YMP-116-R0
8/7/92

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
DOCUMENT TRANSMITTAL/ACKNOWLEDGMENT RECORD

WBS: _____
QA: N/A
Page 1 of 1

TO:

LINEHAN J J
NRC/MD
RW-30
ATTN: LINDA DESELL DOE/HQ
US DEPARTMENT OF ENERGY
WASHINGTON, DC 20585-0000

FROM: Document Control Center
101 Convention Center Drive
Mail Stop 423
Las Vegas, Nevada 89109
(702) 794-1887

TRANSMITTAL DATE: 04/03/93

COPY NO.: 100686.0

DOCUMENT TITLE: STUDY PLAN FOR CHARACTERIZATION OF THE UNSATURATED-ZONE...

DOCUMENT REVISION: 2 DOCUMENT IDENTIFICATION NUMBER: 8.3.1.2.2.1

DIRECTIONS

REPLACE: Signature page, Rev. 1, dated 06/01/92 with new
Signature page, Rev. 2, dated 03/23/93.

REPLACE: Table of Contents, pages i/ii and v/vi, with new
Table of Contents, pages i/ii and v/vi

REPLACE: Content page 1.1-1, with new
Content page 1.1-1

REPLACE: Content page 1.3-1 thru 1.3-6 with new
Content page 1.3-1 thru 1.3-6

REPLACE: Content page 2.1-17, with new
Content page 2.1-17

REPLACE: Assession number page (NNA.901203.0019) with
Assession number page (NNA.930310.0013)

*** Destroy or mark obsolete material "Superseded"***

SIGN/DATE IN BLACK INK BELOW TO CONFIRM THAT THE ABOVE DIRECTIONS HAVE BEEN FOLLOWED, AND RETURN THIS TRANSMITTAL RECORD, WITH THE OBSOLETE MATERIAL, AS APPROPRIATE, TO THE ABOVE ADDRESS BY:

05/03/93
Due Date

_____ _____
Recipient Date

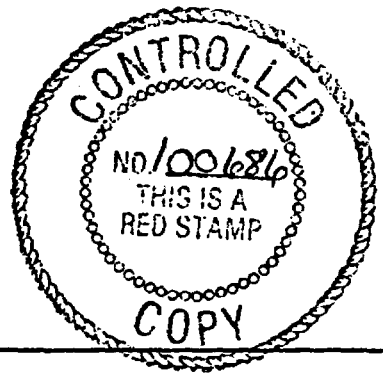
<<< FOR DOCUMENT CONTROL CENTER USE ONLY >>>

OBSOLETE MATERIAL RECEIVED: _____ _____
DCC Personnel Initials Date

9304130282 930405
PDR WASTE
WM-11 PDR

YMP-021-R1
4/15/92

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
STUDY PLAN APPROVAL FORM



Study Plan Number 8.3.1.2.2.1

Study Plan Title CHARACTERIZATION OF THE UNSATURATED-ZONE INFILTRATION

Revision Number 2

Prepared by: U. S. GEOLOGICAL SURVEY

Date: 2/22/93

Approved:

J. Timothy Sullivan 3/18/93
Director, Regulatory and Site Evaluation Division / Date

Effective Date: 3/23/93

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Figures

1. PURPOSE AND OBJECTIVES OF STUDY

1.1 Purpose of the Study Plan

The U.S. Geological Survey (USGS) is conducting studies at Yucca Mountain, Nevada, as part of the Yucca Mountain Project (YMP). The purposes of the USGS studies are to provide hydrologic and geologic information to evaluate the suitability of Yucca Mountain for development as a high-level nuclear-waste repository and the ability of the mined geologic-disposal system (MGDS) to isolate the waste in compliance with regulatory requirements. This study is designed to collect and evaluate data required to assess the performance of the Yucca Mountain Site with respect to the requirements of Federal Regulations 10 CFR Part 60, 10 CFR Part 960, and 40 CFR Part 191.

This study plan describes the USGS plans for surficial hydrologic and shallow-unsaturated zone characterization of Yucca Mountain. The study is organized into three activities:

- 8.3.1.2.2.1.1 - Characterization of hydrologic properties of surficial materials;
- 8.3.1.2.2.1.2 - Evaluation of natural infiltration; and
- 8.3.1.2.2.1.3 - Evaluation of artificial infiltration.

Note that the numbers (e.g., 8.3.1.2.2.1.1) used throughout this plan serve as references to specific sections of the YMP Site Characterization Plan (SCP). The SCP (U.S. DOE, 1988) describes the technical rationale of the overall site-characterization program and provides general descriptions of the activities described in detail in Section 3 of this study plan.

Figure 1.1-1 illustrates the location of the study within the SCP geohydrology program. The unsaturated-zone infiltration study is one of nine studies planned to characterize the unsaturated zone at Yucca Mountain. Seven of the studies are surface-based evaluations and two studies, (8.3.1.2.2.4 - Characterization of the Yucca Mountain unsaturated zone in the exploratory studies facility and 8.3.1.2.2.5 - Diffusion tests in the exploratory studies facility), will study the *in situ* hydrologic characteristics of Yucca Mountain from ramps and drifts. The three activities in this study were selected on the basis of a number of factors, including design/performance-parameter needs, available test/analysis methods, test scale, time requirements, and schedule constraints. (*Parameter* is used in this plan to mean a property, characteristic, and/or the numerical value of a constant that is used to describe the unsaturated-zone hydrologic system). These factors are described in Sections 2 and 3.

The plans for each activity are presented in Section 3. The descriptions include (a) objectives and parameters, (b) technical rationale, and (c) tests and analyses. Alternate test and analysis methods are summarized, and cross references are provided for technical procedures.

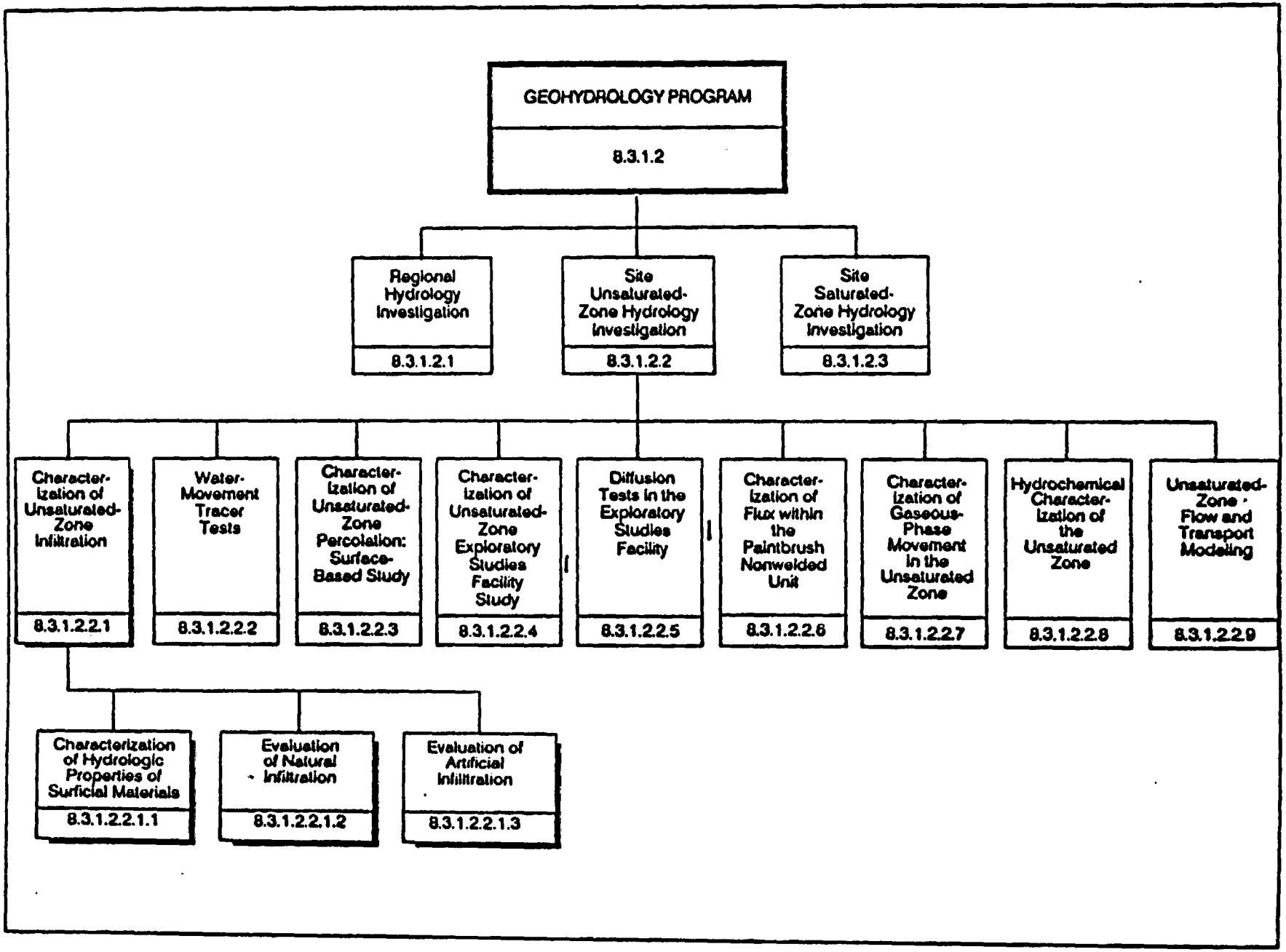


Figure 1.1-1. Diagram showing location of study within the unsaturated-zone investigation and organization of the geohydrologic-characterization program.

1.3 Regulatory rationale and justification

The results of unsaturated-zone infiltration characterization provide hydrologic data needed for performance-assessment calculations of unsaturated-zone ground-water travel times and rates of radionuclide releases to the accessible environment. Hydrologic properties determined in the study will also be used in design analyses of the underground facility, repository seals, and waste packages.

The overall regulatory-technical relations between SCP design and performance information needs and data collected in this study are presented in the geohydrology testing strategy presented in SCP Section 8.3.1.2 and the issue-resolution strategies (repository, seals, waste package, and performance assessment) presented in SCP Sections 8.3.2 - 8.3.5. The description presented below provides a more specific identification of these relations as they apply to this study. A detailed tabulation of parameter relations is in Appendix 7.2.

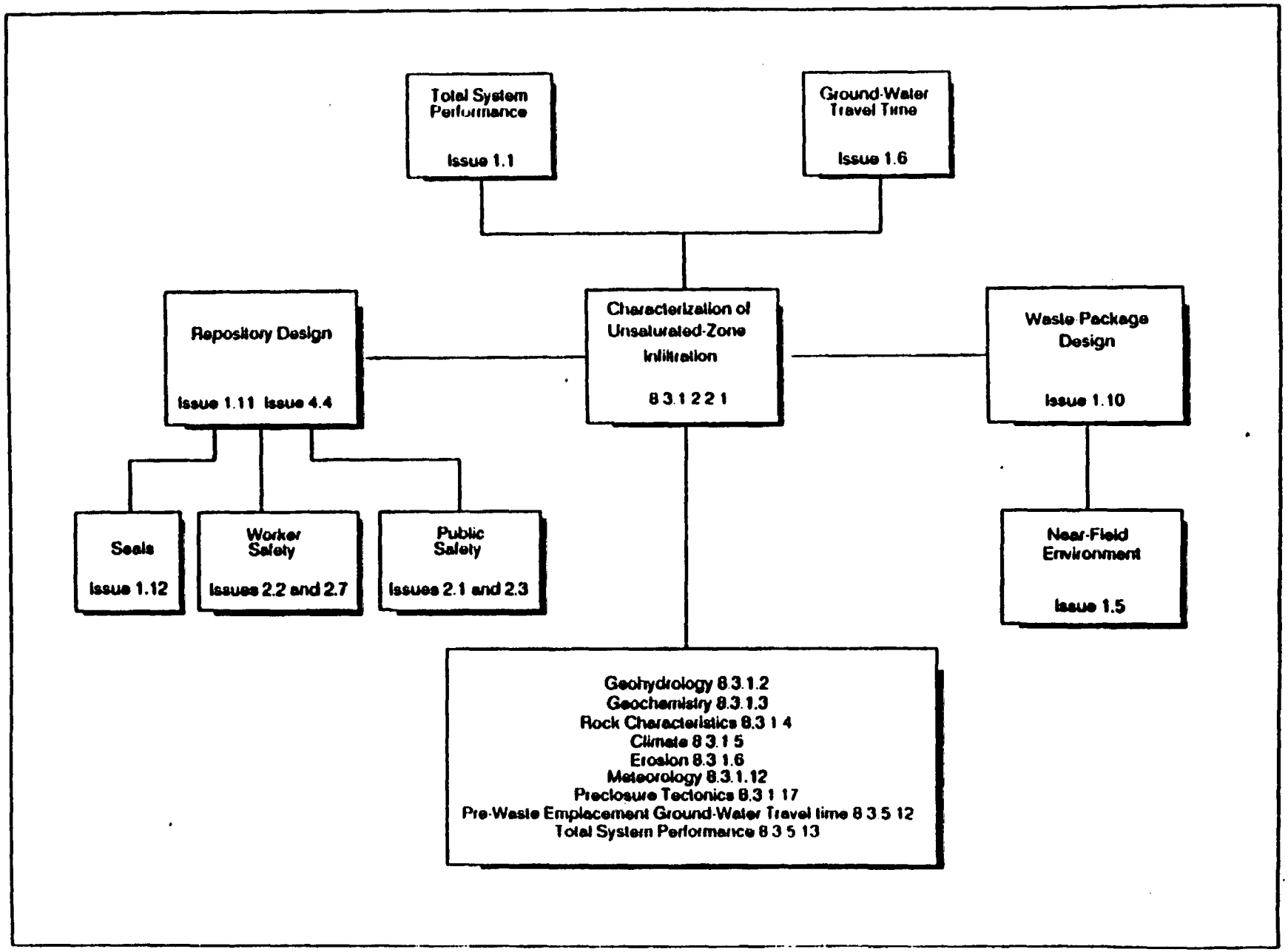
Project-organization interfaces between the unsaturated-zone infiltration study (8.3.1.2.2.1) and the YMP performance and design issues are illustrated in Figure 1.3-1. The figure also indicates project interfaces with other site studies; these relations are described further in Section 4.2. The relations between the design and performance issues noted below and the regulatory requirements of 10 CFR 60 and 10 CFR 960 are described in Section 8.2.1 of the SCP.

Information derived from the study will principally support the performance determinations of pre-waste-emplacement, ground-water travel time (Issue 1.6) and the predictions of radionuclide releases to the accessible environment (Issue 1.1). Study results will also provide information for the resolution of issues concerned with waste package design (Issue 1.10), releases from the repository engineered-barrier system (Issue 1.5), and repository design (Issues 1.11 and 4.4).

Physical and hydrologic information about the near-surface unsaturated zone obtained from this study will be used in the analyses for repository underground-facility design (Issue 4.4) and in the assessments of repository postclosure performance (Issue 1.11). Unsaturated-zone information on fracture characteristics and hydrologic conditions will be used in developing the design requirements for ESF and borehole seals (Issue 1.12). Information on the water conditions will be used in the analyses of waste-package performance (Issue 1.10).

Performance Issue 1.1
(Total-system radionuclide release to the accessible environment)

This issue requires that the geologic setting, engineered-barrier system, ramps, drifts, boreholes, and seals be selected and designed so as to limit the cumulative release of radionuclides for 10,000 years following permanent closure of this repository. Site information resulting from this study will be used to satisfy the requirements of numerous supporting parameters needed to evaluate the nominal case of Scenario Class E of the issue-resolution strategy for total system performance. The study results will also provide baseline data for the



ure 1.3-1 Diagram showing interfaces of the u turated-zone infiltration study with YMP perform e

disturbed cases. Descriptions of the scenarios are given in SCP Section 8.3.5.13. These supporting parameters (e.g., hydrologic characteristics of the rock matrix, fracture network, or fault zones specific to the repository area) are used in calculations of the performance parameters for the different scenarios. Examples of performance parameters for the nominal case are average flux and average effective porosity in the unsaturated zone in the repository area.

The performance parameters for each of the scenario classes apply to expected partial performance measures (EPPM's). For example, Scenario Class E has three EPPM's: one for the unsaturated-zone liquid pathway, one for the saturated-zone liquid pathway, and one for the gas pathway. Determination of each of these EPPM's depends upon data from performance parameters, which in turn depend upon calculations from supporting parameters, which in turn depend upon site information collected in the this study. These relations are described in the SCP and are further documented in the tabulations of Appendix 7.2.

Knowledge of hydrologic properties is required for postclosure-performance evaluation of the near-field environment of the repository and underground openings. Data on Topopah Spring unit hydrologic properties resulting from this study, along with estimates of how these properties (or parameter values) may change due to climate changes, will be useful in computer modeling of engineered-barrier, system-release scenarios.

Performance Issue 1.6
(Pre-waste emplacement, ground-water travel time)

As in Issue 1.1, site information from the study will be used to satisfy numerous supporting performance parameters needed to assess ground-water travel time in individual unsaturated-zone units. These supporting parameters are used to define various aspects of the unsaturated-zone model, spatial correlation structure model, and fracture-hydrologic-characteristics model. These aspects include initial and boundary conditions, material properties, system geometry, and validation of model concepts. The results of the ground-water travel-time calculations yield performance parameters for each of the unsaturated-zone units. Examples of these performance parameters are fracture characteristics, flux, percolation rate, and volumetric-water content: these are applied to the performance measure of ground-water travel time for each hydrogeologic component of the ground-water regime.

Rock hydrologic and physical properties measured in this study are required for the calculation of ground-water travel time. For example, information on natural- and artificial-infiltration rates, surficial-material water content, and near-surface water-potential profiles will support the determination of upper flux boundary conditions for the ground-water travel-time model. Material properties such as porosity and hydraulic conductivity will be determined for a number of hydrogeologic units where they are exposed at the surface using both laboratory and *in situ* tests. This information is important to the determination of ground-water travel time for each of those units. Information on fracture characteristics from this study will also support these travel-time calculations.

Performance Issues 1.8 and 1.9
(Favorable and potentially adverse conditions) (Qualifying and disqualifying conditions)

The results of this study have indirect applications to the NRC siting criteria - Favorable Condition 7 (pre-waste-emplacement, groundwater travel time) through Issue 1.6, and Favorable Condition 8 (unsaturated-zone hydrogeologic conditions) through Issue 1.1. The study also has indirect applications to the higher-level findings for the geohydrology qualifying and disqualifying conditions through Issues 1.1 and 1.6.

Design Issue 1.10
(Characteristics and configuration of the waste package)

Unsaturated-zone transmissive properties (such as saturated and unsaturated hydraulic conductivity) and water-content information obtained from this study may be useful in characterizing the near-field (pre-waste-emplacement) environment of the waste packages by indicating zones near the surface where high water flow rate may be expected (i.e., fracture zones).

Information on the quantity of unsaturated-zone water obtained from this study will be used in assessing the performance of the engineered-barrier system in limiting the release of radionuclides. Hydrologic properties data of the Topopah Spring unit obtained from this study will be used in calculating the flow and transport in the near-field host rock. The performance parameters receiving site information are host-rock hydrologic properties.

The results of the this study will also support (indirectly through Issue 1.10) resolution of the performance issue concerned with releases from the engineered-barrier system (Issue 1.5) where the applicable performance measure is the concentration of radionuclide species in the gas phase, liquid water, and adsorbed to solid phases within the near-field host rock. Host-rock hydrologic properties collected in this study will apply to the hydrologic performance parameters of the issue.

Design Issue 1.11
(Characteristics and configurations of repository and engineered barriers - postclosure)

Postclosure characteristics and configurations of the repository underground openings will rely, in part, on the rock physical and hydrologic properties information derived from this study. Data on fracture characteristics will help support the determination of the potential for significant displacement. Possible changes in saturation and water chemistry in the near-field host rock will be supported by water-content information gathered in this study, in particular, fracture flow and geochemical analysis of infiltration water, as determined at the surface.

Preclosure assessment of repository characteristics and configurations (Issue 2.7, which is supported indirectly through Issue 1.11) will use

rainfall-runoff-infiltration relations determined by this study to support a variety of performance measures (such as surface flooding at the facility and volume of surface water flowing to nearby water bodies) which may affect worker safety.

Design Issue 1.12
(Characteristics and configurations of ESF and borehole seals)

Site information of surficial-hydrologic properties will be applied to the design and placement of the following sealing system elements: anchor-to-bedrock plug/seals, station plugs, and general fill. The saturated hydraulic conductivity, thickness, and water-content profiles of the alluvium, along with rainfall-runoff-infiltration relations, will be used in calculating the amount of surface waters entering the ESF that could potentially reach the waste disposal rooms of the underground facilities. Similarly, saturated bulk-rock hydraulic conductivities and erosion potential in the emplacement area are design and performance parameters supported by information from this study.

Design Issue 4.4
(Repository design and technical feasibility)

Data generated by the shallow unsaturated-zone infiltration studies address this issue in limited capacity. Surface hydrology data for different climatic scenarios, however, will be useful in the evaluation of facility designs that are not jeopardized by natural (e.g., surface runoff, floods) and man-made phenomena. Similarly, an understanding of infiltration/runoff ratios and hydraulically-induced erosion characteristics will lead to the development of facilities adequate to withstanding natural phenomena (i.e., meteorological) without damage to functional capability. Rainfall-runoff-infiltration relations characterized by this study will also support worker and public safety concerns (Issues 2.1, 2.2, 2.3, and 2.7).

The following paragraphs briefly summarize the information to be obtained by the activities of this study. More detailed descriptions are presented in Section 3.

The activity designed to characterize hydrologic parameters of surficial units (8.3.1.2.2.1.1) will provide an analysis of infiltration and related hydrologic data to define hydrogeologic-surficial units, each characterized by a different set of representative infiltration properties. The useful parameters this activity will evaluate are infiltration and runoff rates, porosity, density, water content, water potential, soil texture, and depth to bedrock.

The evaluation of natural infiltration (8.3.1.2.2.1.2) will provide information necessary for defining the upper-flux boundary conditions for each hydrogeologic-surficial unit. The parameters to be measured in this activity are infiltration rates, net infiltration, flow velocities, precipitation, runoff, and evapotranspiration.

The evaluation of artificial infiltration (8.3.1.2.2.1.3) will provide data on infiltration processes under different possible climatic conditions for each hydrogeologic-surficial unit. The parameters of this activity are

saturated- and unsaturated-infiltration rates, flow velocities, flow pathways, precipitation, runoff, evapotranspiration, saturated- and unsaturated-hydraulic conductivity and water content-water potential characteristic curves.

Specific relations among the site parameters obtained from this study and their relations to the design and performance parameters are documented in Table 7.2-1 in the appendix of this plan.

2.2 Constraints on the study

2.2.1 Representativeness of repository scale and correlation to repository conditions

The unsaturated-zone infiltration tests will be performed at sites on Yucca Mountain and overlying the repository block. Because of this, the environment in which the infiltration tests will be conducted is representative of the repository area. How well each test will represent present or future conditions of the repository area at the scale of the repository depends on factors particular to each test.

2.2.2 Accuracy and precision of methods

Selected and alternate field tests are summarized in tables at the end of each activity description (Section 3). These tests were selected on the basis of their expected precision and accuracy, duration, and interference with other tests and analyses. The actual accuracy and precision of the surficial-hydrologic and infiltration-properties tests is difficult to quantify prior to any implementation of testing.

2.2.3 Potential impacts of activities on the site

The tests described in this plan are not expected to impact the repository block site conditions, nor have adverse effect on the ability of Yucca Mountain to isolate waste. The proposed work should not affect the site in terms of either exploratory study facility or repository design. Approximately 100 neutron-access boreholes for site characterization and monitoring natural infiltration will be drilled in the surficial units. These boreholes will only penetrate several meters into the bedrock and will not penetrate the repository block. The construction of rainfall-simulation plots will impact only a small area of the ground surface and have no impact on the repository block. The small amount of water supplied to the surface (<30 cm) is equivalent to one or two years of precipitation. The rainfall simulations are designed to cause runoff so that the majority of water applied is later collected and measured.

2.2.4 Time required versus time available

A tentative schedule of work activities and reports is given for the three activities in Section 5. These schedules assume that five years will be available for site characterization. The start of the natural- and artificial-infiltration activities is constrained by the construction of the rainfall-simulation plots. The drilling of neutron-access holes is not considered to be a major constraint on the timing of this study. Also, the time required to complete each test and analyze the data will not be a constraint.

2.2.5 Interference

There are no known interferences between this study and other studies within the site-characterization plan, nor will the proposed work interfere with the design and construction of the exploratory studies facility.

directional changes in the range of spatial correlation (geometric anisotropism), the range of quasi-stationarity, etc. The validity of the fitted model can be tested using cross-validation in which each measured value is individually removed and estimated using the remaining values. A comparison of the measured and estimated values gives a measure of the validity of the model.

Therefore, it is important that the model of spatial structure reflect geologic reality, and these procedures can be modified to incorporate qualitative or subjective information (so-called "soft" data). Through the use of techniques such as soft kriging, interval kriging, and Bayesian kriging, the estimates and estimation variances can be constrained to reflect soft data (e.g., prior knowledge of geologic structure and stratigraphy). With these processes, the most accurate and realistic estimates may be obtained.

The following is for the Office of Civilian Radioactive Waste Management Records Management purposes only and should not be used when ordering this document:

Assession number: NNA.930310.0013