NRC PHASE II REVIEW OF DOE STUDY PLAN FOR CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW (STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0)

by

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INTRODUCTION

Background

In the Phase I review (Coleman, 1991) of Study Plan for Characterization of the Yucca Mountain Regional Surface-water Runoff and Streamflow, it was determined that the Study Plan qualified for a NRC detailed technical review because of the NRC study plan review criteria 3 and 4 (U.S. NRC, 1990, Section 4.2, Step 6, pp. 7-8). Criterion 3 specifies a detailed technical review if "unique methods that have not been well developed and therefore do not have a supportive scientific history of providing data useable in licensing." Criterion 4 specifies a detailed technical review if "the plan includes the monitoring of natural phenomena and results in the collection of non-reproducible historical data important to the evaluation of repository performance." In response to that determination the Project Directorate requested a detailed technical review (Stablein, 1991).

Review Objectives

The detailed technical review of this study plan was based on the Draft Review Plan for NRC Staff Review of DOE Study Plans and Procedures (U.S. NRC, 1990), and which stipulates an evaluation of "the extent to which activities, tests, and analyses presented in the study plan will enable DOE to obtain the information for licensing that the study is designed to obtain and that it should obtain"(p. 4), or evaluate "the adequacy of a given study to provide the information for licensing that it should provide ..." (p. 5), or that the study plan is "adequate to provide the data for

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licensing that the study plan should provide and that it was designed to provide."(p. 9). It was also evaluated for "whether progress toward resolution of any SCA or other NRC open items can be identified on the basis of the contents of the study plan."(p. 4).

Focus of the Detailed Technical Review

For this study plan, the detailed technical review focused on Section 3, "Description of Activities." The activities of this study plan are:

3.1 Surface-water runoff monitoring
3.2 Transport of debris by severe runoff

GENERAL COMMENTS

On page 2.1-5 (3rd paragraph) of the study plan, it is stated that "Current time lines call for four additional years of surface-water data collection" and that "[f]ortunately, six years of record already exist." Table 3.1.1 (p. 3.1-13) lists 49 streamflow gaging sites of which 23 are shown as proposed locations in Figure 3.1-4. (Note: Table 3.1.1 should indicate the installation date of a gage and period or periods of record, or if it is a proposed site.) Thus it appears that there are not 6 or more years of data for a significant number of locations and particularly those over or adjacent to the planned repository location.

Also, it is noted that of the 20 SR gaging locations, 10 have "crest stage" measuring devices which will provide little data for determining flow volumes and determinations of channel flow contributions to the regional groundwater system.

DETAILED TECHNICAL REVIEW

Review of 3.1 Surface-water runoff monitoring

One of the six objectives of this activity of the Study Plan is "to collect runoff data at many sites on Yucca Mountain, in order to quantitatively assess the runoff component of the hydrologic cycle as an aid to unsaturated-zone ground-water studies." In response to this objective, an impressive array of surface-runoff measuring sites have been proposed and the program has been divided into two types of stream-gaging networks. One is for a regional study and the other is for a site study. However, the focus of the investigations and location of the majority of the runoff gaging sites are associated with an attempt to assess the contribution of channel flow to the regional groundwater table. This focus is reflected in objective 5 which states, "to develop needed data bases to assess the feasibility of adapting and applying a

precipitation-runoff model for Fortymile Wash" and the extensive study plan discussion that focuses on Fortymile Wash and the large regional channels (Subsection, 3.1.3.2 Streamflow Measurements, pp. 3.1-10,& 3.1-21-25). In contrast, about one page of the study plan (pp. 3.1-25,26) is devoted to description and discussion of the site study.

DOE acknowledges that the "regional streamflow-measurement network is not of adequate areal density, or of a needed level of detail, to satisfy the information needs" (p. 3.1-25) to determine the contribution (if any) of infiltration and surface runoff to the moisture flow in the "deep" unsaturated zone. Because of this need, DOE has proposed the 23 locations shown on Figure 3.1-4. With respect to the input to the unsaturated flow regime above the repository and an evaluation of repository performance, this aspect of the study is as important if not more important than the regional study. Also given the nature of the precipitation and runoff events of this region, a network of small watershed sites may also provide more data and information over the duration of the study. Thus it becomes important to place additional emphasis on this part of the investigation, and within the site runoff studies, to give specific consideration to the surface flow from the west face of Yucca Mountain and in the Solitario Canyon (Comment 1, Attachment A).

Two cross-sections that begin on the west side of Solitario Canyon and extend in an easterly direction along the dip of the geologic formations under Yucca Mountain are shown in Figure 1 and 2. As is shown in Figures 1 and 2, the geologic formations dip down from Solitario Canyon fault zone which, in part, lies under the ephemeral stream channel of Solitario Canyon. Also note that the Topopah formation tilts to the north (the bottom of the formation is higher in the C-C' cross-section than it is in the A-B-B' cross-section). The locations of these cross-sections are shown in Figure 3. There is a possibility that ephemeral flows from the face of Yucca Mountain and in Solitario Canyon could be a supply of water (amounts, duration and ponded heads) for porous and fracture groundwater flow in the geologic formations above and in which it is proposed to locate the repository. The orientation of the geologic formations are such that the groundwater flow could be conveyed toward the proposed repository location. Also the shortest distance from the ground surface to the repository is from the Solitario Canyon face of Yucca Mountain as is indicated in Mansure and Ortiz (1984, Fig. 6). It is further noted that the Solitario Canyon fault zone is comprised of some brecciated regions which is covered by shallow soils and poorly sorted sandy and gravely matrices (see Figures 5 and 6 which were copied from Swadley et al., 1984).

Given these conditions of the site, consideration should also be given to locating the gaging stations with respect to the site characterization wells proposed in other parts of the Site

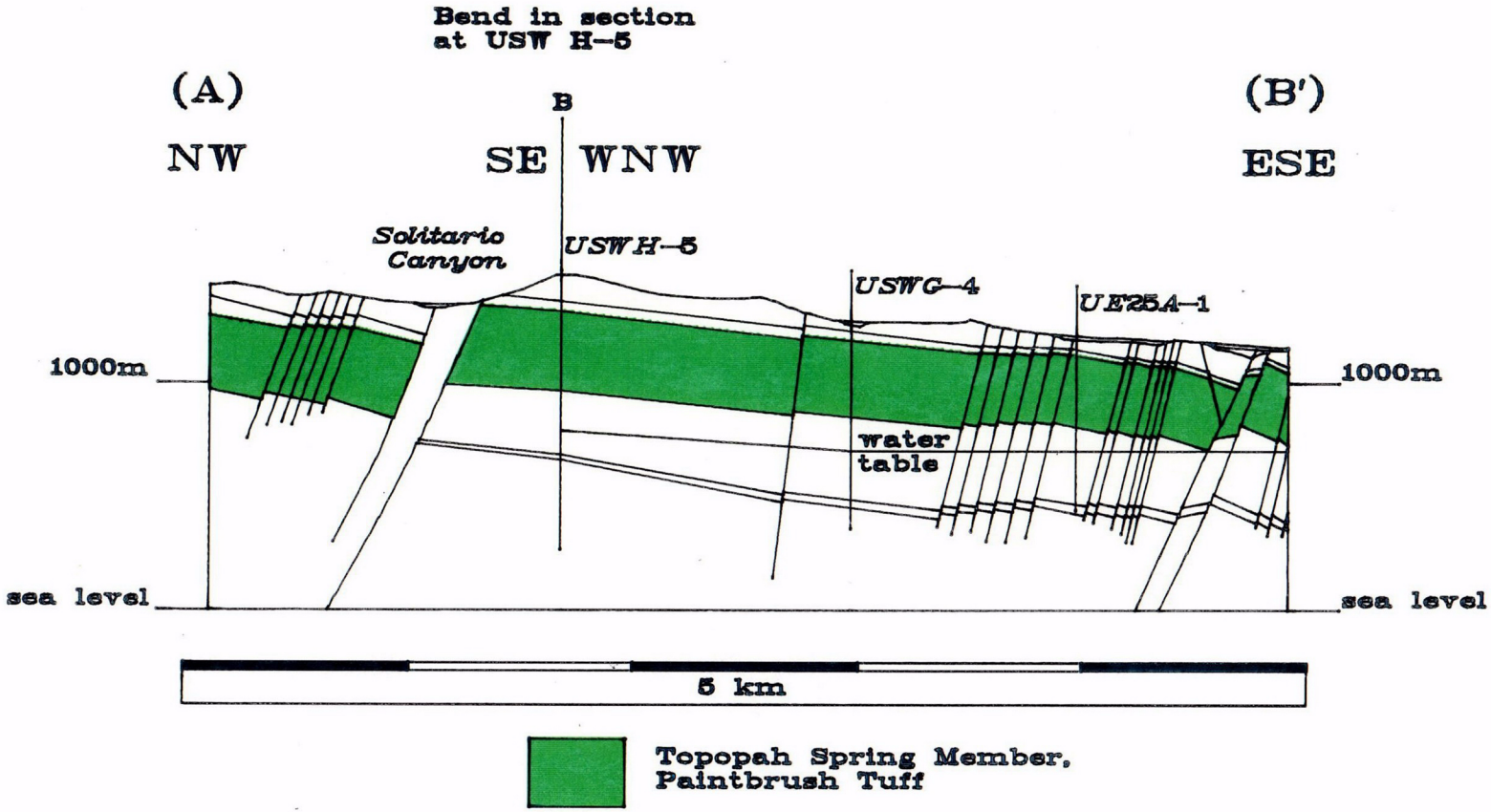

Figure 1: Composite cross-section A-A' and B-B' of Yucca Mountain from Solitario Canyon east (modified from Scott and Bonk, 1984 and Young, Stirewalt and Ratliff, 1990)

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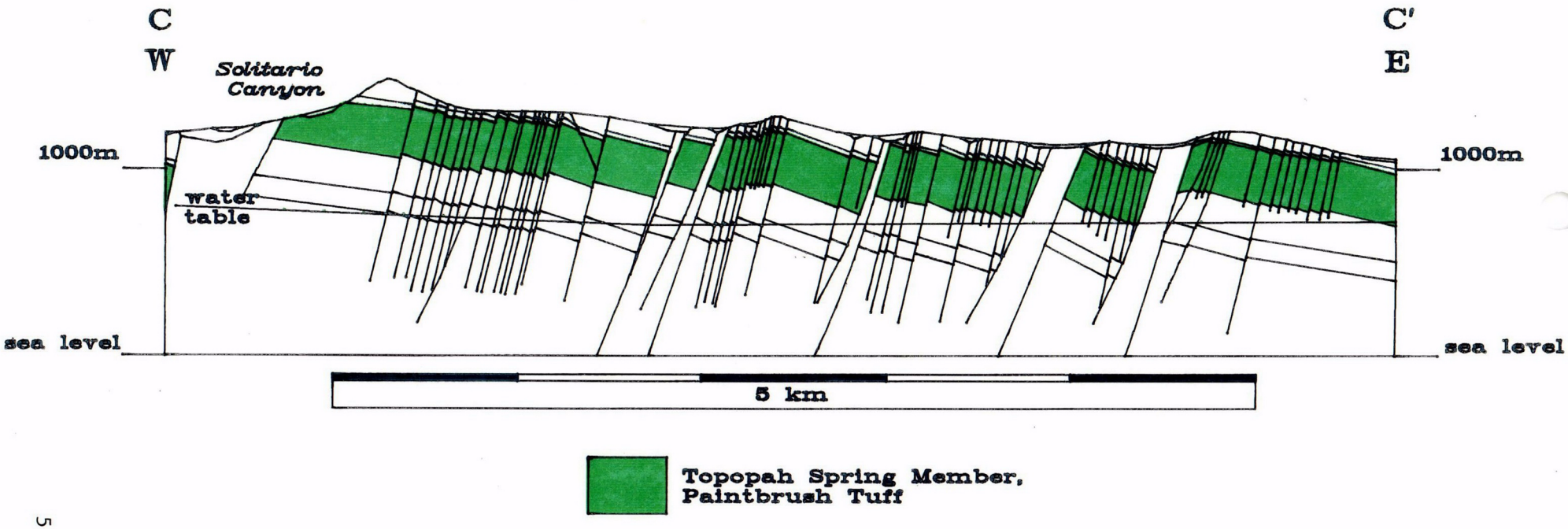

Figure 2: Cross-section C–C' of Yucca Mountain from Solitario Canyon east (modifed from Scott and Bonk, 1984 and Young, Stirewalt and Ratliff, 1990).

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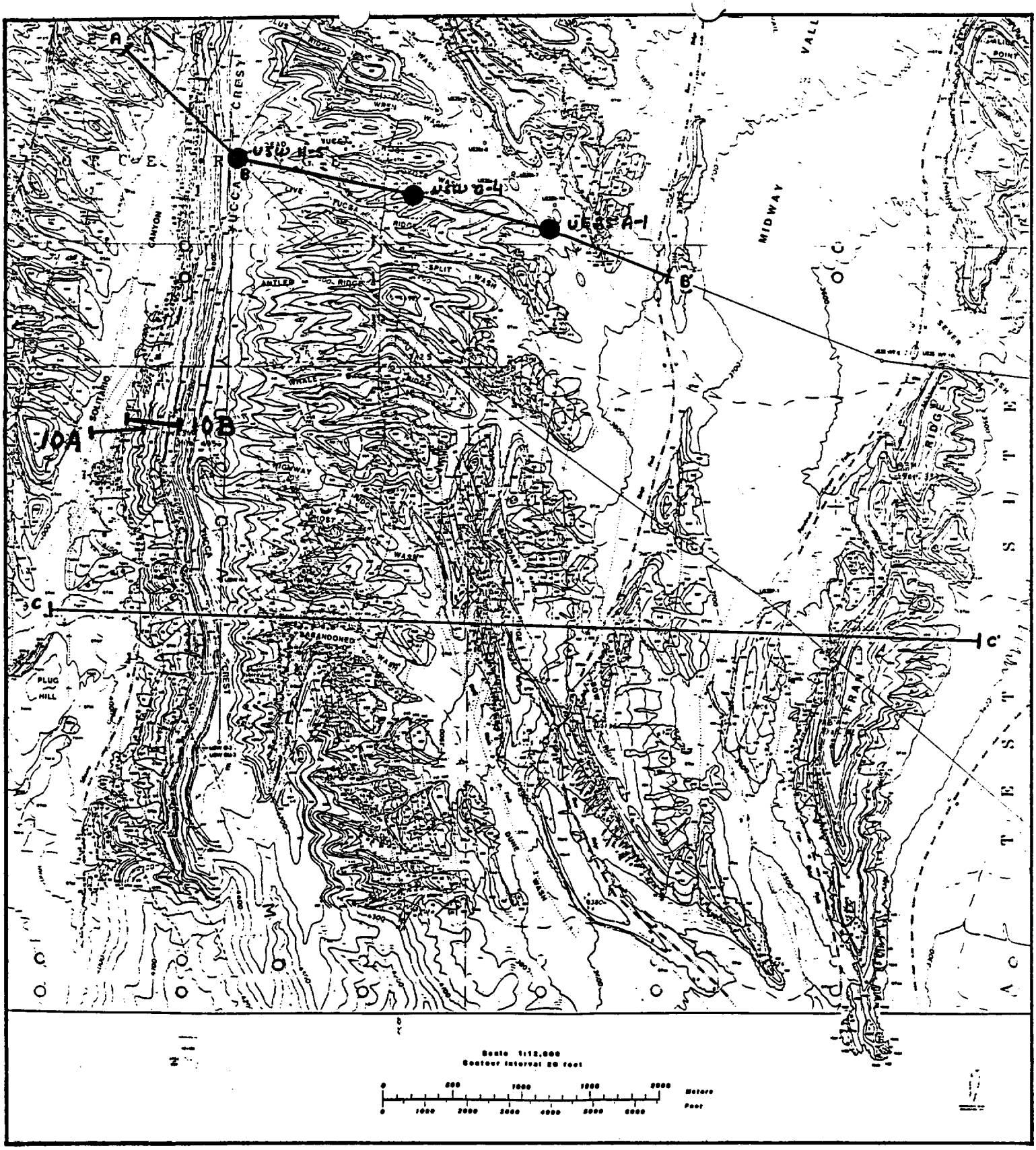

Figure 3. Location of cross-sections and Trenches 10A and 10B, Yucca Mountain. (Location of Trenches 10A and 10B are approximate - transferred from Plate 1, Swadley et al., 1984)

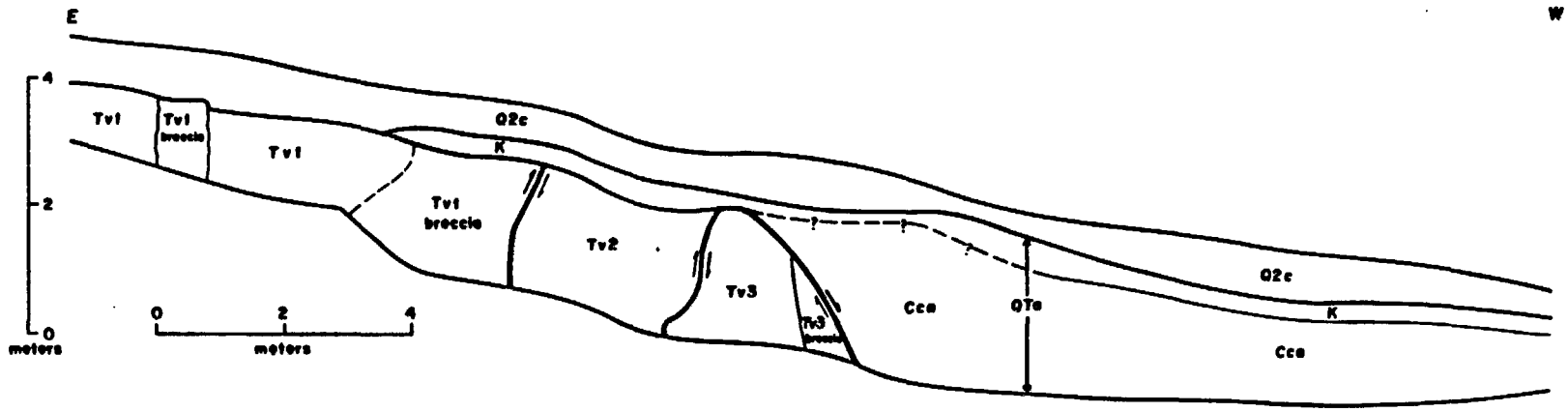

Figure A7.--Diagram of south wall of trench 10B, Solitario Canyon fault zone. Trench trends N. 80° W. Mapped in April 1983 by Swadley and H. E. Huckins. Fault at west edge of fault zone offsets QTa against Tertiary volcanic rocks. K horizon, developed in faulted QTa, and the overlying Q2c extend across the fault without offset.

Unit	Description
Q2c	Gravel, angular, poorly sorted, sandy matrix. Soil (not mapped separately) consists of light-brown cambic B horizon and a stage II Cca horizon
QTa	Gravel, coarse, poorly sorted, sandy matrix; cemented with stage III to IV carbonate development.
K	K horizon--gravel, angular, sandy matrix; cemented with stage III to IV carbonate development
Cca	CCa horizon--gravel, angular, poorly sorted; sandy, tuffaceous matrix; stage II carbonate development
Tv1	Tuff, welded, purplish-brown
Tv2	Vitrophyre, black
Tv3	Tuff, slightly welded, light-brown

Figure 4. Solitario Canyon trench 10B south face from Swadley et al. 1984

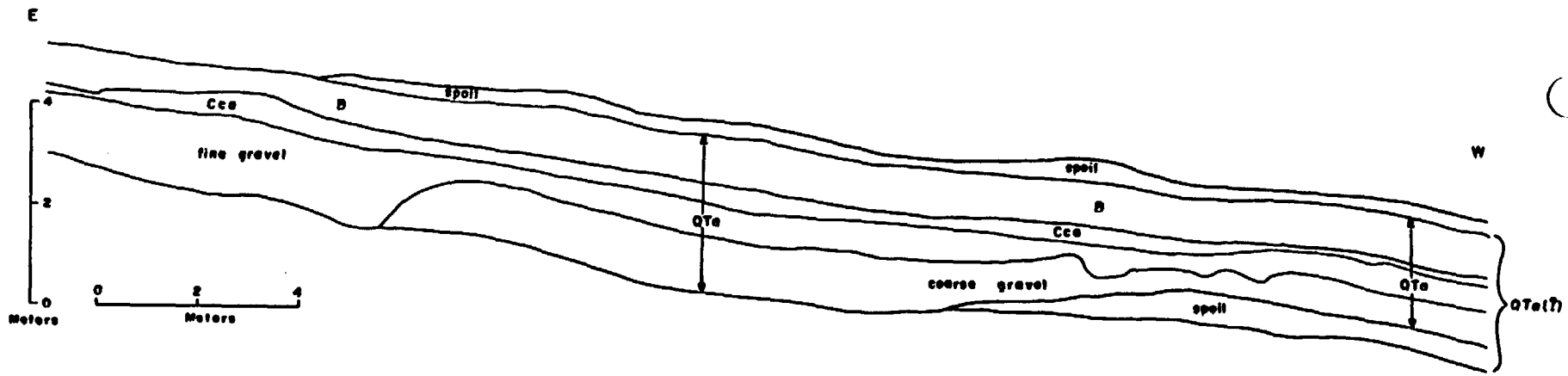

Figure A6.--Diagram of south wall of trench 10A. Trench trends N. 80° E. across a projection of the Solitario Canyon fault zone. Mapped in April 1983 by Swadley and H. E. Huckins.

Unit	Description
QTa(?)	Gravel--consists of a coarse cobble to boulder unit that is unsorted and nonbedded overlain by a sandy, angular pebble to cobble gravel that is poorly sorted and poorly to moderately well bedded. Soil developed in unit consits of B and Cca horizons
B	B horizon--cambic, light-brown; 0.2-0.3 m thick; may include younger slope wash unit at top
Cca	Cca horizon--developed in poorly sorted sandy gravel, stage II to III carbonate development

Figure 5. Solitario Canyon trench 10A south face from Swadley et al. 1984

Characterization Plan (i.e. 8.3.1.2.2.3.2, 8.3.1.2.2.3.3, 8.3.1.2.2.4.9, and 8.3.1.4.3.1.1) or vice versa. In addition, the NRC staff thinks that specific attention should be given to the study of surface runoff flows from the west face of Yucca Mountain and in Solitario Canyon (Comment 1, Attachment 1).

From the information in Figure 3.1-4, NRC recognizes that three gaging stations are proposed for Solitario canyon. Although gaging sites are proposed for the east side of the mountain (i.e. SY 1, 6, 8, 10, and 11), no sites are proposed for the west face of the mountain. Because of the potential significance of the surface flow in the area being discussed, DOE should consider additional gaging sites on the western side of the mountain, show the boundaries of the drainage areas for all watersheds, and develop in more detail the relationship of the three proposed Solitario Canyon gaging sites and any additional sites with respect to the existing wells, proposed wells, raingage locations, soils and surficial deposits, channel incisions, and exposed geologic formations in the Solitario Canyon area (Comment 1, Attachment A).

In general, a raingage located at the runoff gaging site is not adequate for the development of rainfall-runoff relationships. Thus it is important to indicate the type and location of all raingages that will be utilized in these evaluations (i.e. from Activity 8.3.1.2.2.1.2 and anywhere else that precipitation measurements are being or will be obtained.

DOE has indicated that it is important to have the "site" runoff measuring stations operating as soon as possible, "in the near future (FY 1991 and 1992)" [p. 3.1-25]. However this operational phase is dependent upon the completion of a field-test of the measurement devices, systems, and techniques to be used which was to be done "hopefully" in FY 1990 (p. 3.1-26). However, NRC staff has no knowledge that such field-testing has been accomplished. If the "site" runoff measurement locations are not instrumented at the beginning of the "restart" of site characterization activities, it will be difficult to collect the needed information from these studies prior to the submittal of a license application (Question 1, Attachment A).

In the paragraphs discussing the estimation of runoff frequencies (p. 3.1-28), it is stated that the alternatives to at site evaluation of runoff magnitude recurrence frequencies of 1) using precipitation and basin characteristics and 2) regionalized runoff relations were rejected. In the publication "Estimating Probabilities of Extreme Floods; Methods and Recommended Research" by the National Research Council (1988, p. 8), it is stated that "[i]nitially a single at-site analysis can be performed. This is a good starting point, and it uses recorded data at the point of interest. However, it must be recognized that data at a single site are too limited to permit more than a rough estimate and then only for relatively common floods." After some discussion about

the consideration of appropriate probability distributions, it is stated in the report,

> "After these preliminaries, the emphasis should be on increasing the data pool as much as practicable. There are two ways to do this: use of historical and other data, and the use of regional analysis." (NRC, 1988, p.8)

Therefore the NRC staff refers DOE to the guidance in this publication by the National Research Council and cautions against rejecting evaluating the probabilities of runoff magnitudes by any "regionalization" procedure or method (Comment 2, Attachment A).

In Table 3.1-3, DOE has listed a number of Technical Procedures that will be used for this study. Two of these procedures (HP-116,RO and HP-100,RO) are associated with the measurement of channel flow. It may be possible to augment or supplement the stilling well with float or bubbler measurements of stage with the use of sonar and pressure transducers, and it is not apparent that DOE has considered such instrumentation. Price current meters have limitations with respect to making velocity measurements in large ephemeral flows that occur in the semiarid environment. Thus, DOE could consider using other types of instrumentation for measuring flow velocity, especially for large ephemeral flows, in the planned measuring flumes. In this respect, there has been some experience with induction velocity probes for the measurement of high velocity flow in flumes which might be considered. (Question 2, Attachment A)

Review of 3.2 Transport of debris by severe runoff

This activity is significantly different from that of Activity 3.1 in that it is a "field-reconnaissance" type of investigation as contrasted to the extensive field instrumentation planned for the 3.1 activity. Thus, there will be limited "quantifiable" data except for the description (size and composition) of a "found" debris flow and of selected point surface and channel erosion. The information about the storm events and size of runoff or flow that caused or deposited a debris flow can only be inferred. Therefore the references to monitoring on pages 3.2-3 and 3.2-4 can only be associated with some aspects of the erosion part of the investigation unless there are plans to do sediment transport sampling at the gaging sites proposed in activity 3.1. This raises the question about whether there has been any consideration of doing sediment sampling at the gaging stations (Question 3, Attachment A).

Finally, the contemplated remote sensing (aerial photography) data collection activities for these type of reconnaissance studies may be quite useful, and it will be interesting to follow these developments.

SUMMARY

With respect to the general objective of a detailed technical review, the methods, in general, are adequate for the collection of the proposed information, however specific comments and questions have been made about the study emphasis, specific runoff gage locations, raingage locations, type of instrumentation contemplated and certain analysis procedures. The comments and questions of this review have been appended to this report in the standard NRC, DHLWM, comment format.

The NRC Staff analysis (U.S. NRC, 1989) of the Site Characterization Plan for the Yucca Mountain site developed comments 13, 15, and 18 that are directly associated with this study plan. The information in the study plan and the questions raised in this review about specific gage location do not contribute to progress toward resolution of these relevant SCA comments.

Action Items:

1. Add the comments and questions of this detailed technical review to the Open Items Tracking System and track to closure.

2. Have NRC staff hydrologists review the plans for locating and type of instrumentation for measuring precipitation and ephemeral stream flow in the channels on the east and west side of Yucca Mountain (the site study investigations).

REFERENCES

Coleman, N., 1991, "Phase I Review: DOE Study Plan for Characterization of the Yucca Mountain Regional Surface-water Runoff and Streamflow (Study Plan 8.3.1.2.1.2, Revision 0)," Hydrologic Transport Section, Geosciences & Systems Performance Branch, Division of High-Level Waste Management, NMSS, U.S. Nuclear Regulatory Commission, February 8.

Mansure A. J. and T. S. Ortiz, 1984, "Preliminary Evaluation of the Subsurface Area Available for a Potential Nuclear Waste Repository at Yucca Mountain," SAND84-0175, Sandia National Laboratories, December.

National Research Council (NRC), 1988, "Estimating Probabilities of Extreme Floods; Methods and Recommended Research," Committee on Techniques for Estimating Probabilities of Extreme Floods, Water Science and Technology Board, National Academy Press,

Washington, D.C.

Stablein, K., 1991, Note To: Dave Brooks, Subject: DETAILED TECHNICAL REVIEW OF STUDY PLAN FOR CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW (Study Plan 8.3.1.2.1.2), U.S. Nuclear Regulatory Commission, April 17.

Swadley, W. C., D. L. Hoover, and J. N. Rosholt, 1984, "Preliminary Report on Late Cenozoic Faulting and Stratigraphy in the Vicinity of Yucca Mountain, Nye County, Nevada," Open-File Report 84-788, U.S. Dept. of Interior, Geologic Survey, Denver, Colorado.

U.S. Nuclear Regulatory Commission (U.S. NRC), 1989, "NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada," Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, Washington D.C., August.

U.S. Nuclear Regulatory Commission (U.S. NRC), 1990, "Review Plan for NRC Staff Review of DOE Study Plans, Revision 1," Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, Washington D.C., December 6.

Attachment A of NRC Phase II Review of:

STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0, CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW
Activity 8.3.1.2.1.2.1, Surface-water runoff monitoring

Comment 1

The NRC staff thinks that specific attention should be given to the study of surface runoff flows from the west face of Yucca Mountain and in Solitario Canyon.

Basis

In response to the objectives of the study plan, an impressive array of surface-runoff measuring sites have been proposed and the program has been divided into two types of stream-gaging networks. One is for a regional study and the other is for a site study. However, the focus of the investigations and location of the majority of the runoff gaging sites are associated with an attempt to assess the contribution of channel flow the regional groundwater table.

DOE acknowledges that the "regional streamflow-measurement network is not of adequate areal density, or of a needed level of detail, to satisfy the information needs" (p. 3.1-25) to determine the contribution (if any) of infiltration and surface runoff to the moisture flow in the "deep" unsaturated zone. Because of this

NRC recognizes that three gaging stations are proposed for Solitario canyon from the information in Figure 3.1-4. Although gaging sites are proposed for the east side of the mountain (i.e. SY 1, 6, 8, 10, and 11), no sites are proposed for the west face of the mountain.

Recommendation

DOE should consider placing some gaging sites on the western side of the mountain, show the boundaries of the drainage areas for all watersheds, and develop in more detail the relationship of the three proposed Solitario Canyon gaging sites and any additional sites with respect to the existing wells, proposed wells, raingage locations, soils and surficial deposits, channel incisions, and exposed geologic formations in the Solitario Canyon area.

Attachment A of NRC Phase II Review of:

STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0, CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW
Activity 8.3.1.2.1.2.1, Surface-water runoff monitoring

Comment 2

The NRC staff cautions against rejecting evaluating the probabilities of runoff magnitudes by any "regionalization" procedure or method.

Basis

In the paragraphs discussing the estimation of runoff frequencies (p. 3.1-28), it is stated that the alternatives to at site evaluation of runoff magnitude recurrence frequencies of 1) using precipitation and basin characteristics and 2) regionalized runoff relations were rejected. In the publication "Estimating Probabilities of Extreme Floods; Methods and Recommended Research" by the National Research Council (1988, p. 8), it is stated that "[i]nitially a single at-site analysis can be performed. This is a good starting point, and it uses recorded data at the point of interest. However, it must be recognized that data at a single site are too limited to permit more than a rough estimate and then only for relatively common floods." After some discussion about the consideration of appropriate probability distributions, it is stated in the report,

> "After these preliminaries, the emphasis should be on increasing the data pool as much as practicable. There are two ways to do this: use of historical and other data, and the use of regional analysis." (NRC, 1988, p.8)

Recommendation

The NRC staff refers DOE to guidance of the 1988 publication, "Estimating Probabilities of Extreme Floods; Methods and Recommended Research" by the National Research Council and suggests that regional methods be included in the analyses.

Attachment A of NRC Phase II Review of:

STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0, CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW
Activity 8.3.1.2.1.2.1, Surface-water runoff monitoring

Question 1

Has the field-test of the surface runoff measurement devices, systems, and techniques to be used been completed? And if not when will they be completed?

Basis

DOE has indicated that it is important to have the "site" runoff measuring stations operating as soon as possible, "in the near future (FY 1991 and 1992)" [p. 3.1-25]. However this operational phase is dependent upon the completion of a field-test of the measurement devices, systems, and techniques to be used which was to be done "hopefully" in FY 1990 (p. 3.1-26). However NRC staff has no knowledge that such field-testing has been accomplished. If the "site" runoff measurement locations are not instrumented at the beginning of the "restart" of site characterization activities, it will be difficult to collect the needed information from these studies prior to the submittal of a license application.

Recommendation

Provide a discussion of the status and schedules for the planned field-test of the surface runoff measurement devices.

Attachment A of NRC Phase II Review of:

STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0, CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW
Activity 8.3.1.2.1.2.1, Surface-water runoff monitoring

Question 2

Has DOE considered any other instrumentation for measuring in situ flow depth and velocity, especially for large ephemeral flows such as sonar, pressure transducers, and induction probes?

Basis

In Table 3.1-3 of the study plan, DOE has listed a number of Technical Procedures that will be used for this study. Two of these procedures (HP-116,RO and HP-100,RO) are associated with the measurement of channel flow. To augment or supplement the stilling well with float or bubbler measurements of stage, the DOE might considered the use of sonar and pressure transducers. Price current meters have limitations with respect to making velocity measurements in large ephemeral flows that occur in the semiarid environment. Thus, DOE could consider using other types of instrumentation for measuring flow velocity, especially for the large ephemeral flows, in the planned measuring flumes. There has been some experience with induction velocity probes for the measurement of high velocity flow in flumes which might be considered.

Recommendation

Provide a discussion of the evaluations made and the types of flow measuring structures and instrumentation considered and selected (if appropriate) for the surface runoff monitoring activity.

Attachment A of NRC Phase II Review of:

STUDY PLAN FOR STUDY 8.3.1.2.1.2, Revision 0, CHARACTERIZATION OF THE YUCCA MOUNTAIN REGIONAL SURFACE-WATER RUNOFF AND STREAMFLOW
Activity 8.3.1.2.1.2.2, Transport of debris by severe runoff

Question 3

Are there plans for taking sediment samples at the gaging stations?

Basis

The debris transport activity is significantly different from that of the surface-water runoff monitoring activity (Section 3.1) in that it is a "field-reconnaissance" type of investigation as contrasted to the extensive field instrumentation planned for the 3.1 activity. Thus, there will be limited "quantifiable" data except for the description (size and composition) of a "found" debris flow and of selected point surface and channel erosion. The information about the storm events and size of runoff or flow that caused or deposited a debris flow can only be inferred. Therefore the references to monitoring on pages 3.2-3 and 3.2-4 can only be associated with some aspects of the erosion part of the investigation unless there are plans to do sediment transport sampling at the gaging sites proposed in activity 3.1.

Recommendation

Provide a discussion of plans (if any) for sediment sampling.