.5	107.2	106.7	106.9	106.1	N/A
13	**100% Saturation Moisture**	**18.3**	**17.9**	**18.2**	**18.1**	**18.6**	**N/A**



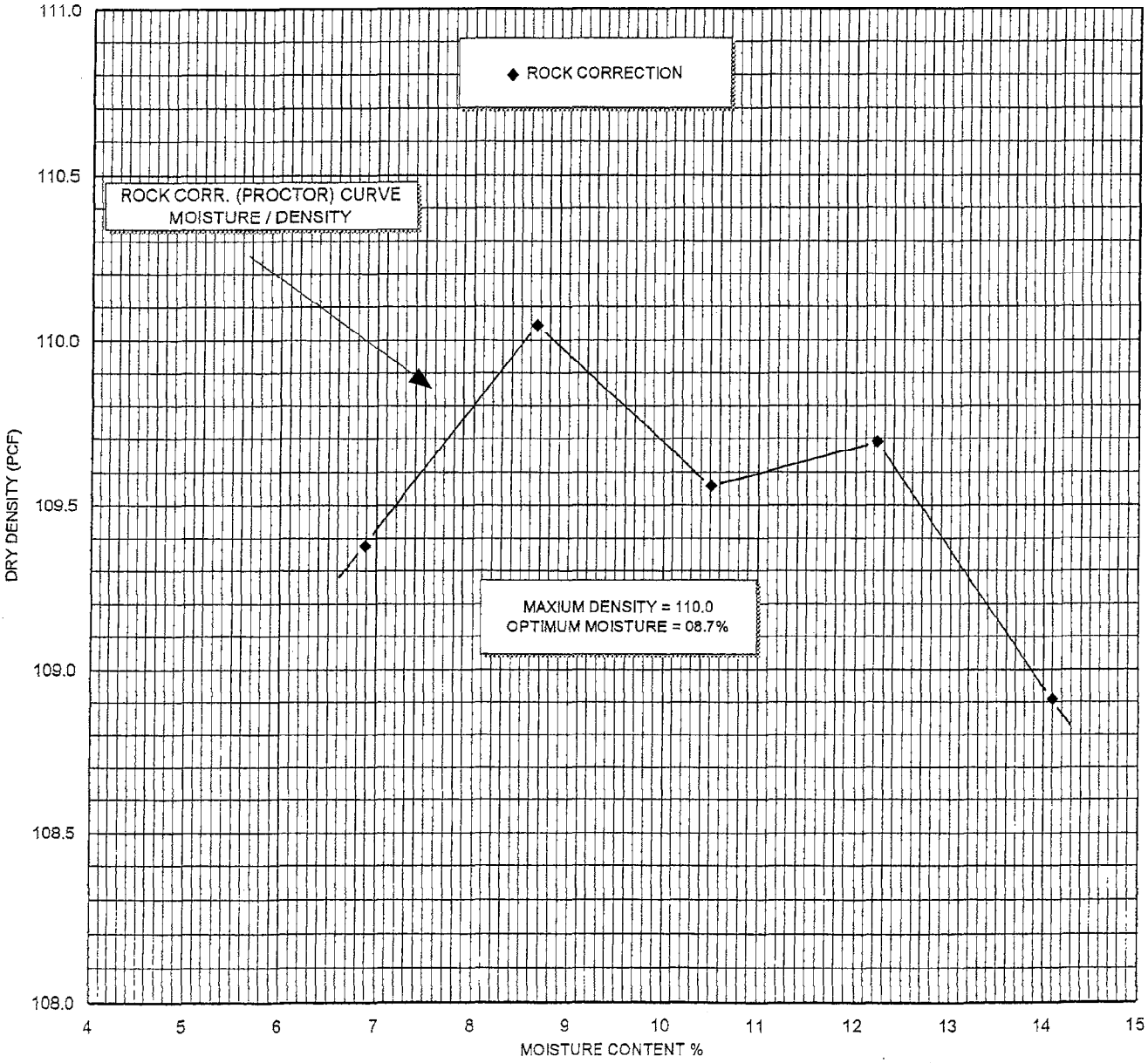
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES
ASTM D 4718-87

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB # 1798
DATE 09/11/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: TO1U-TO7U Sample Loc.: Grid Pt. # B4
Tested by: D. HERRINGTON Date tested: 09/09/2002 Checked by:

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	62.42	N/A
2	Percent of +3/4" size:	9.6%	9.6%	9.6%	9.6%	9.6%	N/A
3	Sp. Gr. of +3/4" size:	2.34	2.34	2.34	2.34	2.34	N/A
4	% Water Content of 3/4":	2.0%	2.0%	2.0%	2.0%	2.0%	N/A
5	% Water Content of Fines:	7.4%	9.4%	11.4%	13.3%	15.4%	N/A
6	Dry Unit Wt. of Fines: PCF	106.5	107.2	106.7	106.9	106.1	N/A
7	% Corrected Water Content:	6.9%	8.7%	10.5%	12.2%	14.1%	N/A
8	Corrected Dry Unit Wt.: PCF	109.4	110.0	109.6	109.7	108.9	N/A



PROCTOR TEST
ASTM D 1557-2000
METHOD: C
PREP. METHOD: MOIST

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

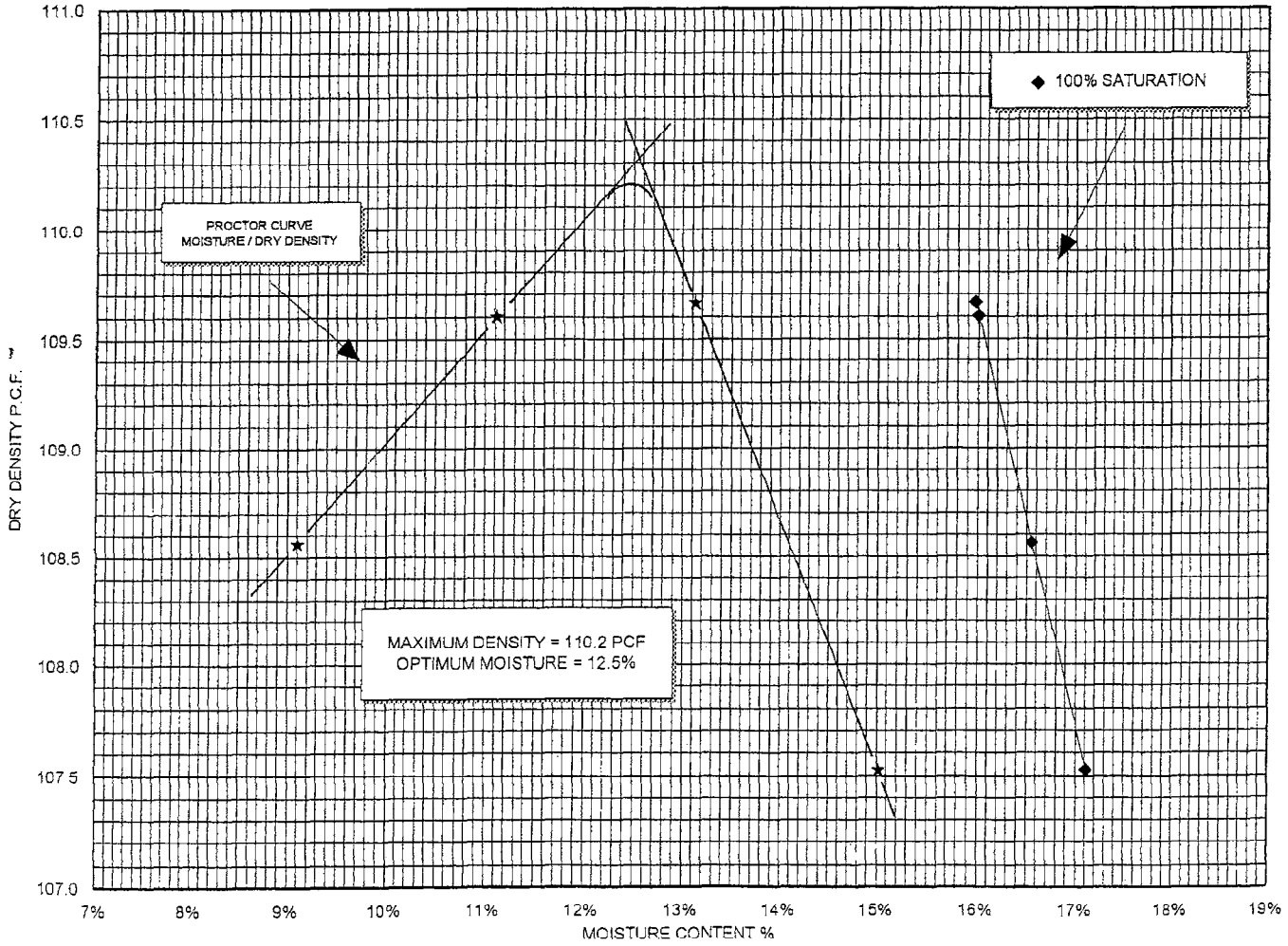
CHARGE #
LAB # 1799
DATE 09/12/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Requested by: S. RAWLINSON | User/Agency BN

Sampled by: J. DENNY | Date sampled: 07/03/2002 | Operational Cover: TO1C-TO6C | Sample Loc.: Grid Pt. # C10

Tested by: D. HERRINGTON | Date tested: 09/11/2002 | Checked by: V. Rennick

	TRIAL	1	2	3	4	5	6
1	Wt.mold + wet soil	6858.4	6971.9	7049.5	7036.0	N/A	N/A
2	Wt. mold	2828.8	2828.8	2828.8	2828.8	N/A	N/A
3	Wt. wet soil	4029.6	4143.1	4220.7	4207.2	N/A	N/A
4	Wet Density, PCF	118.5	121.8	124.1	123.7	N/A	N/A
5	Moisture Tare #	1	2	3	4.0	N/A	N/A
6	Wt wet soil + tare	1599.9	1612.3	1627.3	1654.7	N/A	N/A
7	Wt dry soil + tare	1467.8	1452.7	1440.3	1440.9	N/A	N/A
8	Wt moisture	132.1	159.6	187.0	213.8	N/A	N/A
9	Wt tare	17.4	17.3	16.9	17.2	N/A	N/A
10	Wt dry soil	1450.4	1435.4	1423.4	1423.7	N/A	N/A
11	**% Moisture**	**9.1**	**11.1**	**13.1**	**15.0**	**N/A**	**N/A**
12	**Dry Density, PCF**	108.6	109.6	109.7	107.5	N/A	N/A
13	**100% Saturation Moisture**	**16.6**	**16.0**	**16.0**	**17.1**	**N/A**	**N/A**



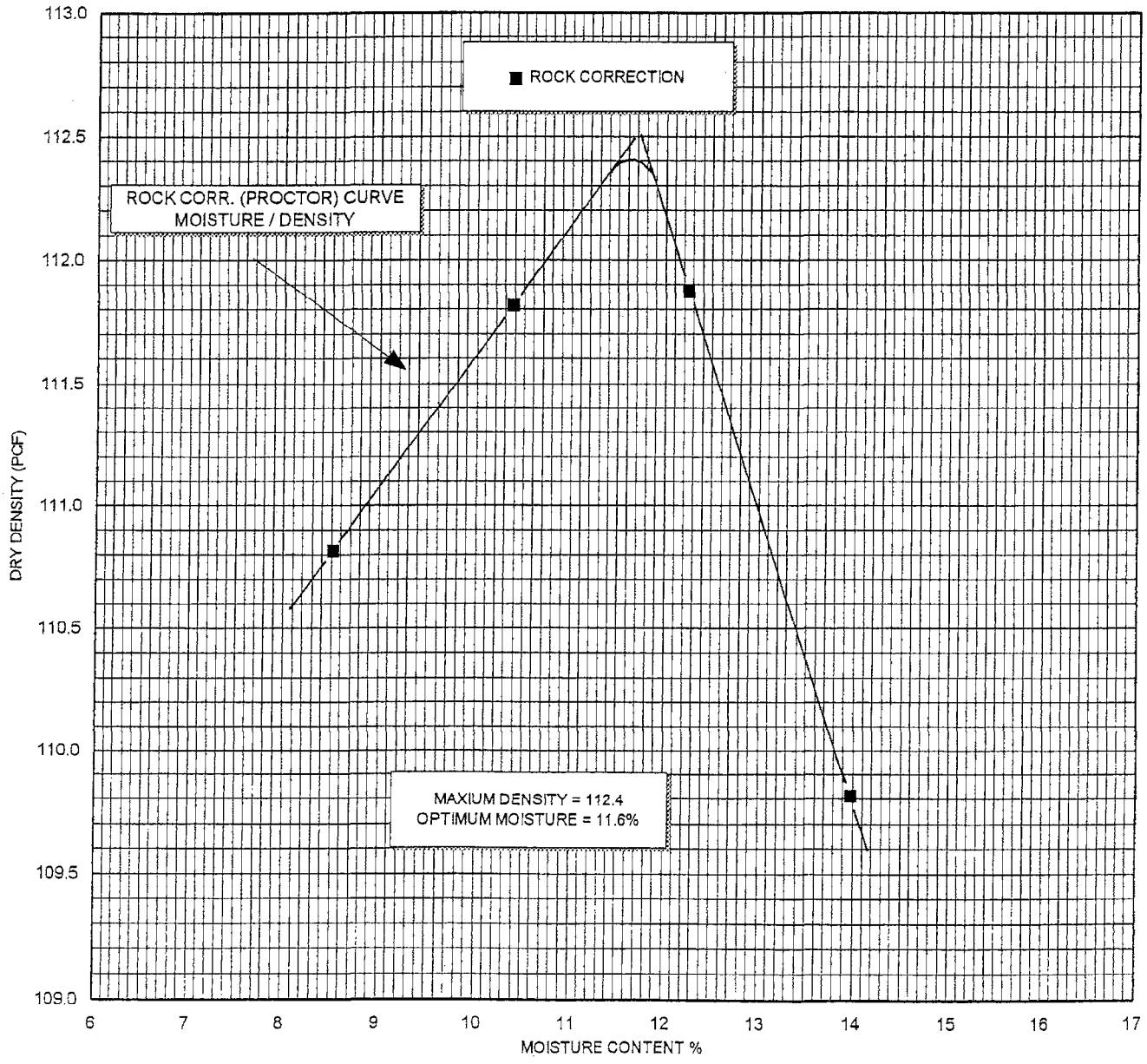
CORRECTION OF UNIT WEIGHT AND WATER CONTENT FOR SOILS CONTAINING OVERSIZE PARTICLES ASTM D 4718-87

DESERT RESEARCH INSTITUTE NEVADA
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # SLIPCHAR
LAB # 1799
DATE 09/12/2002
RAMMER: MECH.

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES Requested by: S. RAWLINSON User/Agency BN
Sampled by: J. DENNY Date sampled: 05/29/2002 Operational Cover: TO1C-TO6C Sample Loc.: Grid Pt. # C10
Tested by: D. HERRINGTON Date tested: 09/11/2002 Checked by: V. Quinn

		1	2	3	4	5	6
1	Unit Wt. of Water: PCF	62.42	62.42	62.42	62.42	N/A	N/A
2	Percent of +3/4" size:	7.5%	7.5%	7.5%	7.5%	N/A	N/A
3	Sp. Gr. of +3/4" size:	2.38	2.38	2.38	2.38	N/A	N/A
4	% Water Content of 3/4":	1.3%	1.3%	1.3%	1.3%	N/A	N/A
5	% Water Content of Fines:	9.1%	11.1%	13.1%	15.0%	N/A	N/A
6	Dry Unit Wt. of Fines: PCF	108.6	109.6	109.7	107.5	N/A	N/A
7	% Corrected Water Content:	8.5%	10.4%	12.2%	14.0%	N/A	N/A
8	Corrected Dry Unit Wt.: PCF	110.8	111.8	111.9	109.8	N/A	N/A



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Appendix B-6

Sieve Analyses and Gradation Curves

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Bechtel Nevada

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON | Charge #: 5LDPCHAR
User/Agency: BECHTEL | Log # N/A | MTL Lab #: 1794

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Sample Location: LOGGING TUBE 22
Sampled by: J. DENNY | Date Sampled: 05/29/2002 | Operational Cover: PO3U
Tested By: D. HERRINGTON | Date tested: 08/15/2002
Checked by: V. Quintana | Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] Sieve Analysis (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- [ ] Moisture Content (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- [ ] Unit Weight (ASTM C-29-97)
- [X] Soil Classification
- [ ] Percent Porosity
- [ ] Specific Gravity (ASTM C-127-88/128-97)
- [X] (ASTM D-854-98)
- [ ] Other (as noted)

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	45.8	2%	98%	N/A
3/4	125.4	6%	94%	N/A
3/8	250.4	13%	87%	N/A
4	406.6	21%	79%	N/A
10	632.2	32%	68%	N/A
40	1137.5	58%	42%	N/A
100	1648.2	84%	16%	N/A
200	1819.4	92.6%	7.4%	N/A

Soil Class: SM /SW | **Sample Wt (g):** DRY = 1964.7

MOISTURE CONTENT

TARE # =	Native # 29	Oversize # 30	Proctor
Wet Weight + Tare	2890.2	4248.3	N/A
Dry Weight + Tare	2796.4	4138.6	
Water	93.8	109.7	0.0
Tare	908.3	896.1	
Dry Weight	1888.1	3242.5	0.0
Moisture %	5.0%	3.4%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR | HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.303 | **Average Specific Gravity:** 2.481

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON | Charge #: 5LDPCHAR

User/Agency: BECHTEL | Log # N/A | MTL Lab #: 1795

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Sample Location: GRID PT. #B4

Sampled by: J. DENNY | Date Sampled: 05/29/2002 | Operational Cover: PO4U

Tested By: D. HERRINGTON | Date tested: 08/20/2002

Checked by: V. Dieudonne | Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] Sieve Analysis (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- [ ] Moisture Content (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- [ ] Unit Weight (ASTM C-29-97)
- [X] Soil Classification
- [ ] Percent Porosity
- [ ] Specific Gravity (ASTM C-127-88/128-97)
- [ ] (ASTM D-854-98)
- [ ] Other (as noted)

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	18.6	1%	99%	N/A
3/4	99.5	6%	94%	N/A
3/8	183.5	11%	89%	N/A
4	307.0	18%	82%	N/A
10	499.9	30%	70%	N/A
40	888.0	53%	47%	N/A
100	1330.5	80%	20%	N/A
200	1493.0	89.6%	10.4%	N/A

Soil Class: SM / SP | **Sample Wt (g):** DRY = 1666.7

MOISTURE CONTENT

TARE # =	Native # 31	Oversize # 32	Proctor
Wet Weight + Tare	2580.6	3710.4	N/A
Dry Weight + Tare	2486.2	3621.7	
Water	94.4	88.7	0.0
Tare	896.7	894.6	
Dry Weight	1589.5	2727.1	0.0
Moisture %	5.9%	3.3%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR | HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.311 | **Average Specific Gravity:** 2.462

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON | Charge #: 5LDPCHAR
User/Agency: BECHTEL | Log # N/A | MTL Lab #: 1796

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Sample Location: GRID PT. #C10
Sampled by: J. DENNY | Date Sampled: 06/19/2002 | Operational Cover: PO4U
Tested By: D. HERRINGTON | Date tested: 08/26/2002
Checked by: V. Herrington | Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] Sieve Analysis (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- Moisture Content
- [ ] (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- Unit Weight
- [ ] (ASTM C-29-97)
- [X] Soil Classification
- [ ] Percent Porosity
- Specific Gravity
- [X] (ASTM C-127-88/128-97)
- [ ] (ASTM D-854-98)
- [ ] Other (as noted)

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	133.4	5%	95%	N/A
3/4	279.3	10%	90%	N/A
3/8	477.5	17%	83%	N/A
4	710.1	25%	75%	N/A
10	1015.8	36%	64%	N/A
40	1674.4	59%	41%	N/A
100	2448.9	86%	14%	N/A
200	2662.6	93.6%	6.4%	N/A

Soil Class: SM / SW | **Sample Wt (g):** DRY = 2845.1

MOISTURE CONTENT

TARE # =	Native # 32	Oversize # 33	Proctor
Wet Weight + Tare	3747.5	5678.6	N/A
Dry Weight + Tare	3601.1	5517.5	
Water	146.4	161.1	0.0
Tare	894.7	939.8	
Dry Weight	2706.4	4577.7	0.0
Moisture %	5.4%	3.5%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR | HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.254 | **Average Specific Gravity:** 2.343

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON | Charge #: 5LDPCHAR

User/Agency: BECHTEL | Log # N/A | MTL Lab #: 1797

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Sample Location: GRID PT. #F4

Sampled by: J. DENNY | Date Sampled: 06/19/2002 | Operational Cover: TO1U - TO7U

Tested By: D. HERRINGTON | Date tested: 08/26/2002

Checked by: V. Herrington | Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] **Sieve Analysis** (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- **Moisture Content**
- [ ] (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- **Unit Weight**
- [ ] (ASTM C-29-97)
- [X] **Soil Classification**
- [ ] **Percent Porosity**
- **Specific Gravity**
- [X] (ASTM C-127-88/128-97)
- [ ] (ASTM D-854-98)
- [ ] **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	142.0	6%	94%	N/A
3/4	225.3	9%	91%	N/A
3/8	341.9	13%	87%	N/A
4	537.7	21%	79%	N/A
10	815.2	32%	68%	N/A
40	1350.5	53%	47%	N/A
100	2047.2	81%	19%	N/A
200	2325.7	91.6%	8.4%	N/A

Soil Class: SM / SP | **Sample Wt (g):** | **DRY =** 2539.6

MOISTURE CONTENT

TARE # =	Native # 34	Oversize # 35	Proctor
Wet Weight + Tare	3541.3	5567.5	N/A
Dry Weight + Tare	3395.2	5428.1	
Water	146.1	139.4	0.0
Tare	936.3	897.0	
Dry Weight	2458.9	4531.1	0.0
Moisture %	5.9%	3.1%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR | HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.210 | **Average Specific Gravity:** 2.346

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 | Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Bechtel Nevada

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON | Charge #: 5LDPCHAR

User/Agency: BECHTEL | Log # N/A | MTL Lab #: 1798

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES | Sample Location: GRID PT. #B4

Sampled by: J. DENNY | Date Sampled: 07/03/2002 | Operational Cover: TO1U - TO7U

Tested By: D. HERRINGTON | Date tested: 08/26/2002

Checked by: V. Quennell | Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] **Sieve Analysis** (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- **Moisture Content**
- [ ] (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- **Unit Weight**
- [ ] (ASTM C-29-97)
- [X] **Soil Classification**
- [ ] **Percent Porosity**
- **Specific Gravity**
- [X] (ASTM C-127-88/128-97)
- [ ] (ASTM D-854-98)
- [ ] **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	151.1	5%	95%	N/A
3/4	306.4	10%	90%	N/A
3/8	452.6	14%	86%	N/A
4	674.6	21%	79%	N/A
10	999.4	31%	69%	N/A
40	1808.6	57%	43%	N/A
100	2751.7	86%	14%	N/A
200	2995.2	94.1%	5.9%	N/A

Soil Class: SM / SW | **Sample Wt (g):** DRY = 3182.9

MOISTURE CONTENT

TARE # =	Native # 36	Oversize # 37	Proctor
Wet Weight + Tare	4044.6	6044.6	N/A
Dry Weight + Tare	3931.2	5945.1	
Water	113.4	99.5	0.0
Tare	896.4	981.3	
Dry Weight	3034.8	4963.8	0.0
Moisture %	3.7%	2.0%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR | HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.335 | **Average Specific Gravity:** 2.464

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

Bechtel Nevada
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

Request / Test Report

Requested by: S. RAWLINSON — Charge #: 5LDPCHAR

User/Agency: BECHTEL — Log #: N/A — MTL Lab #: 1799

Project: A/5 RWMS, OPERATIONAL COVER CLOSURES — Sample Location: GRID PT. #C10

Sampled by: J. DENNY — Date Sampled: 07/03/2002 — Operational Cover: TO1C - TO6C

Tested By: D. HERRINGTON — Date tested: 08/26/2002

Checked by: V. Greenamoble — Date checked: 9/12/02

LABORATORY TEST REQUIRED

- [ ] **Sieve Analysis** (ASTM C-136-96)
- [ ] (ASTM C-117-95)
- [X] (ASTM D-422-63)
- [X] (ASTM D-1140-97)
- [ ] **Moisture Content** (ASTM C-566-97)
- [X] (ASTM D-2216-98)
- [ ] **Unit Weight** (ASTM C-29-97)
- [X] **Soil Classification**
- [ ] **Percent Porosity**
- [ ] **Specific Gravity** (ASTM C-127-88/128-97)
- [ ] (ASTM D-854-98)
- [ ] **Other (as noted)**

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	% Retained	% Passing	Spec % Passing
3	0.0	0%	100%	N/A
1 1/2	107.6	4%	96%	N/A
3/4	208.9	8%	92%	N/A
3/8	327.8	12%	88%	N/A
4	549.2	20%	80%	N/A
10	866.0	31%	69%	N/A
40	1447.6	52%	48%	N/A
100	2239.5	81%	19%	N/A
200	2522.2	91.0%	9.0%	N/A

Soil Class: SM / SP — **Sample Wt (g):** DRY = 2771.5

MOISTURE CONTENT

TARE # =	Native # 38	Oversize # 39	Proctor
Wet Weight + Tare	3769.1	4831.1	N/A
Dry Weight + Tare	3677.6	4780.0	
Water	91.5	51.1	0.0
Tare	1003.8	875.4	
Dry Weight	2673.8	3904.6	0.0
Moisture %	3.4%	1.3%	N/A

UNIT WEIGHT

	Loose	Rodded
Container Size(ft^3)	0.0997506	0.0997506
Total Weight (lb)		
Tare Weight (lb)		
Material Weight (lb)		
Unit Weight (P.C.F.)	**N/A**	**N/A**
Percent Porosity	**N/A**	**N/A**

SHAPE: ANGULAR — HARDNESS: HARD AND DURABLE

Oversize Specific Gravity: 2.381 — **Average Specific Gravity:** 2.434

EQUIPMENT USED: PM 16, #301667, Calibration Date: 03/11/2002 — Calibration Due: 03/11/2003

Sieve 3"	PTL # 303221	Cal. Date: 04/30/02	Cal. Due: 04/30/03
Sieve 1 1/2"	PTL # 303278	Cal. Date: 09/18/01	Cal. Due: 09/18/02
Sieve 3/4"	PTL # 303276	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve 3/8	PTL # 302106	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 4	PTL # 302043	Cal. Date: 09/19/01	Cal. Due: 09/19/02
Sieve # 10	PTL # 312339	Cal. Date: 09/20/01	Cal. Due: 09/20/02
Sieve # 40	PTL # 310013	Cal. Date: 09/24/01	Cal. Due: 09/24/02
Sieve # 100	PTL # 300103	Cal. Date: 04/30/02	Cal. Due: 04/30/03

REMARKS: N/A

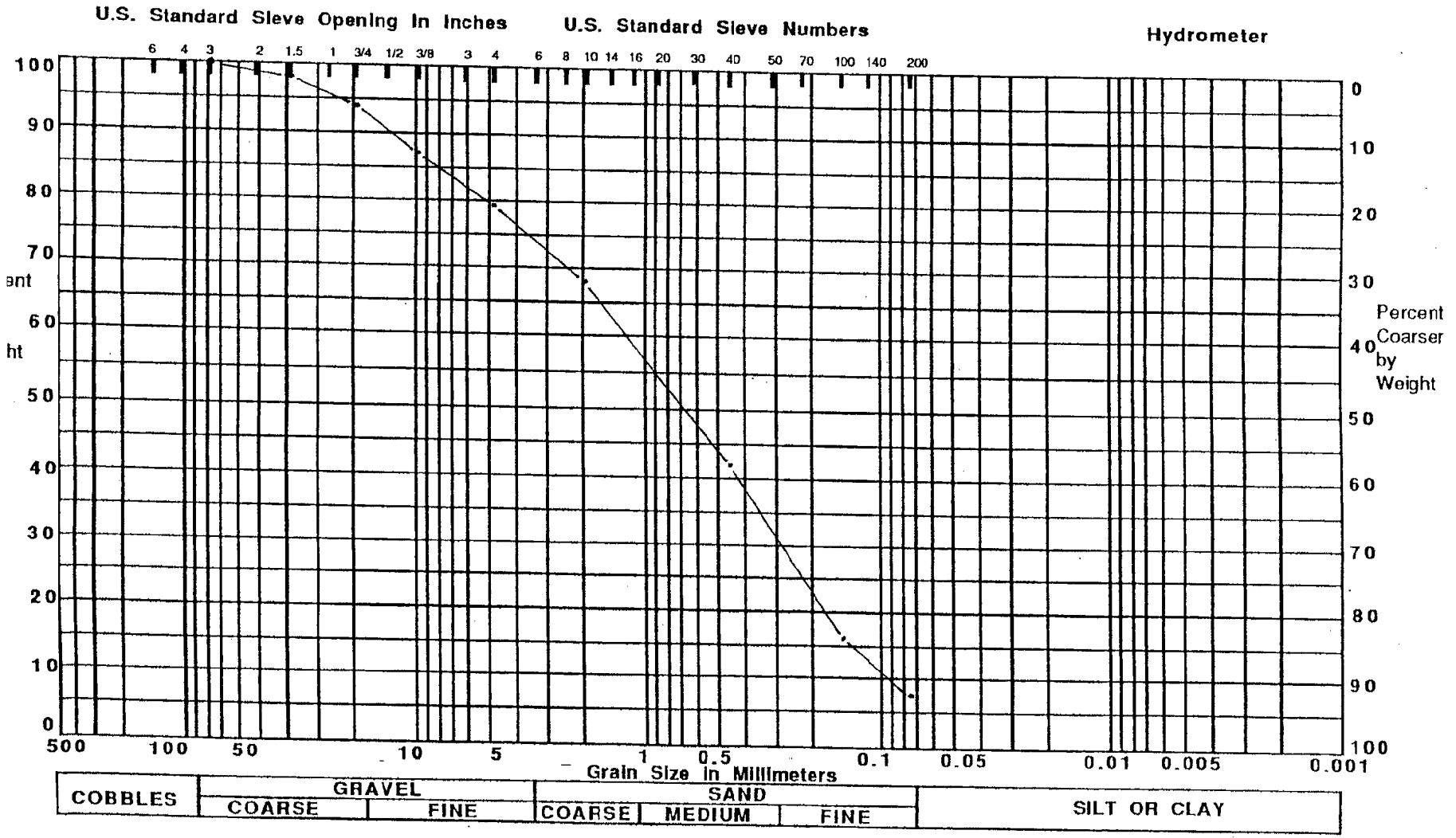
RADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5LDPCHAR
DATE 08/26/20 50X0

PROJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SW

IECKED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: LOGGING TUBE 22 Operational Cover: PO3U



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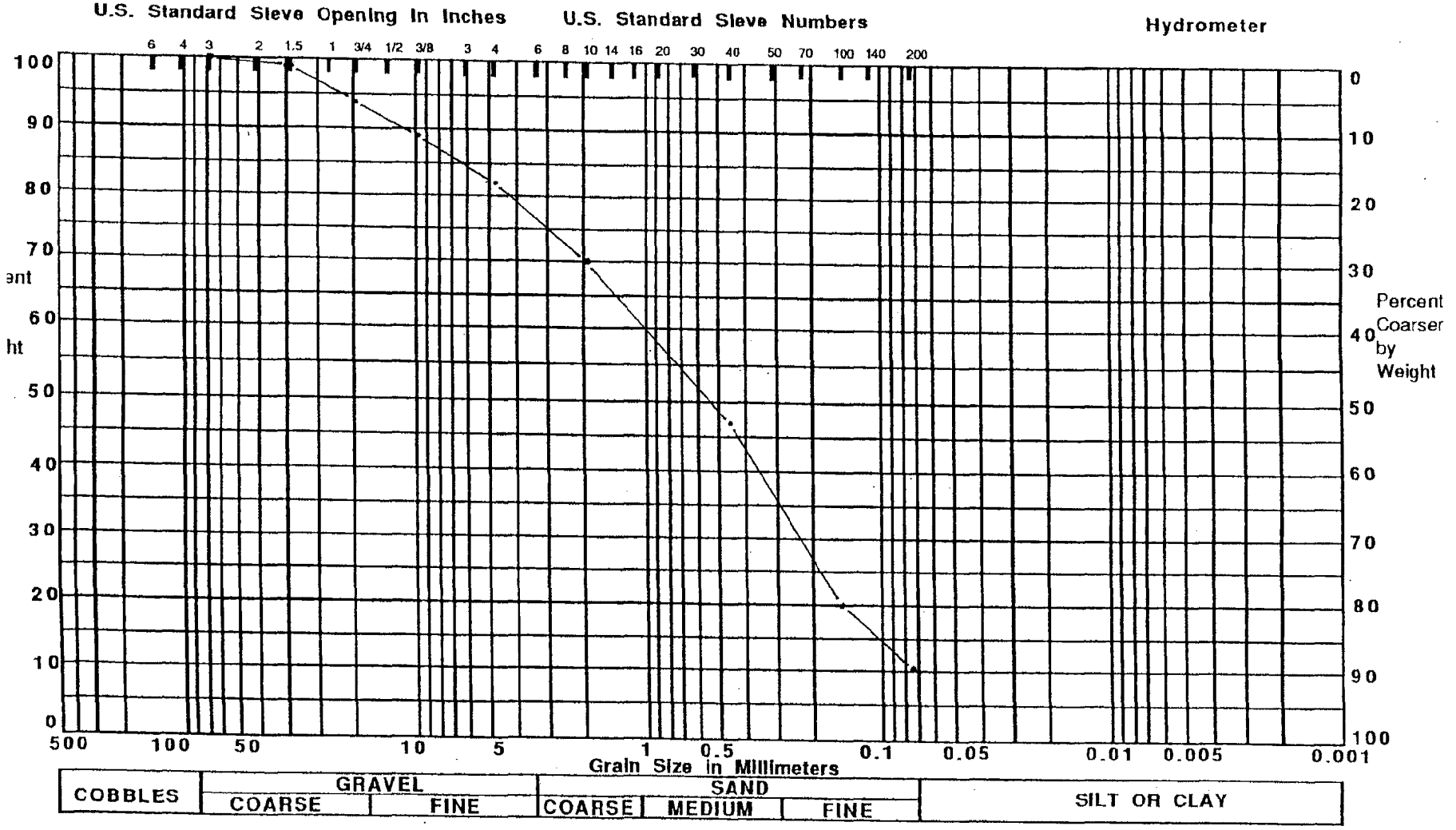
RADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

CHARGE # 5LDPCHAR
DATE 08/26/2002

ROJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SP

ECKED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: GRID PT. # B4 Operational Cover: PO4U



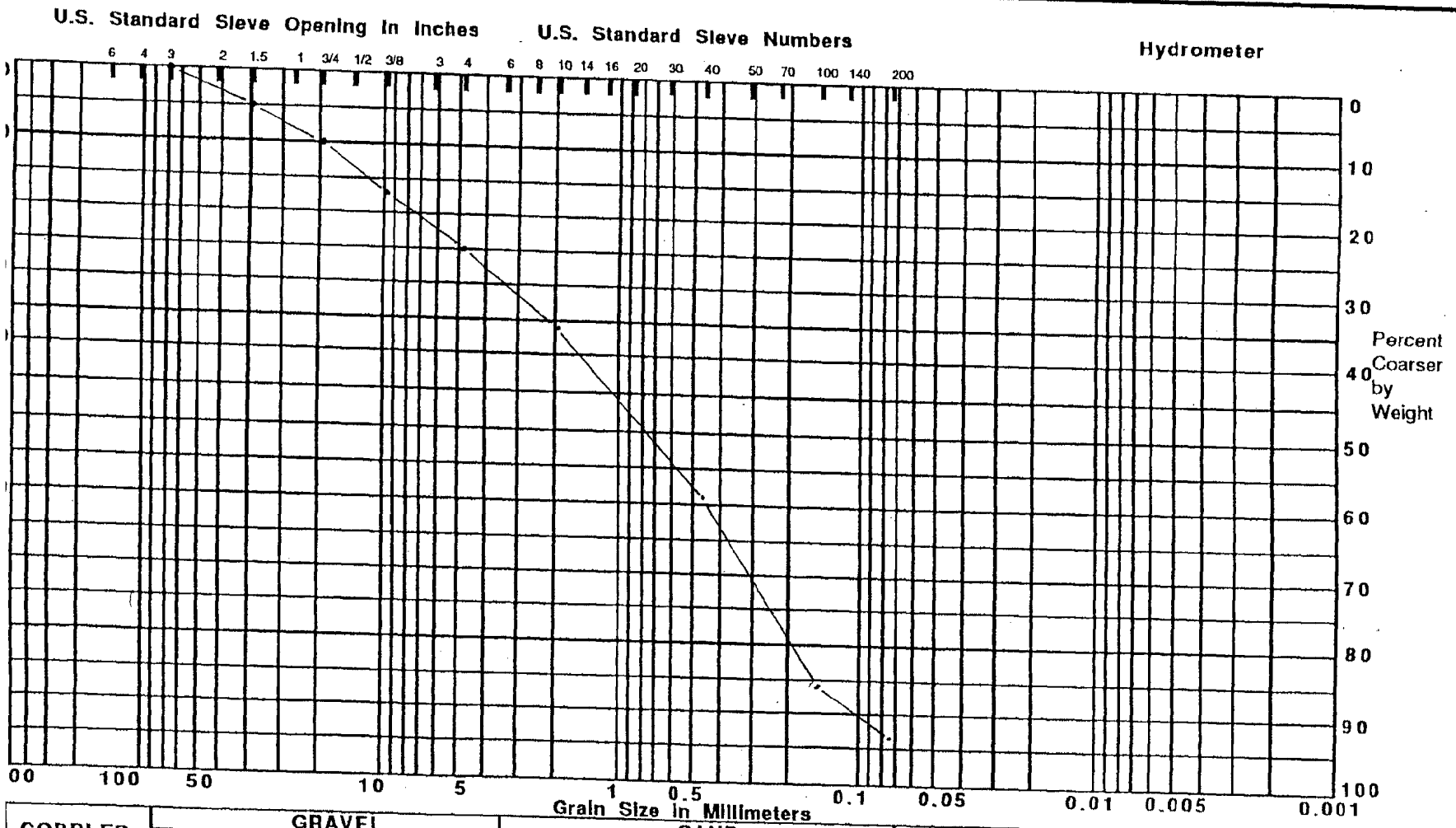
)ATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO: 1796
CHARGE # 5LDPCHAR
DATE 08/26/2002

ECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SW

ED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: GRID PT. # C10 Operational Cover: PO4U



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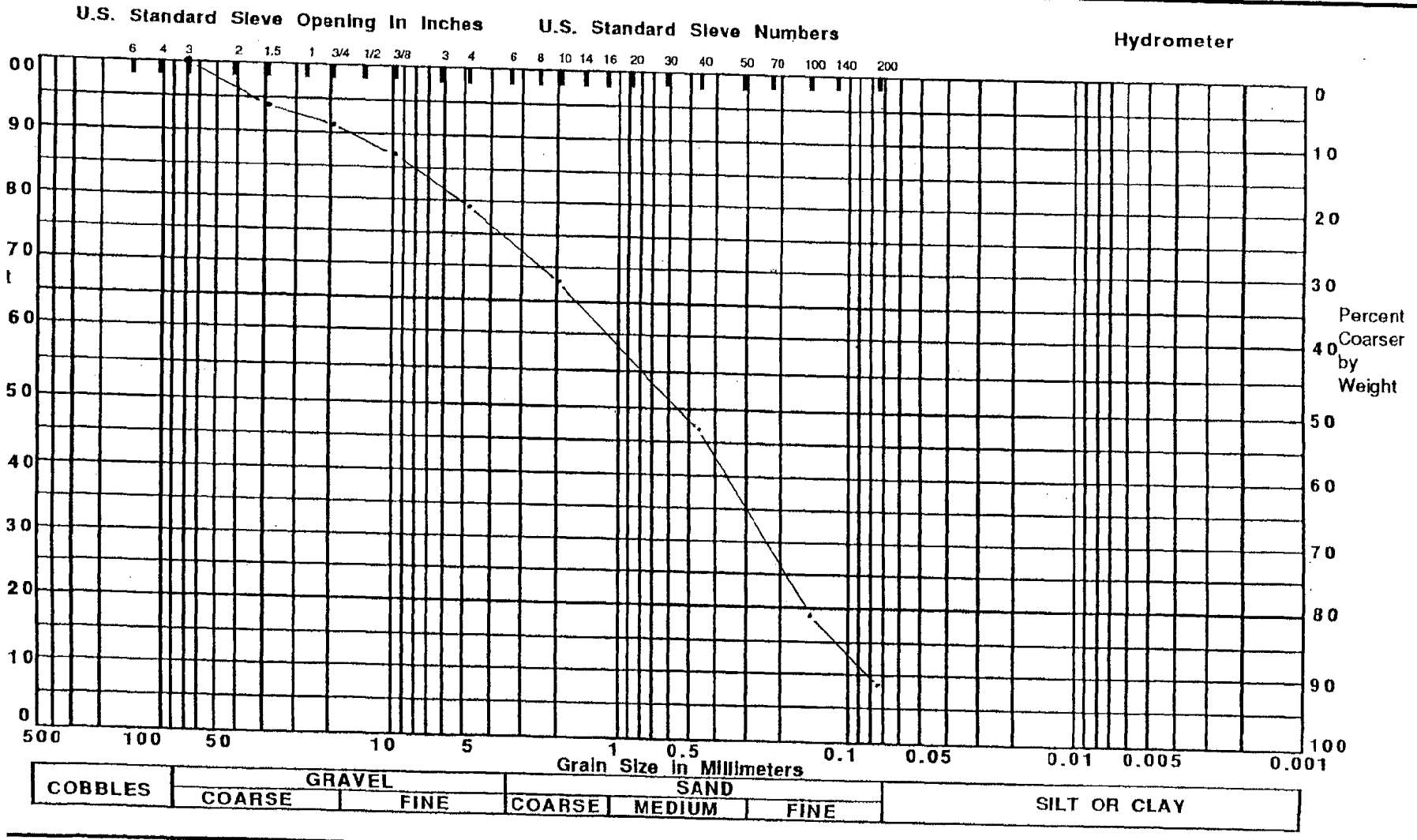
ADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO: 1797
CHARGE # 5LDPCHAR
DATE 08/26/2002

OJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SP

CKED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: GRID PT. # F4 Operational Cover: TO1U-TO7U



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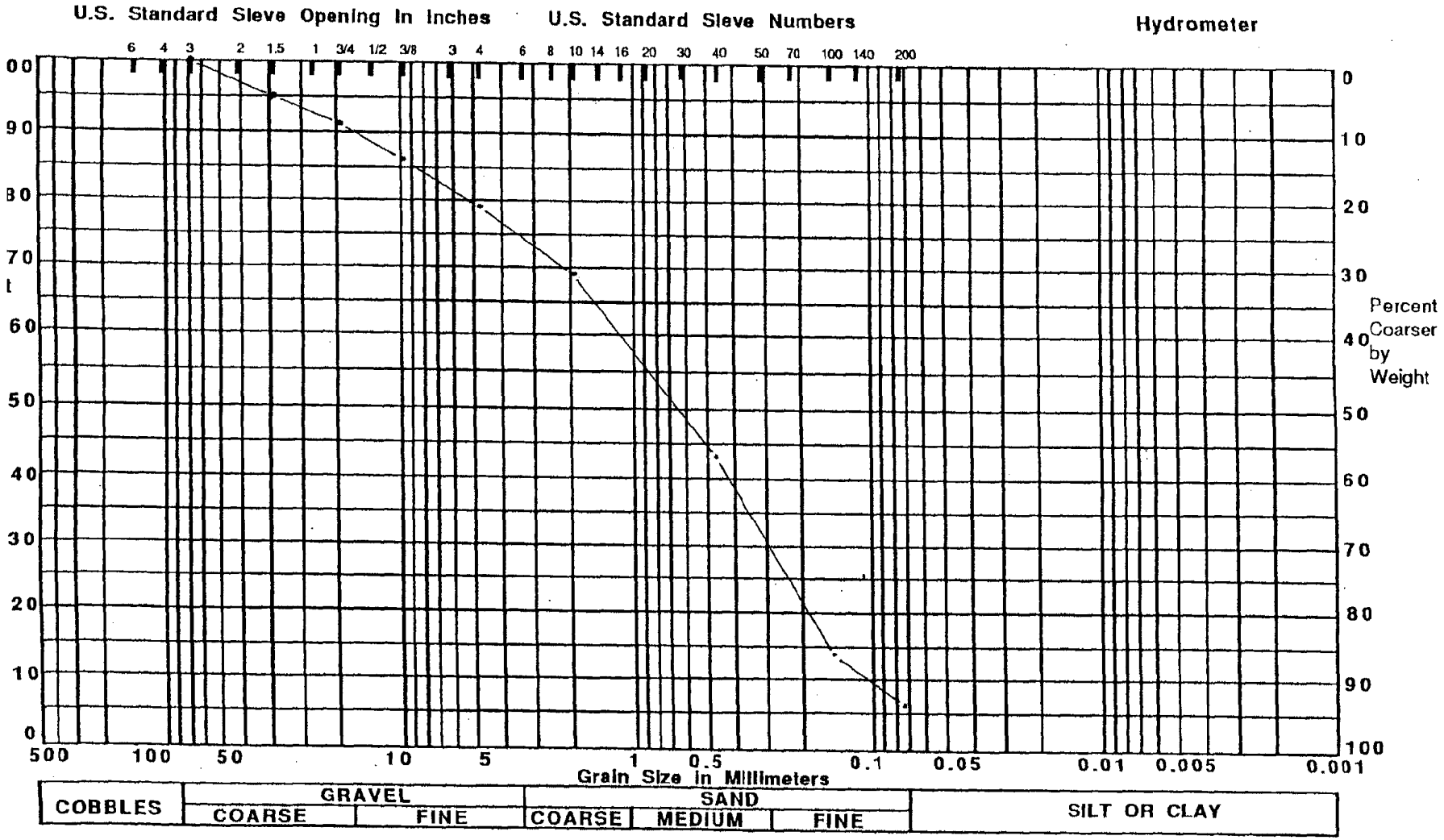
ADATION CURVES

DESERT RESEARCH INSTITUTE
MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO. 1798
CHARGE # 5LDPCHAR
DATE 08/26/2002

OJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SW

CKED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: GRID PT. # B4 Operational Cover: TO1U-TO7U



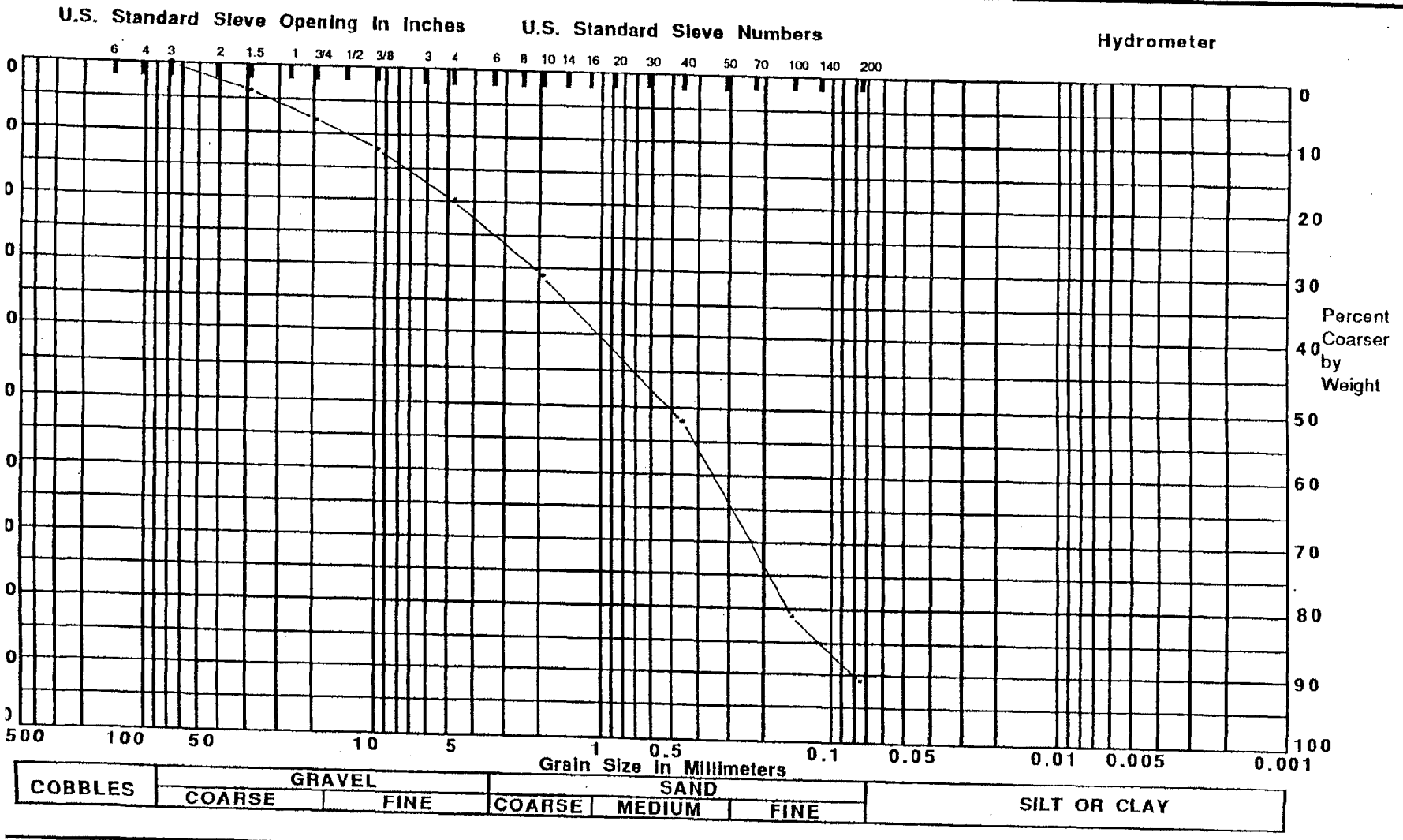
ADATION CURVES

MATERIALS TESTING LABORATORY
P. O. BOX 98521
LAS VEGAS, NV 89193-8521

LAB NO: 1799
CHARGE # 5LDPCHAR
DATE 08/26/2002

OJECT: A/5 RWMS, OPERATIONAL COVER CLOSURES LOG # N/A CLASSIFICATION: SM / SP

KED BY: D. HERRINGTON DH DATE CHECKED: 9-11-02 Sample Location: GRID PT. # C10 Operational Cover: TO1C-TO6C



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Appendix B-7

Permeability

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Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152		
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.25**	**= Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	Pit #3, Loc 22, -1'	**5.99**	**= Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**28.22**	**= X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala V. Denny		
Test date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)	

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1746	94.80	4.50	90.30	25.00	54.16	0.016356	5.92	**2.76E-03**	07/15/02
1746	94.30	4.50	89.80	25.00	52.78	0.016784	5.89	**2.85E-03**	07/15/02
1746	94.20	4.50	89.70	25.00	52.68	0.016816	5.88	**2.86E-03**	07/15/02
1746	94.00	4.50	89.50	25.00	51.10	0.017336	5.87	**2.95E-03**	07/15/02
Average	***94.33***	***4.50***	***89.83***	***25.00***	***52.68***	***0.016823***	***5.89***	***2.86E-03***	

EQUIPMENT USED:

	Calibration Date:	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.24 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	Pit #3, Loc 22, -3'	**6.02 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**28.46 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	01/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1749	90.9	5.1	85.80	25.00	47.000	0.01869	5.6299	**3.32E-03**	07/15/02
1749	90.8	5.1	85.70	25.00	47.650	0.01843	5.6234	**3.28E-03**	07/15/02
1749	90.5	5.1	85.40	25.00	48.410	0.01814	5.6037	**3.24E-03**	07/15/02
1749	90.4	5.1	85.30	25.00	49.060	0.01790	5.5971	**3.20E-03**	07/15/02
Average	***90.65***	***5.10***	***85.55***	***25.00***	***48.03***	***0.018292***	***5.61***	***3.26E-03***	

EQUIPMENT USED:

	Calibration Date:	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152		
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.010**	**= Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	Pit #4, Grid Pt. -1', well #8	**6.022**	**= Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil	**28.48**	**= X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT		
Test date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)	

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1752	88.5	3.00	85.50	25.00	24.1	0.03648	5.6962	**6.40E-03**	07/16/02
1752	88.4	3.00	85.40	25.00	24.1	0.03639	5.6895	**6.40E-03**	07/16/02
1752	88.3	3.00	85.30	25.00	23.1	0.03796	5.6829	**6.68E-03**	07/16/02
1752	88.1	3.00	85.10	25.00	23.8	0.03685	5.6696	**6.50E-03**	07/16/02
Average	***88.33***	***3.00***	***85.33***	***25.00***	***23.78***	***0.036918***	***5.68***	***6.49E-03***	

EQUIPMENT USED:

	Calibration Date:	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR
Organization:	Bechtel	**Sample Origin:**	Pit #4, Grid Pt. B4 -3', well #8
Phone:	295-1185	**Sample Type:**	Soil core
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT
Test date:	See Below	**Check date:**	9/30/02

15.11 = Sample Length (cm)
6.02 = Sample Diameter (cm)
28.51 = X-Sec. Area (sq cm)

Test Performed at Room Temperature (20-22 deg. C)

Lab#	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1755	87.20	8.10	79.10	25.00	53.44	0.01641	5.2349	**3.13E-03**	07/17/02
1755	87.00	8.10	78.90	25.00	54.22	0.01617	5.2217	**3.10E-03**	07/17/02
1755	87.00	8.10	78.90	25.00	53.93	0.01626	5.2217	**3.11E-03**	07/17/02
1755	86.80	8.10	78.70	25.00	53.56	0.01637	5.2085	**3.14E-03**	07/17/02
Average	***87.00***	***8.10***	***78.90***	***25.00***	***53.79***	***0.016304***	***5.22***	***3.12E-03***	

EQUIPMENT USED:

	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

ject:	A-5 Cover Closure	**Request #:**	S-152	
uestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.23 = Sample Length (cm)**
anization:	Bechtel	**Sample Origin:**	Pit #4, Grid Pt. c10 -1'	**5.98 = Sample Diameter (cm)**
one:	295-1185	**Sample Type:**	Soil Core	**28.10 = X-Sec. Area (sq cm)**
ted by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
t date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1758	86.20	4.00	82.20	5.00	178.09	0.00100	5.3961	**1.85E-04**	07/17/02
1758	86.20	4.00	82.20	5.00	178.15	0.00100	5.3961	**1.85E-04**	07/17/02
1758	86.10	4.00	82.10	5.00	168.47	0.00106	5.3895	**1.96E-04**	07/17/02
1758	86.10	4.00	82.10	5.00	178.66	0.00100	5.3895	**1.85E-04**	07/17/02
Average	***86.15***	***4.00***	***82.15***	***5.00***	***175.84***	***0.001012***	***5.39***	***1.88E-04***	

UIPMENT USED:

	Calibration Date:	**Calibration Due:**
le: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
rmometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

ject:	A-5 Cover Closure	**Request #:**	S-152
questor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR
ganization:	Bechtel	**Sample Origin:**	Pit #4, Grid Pt C10. -3'
one:	295-1185	**Sample Type:**	Soil Core
ted by:	Johnny H Denny	**Checked by:**	V. Thummala VT
t date:	See Below	**Check date:**	9/30/02

15.23 = Sample Length (cm)
6.02 = Sample Diameter (cm)
28.47 = X-Sec. Area (sq cm)

Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1761	89.20	3.90	85.30	5.00	785.25	0.000224	5.60	**3.99E-05**	07/18/02
1761	88.30	3.60	84.70	5.00	834.85	0.000210	5.56	**3.78E-05**	07/18/02
1761	87.70	2.60	85.10	1.90	345.69	0.000193	5.59	**3.45E-05**	07/18/02
1761	86.20	2.20	84.00	1.90	303.25	0.000220	5.52	**3.99E-05**	07/18/02
Average	***86.95***	***2.40***	***84.55***	***1.90***	***324.47***	***0.000207***	***5.55***	***3.72E-05***	

UIPMENT USED:

	Calibration Date:	Calibration Due:
le: Mettler PM 6100, ID# 301723	37326.00	37691.00
rmometer: Omegasys, ID# 002875	37244.00	37609.00

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Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**14.98 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. F4 -3'	**5.98 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**28.08 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	9/30/02 Test Performed at Room Temperature (20-22 deg. C)	

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1764	89.20	4.30	84.90	10.00	478.43	0.00074	5.6676	**1.31E-04**	07/22/02
1764	89.00	4.30	84.70	10.00	500.86	0.00071	5.6542	**1.26E-04**	07/22/02
1764	88.70	3.60	85.10	10.00	452.00	0.00079	5.6809	**1.39E-04**	07/22/02
1764	88.50	3.60	84.90	10.00	459.85	0.00077	5.6676	**1.37E-04**	07/22/02
1764	88.30	3.60	84.70	10.00	468.69	0.00076	5.6542	**1.34E-04**	07/22/02
Average	***88.74***	***3.88***	***84.86***	***10.00***	***471.97***	***0.000756***	***5.66***	***1.33E-04***	

EQUIPMENT USED:	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. F4 -3'
Phone:	295-1185	**Sample Type:**	Soil Core
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT
Test date:	See Below	**Check date:**	9/30/02

15.23 = Sample Length (cm)

5.98 = Sample Diameter (cm)

28.08 = X-Sec. Area (sq cm)

Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1767	92.60	6.30	86.30	25.00	359.87	0.00247	5.6675	**4.37E-04**	07/22/02
1767	91.20	6.30	84.90	25.00	366.66	0.00243	5.5755	**4.36E-04**	07/22/02
1767	87.30	6.30	81.00	25.00	390.70	0.00228	5.3194	**4.28E-04**	07/22/02
1767	95.90	6.30	89.60	25.00	348.50	0.00255	5.8842	**4.34E-04**	07/22/02
1767	95.10	6.30	88.80	25.00	343.53	0.00259	5.8316	**4.44E-04**	07/22/02
1767	94.00	6.30	87.70	25.00	344.56	0.00258	5.7594	**4.49E-04**	07/22/02
Average	***93.08***	***6.30***	***86.78***	***25.00***	***356.82***	***0.002502***	***5.70***	***4.39E-04***	

EQUIPMENT USED:

	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
Bechtel Nevada
Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. F7 -3'
Phone:	295-1185	**Sample Type:**	Soil Core
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT
Test date:	See Below	**Check date:**	9/30/02

15.24 = Sample Length (cm)
6.01 = Sample Diameter (cm)
28.34 = X-Sec. Area (sq cm)

Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1773	96.40	5.30	91.10	10.00	141.53	0.00249	5.9796	**4.17E-04**	07/23/02
1773	96.40	5.30	91.10	10.00	141.27	0.00250	5.9796	**4.18E-04**	07/23/02
1773	96.00	5.30	90.70	10.00	154.20	0.00229	5.9533	**3.84E-04**	07/23/02
1773	95.30	5.30	90.00	10.00	155.79	0.00226	5.9074	**3.83E-04**	07/23/02
Average	***96.03***	***5.30***	***90.73***	***10.00***	***148.20***	***0.002386***	***5.95***	***4.01E-04***	

EQUIPMENT USED:

	Calibration Date:	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.22 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. D5 -1'	**5.97 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**27.99 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	07/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1776	93.60	4.70	88.90	25.00	239.85	0.00372	5.8404	**6.38E-04**	07/24/02
1776	93.40	4.70	88.70	25.00	228.37	0.00391	5.8272	**6.71E-04**	07/24/02
1776	92.30	5.60	86.70	25.00	225.75	0.00396	5.6959	**6.95E-04**	07/24/02
Average	***93.10***	***5.00***	***88.10***	***25.00***	***231.32***	***0.003863***	***5.79***	***6.68E-04***	

EQUIPMENT USED:	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
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Nevada Test Site

AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

oject:	A-5 Cover Closure	**Request #:**	S-152
equestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR
ganization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. D5 -3'
one:	295-1185	**Sample Type:**	Soil Core
sted by:	Johnny H Denny	**Checked by:**	V. Thummala *VT*
st date:	See Below	**Check date:**	9/24/02 Test Performed at Room Temperature (20-22 deg. C)

15.28 = Sample Length (cm)
6.10 = Sample Diameter (cm)
29.19 = X-Sec. Area (sq cm)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1779	87.10	4.20	82.90	25.00	181.63	0.00472	5.4251	**8.69E-04**	07/26/02
1779	86.20	4.20	82.00	25.00	186.56	0.00459	5.3662	**8.56E-04**	07/26/02
1779	86.00	4.20	81.80	25.00	193.90	0.00442	5.3532	**8.25E-04**	07/26/02
1779	85.80	4.20	81.60	25.00	198.66	0.00431	5.3401	**8.07E-04**	07/26/02
Average	***86.28***	***4.20***	***82.08***	***25.00***	***190.19***	***0.004509***	***5.37***	***8.39E-04***	

UIPMENT USED:

ale: Mettler PM 6100, ID# 301723	**Calibration Date:** 03/11/02	**Calibration Due:** 03/11/03
ermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY
ASTM D 2434-68 (Reapproved 1974)
Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.23 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. B4 -1'	**5.97 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**27.99 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1782	92.30	4.30	88.00	25.00	357.65	0.00250	5.7798	**4.32E-04**	07/26/02
1782	91.40	4.40	87.00	25.00	364.84	0.00245	5.7141	**4.28E-04**	07/26/02
1782	88.30	4.40	83.90	25.00	365.82	0.00244	5.5105	**4.43E-04**	07/26/02
1782	97.40	4.30	93.10	25.00	296.38	0.00301	6.1148	**4.93E-04**	07/26/02
1782	96.10	4.40	91.70	25.00	279.06	0.00320	6.0228	**5.31E-04**	07/26/02
1782	95.50	4.40	91.10	25.00	275.10	0.00325	5.9834	**5.43E-04**	07/26/02
Average	***94.33***	***4.38***	***89.95***	***25.00***	***304.09***	***0.002975***	***5.91***	***5.02E-04***	

EQUIPMENT USED:	**Calibration Date:**	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.23 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. B4 -3'	**5.99 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**28.22 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	9/30/02	Test Perfomed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1785	95.00	12.60	82.40	25.00	18.25	0.04854	5.4115	**8.97E-03**	07/27/02
1785	95.60	13.30	82.30	25.00	17.69	0.05008	5.4050	**9.26E-03**	07/27/02
1785	95.50	13.30	82.20	25.00	18.28	0.04846	5.3984	**8.98E-03**	07/27/02
1785	95.50	13.30	82.20	25.00	17.72	0.04999	5.3984	**9.26E-03**	07/27/02
Average	***95.40***	***13.13***	***82.28***	***25.00***	***17.99***	***0.049267***	***5.40***	***9.12E-03***	

EQUIPMENT USED:

	Calibration Date:	Calibration Due:
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.23 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. B8 -1'	**5.97 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**27.98 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1788	92.60	5.70	86.90	25.00	258.22	0.00346	5.7061	**6.06E-04**	07/29/02
1788	91.20	5.80	85.40	25.00	245.78	0.00363	5.6076	**6.48E-04**	07/29/02
1788	87.50	5.80	81.70	25.00	234.85	0.00380	5.3647	**7.09E-04**	07/29/02
1788	95.90	5.80	90.10	25.00	171.47	0.00521	5.9163	**8.81E-04**	07/29/02
1788	95.10	5.70	89.40	25.00	172.82	0.00517	5.8703	**8.81E-04**	07/29/02
1788	94.00	5.80	88.20	25.00	177.72	0.00503	5.7915	**8.68E-04**	07/29/02
Average	92.72	5.77	86.95	25.00	210.14	0.00438	5.7094	**7.65E-04**	

EQUIPMENT USED:	**Calibration Date:**	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Materials Testing Laboratory
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AREA 5 RWMS OPERATIONAL COVER CLOSURE STUDY

ASTM D 2434-68 (Reapproved 1974)

Standard Test Method for Permeability of Granular Soils (Constant Head)

Project:	A-5 Cover Closure	**Request #:**	S-152	
Requestor:	Stuart Rawlinson	**Charge #:**	5LDPCHAR	**15.23 = Sample Length (cm)**
Organization:	Bechtel	**Sample Origin:**	TO1U / TO7U, Grid Pt. B8 -3'	**5.94 = Sample Diameter (cm)**
Phone:	295-1185	**Sample Type:**	Soil Core	**27.75 = X-Sec. Area (sq cm)**
Tested by:	Johnny H Denny	**Checked by:**	V. Thummala VT	
Test date:	See Below	**Check date:**	9/30/02	Test Performed at Room Temperature (20-22 deg. C)

Lab #	Manometers		Head	Q	t	Q/At	h/l	k	Date
	H1 mm	H2 mm	cm	cm^3	sec.			cm/sec	Tested
1791	92.30	5.00	87.30	25.00	253.50	0.00355	5.7333	**6.20E-04**	07/29/02
1791	91.20	4.80	86.40	25.00	281.07	0.00321	5.6742	**5.65E-04**	07/29/02
1791	88.20	4.50	83.70	25.00	306.60	0.00294	5.4969	**5.35E-04**	07/29/02
1791	97.40	4.50	92.90	25.00	243.50	0.00370	6.1011	**6.07E-04**	07/29/02
1791	96.10	4.60	91.50	25.00	244.91	0.00368	6.0092	**6.12E-04**	07/29/02
1791	95.50	4.60	90.90	25.00	242.87	0.00371	5.9698	**6.21E-04**	07/29/02
Average	***94.30***	***4.55***	***89.75***	***25.00***	***259.47***	***0.003507***	***5.89***	***5.94E-04***	

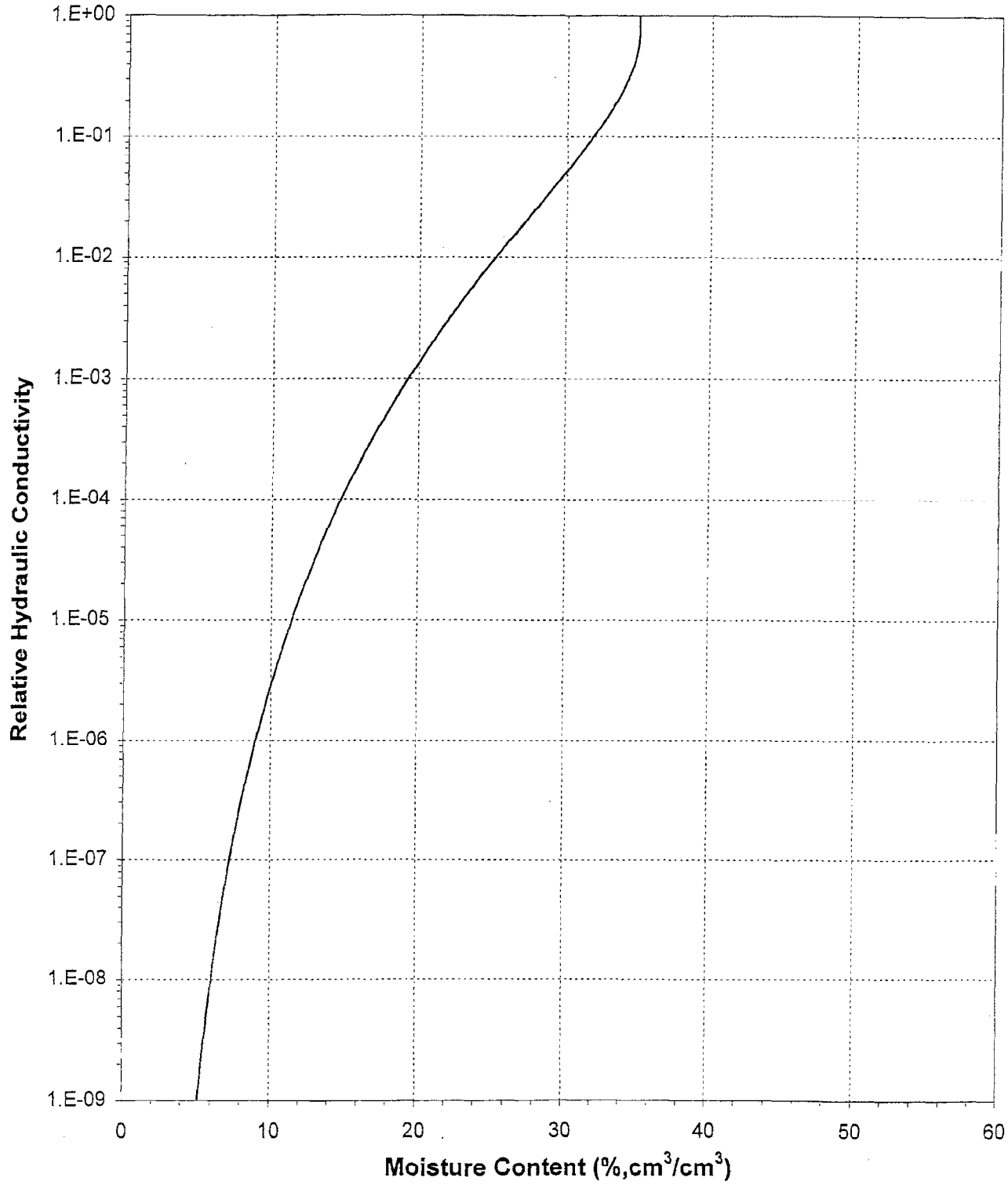
EQUIPMENT USED:	**Calibration Date:**	**Calibration Due:**
Scale: Mettler PM 6100, ID# 301723	03/11/02	03/11/03
Thermometer: Omegasys, ID# 002875	12/19/01	12/19/02

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Method of Analysis	
		Constant Head	Falling Head
1771	5.4E-05	X	

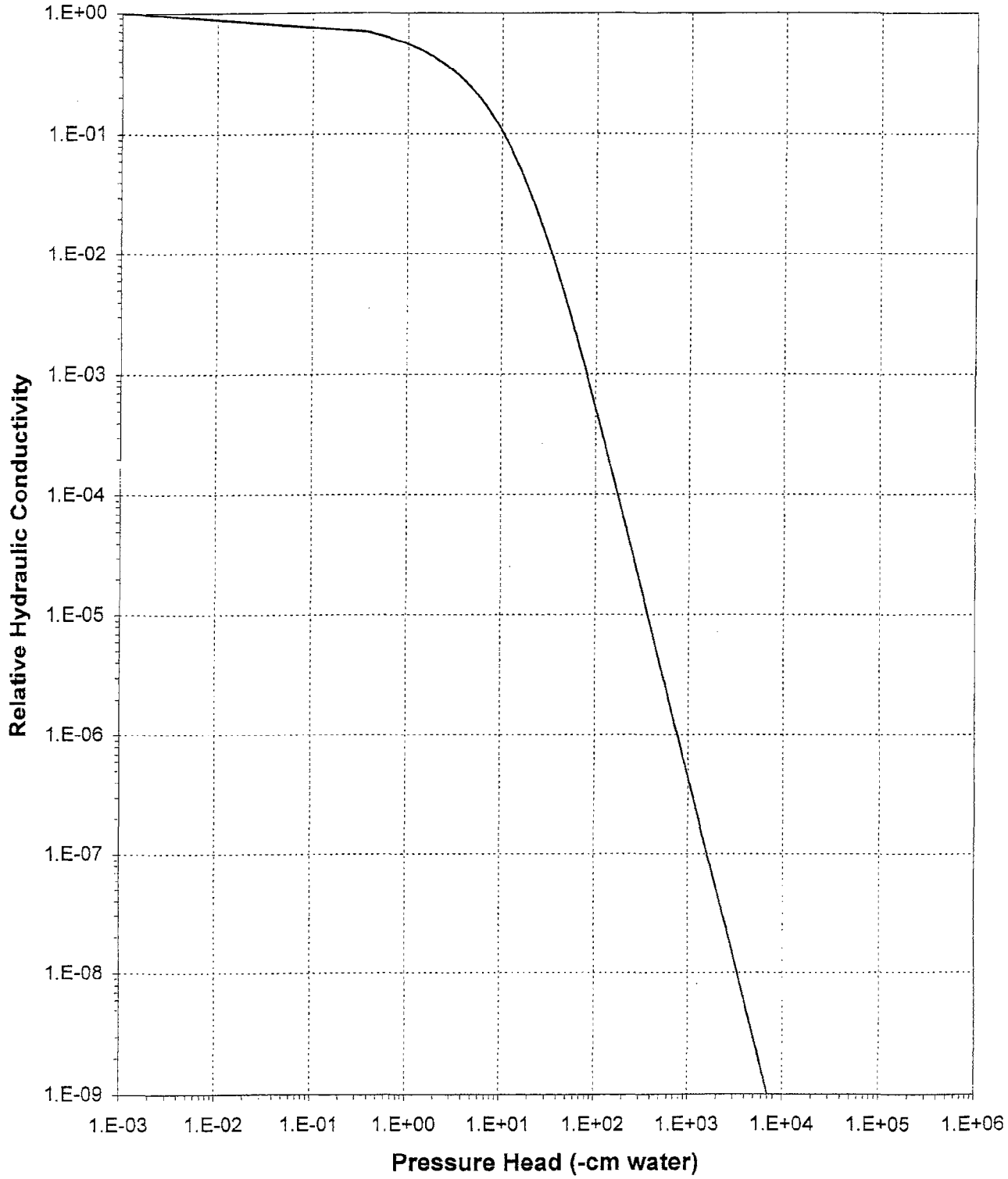
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: 1747



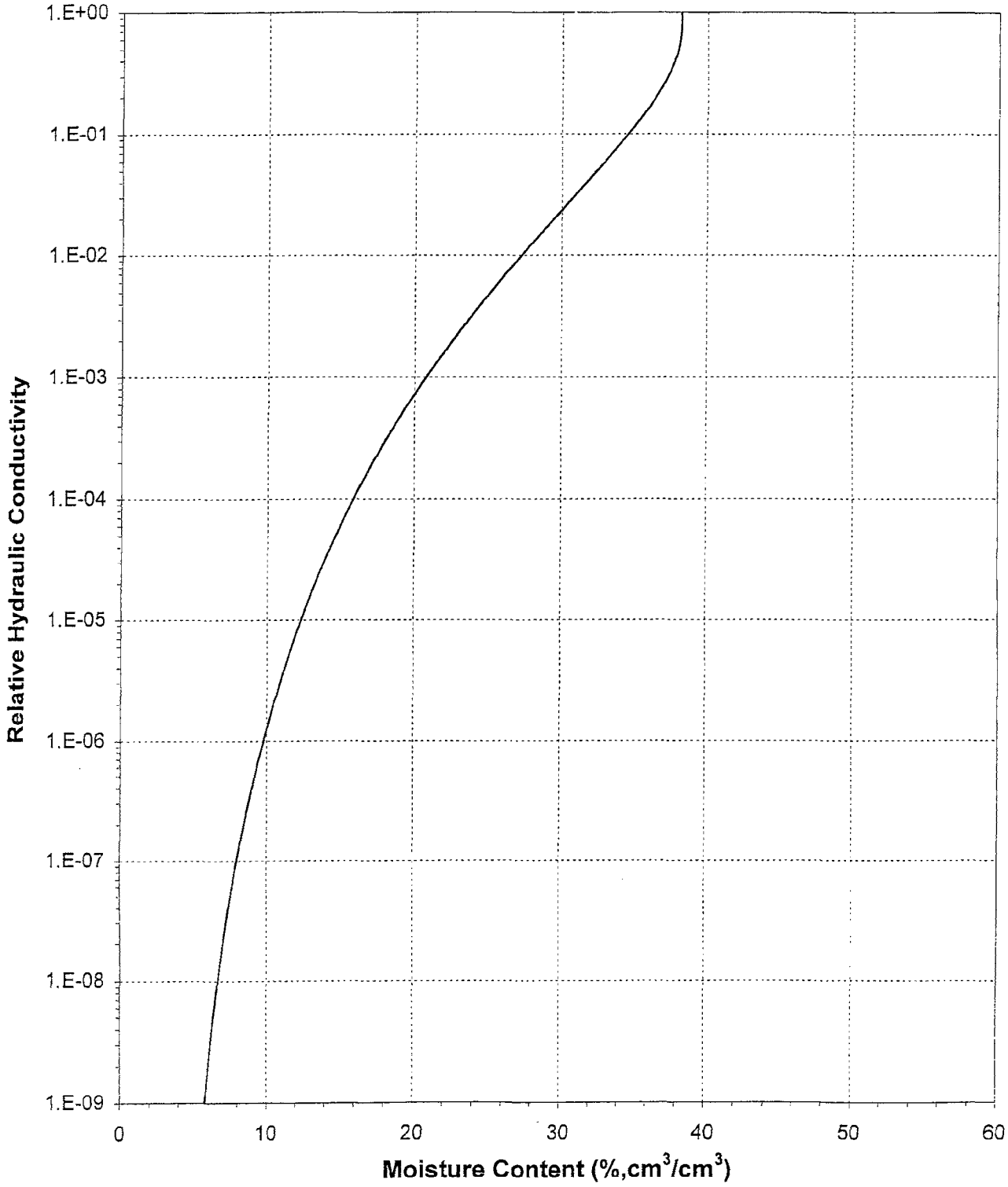
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 1747



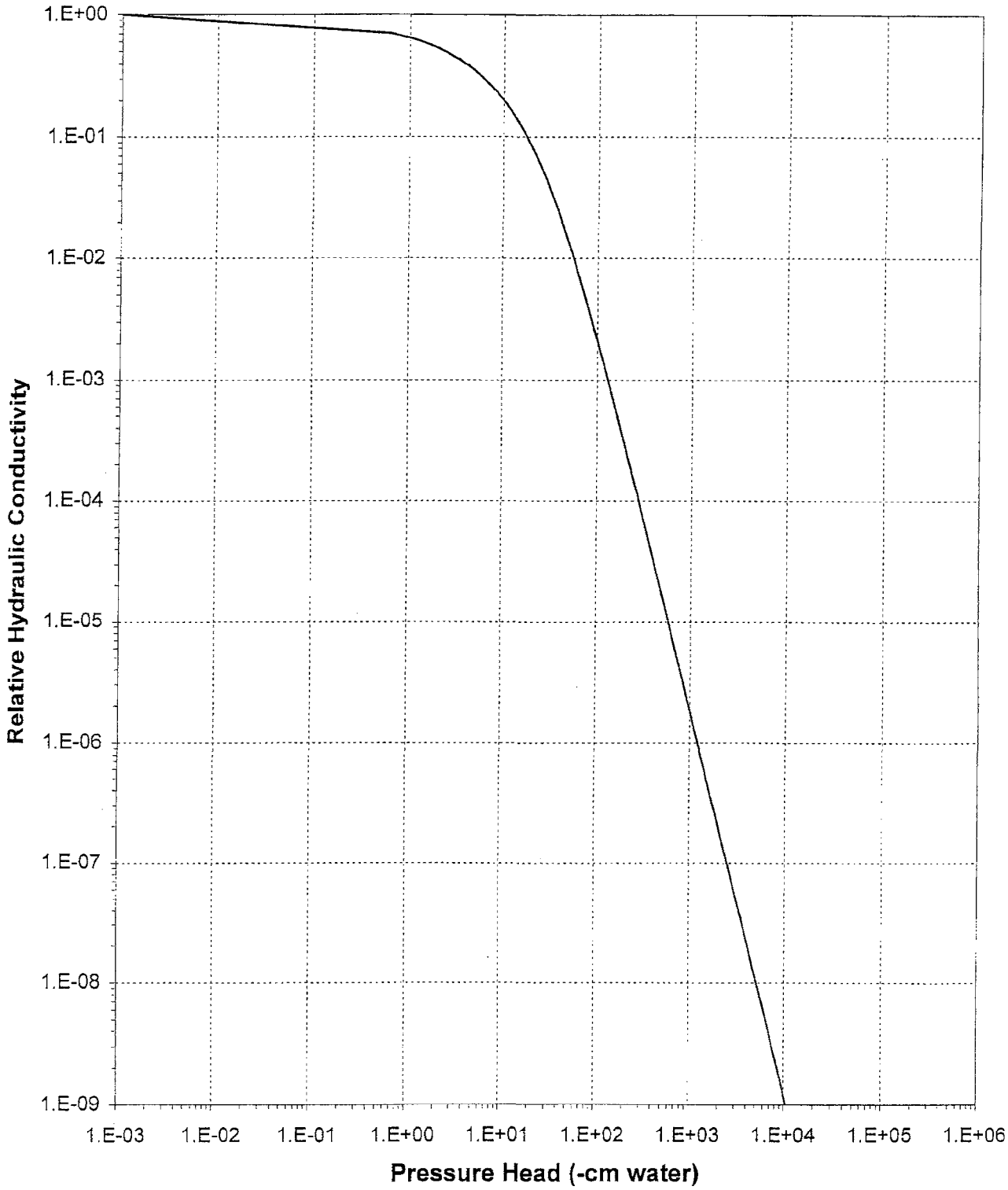
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: 1750



Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 1750



Plot of Relative Hydraulic Conductivity vs Moisture Content

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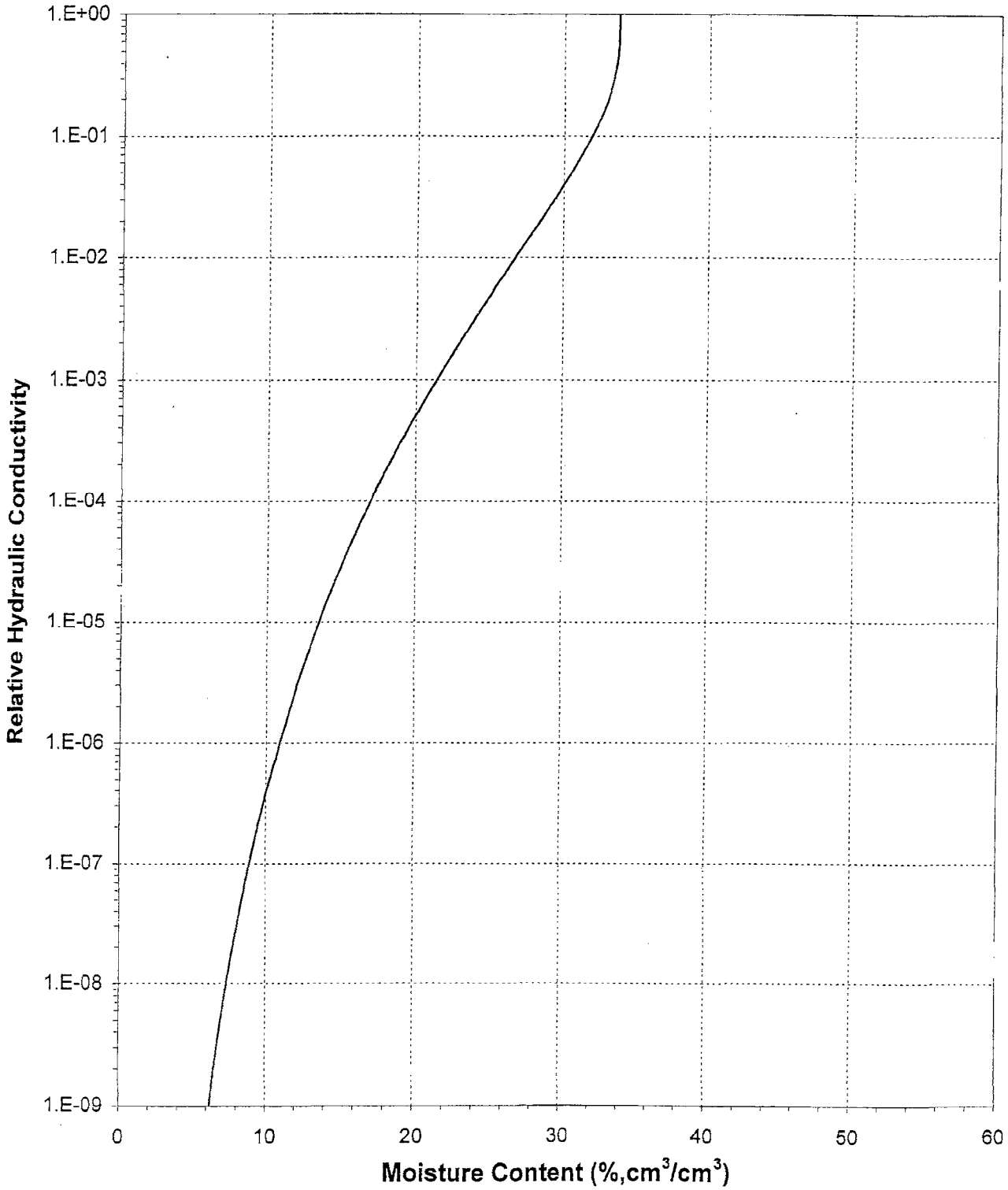
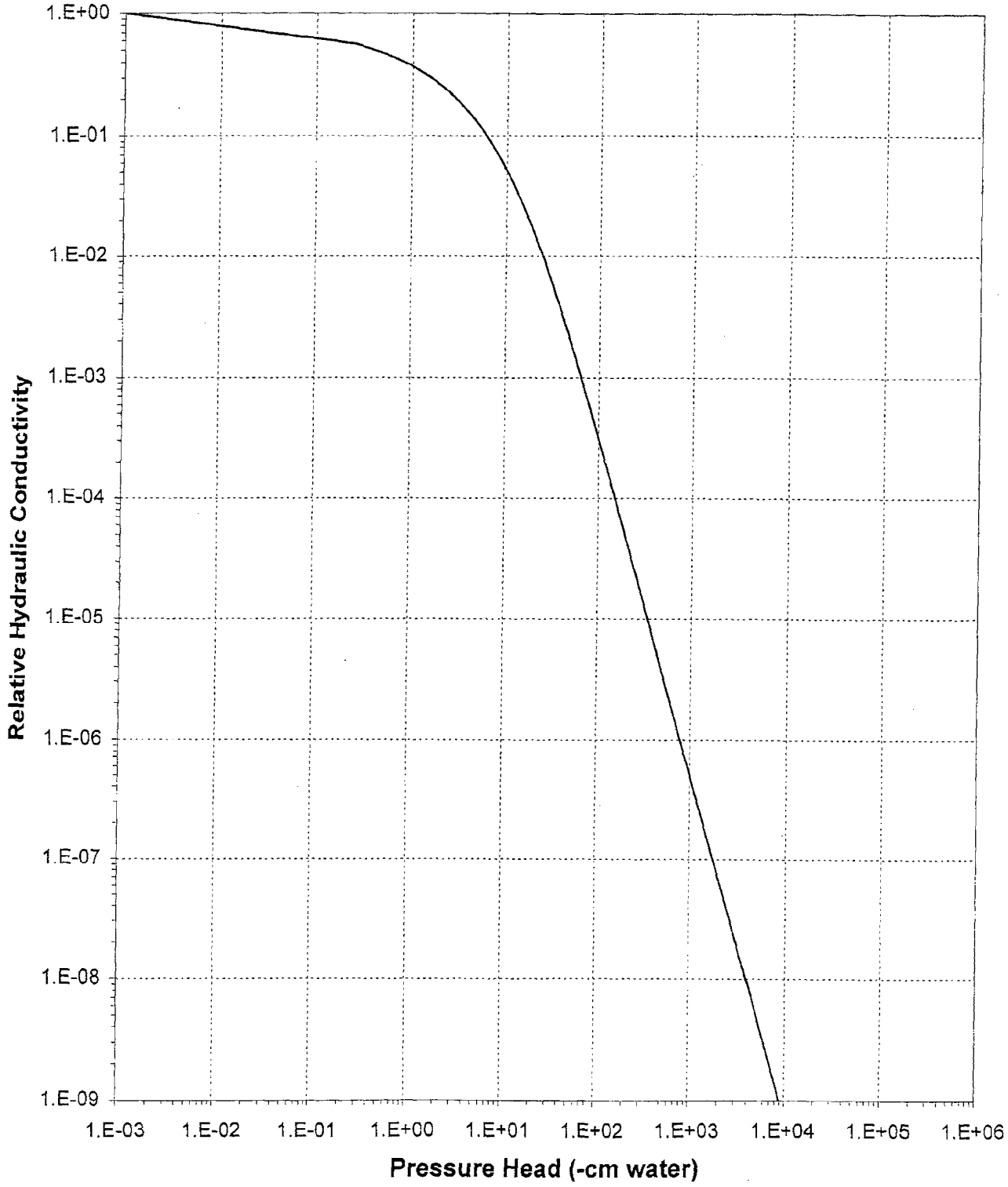


Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 1753



Plot of Relative Hydraulic Conductivity vs Moisture Content

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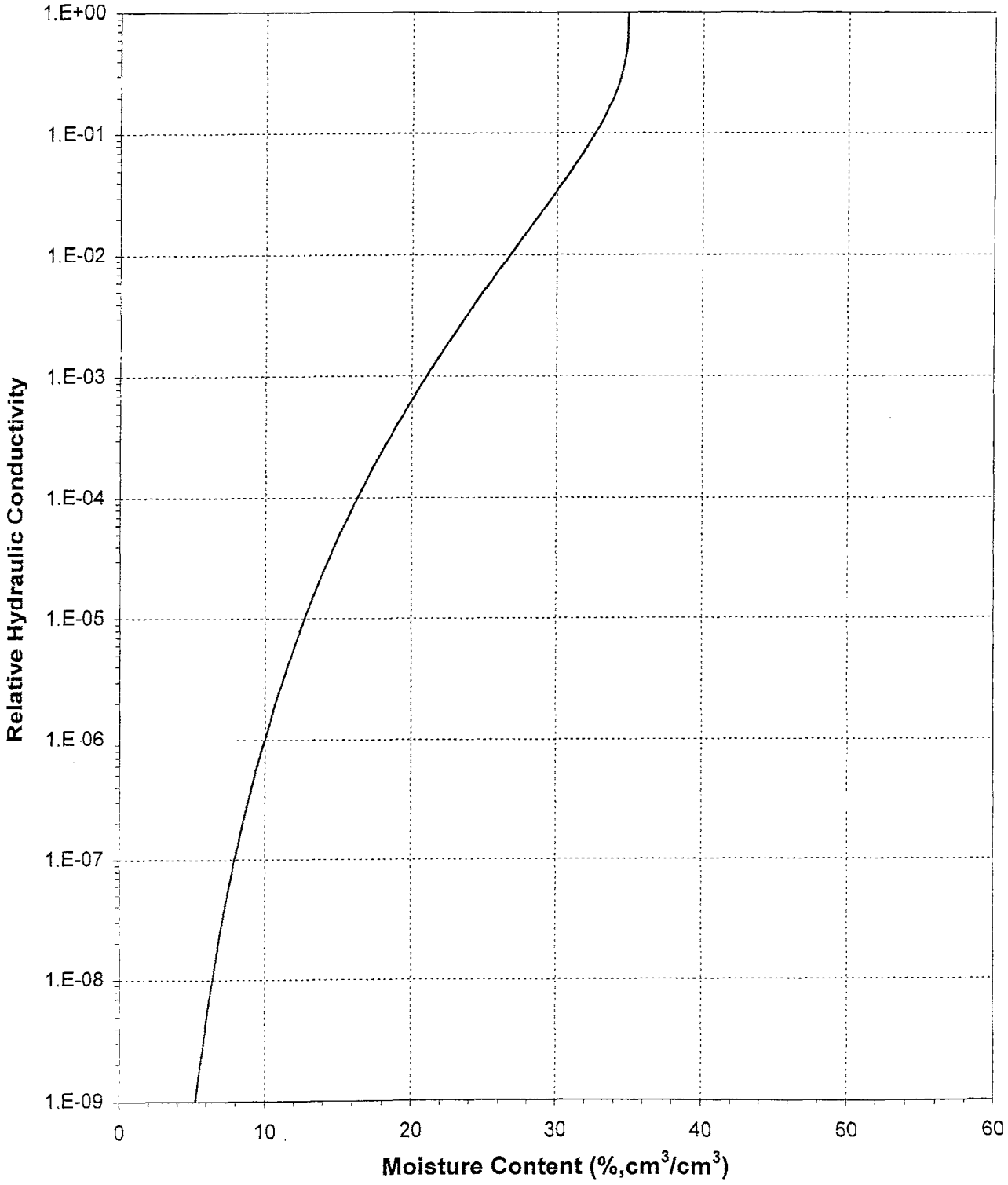

Plot of Relative Hydraulic Conductivity vs Pressure Head

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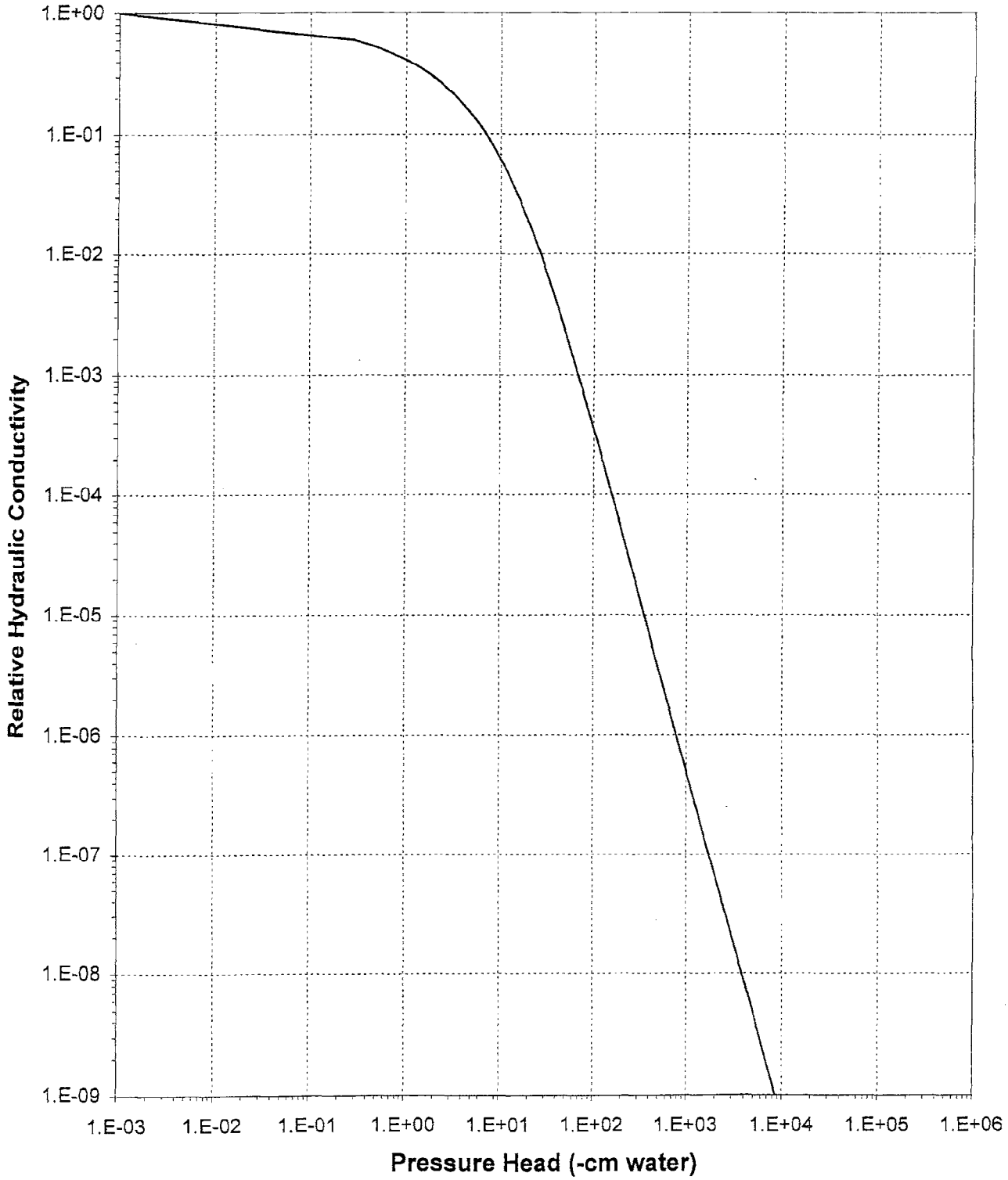

Plot of Relative Hydraulic Conductivity vs Moisture Content

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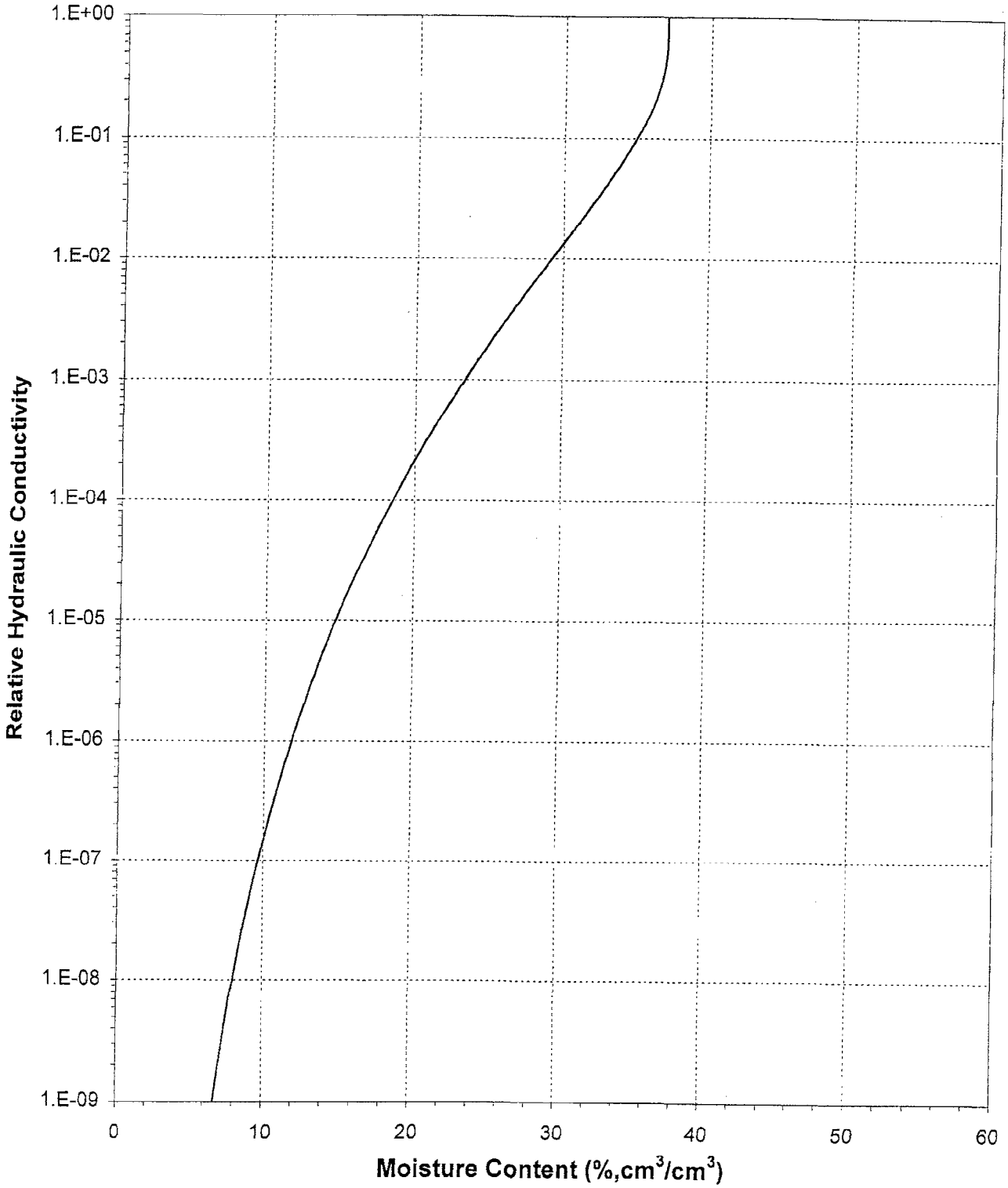

Plot of Relative Hydraulic Conductivity vs Pressure Head

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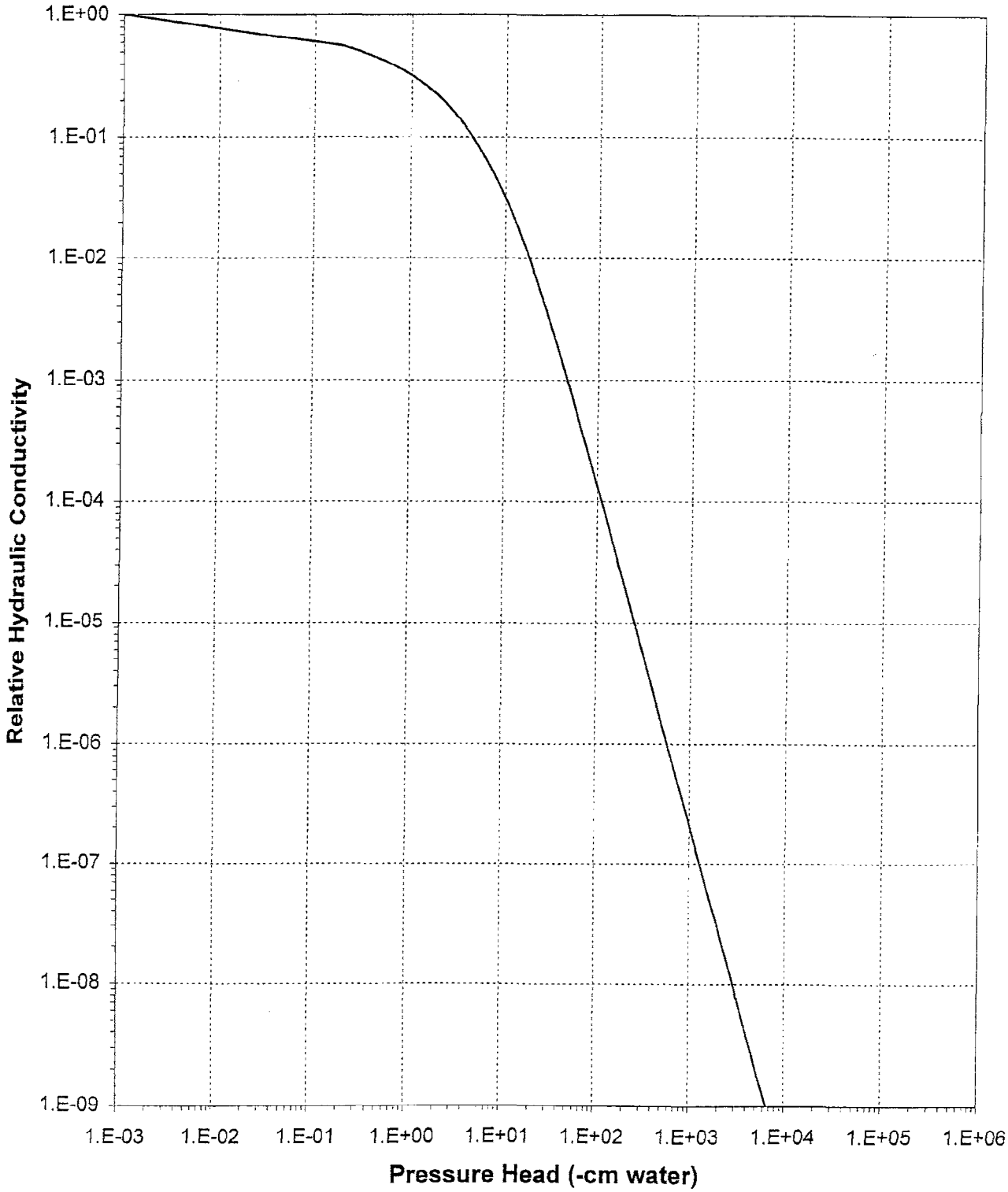

Plot of Relative Hydraulic Conductivity vs Moisture Content

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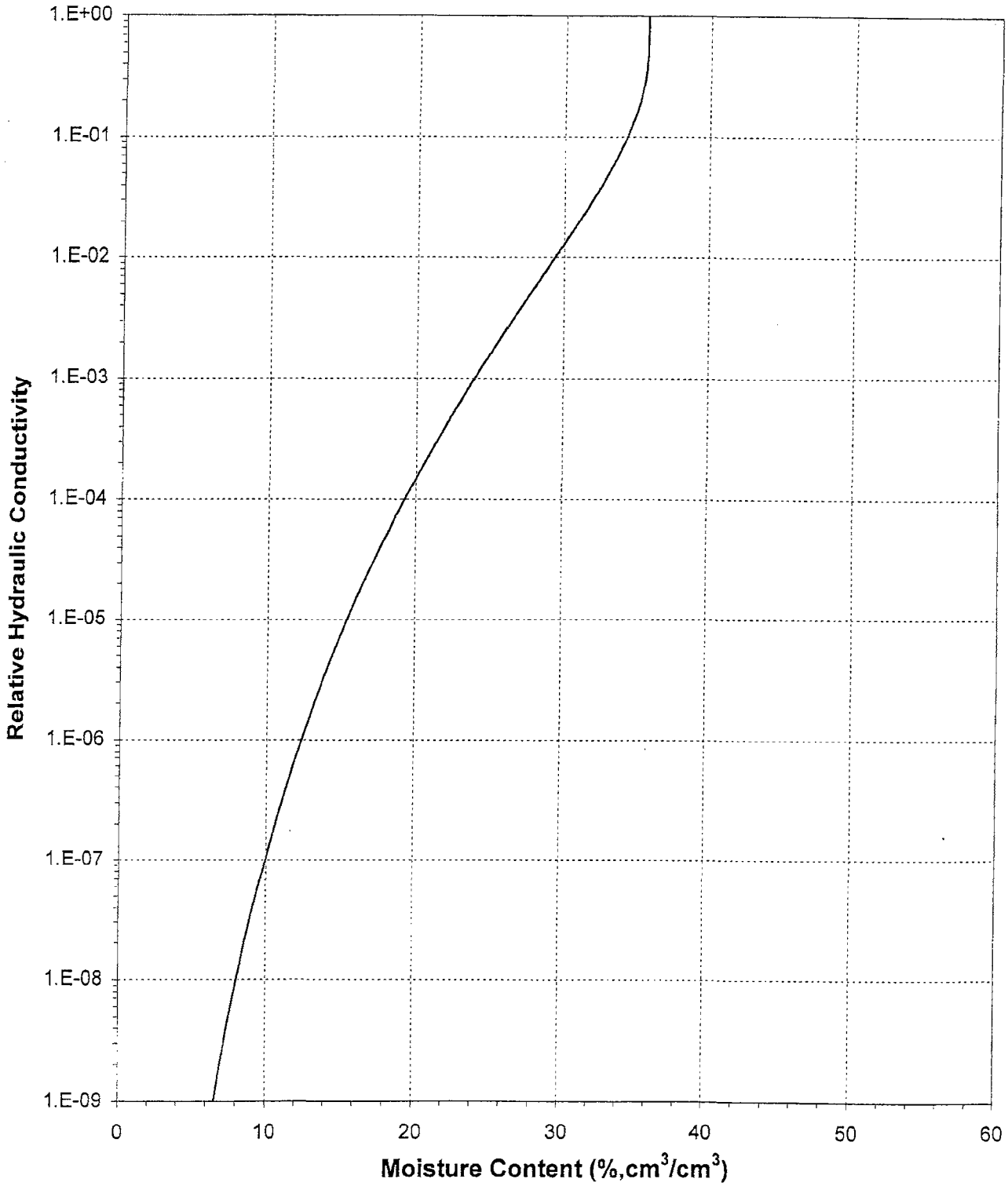
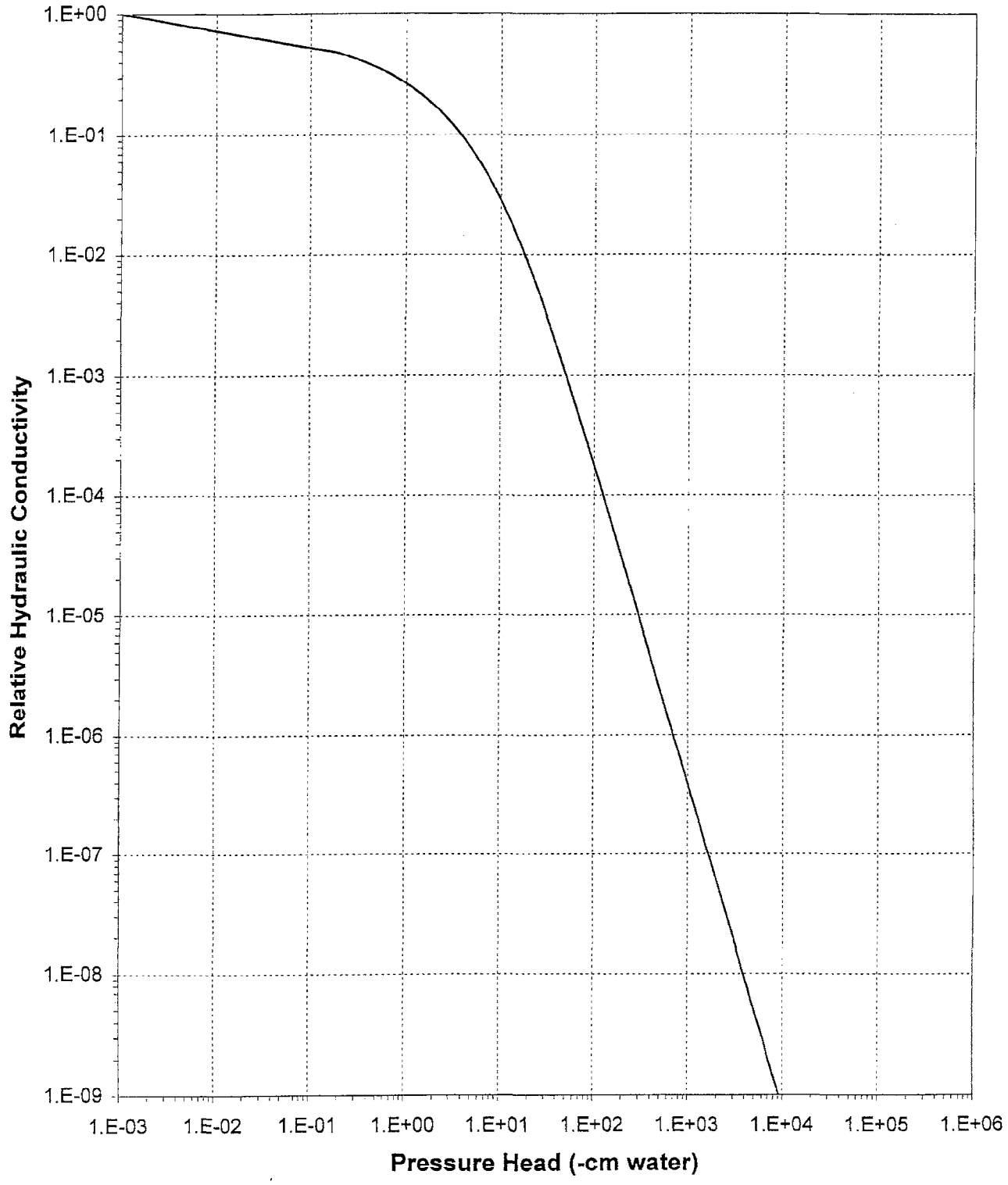


Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 1762



Plot of Relative Hydraulic Conductivity vs Moisture Content

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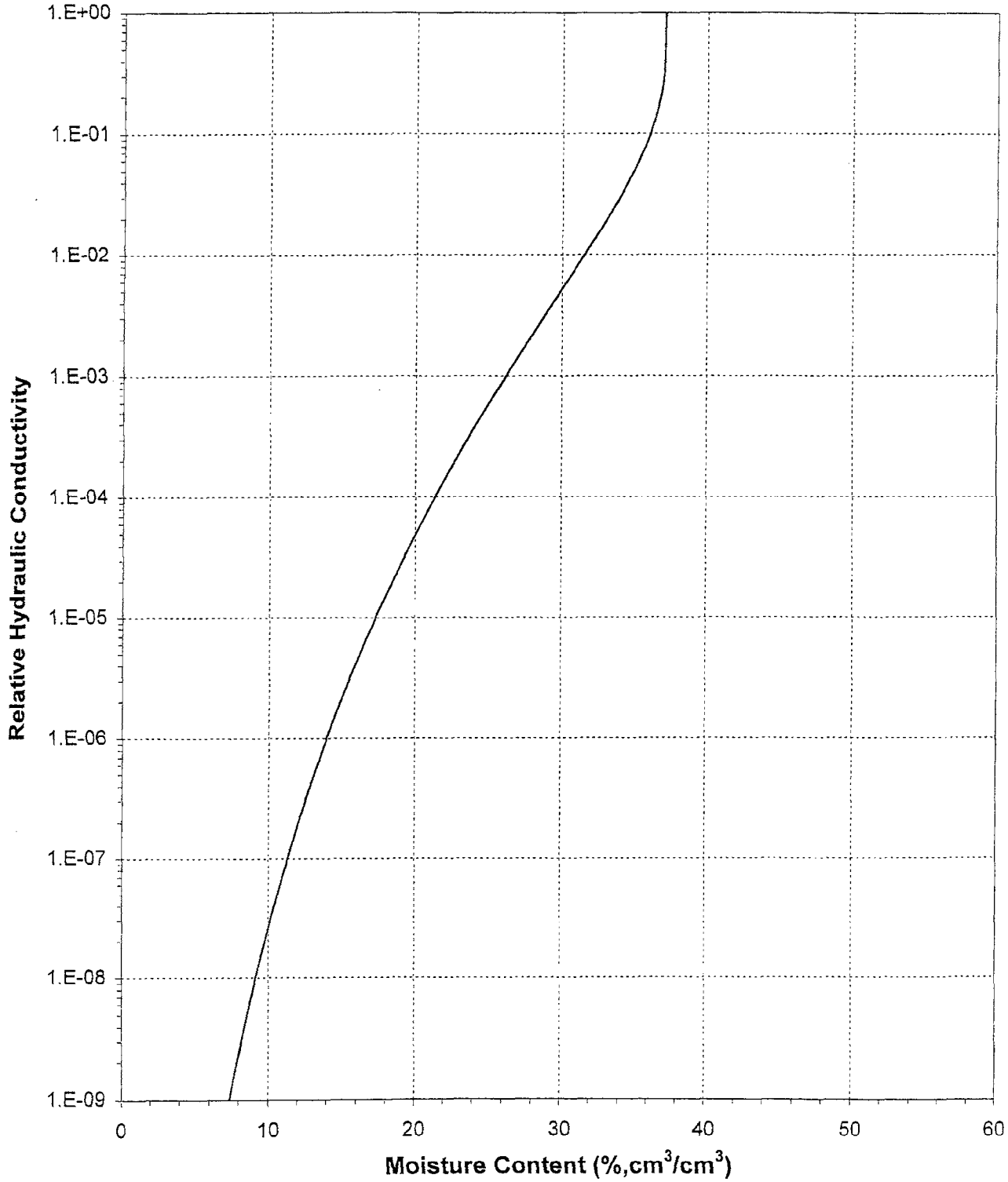

Plot of Relative Hydraulic Conductivity vs Pressure Head

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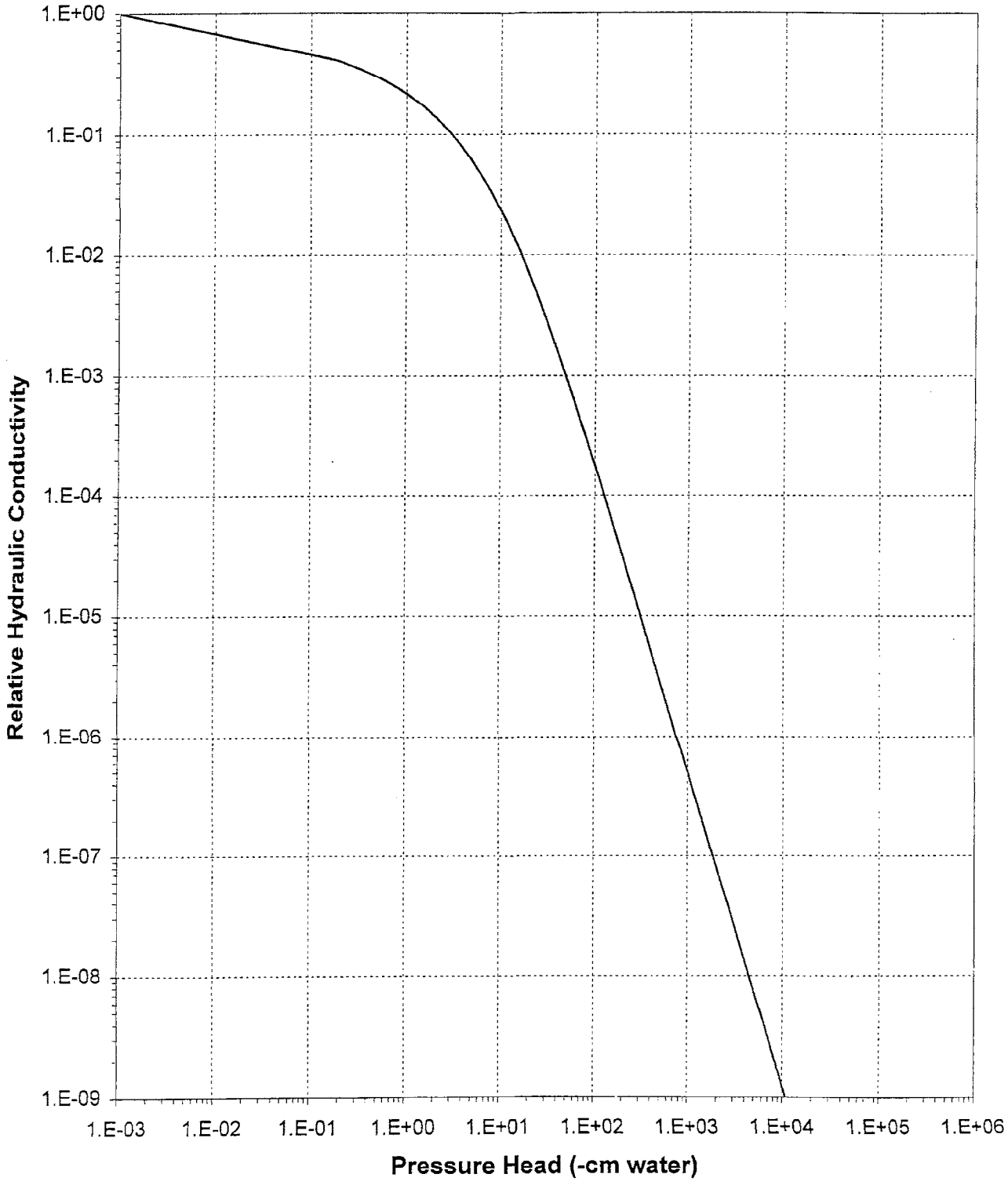

Plot of Relative Hydraulic Conductivity vs Moisture Content

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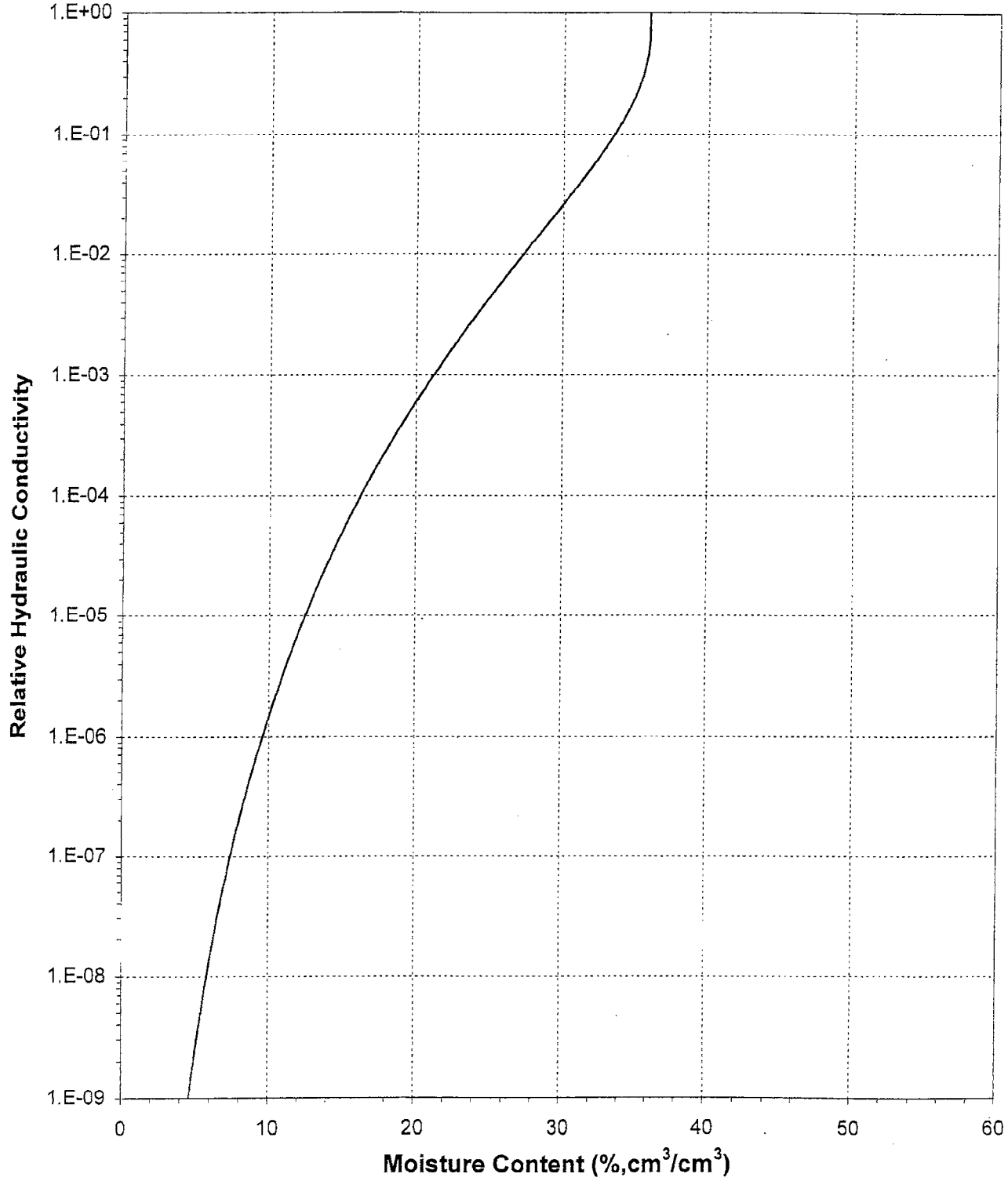

Plot of Relative Hydraulic Conductivity vs Pressure Head

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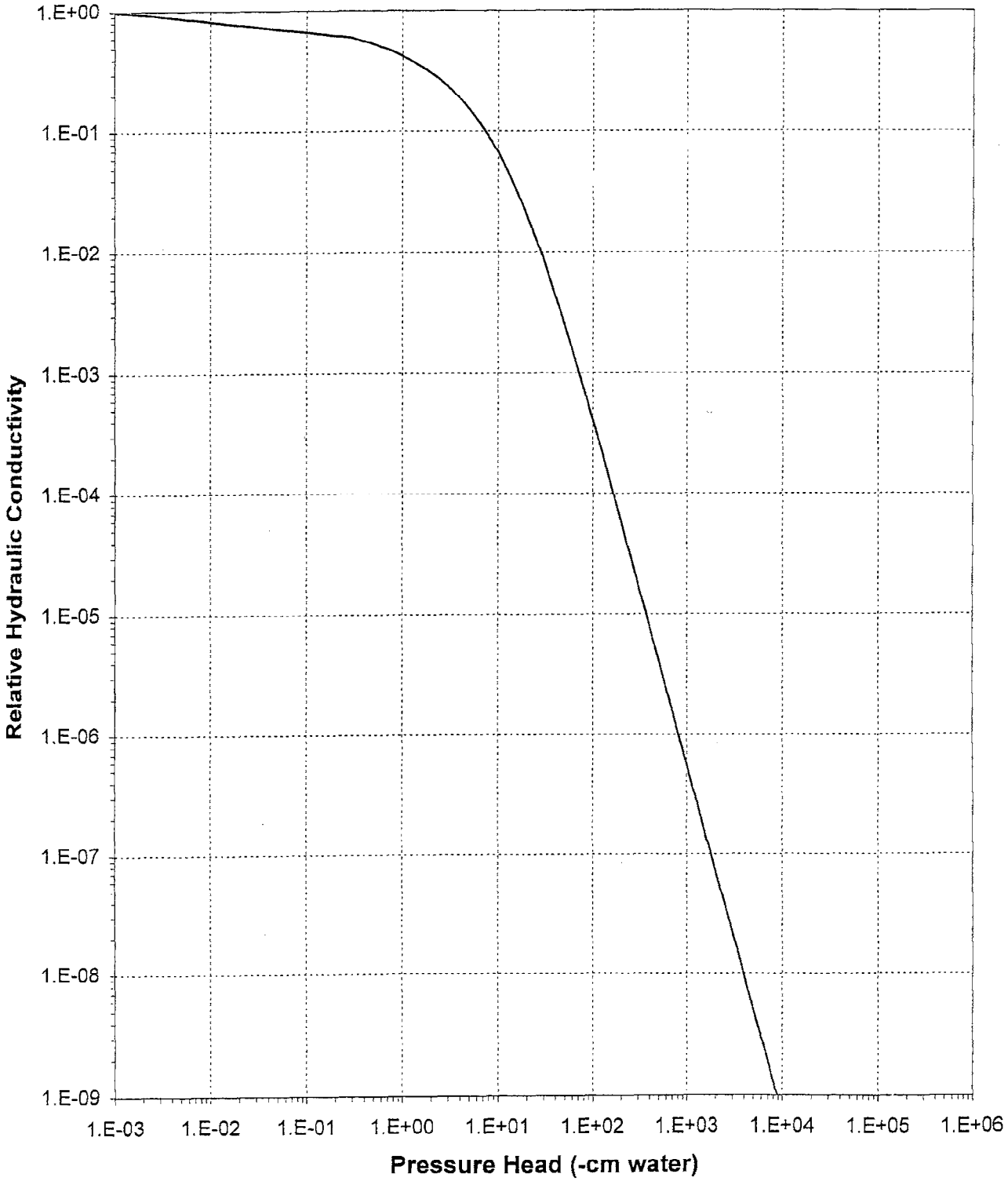

Plot of Hydraulic Conductivity vs Moisture Content

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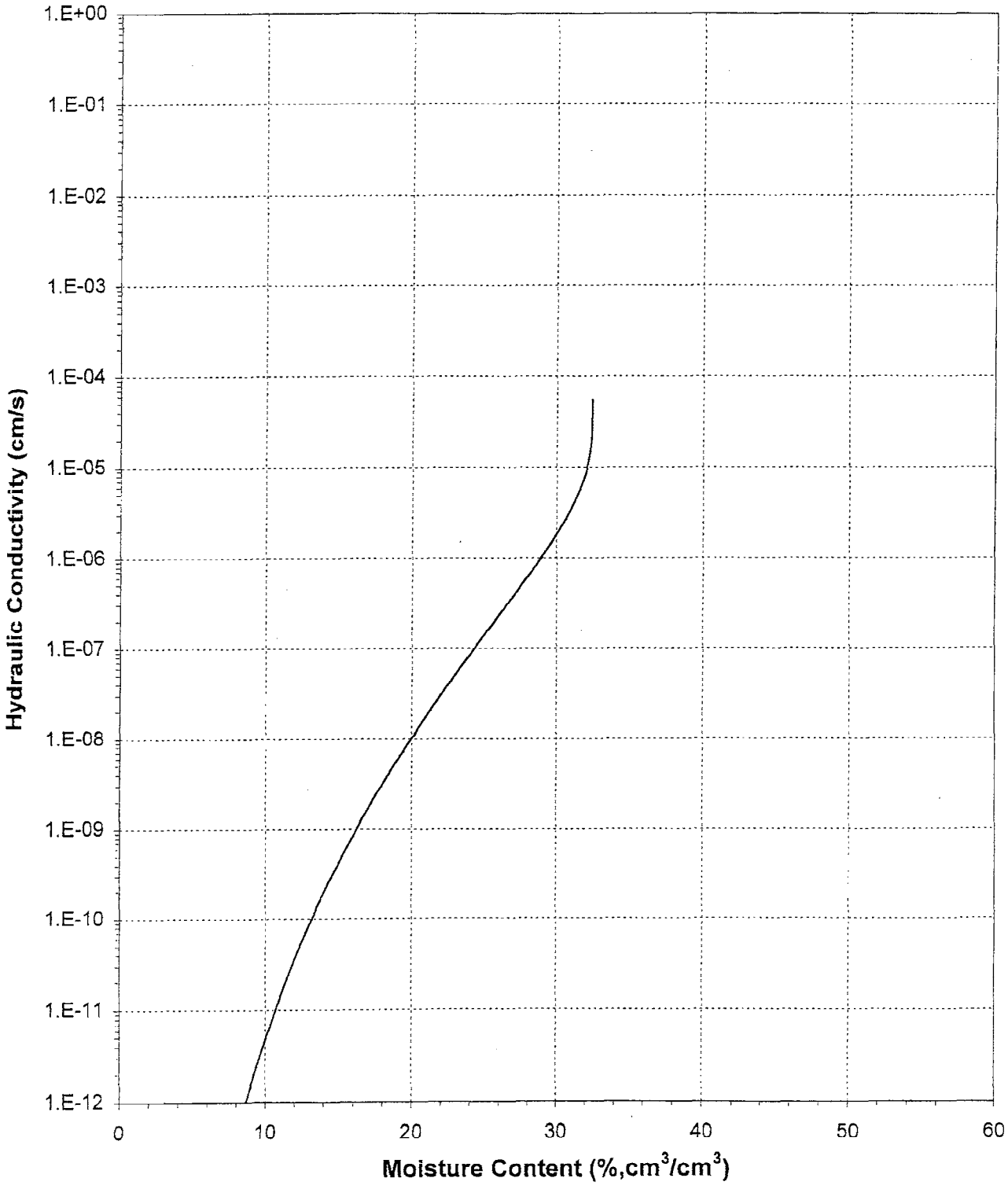

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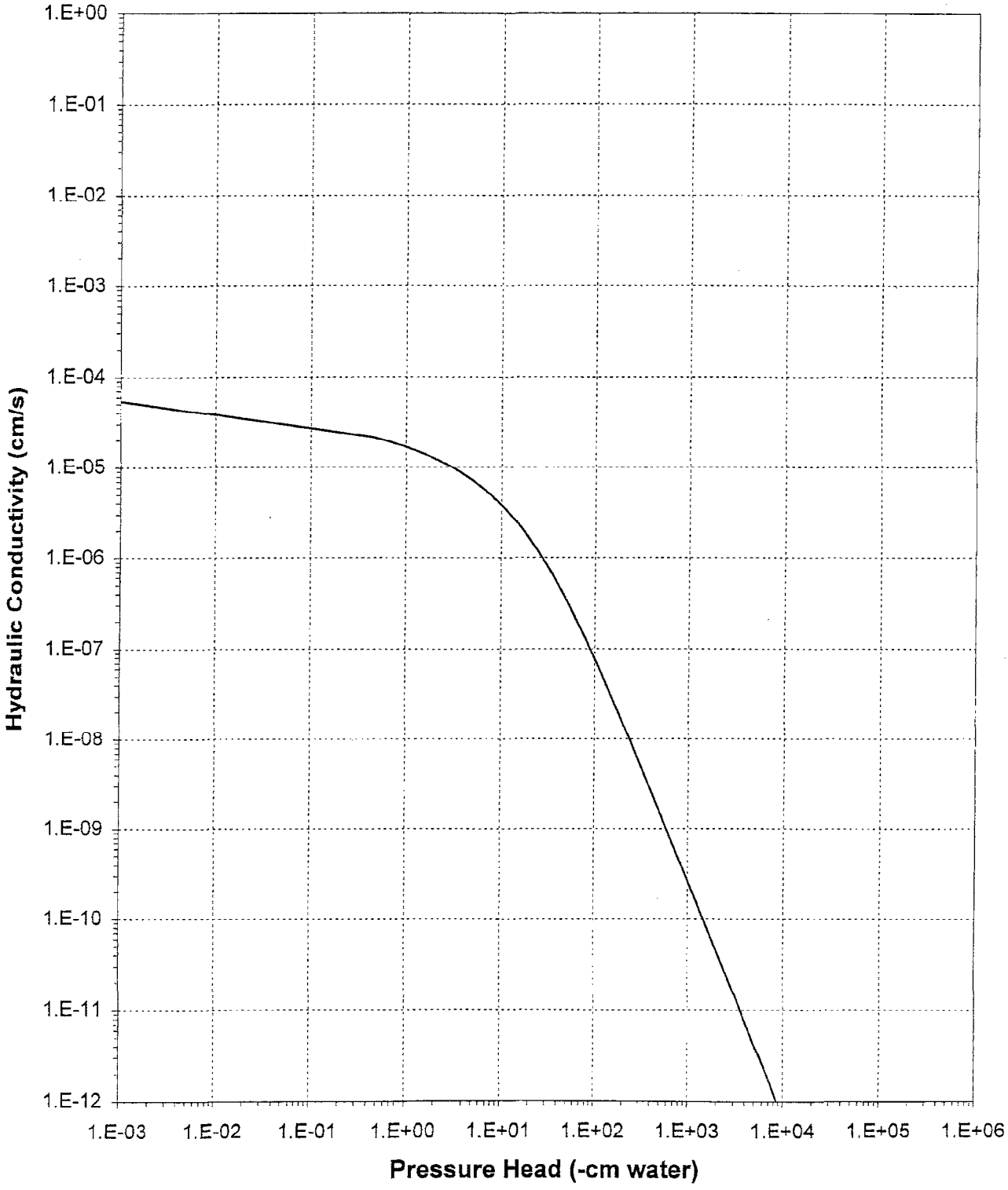

Plot of Relative Hydraulic Conductivity vs Moisture Content

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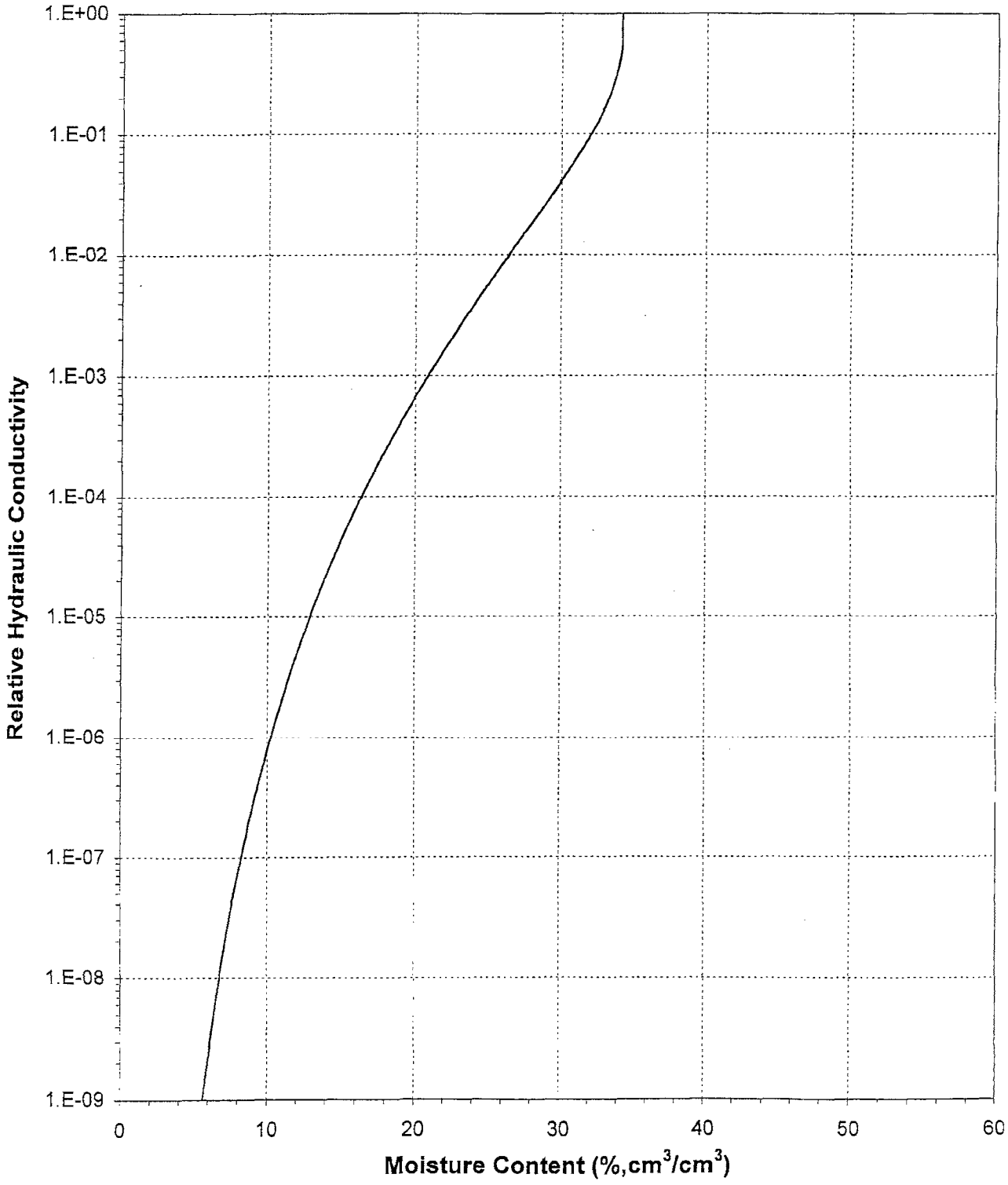
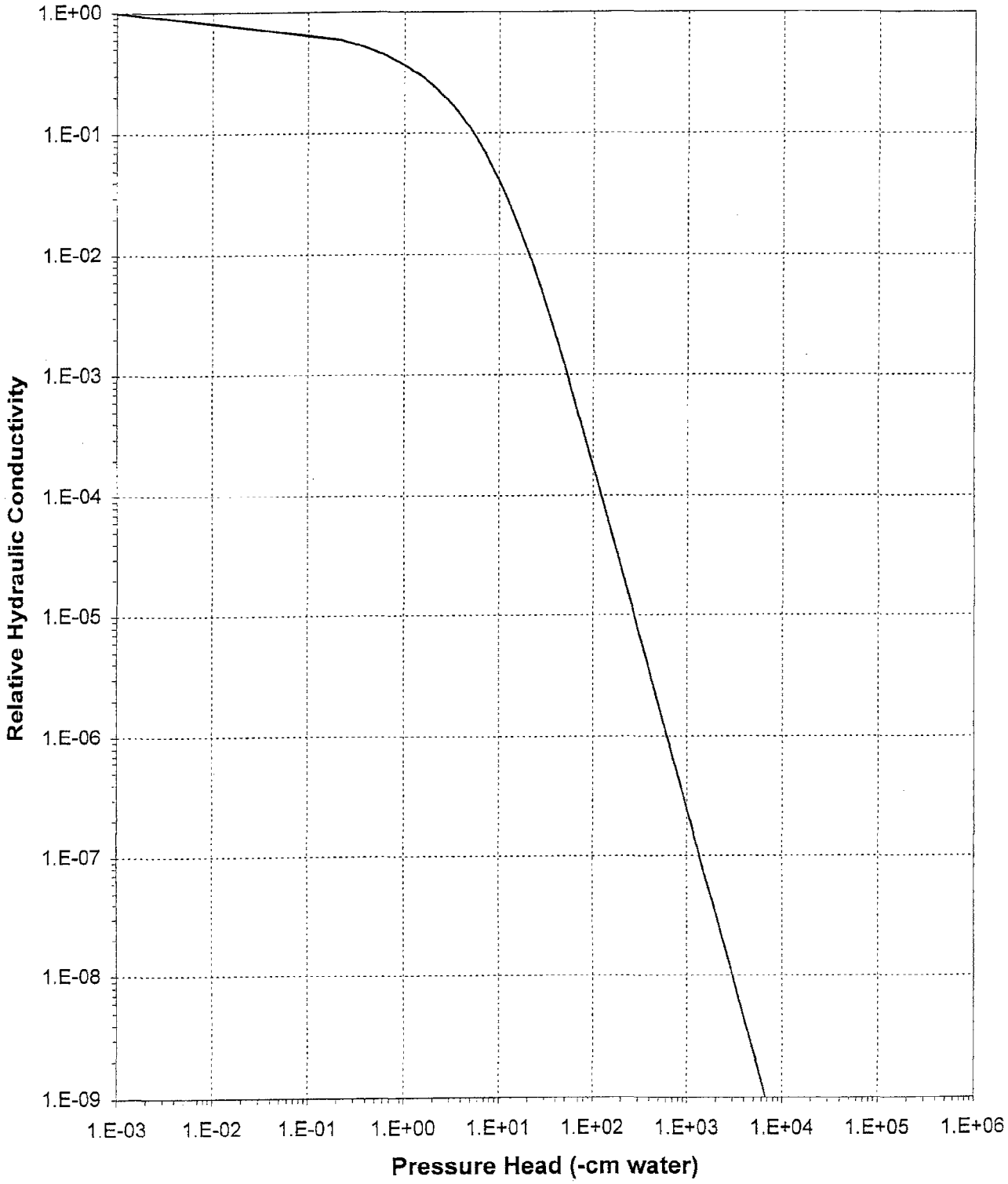


Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 1774



Plot of Relative Hydraulic Conductivity vs Moisture Content

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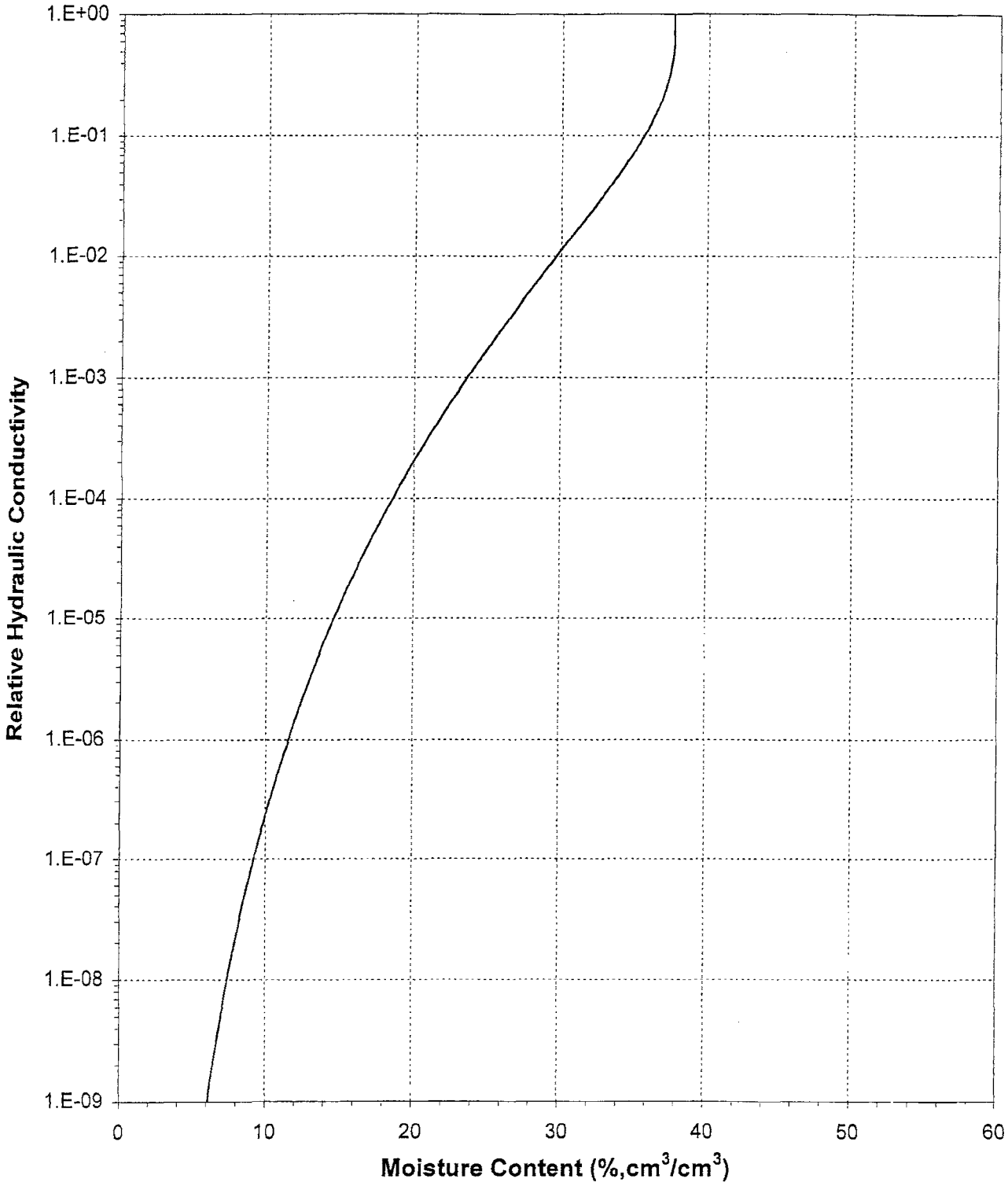

Plot of Relative Hydraulic Conductivity vs Pressure Head

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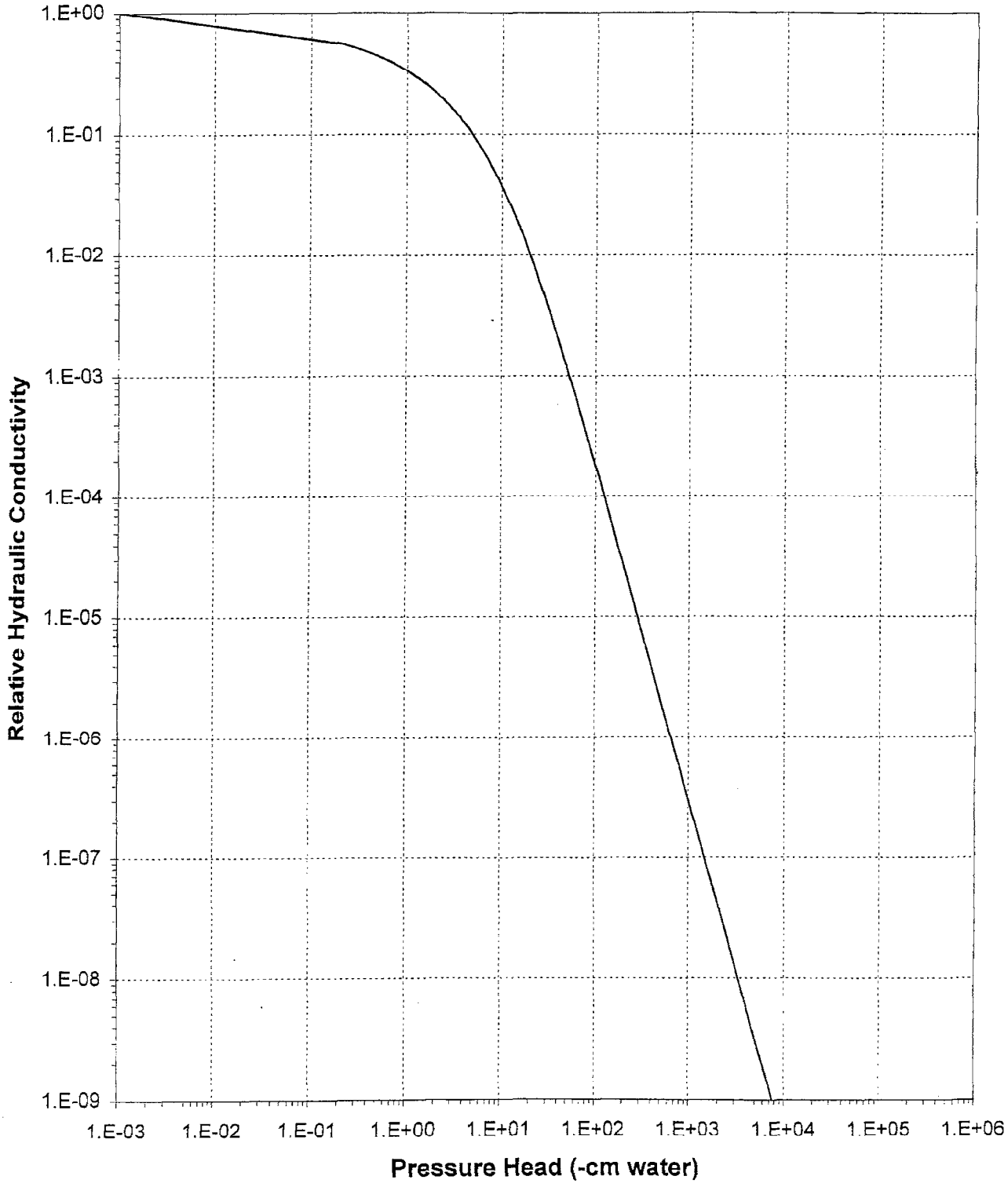

Plot of Relative Hydraulic Conductivity vs Moisture Content

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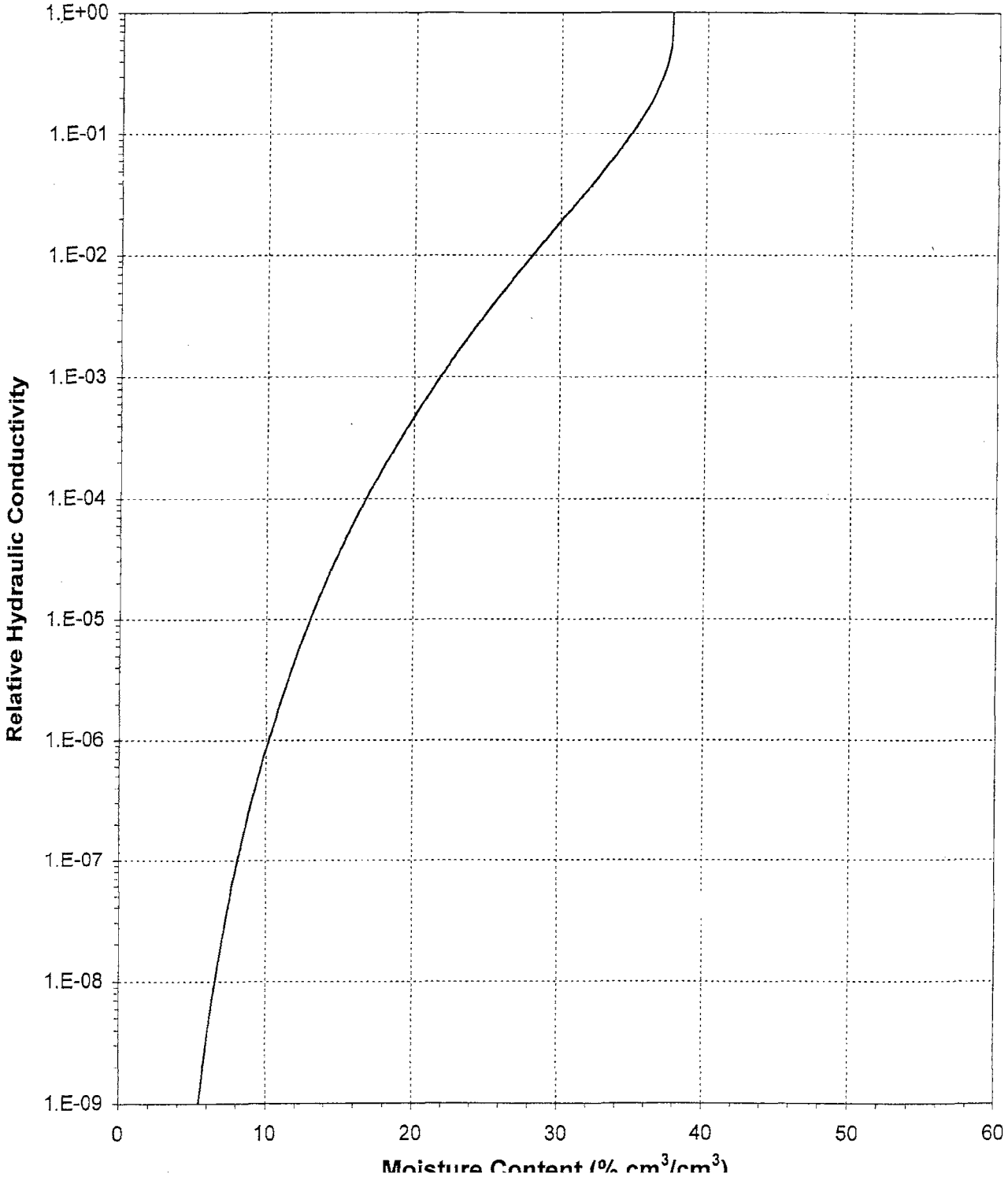

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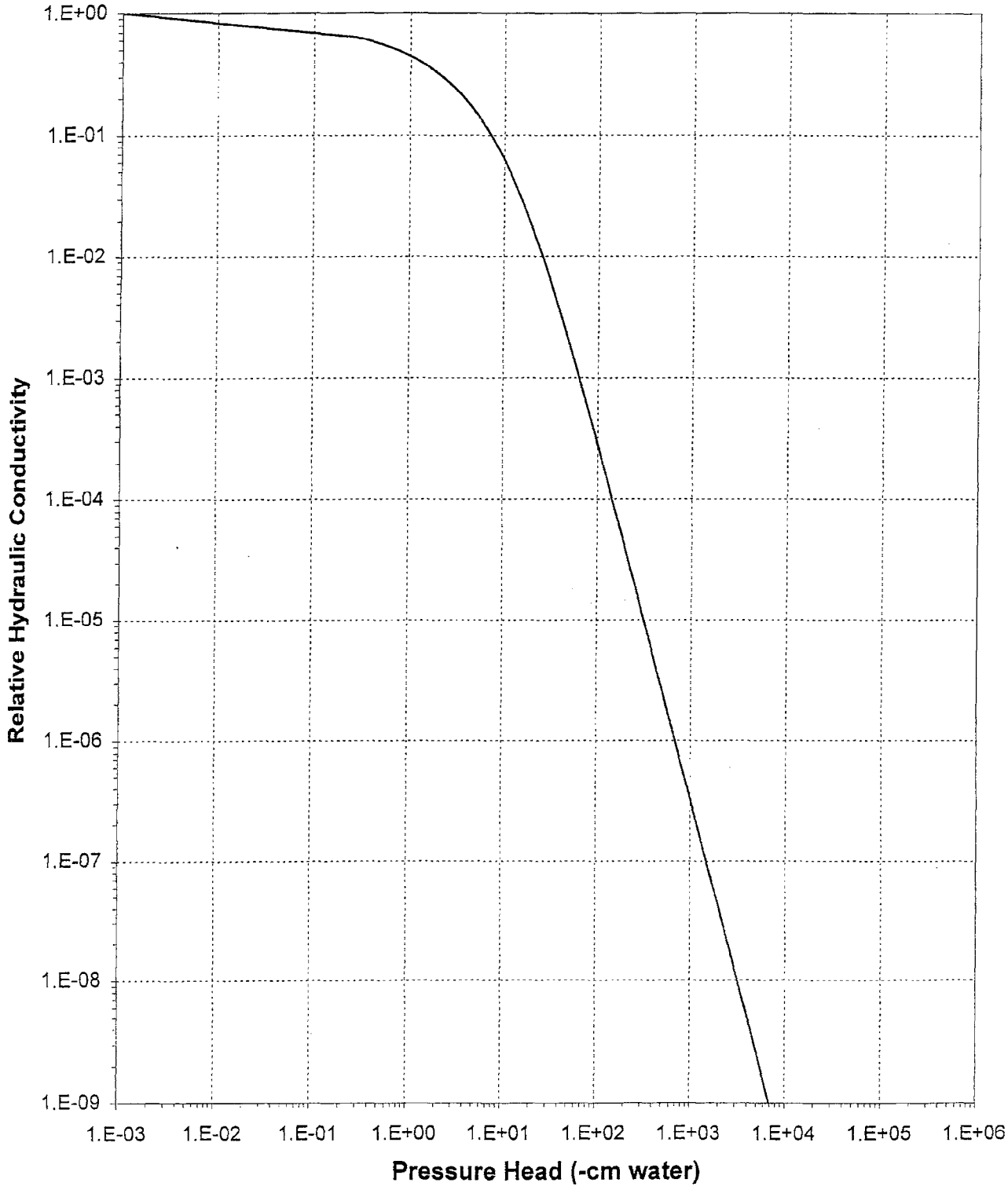

Plot of Relative Hydraulic Conductivity vs Moisture Content

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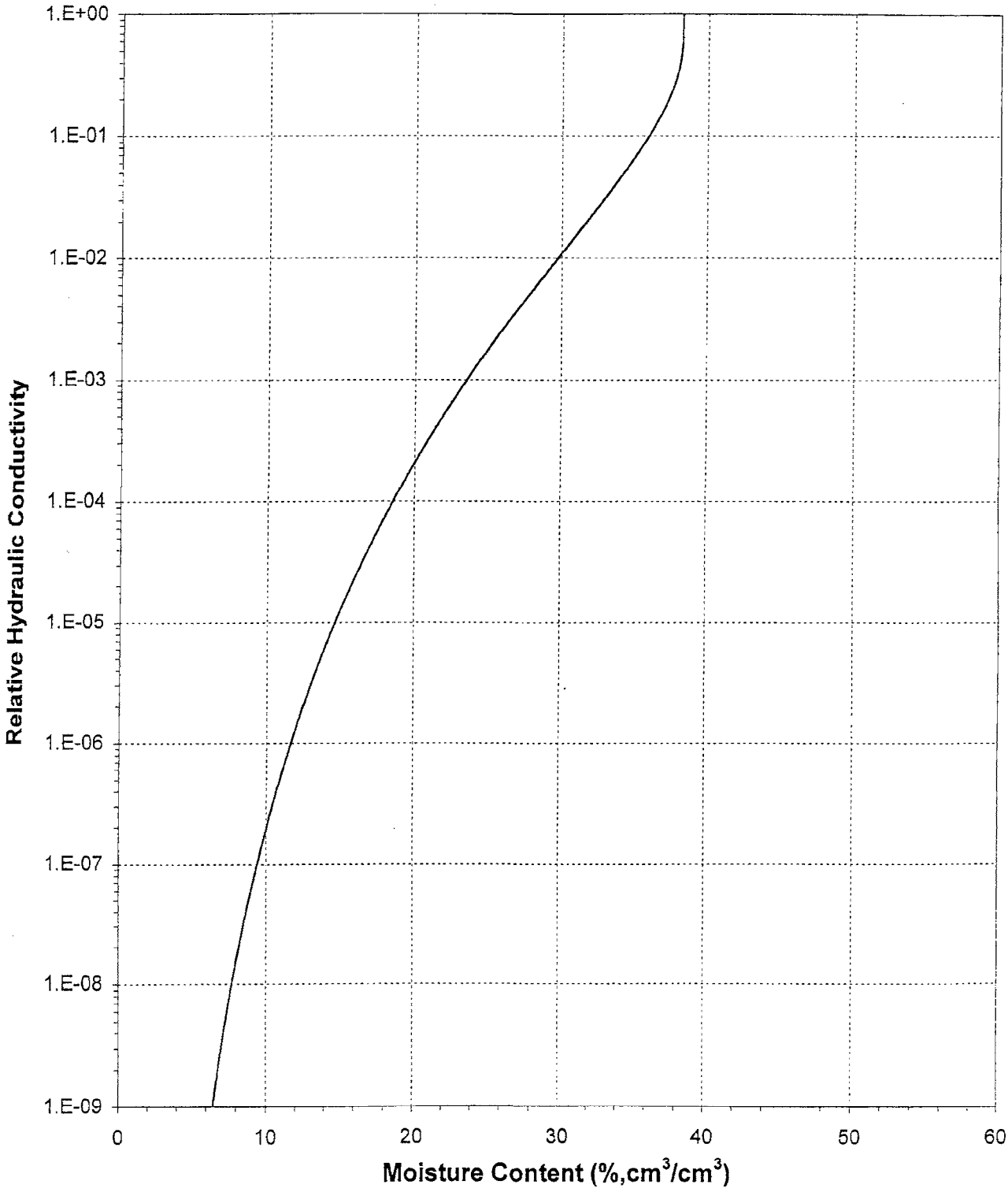

Plot of Relative Hydraulic Conductivity vs Pressure Head

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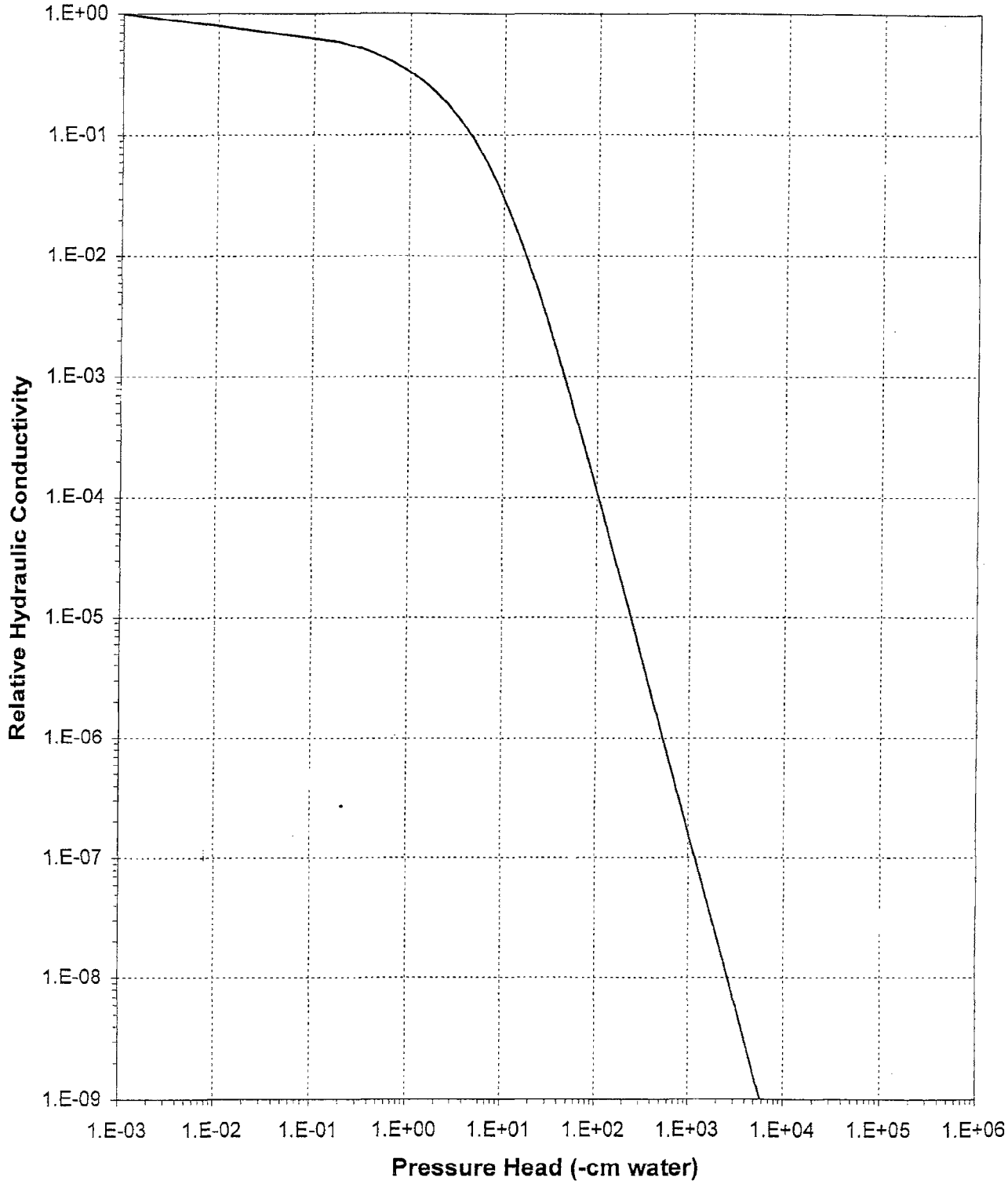

Plot of Relative Hydraulic Conductivity vs Moisture Content

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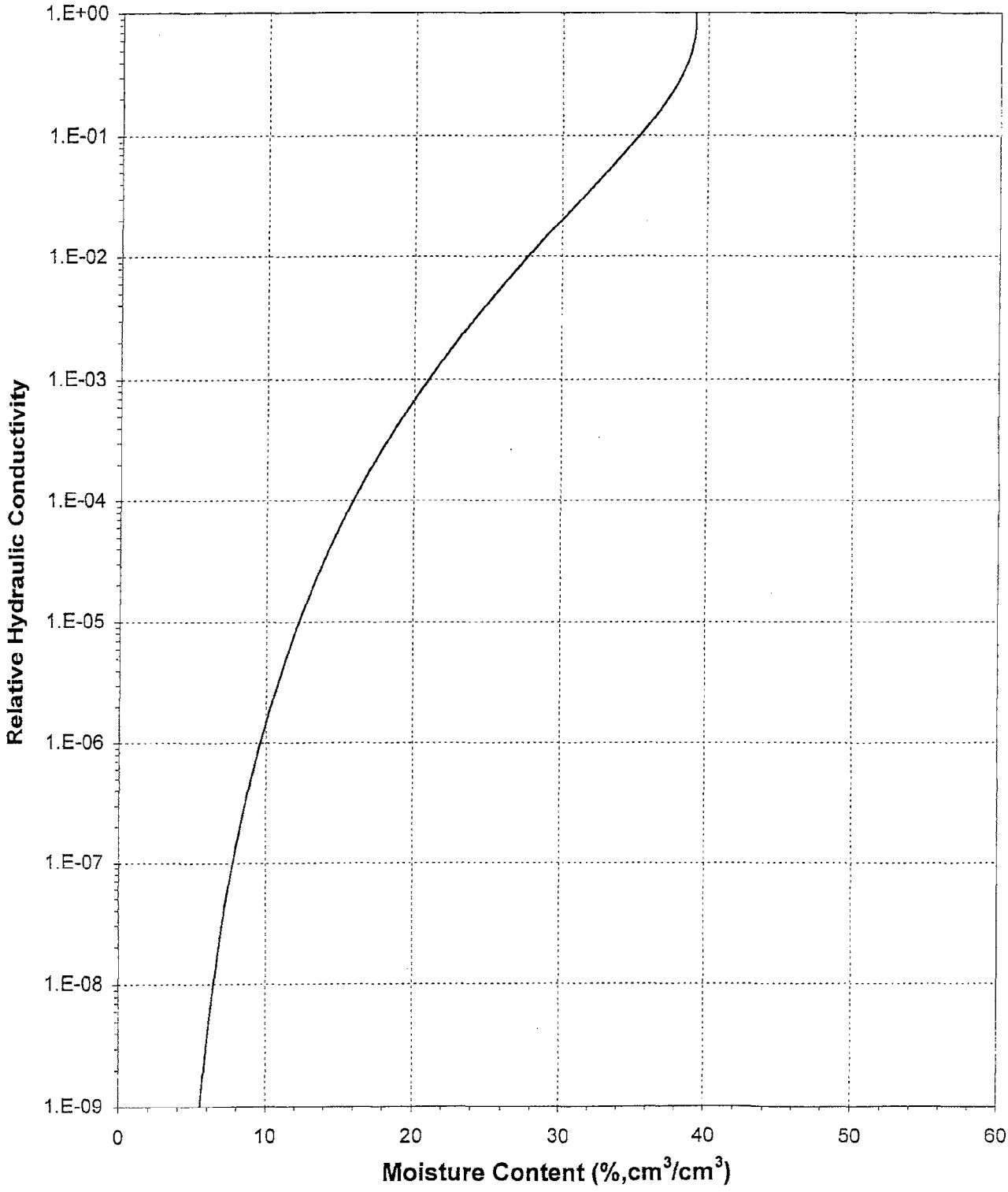

Plot of Relative Hydraulic Conductivity vs Pressure Head

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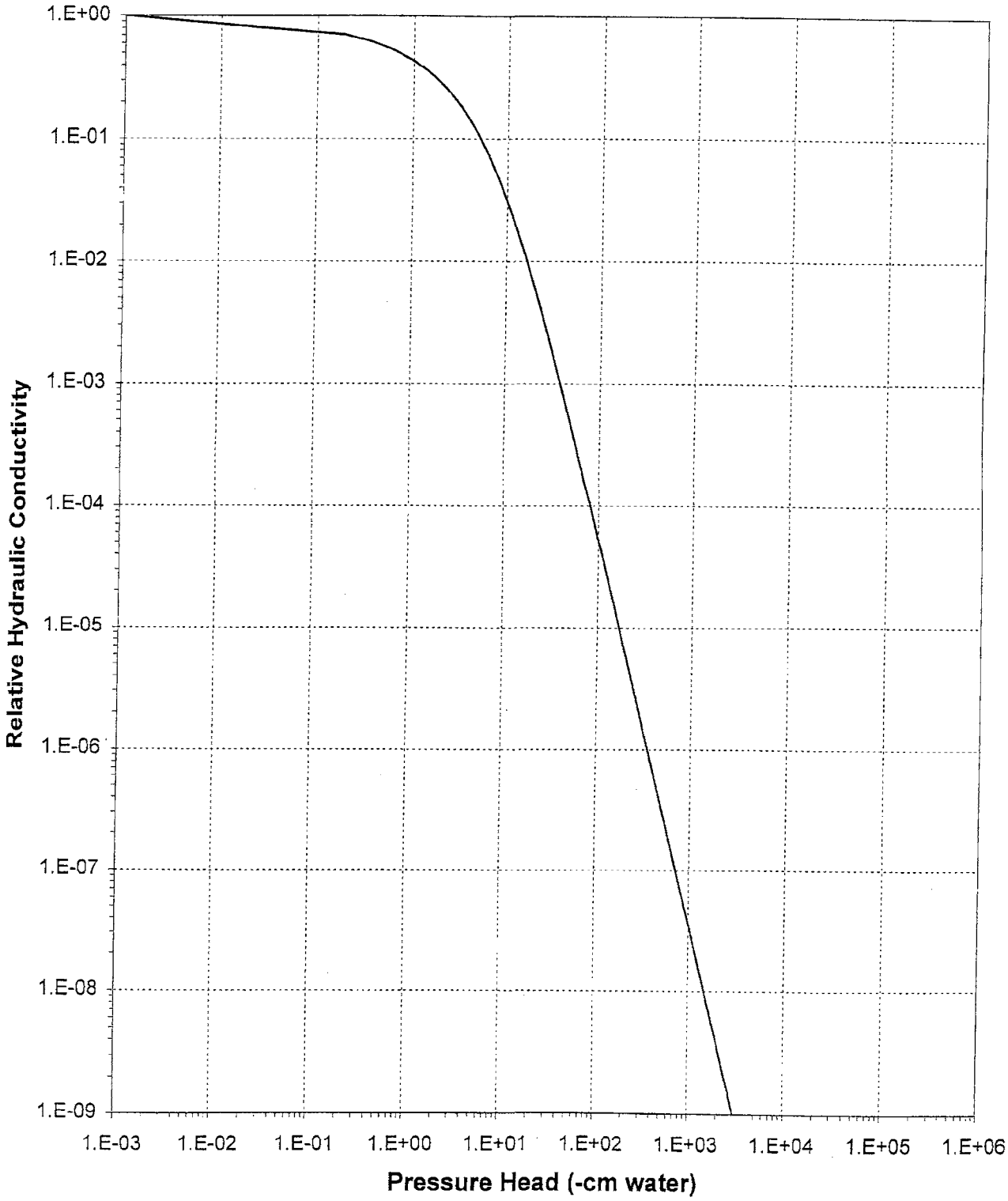

Plot of Relative Hydraulic Conductivity vs Moisture Content

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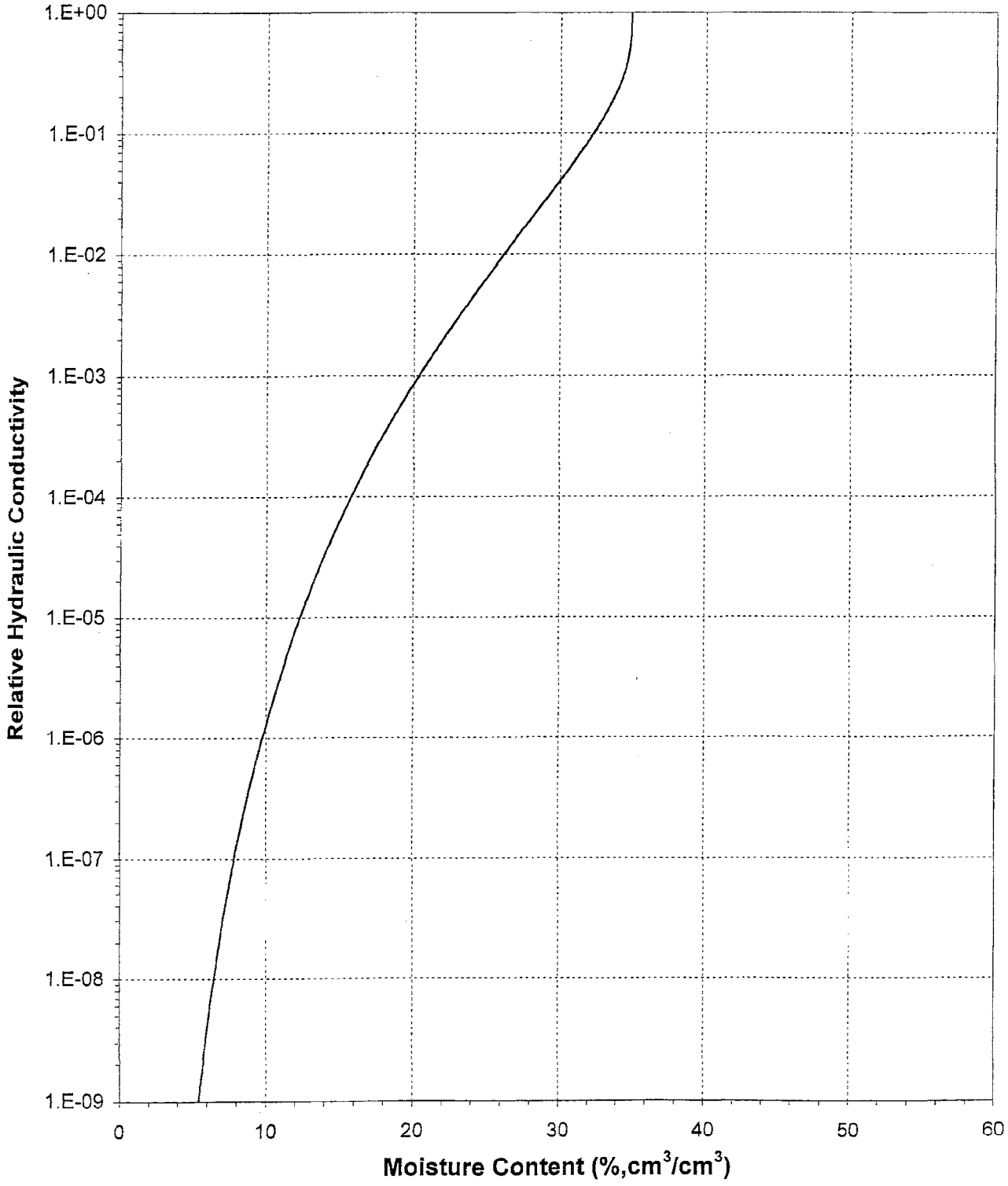

Plot of Relative Hydraulic Conductivity vs Pressure Head

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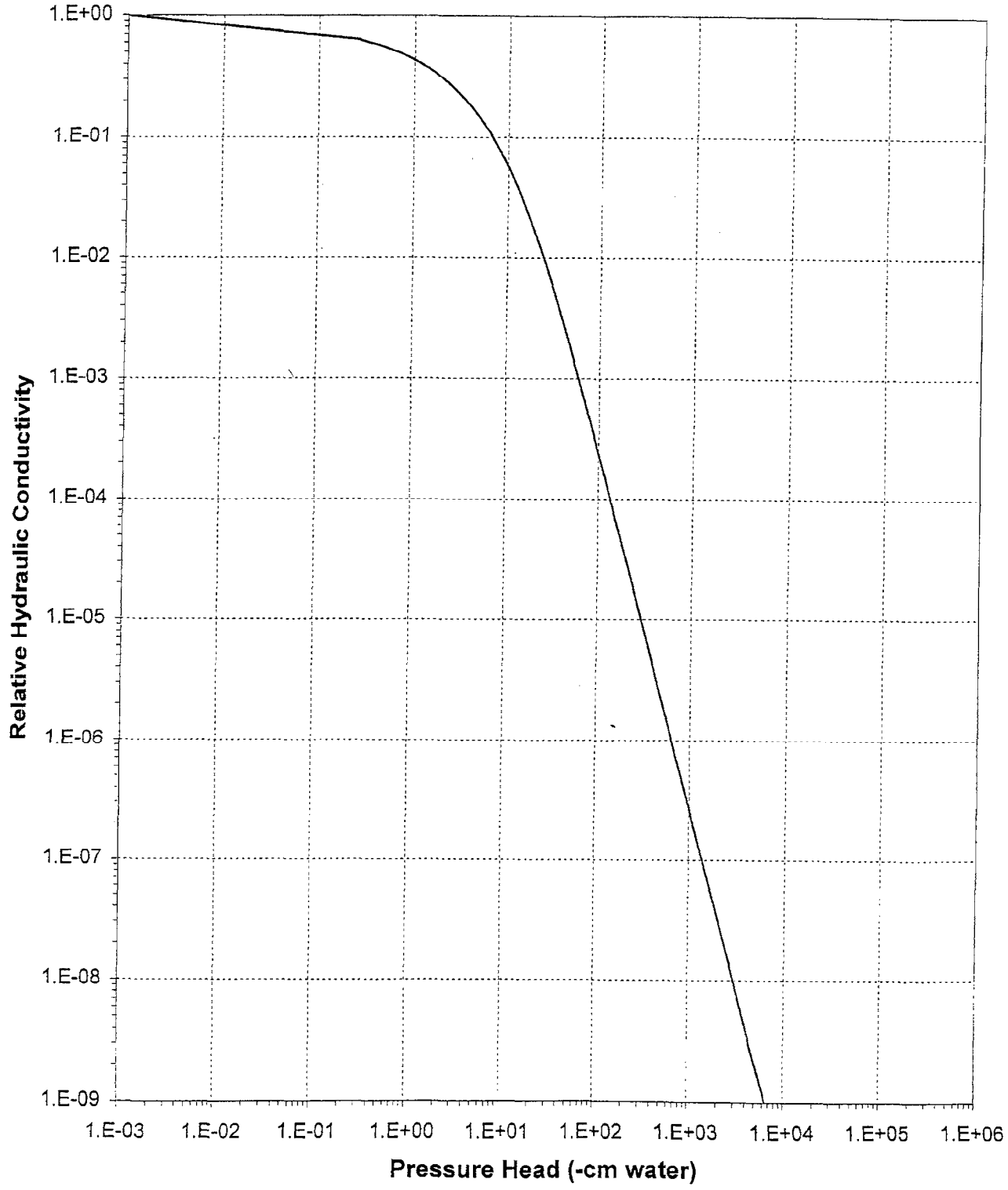

Plot of Relative Hydraulic Conductivity vs Moisture Content

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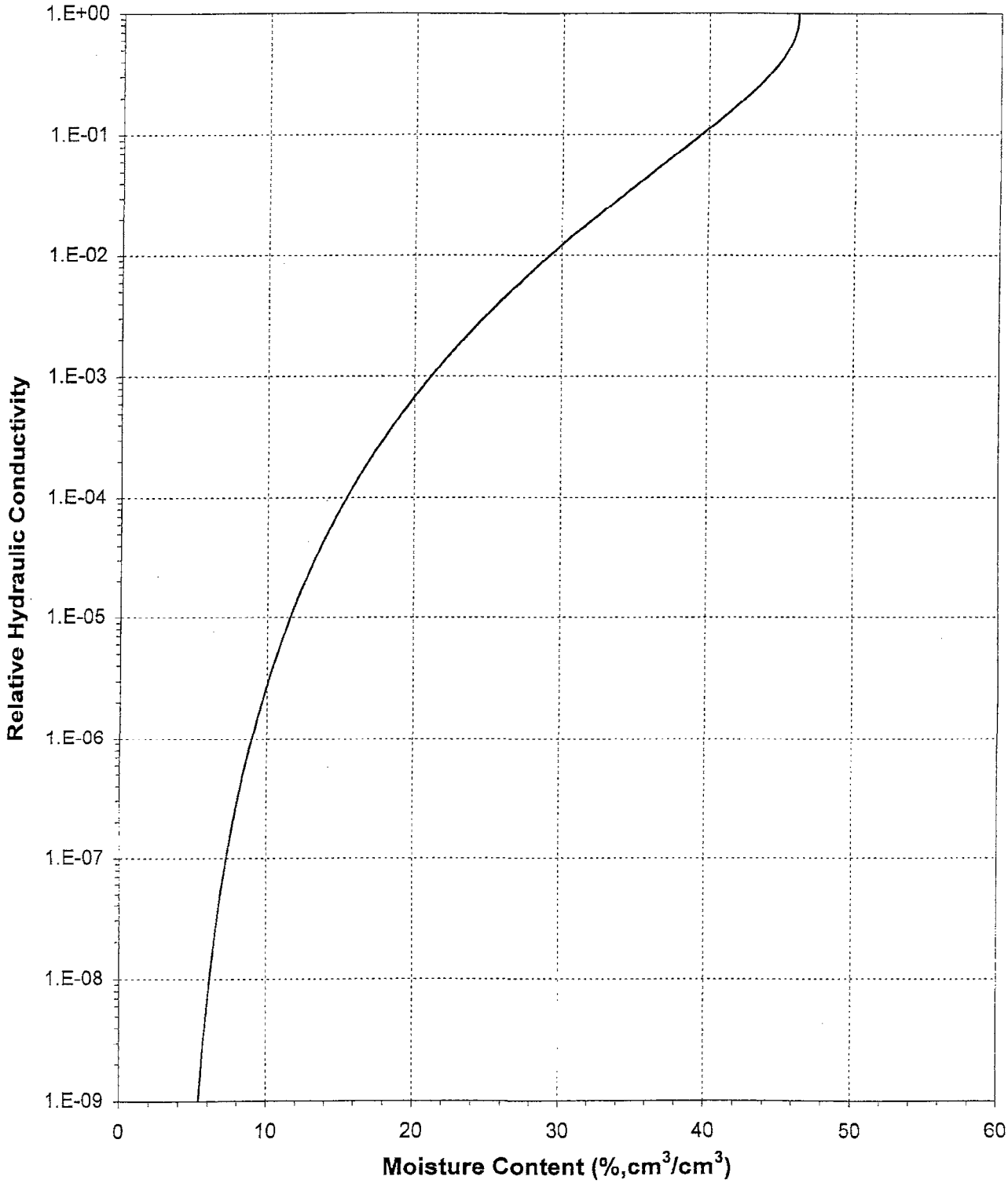

Plot of Relative Hydraulic Conductivity vs Pressure Head

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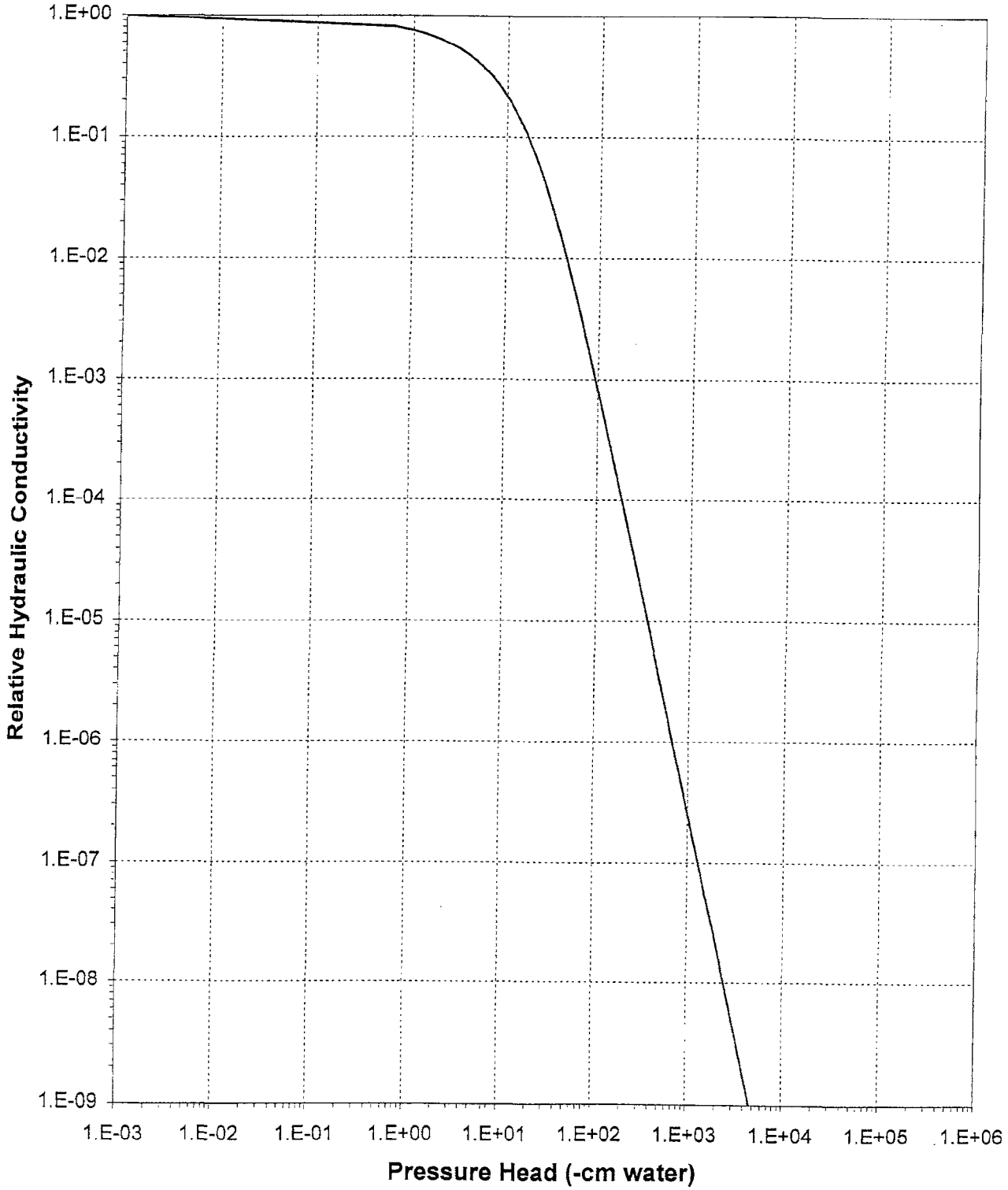

Plot of Relative Hydraulic Conductivity vs Moisture Content

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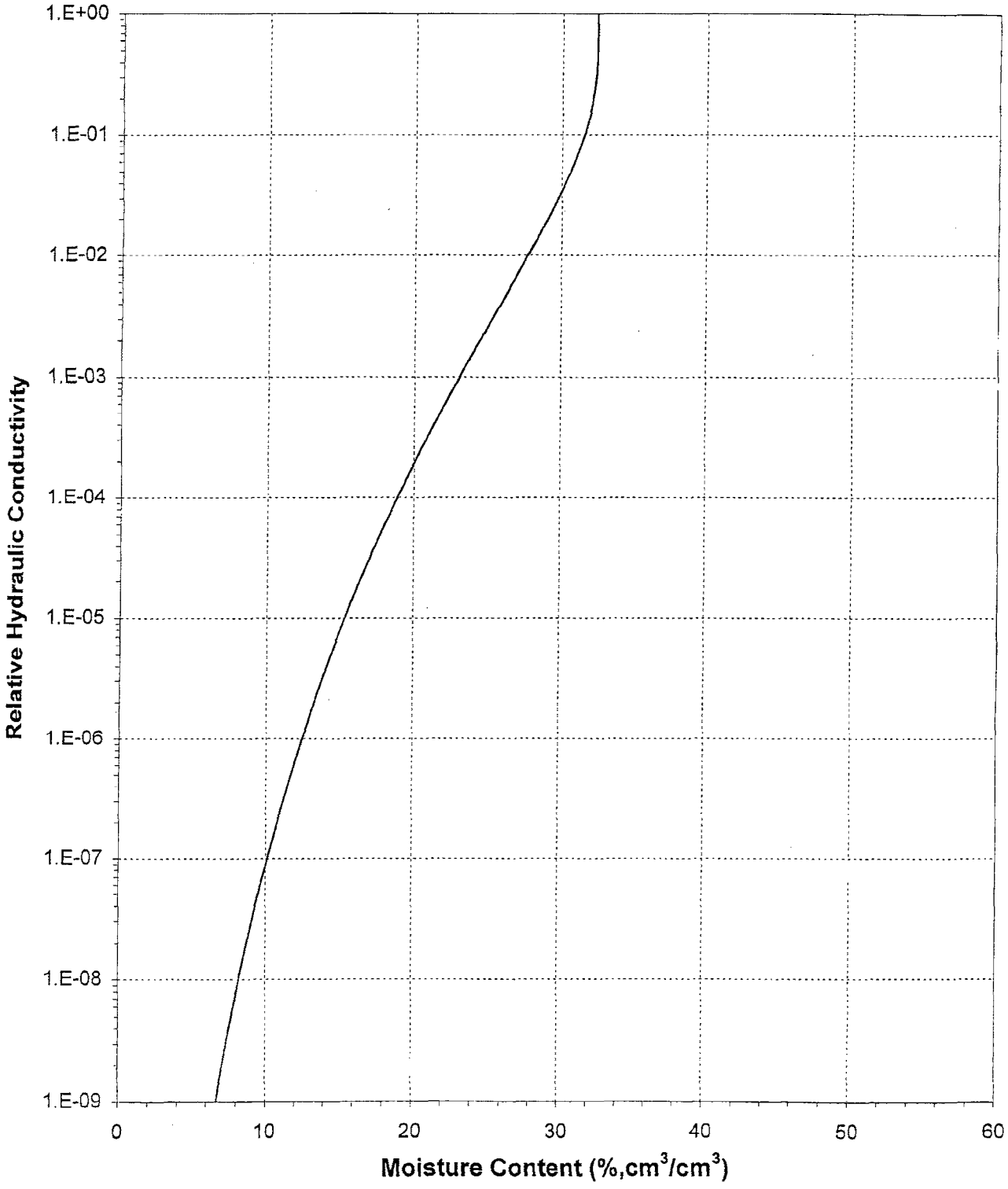

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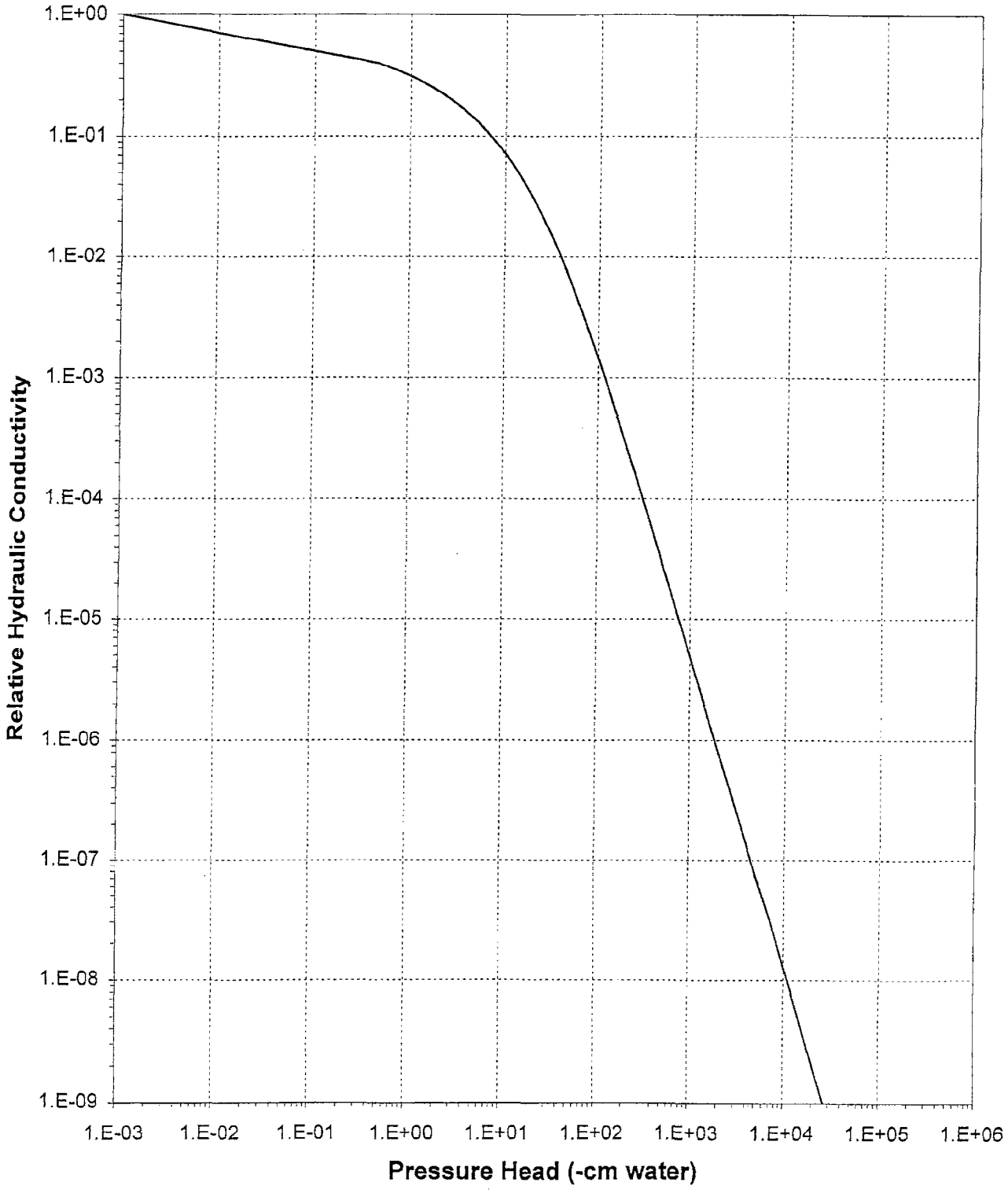

Appendix C

Topographic Map of the Area 5 RWMS, September 2002

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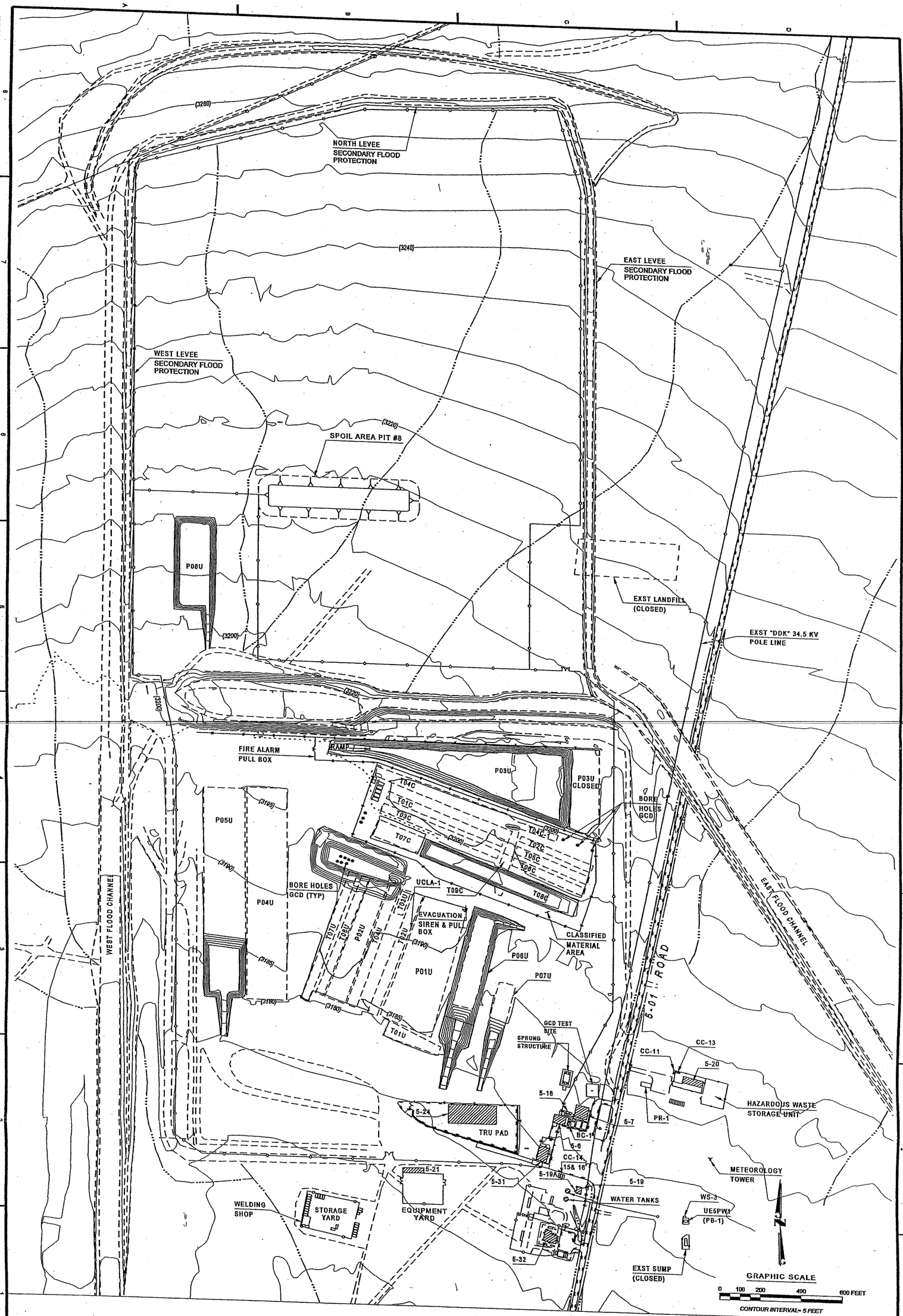

Figure C-1. Topographic Map of the Area 5 RWMS, September 2002

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