

PHASE I REVIEW
HYDROCHEMICAL CHARACTERIZATION OF THE UNSATURATED ZONE
STUDY PLAN 8.3.1.2.2.7

by

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Introduction

This study plan describes the plans for gaseous- and aqueous-phase chemical investigations of the unsaturated zone at Yucca Mountain. The two activities described involve collection of water and gas samples from surface-based boreholes, preparation of the samples for analysis, and methods of hydrochemical analyses to be employed. The chemical and isotopic tests will include analysis for inorganic cations and anions, organic compounds, and stable isotopes. In addition, age dating, gas diffusion, and contamination testing will be conducted.

The objectives of Activity 8.3.1.2.2.7.1 - Gaseous-phase chemical investigations are to understand the transport mechanism, flow direction, flux, and travel time of gas within the unsaturated zone. The objectives of Activity 8.3.1.2.2.7.2 - Aqueous-phase chemical investigations are to implement methods designed in prototype testing for extracting unaltered pore water from unsaturated-zone tuff units; to obtain hydrochemical data to provide evidence of flow direction, flux and travel time of water; and to determine the geochemical evolution of ground water within the unsaturated zone by hydrochemical and isotopic techniques.

This study will extract gas samples from existing boreholes or boreholes drilled under Study 8.3.1.2.2.3 (Characterization of Yucca Mountain percolation in the unsaturated zone -- surface-based study) and from radial boreholes in ES-1 as described in Study 8.3.1.2.2.4 -- (Characterization of Yucca Mountain percolation in the unsaturated zone -- exploratory-shaft-facility study). Core samples for pore water extractions will be collected from all air-drilled boreholes, approximately fifty in all.

The chemical and isotopic analyses will include the major ions, rare-earth elements and other trace elements, organic compounds, oxygen and hydrogen stable isotopes, C-14, H-3, C-13/C-12, Cl-36, Freon-11, Freon-12, CO₂, H₂, SF₆, CH₄, Ar, O₂, N₂, Li, Br, I, NO₃, BO₃.

A Phase I review of Revision I of the study plan was done with respect to (A) DOE/NRC agreements on the content of study plans, (B) Identification of objections, (C) Closure of NRC open items, and (D) The Need for a Detailed

Review (See Review Plan for Staff Review of DOE Study Plans, Revision I, 12/6/90).

Evaluation of Study Plans Relative to the Agreement and to the Responsible DOE Contractor's QA Program (Objectives 1 and 5)

Criterion 1 The content of the study plan under review is reasonably consistent, as appropriate for the activities, tests and analyses described, with the Agreement (NRC-DOE meeting on the level of detail for site characterization plans (SCP) and study plans, May 7-8, 1986)

Staff Review: In general, the content of the study plan is reasonably consistent with the NRC/DOE agreements on the content of study plans (See Attachment 1).

Not all of the technical procedures have been provided in the study plan. Some have yet to be written; others such as the prototype tests have yet to be developed and tested. Tables 3.1-2 and 3.2-2 contain a footnote stating that "Procedures not listed are in place and will be performed by certified external laboratories which have been approved by the USGS Quality Assurance Program." As a result, the study plan lists only eleven procedures, three of which have yet to be written. However, Table 2.2-1 lists many more procedures to be used in this study.

It should also be noted that for each type of test the study plan did not indicate the level of QA and provide the rationale for any tests that are not QA level one. Determination of the quality status for the activities of this study will be made separately, according to AP-6.17Q, "Determination of the Importance of Items and Activities", which implements NUREG-1318, "Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements". The results of that determination will be contained in the Q-List, Quality Activities List and Non-Selection Record, which will be controlled documents. QA grading packages for the activities of this study plan will be prepared separately, according to AP-5.28Q, "Quality Assurance Grading". The resultant Quality Assurance Grading Report will be issued as a controlled document.

Criterion 2 All study plan references have been provided when the study plan was issued.

Staff Review: All references have not been provided. However, the study plan lists 50 references and of these only six are considered not readily obtainable by the U.S. NRC library. Attachment 2 is a copy of the list of references from the study plan with all references marked either SCP (referenced in the Site Characterization Plan), AA (assumed to be available), or NAA (not assumed to be available). DOE should provide copies of all references marked NAA to the NRC. References marked AA may be requested later if they turn out to be not readily obtainable and are needed for future reviews or technical exchanges.

Criterion 3 Open items relative to the QA program of the DOE contractor responsible for the study plan that could call into question

the quality of the study plan have been resolved.

Staff Review: Based on a meeting with K. Hooks (QA), there currently are no QA inadequacies that have to be resolved before the work begins.

Identification of Objections (Objectives 2 through 6)

Criterion 1 Potential adverse effects on repository performance;

Staff Review: The analytical activities described in this study plan will have little or no impact on the natural-state site conditions, and no adverse effect on the ability of Yucca Mountain to isolate waste. The proposed work should not affect the site in terms of either exploratory shaft or repository design, nor will the study require any permitting or environmental analysis at Yucca Mountain. The planned work for Activities 8.3.1.2.2.7.1 and 8.3.1.2.2.7.2 does include extensive sampling from unsaturated-zone boreholes. The impacts of drilling into the repository block, however, are not within the scope of this study and are addressed in detail in 8.3.1.2.2.3 (Characterization of percolation in the unsaturated zone -- surface-based study), and Section 8.4 of the SCP. Basically, analysis of impacts on site performance from drilling, testing, stemming, and monitoring of boreholes can be reduced to two significant concerns which include (1) limiting the number and location of boreholes needed for site characterization, and (2) preserving the capability to seal the holes effectively, as necessary, at the time of repository closure.

Criterion 2 Potential significant and irreversible/unmitigatable effects on characterization that would physically preclude obtaining information necessary for licensing;

Staff Review: No effects of this type have been identified. It is stated that because of the nonstandard nature of some of the tests, the possibility that one of these tests may fail in achieving the desired objectives is recognized. The use of various methods for determining parameters increases confidence that the failure or partial failure of one or more tests will not severely inhibit the ability of the characterization activities to provide the information required. In addition, prototype testing for site characterization, especially those related to characterization of the unsaturated zone, will be performed to increase confidence that test objectives will be achieved. For clustered boreholes, drilling and testing during construction are likely to have some effect on the region of the rock mass which either contains or will contain another borehole, thereby affecting measurements of in situ moisture potential. Interference between widely spaced boreholes might involve some combination of separated unsaturated-zone boreholes, the boreholes of the systematic drilling program, the exploratory shaft, or any of the existing boreholes at Yucca Mountain. Sampling needs of other studies for unsaturated-zone core is being coordinated by a sampling overview committee to ensure that there is no interference between sampling requirements.

Criterion 3 Potential significant disruption to characterization schedules or sequencing of studies that would substantially reduce the

ability of DOE to obtain information necessary for licensing.

Staff Review: No significant disruption in schedules is expected. The schedule of this study has taken into account how the study will be affected by contributions of data or interferences from other studies, and also how the present study will contribute or may interfere with other studies.

Criterion 4 Inadequacies in the QA program which must be resolved before work begins.

Staff Review: Based on a meeting with K. Hooks (QA), there currently are no QA inadequacies that have to be resolved before the work begins.

Closure of NRC Open Items (Objectives 8 and 11)

Criterion 1 If DOE has proposed that one or more NRC open items be closed on the basis of the material in the study plan, determine whether those items can be closed.

Staff Review: The DOE has not proposed to close any open items with this study plan.

Need for Detailed Technical Review

A study plan is a candidate for detailed technical review if it meets any of the following criteria from step 6 of part 4.2 of the Review Plan. This study plan is a candidate for a detailed technical review based on criteria 1, and 3.

Criterion 1 The study plan may be related to one or more key site related issues.

Staff Review: This study plan may provide information to address key site-specific issues. The results of this study will be used in the resolution of performance and design issues concerned with fluid flow (both liquid and gas within the unsaturated zone at Yucca Mountain. Unsaturated zone hydrochemical properties determined in this study such as pore-gas composition, isotopic ratios, pore-water hydrochemical compositions will contribute to addressing Issue 1.1 and specifically incorporated in calculations of coupling factors and radionuclide retardation factors in the unsaturated zone, calculations of gas-phase C-14 transport in the overburden, Issue 1.6 on pre-emplacment ground-water travel time, and design issues (1.10) on characteristics and configuration of the waste package, (1.12) on characteristics and configurations of shaft and borehole seals and (4.4) on repository design and technical feasibility and postclosure repository conditions.

Criterion 2 The study plan pertains to some NRC open items.

Staff Review: In this review, open items are defined as SCA comments and questions and comments and questions from other study plan reviews. No comments or questions pertain to this study plan.

Criterion 3 The study plan describes unique, state-of-the-art tests or analysis methods that therefore do not have a supportive scientific history of providing data usable in licensing.

Staff Review: The testing to be performed under this study does consist of state-of-the-art methods. Prototype testing will be performed as a part of this study. These include tracer tests, triaxial compression tests, and uniaxial compression tests. The critical prototype testing must be completed successfully before the site-characterization testing is started.

Criterion 4 The study plan describes a study critical to the evaluation of site performance that cannot be repeated for a number of years due to its disruption of the natural baseline.

Staff Review: There should be no disruption of the natural baseline by performing this study. However, drilling will cause disruption from which the system will require some period of time to recover. Monitoring the concentrations of tracers such as sulfur hexafluoride introduced in the drilling fluid will be used to indicate a return to ambient conditions.

Criterion 5 The study has some other critical relationship to potential licensing concerns.

Staff Review: Although the study plan describes general relationships between this and other studies including performance assessment, there is no explicit discussion of an overall program of iterative performance assessment, or discussion of the timing of this study relative to such a program. This kind of assessment is a systematic, iterative approach to identifying the information and analyses needed to support a license application. Such an approach was recommended in NRC's SCA Comment #1.

ATTACHMENT 1

Phase I Checklist for Study Plan 8.3.1.2.2.7
Hydrochemical Characterization of the Unsaturated Zone

I. Purpose and Objective

Is the information to be obtained in the study described?

Yes No N/A

Is the rationale for information to be obtained provided?

Yes No N/A

II. Rationale for Study/Investigation

Does the study plan provide the rationale for tests and analysis, indicating alternatives considered and options, advantages, and limitations?

Yes No N/A

Does the study plan provide the rationale for the number, location, duration, and timing of tests, considering uncertainty, and identify obvious alternatives?

Yes No N/A

Does the study plan describe the constraints for the study?

Yes No N/A

In describing the constraints for the study, does the study plan consider potential site impacts?

Yes No N/A

Although the analytical activities of this study will have little impact on the site, samples will be collected from boreholes. The location of these boreholes is not to be determined in this study. Consequently, the potential impacts to the site come from drilling into the repository block is described in 8.3.1.2.2.3 (Characterization of percolation in the unsaturated zone -- surface-based study).

In describing the constraints for the study, does the study plan consider the need to simulate repository conditions?

Yes No N/A

In describing the constraints for the study, does the study plan consider the required accuracy and precision?

Yes No N/A

In describing the constraints for the study, does the study plan consider the limits of analytical methods?

Yes No N/A

In describing the constraints for the study, does the study plan consider the capability of analytical methods?

Yes No ___ N/A ___

In describing the constraints for the study, does the study plan consider the time required vs. time available?

Yes No ___ N/A ___

In describing the constraints for the study, does the study plan consider the scale of phenomena and parameters?

Yes No ___ N/A ___

In describing the constraints for the study, does the study plan consider the interference among tests?

Yes No ___ N/A ___

However, the study plan states that the interferences are discussed in more detail in Study 8.3.1.2.2.3 (Characterization of percolation in the unsaturated zone -- surface-based study).

In describing the constraints for the study, does the study plan consider the interference between tests and ES?

Yes No ___ N/A ___

III. Description of Tests and Analysis

For each type of test does the study plan describe the general approach that will be used?

Yes No ___ N/A ___

For each type of test does the study plan describe key parameters that will be measured in the test and the experimental conditions under which the test will be conducted?

Yes No ___ N/A ___

For each type of test does the study plan indicate number of tests and locations?

Yes No ___ N/A ___

For each type of test does the study plan summarize the test methods if non-standard procedure, summarize steps of test, how it will be modified, and reference technical procedure?

Yes No ___ N/A ___

For each type of test does the study plan indicate the level of QA and provide rationale for any tests not QA level one?

Yes ___ No N/A ___

Determination of the quality status for the activities of this study will be made separately.

For each type of test does the study plan reference the applicable specific QA requirements applied to the test?

Yes No ___ N/A ___

For each type of test does the study plan specify the tolerance,

accuracy, and precision required in the test?

Yes No N/A

For each type of test does the study plan indicate the range of expected results and the basis for those results?

Yes No N/A

For each type of test does the study plan list the equipment requirements, briefly describing special equipment?

Yes No N/A

For each type of test does the study plan describe the techniques to be used for data reduction and analysis?

Yes No N/A

For each type of test does the study plan describe the representativeness of test, indicating limitations and uncertainties that apply to use of results?

Yes No N/A

For each type of test does the study plan provide illustrations of test locations?

Yes No N/A

For each type of test does the study plan discuss the relationship of the test to set performance goals and confidence levels?

Yes No N/A

For each type of analysis does the study plan state the purpose of analysis, indicate conditions to be evaluated and describe any uncertainty analysis?

Yes No N/A

For each type of analysis does the study plan describe the methods of analysis, including analytical expressions and numerical models to be used?

Yes No N/A

For each type of analysis does the study plan reference the technical procedures document that will be followed during analysis?

Yes No N/A

Some procedures have yet to be written. The study plan includes prototype testing indicating the procedures require further development.

For each type of analysis does the study plan indicate levels of QA applied?

Yes No N/A

Determination of the quality status for the activities of this study will be made separately.

For each type of analysis does the study plan identify data input

requirements?
Yes No ___ N/A ___

For each type of analysis does the study plan describe the expected output and accuracy?
Yes No ___ N/A ___

For each type of analysis does the study plan describe the representativeness of analytical approach, indicating limitations and uncertainties that apply to results?
Yes No ___ N/A ___

IV. Application of Results

Does the study plan briefly discuss where results from study will be used for support of other studies?
Yes No ___ N/A ___

Does the study plan refer to specific performance assessment analyses?
Yes No ___ N/A ___

Does the study plan describe where information from the study will be used in construction equipment and engineering system design and development?
Yes No ___ N/A ___

Does the study plan describe where information from study will be used in planning other characterization activities?
Yes No ___ N/A ___

V. Schedules and Milestones

Does the study plan provide durations of and interrelationships among principal activities associated with this study?
Yes No ___ N/A ___

Does the study plan list key milestones including decision points associated with study activities?
Yes No ___ N/A ___

Does the study plan describe the timing of the study relative to other studies and other program activities?
Yes ___ No N/A ___

The study plan mentions that the scheduling is dependent on the schedules of other studies but does not go into details.

Does the study plan provide dates for activities for the study plans: reference section 8.5 in SCP?
Yes ___ No N/A ___

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