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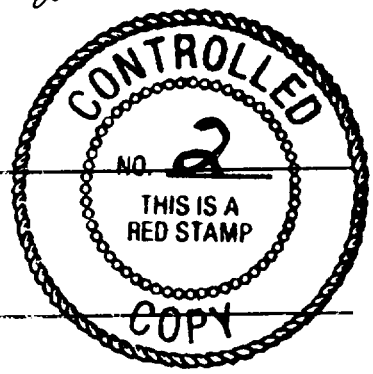

Study Plan for
Study 8.3.1.16.1.1

Characterization of Flood Potential and Debris Hazards of the Yucca Mountain Site

Revision 0

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, DC 20585

Prepared by
U.S. Geological Survey

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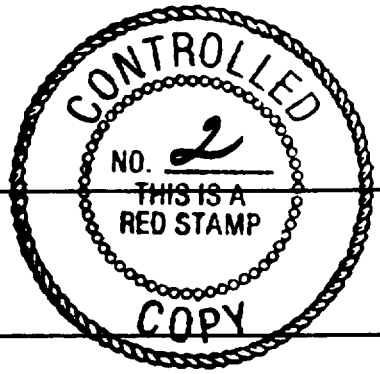

Study Plan for
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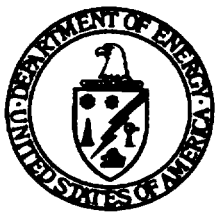

Characterization of Flood Potential and Debris Hazards of the Yucca Mountain Site

Revision 0

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YUCCA MOUNTAIN PROJECT

T-AD-088
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Study Plan Number 8.3.1.16.1.1

Study Plan Title Site Flood and Debris Hazard Study

Revision Number R0

Prepared by: Pat Glancey

Date: August, 1990

Waxwell Blanchard 9/13/90
Director, Regulatory and Site Evaluation Division / Date

James Blaylock for 9/17/90
Director, Quality Assurance Division / Date

Effective Date September 18, 1990

ABSTRACT

This study plan describes the plans for one site-characterization activity to be performed at Yucca Mountain. This activity will contribute to an understanding of the potential for flooding and debris hazards at Yucca Mountain and its immediate environs during the preclosure period of repository operation, and also will provide hydrologic parameter input for the resolution for design and performance issues. The activity comprising this study is:

- Site flood and debris hazards studies.

The rationale of the overall flood-potential and debris-hazards study is described in Sections 1 (regulatory rationale) and 2 (technical rationale). Section 3 describes the specific activity plans, including the tasks and analyses to be performed, the selected and alternate methods considered, and the technical procedures to be used. Section 4 summarizes the application of the study results and Section 5 presents the schedules and associated milestones.

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1 PURPOSE AND OBJECTIVES OF STUDY

1.1 Purpose of the study plan

The U.S. Geological Survey (USGS), as part of the Yucca Mountain Project (YMP), is conducting studies at Yucca Mountain, Nevada. The purposes of these 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. In particular, the project is designed to acquire information necessary for the Department of Energy (DOE) to demonstrate in its environmental-impact statement and license application whether the MGDS will meet the requirements of federal regulations 10 CFR Part 60, 10 CFR Part 960, and 40 CFR Part 191.

The purpose of this study plan is to describe and outline strategies to evaluate flood and debris hazards potential at or near the Yucca Mountain site. The study contains one activity:

- 8.3.1.16.1.1.1 - Site flood and debris hazards studies

Note that the numbers (e.g., 8.3.1.16.1.1.1) used throughout this plan serve as references to specific sections of the YMP Site Characterization Plan (SCP). The SCP (U.S. Department of Energy, 1988) describes the technical rationale of the overall site-characterization program and provides general descriptions of the activity described in detail in Section 3 of this study plan.

Figure 1.1-1 illustrates the relation of this study to other investigations and studies within the SCP preclosure hydrology program. The flood recurrence intervals and levels investigation contains one study, namely, the characterization of flood potential at the Yucca Mountain site. The study in its single activity will employ streamflow and debris transport data collected in other studies in order to estimate frequencies and magnitudes of potential future flood events and to characterize the debris hazards that may be associated with them. This activity was selected on the basis of various factors. Time and schedule requirements were considered in determining the number and types of investigative tasks chosen to obtain the required data. Tasks were designed on the basis of design and performance parameter needs, available task and analysis methods, and task scale and interferences. These factors are described in Sections 2 and 3.

The plans for this activity are presented in Section 3.1. The description includes (a) objectives and parameters, (b) technical rationale, (c) investigative tasks and analyses, (d) site impacts, and (e) schedules and milestones. Alternate task and analysis methods are summarized, and cross references are provided for quality-assurance levels and technical procedures.

Application of the study results is summarized in Sections 1.3 and 4, schedules and milestones are presented in Section 5, and a study-plan reference list is presented in Section 6. Quality-assurance procedures and quality-assurance level assignments are documented in Section 7.1.

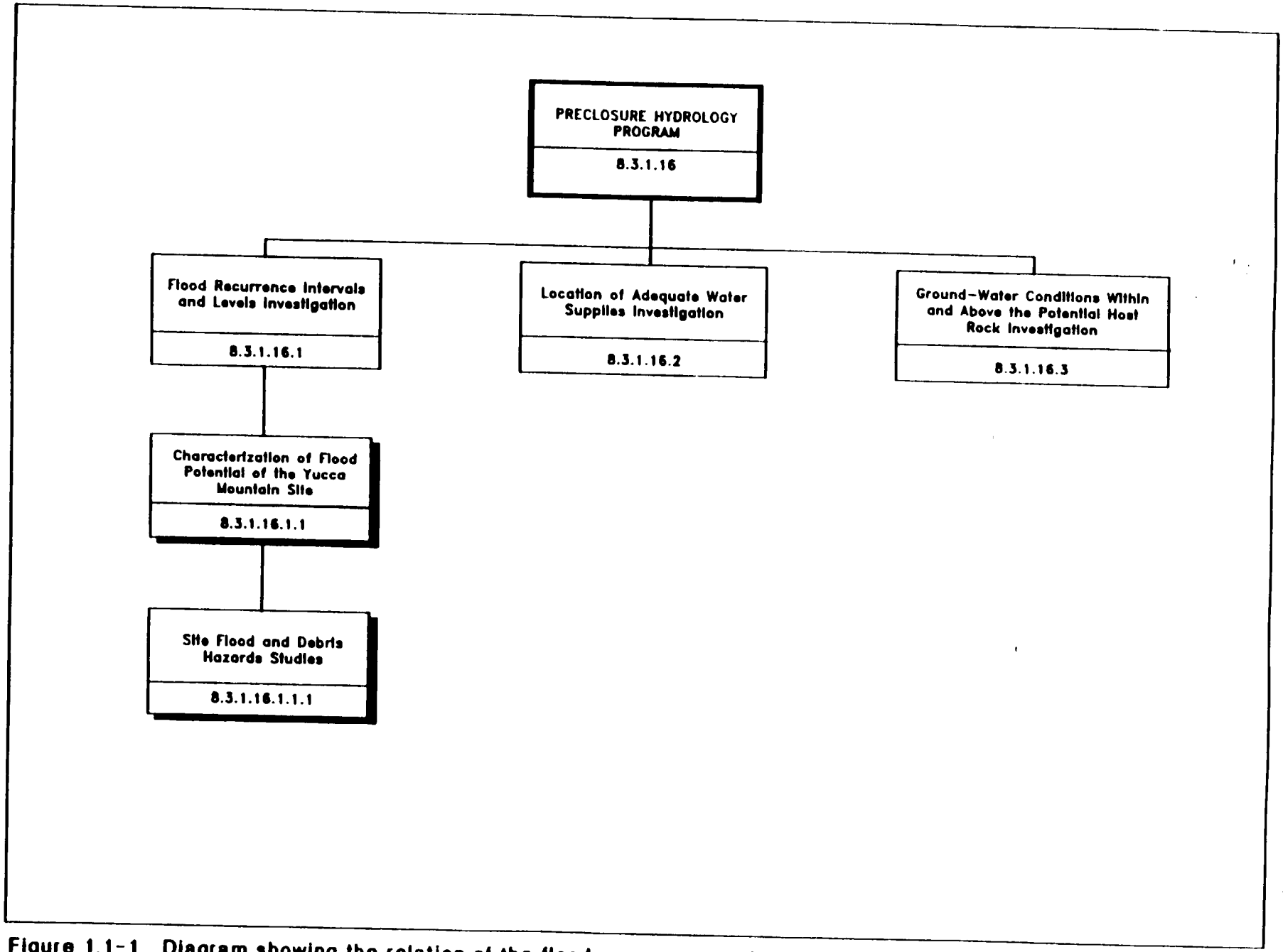

Figure 1.1-1. Diagram showing the relation of the flood recurrence and debris hazards investigations to the organization of the preclosure hydrology program.

1.2 Objectives of study

The objective of the study is to evaluate both qualitatively and quantitatively the potential for flooding and associated debris hazards at Yucca Mountain and immediate environs during the preclosure period of repository operation. The resultant knowledge will contribute to site characterization and design and performance issues so that the repository facilities may be engineered to prevent or reduce the hazards associated with flood events.

To meet the purpose of identifying the potential hazards associated with floods and debris movement, three specific objectives must be met. These are satisfied by Activity 8.3.1.16.1.1.1 by (1) determining the magnitudes and frequencies of major flood events that can potentially occur during the period of repository operation, (2) identifying all potential areas of inundation, and (3) determining the quantities and characteristics of debris transported by flooding.

1.3 Regulatory rationale and justification

The flood and debris hazard data collected and calculated in this study will provide input to performance issues associated with total system performance, radiological health and safety, and NRC siting criteria, and to design issues associated with the underground repository and repository seals.

The overall regulatory-technical relations between the SCP design and performance information needs and the data collected in this study are presented in the preclosure hydrology testing strategy presented in SCP Section 8.3.1.16 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 presented in Appendix 7.2.

Project-organization interfaces between the flood-potential and debris-hazards study (8.3.1.16.1.1) 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.

In this and other study plans, it has been useful to group the measured and calculated parameters of the various activities (activity parameters) into a limited set of site-characterization parameters, broader categories of information that encompass activity-parameter data collected in the field and laboratory or calculated in subsequent analytical methods. By introducing this category, it becomes easier to demonstrate how the study relates to satisfying the information requirements of parameters in the design and performance issues. In the case of the site flood and debris hazards study, the activity parameters (presented in Figure 3.1-2 and Table 3.1-1, Section 3.1) can be brought under site-characterization parameters which are listed below, along with their corresponding activities:

Activity 8.3.1.16.1.1.1 - Site flood and debris transport studies	Potential for future flooding: magnitude and frequency of flooding at specific locations
	Potential for future flooding: potential hazards of debris transported by flood flows
Activity 8.3.1.2.1.2.1 - Surface-runoff monitoring	Runoff and streamflow: temporal, spatial, and physical characteristics
Activity 8.3.1.2.1.2.2 - Transport of debris by severe runoff	Debris transport: quantities and characteristics

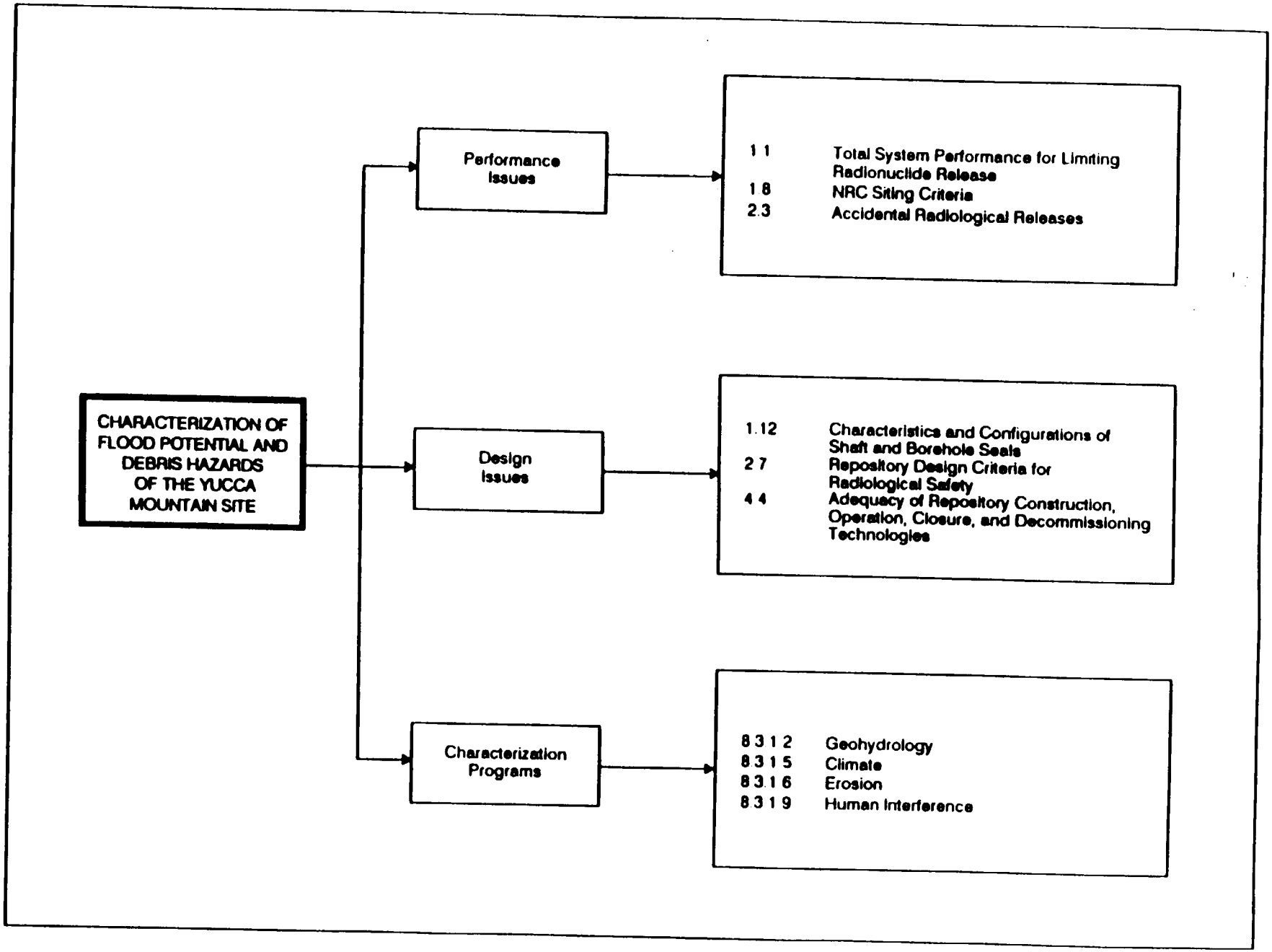

Figure 1.3-1. Interfaces of the site flood and debris hazards study with YMP performance and design issues and other site characterization programs.

The site-characterization parameters of Activities 8.3.1.2.1.2.1 and 8.3.1.2.1.2.2, which constitute the characterization of runoff and streamflow study (SP 8.3.1.2.1.2), have been included in the above list to emphasize the direct contribution that the parameters from that study make to the assessment of potential future flooding and associated debris hazards. The data contributed by the surface-water and debris-transport study will be supplemented and complemented by data on prehistoric floods collected as part of the paleo-flooding activity:

Activity 8.3.1.5.2.1.1 - Regional paleoflood evaluation	Paleoflood flows: magnitudes, frequencies, areal extents, and hydraulic characteristics
	Paleoflood debris movement: quantities and characteristics

The present study may also be supplemented by data on potential changes in the surface-water regime, in response to possible climate changes, generated in Activity 8.3.1.5.2.2.1 (Analysis of future surface hydrology due to climate changes).

The relations between the site-characterization parameters for this study and Study 8.3.1.2.1.2 and their contributing activity parameters are shown in Table 2.1-1, and also in Figure 3.1-2. Relations between site-characterization parameters and design and performance parameters are shown in Table 7.2-1.

It is important to recognize that the present study is the vehicle by which the site information collected in the runoff and streamflow study, paleoflood studies and streamflow modeling exercises contributes to the design and performance parameters concerned with potential flooding and debris hazards. It is for this reason that the activity parameters from the runoff and streamflow study have been included in tables and figures appearing in Sections 2 and 3 of the present study.

The potential for future flooding must be examined to determine if engineering measures that require excessive cost, or technology beyond that which is reasonably available, will be needed. This study will obtain specific data required elsewhere in the project for the design of the systems and components of the repository that are important to safety. These designs will consider the margins of safety under conditions that may result from expected operational occurrences, including those of natural origin such as flooding. They must also consider the adequacy of structures provided for the prevention of accidents and mitigation of their consequences, including natural phenomena. Thus, information on the flood potential of the site is needed to aid in the design of the flood-control measures, should they be required.

The following discussion of the uses of site-characterization data from this study in resolving performance and design issues is based upon performance measures and design and performance parameters identified in SCP Sections 8.3.2 through 8.3.5.

Design Issue 2.7
(Repository design criteria for radiological safety)

Frequencies and magnitudes of repository surface flooding are required as design parameters for this issue, and apply to several of its subfunctions. These are:

- Monitoring and controlling the dispersal of radioactive contamination, where the performance measures are various engineering considerations, including the potential for accidental reversals of airflow, and flow patterns of ventilation systems.

- Providing ventilation systems for the repository facility that will protect against radiation exposure, where the performance measures are the decontamination factor and the number of filter banks in the ventilation system.

- Protecting structures, systems, and components important to safety against natural phenomena and environmental conditions, where the performance measure is the effects of credible natural phenomena on structures, systems, and components that are important to safety.

- Ensuring that utilities important to safety will continue their safety function during emergencies, where the performance measure is the ability of these utilities to continue to perform safety functions during design-basis accidents.

- Providing instrumentation and control systems to monitor and control structures, systems, and components important to safety for all anticipated ranges of operation, where the performance measures are ranges of operation of monitoring and control instrumentation, and the ability to control the above structures, systems, and components.

- Criticality control, where the performance measures are the possibility of accidental disruption of waste geometry leading to unfavorable configurations, possibility of accidental disruption of waste leading to unfavorable concentrations of fissile materials, and possibility of accidental introduction of moderating materials into areas containing waste.

Design Issue 4.4
(Adequacy of repository construction, operation, closure, and decommissioning technologies)

Flood-frequency and -magnitude data are needed for analyses being performed to determine the impacts of potential flooding on the design of the surface facilities. The surface hydrology of floods of various magnitudes and the probable maximum flood are needed, as well as the areas of inundation of these floods. The topography of the drainage areas contributing to the floods must be known, as well as the topography at surface-facility locations. Debris quantity and categories will also be

required for the various potential flood events. This information is required for the surface-system element, so that it can fulfill the function of providing facility sites (including underground accesses) that are not jeopardized by natural or manmade phenomena. The performance measure applying to this function is the location of surface facilities relative to the floodplains for potential flood events, with the tentative goal that the surface facilities be constructed to minimize flood hazards.

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

This issue requires the same site-characterization data as does Issue 4.4. In this issue the flood-potential data will be applied to the design and placement of the following sealing-system elements.

- Anchor-to-bedrock plug/seal: The quantity of water is the performance measure, with the process being water entering the upper portion of the shaft or ramp. Site information from this study will be used to assess one of the plug/seal functions, which is to reduce the amount of water that could potentially reach the waste-disposal rooms.

- General fill: The quantity of water is the performance measure, with the process being infiltration of surface and subsurface waters reaching the base of the shafts. Site information from this study will be used to assess one of the general fill functions, which is to reduce the amount of water that could potentially reach the waste-disposal rooms.

- Station plugs: The quantity of water is the performance measure, with the process being water passage from the base of the shaft to the waste-emplacement drifts. Site information from this study will be used to assess the function of the station plugs, which is also to reduce the amount of water that could eventually reach the waste-disposal rooms.

Performance Issue 1.1
(Total system performance for limiting radionuclide release)

The performance parameter requiring site information from this study is the expected magnitude of local moisture flux change, and quantitative bounds on local moisture flux change, caused by flooding through access shafts. The intermediate performance measure is the time of radionuclide transport through the unsaturated zone, and the initiating event is the formation of natural surface-water impoundments over access shafts connecting the ground surface and the repository. This event is part of Scenario Class C1, local or extensive increases in percolation flux through the unsaturated zone. The site-characterization data from this study applying to the above performance parameter are the frequencies and magnitudes of potential future flooding.

Performance Issue 2.3
(Accidental radiological releases)

Frequencies and magnitudes of repository surface flooding constitute the performance parameter in this issue. It applies to the site-system element, whose function in the context of this issue is to provide a location that assists in limiting potential radiation exposure to the public and workers from accidents. The performance measure here consists of consequences of credible site-related accidents, and the tentative goal for the performance measure is to keep radiation doses well below applicable limiting values.

Performance Issue 1.8
(NRC siting criteria)

Site information collected from the present study will be applied indirectly through design issues to the resolution of Issue 1.8, demonstrations of favorable and potentially adverse conditions as required by 10 CFR 60.122. The study addresses Potentially Adverse Condition (PAC) 1:

> Potential for flooding of the underground facility, whether resulting from the occupancy and modification of the floodplains or from the failure of existing or planned man-made surface-water impoundments.

This PAC describes a pre-closure condition that could affect the postclosure performance of the repository. Flooding of the underground facility during the preclosure period could result in conditions, such as standing pools of water, that could adversely affect the performance of the waste package. Locally intense flooding occurs periodically in the normally dry washes draining down from Yucca Mountain ridge. Preliminary investigations (Squires and Young, 1984) of projected 100- and 500-yr floods have determined that the 100-yr flood would not exceed the banks of incised channels of Fortymile Wash or its major tributaries (Yucca, Drill Hole, and Dune washes). The 500-yr flood, however, could exceed the banks of Dune (Busted Butte) and Drill Hole washes. The available evidence suggests, therefore, that this PAC may be present. It will be necessary, in order to resolve this PAC, to show that it will not significantly affect the ability of the repository to isolate waste.

2 RATIONALE FOR STUDY

2.1 Technical rationale and justification

2.1.1 Role of study in assessing future flooding potential

Largely for safety and economic reasons, surface facilities such as roadways, building pads, and buildings to serve as workshops, offices, laboratories, and living spaces must be located and designed for minimum natural disturbance during their intended life (approximately 100 years). It is also critical that all surface sites for handling the waste packages, including building, storage areas, and repository-access facilities such as shaft collar and hoisting structures be located in an area where flood or debris-flow events would not have serious effects on their stability during the preclosure period.

To accomplish this, this study has been designed to document flooding and severe sediment erosion, transport, and deposition to aid in predicting the maximum flood intensities and recurrence intervals which are necessary for the design of safe facilities. By estimating the flood magnitudes of different recurrence intervals, and quantifying the associated probable-maximum flood levels, adequate design measures can be implemented to avoid and mitigate the hazards associated with flood events.

2.1.2 Parameters and testing strategies

In SCP usage (DOE, 1988) hydrologic activity parameters are those parameters that are generated by field and laboratory testing activities; they represent the most basic measurements that will be used to characterize the geohydrology of Yucca Mountain and vicinity. Many of the activity parameters are building blocks to support various aspects of the project. Some, such as magnitudes and frequencies of potential future floods, support design and performance issues directly. Others, such as the sediment component of potential future floods, primarily provide bases for analyses and evaluations to be conducted within the geohydrology program or within other characterization programs.

In SCP Table 8.3.1.2-1, activity parameters for the geohydrology program are grouped according to parameter categories, which also appear in Figure 2.1-1. The activity parameters associated with the site flood and debris hazards activity also appear in Table 3.1-1 of Section 3. Parameter categories serve to group similar types of performance and design parameters supporting design and performance-assessment issues resolutions (SCP Sections 8.3.2-8.3.5) and match them with groups of similar types of activity parameters to be obtained during site characterization. Parameter categories in the SCP were introduced as a classification scheme to aid in assessing the appropriateness and completeness of the data collection program. In Figure 2.1-1, the categories are shown supporting specific model components that make up the surface-water model. This figure corresponds to SCP Figure 8.3.1.2-4, and in that document is accompanied by parallel logic diagrams for

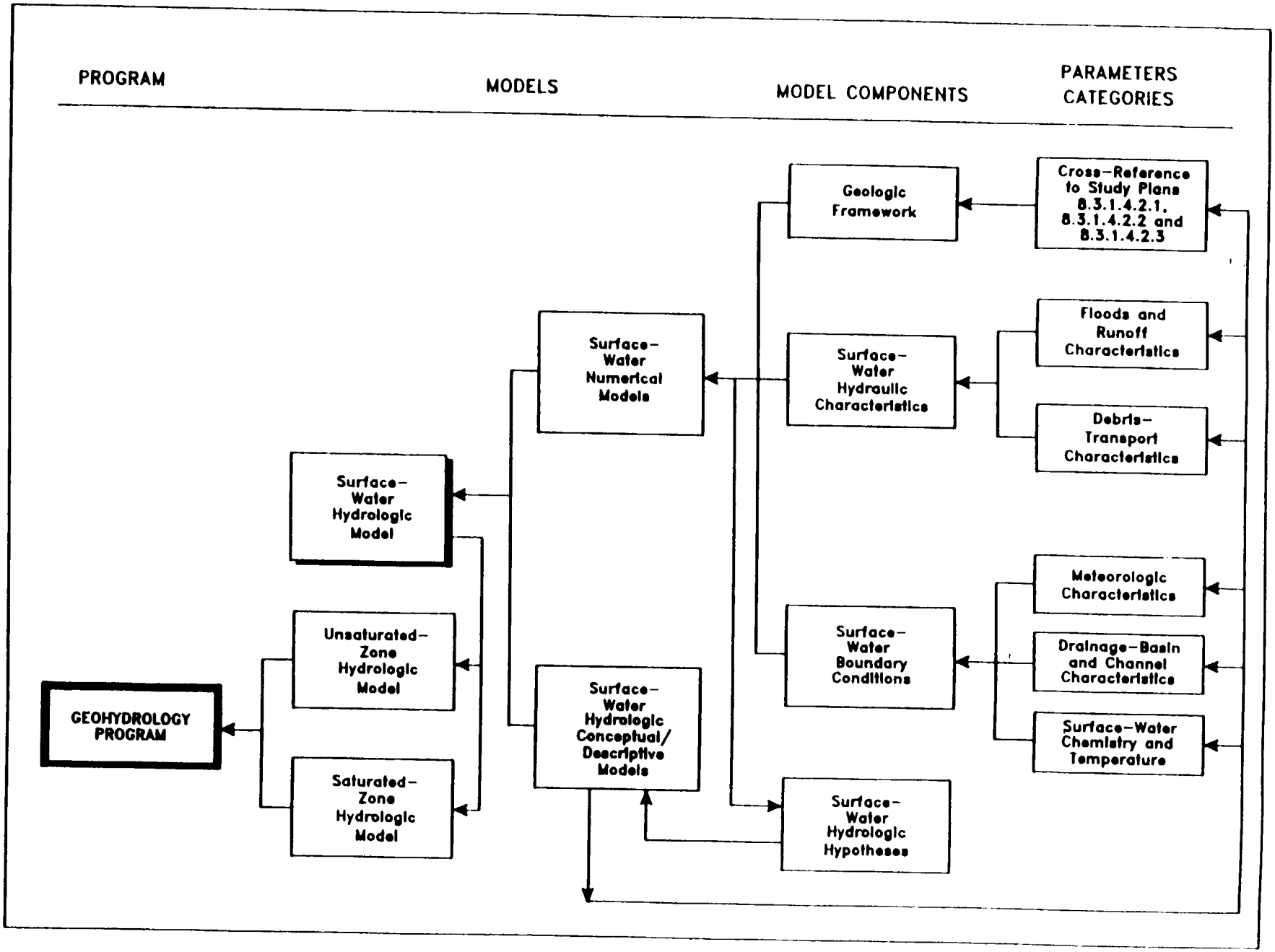

Figure 2.1-1. Diagram of the surface-water hydrology component of the geohydrology program.

the saturated- and unsaturated-zone components of the geohydrology program.

Table 2.1-1 groups the activity parameters of the study according to characterization parameters. In SCP usage, a characterization parameter is a parameter obtained by a characterization program that has a logical, direct tie to a performance or design parameter, and for which a testing basis can be defined. Most characterization parameters will be developed from some combination of activity parameters, and will be the products of data reduction, test analyses, and modeling. Some of the activity parameters listed in Table 2.1-1, although not required directly for resolving performance and design issues, are required to accomplish satisfactory analysis of flood potential, which in turn increases confidence in the accuracy of the characterization parameters that are required for performance and design analyses. Hydrologic data collected in this study can be traced from activity parameters through characterization parameters and to its intended use in satisfying performance and design-parameter requirements for issues resolutions. This last step is addressed by Table 7.2-1.

Characterization parameters will be expressed as functions of space and (or) time and will be presented in formats that will facilitate use of the data in resolving design and performance issues. In future SCP progress reports, a testing basis will be developed for each characterization parameter, and will consist of some means of expressing the goals, confidence limits, and accuracy associated with each characterization parameter, so that requirements of performance and design parameters can be satisfied. An example of a testing basis could be that some statistical measure of the parameter, such as the mean, be known to a specific degree of accuracy. The investigators recognize that the uncertainties associated with flood prediction can be substantial. These uncertainties are discussed further in Section 3.1.3.

In addition to supporting design and performance parameters, the activity parameters listed in Table 2.1-1 and Section 3 are needed to test hypotheses that support conceptual models of flood potential. A sufficient level of confidence in parameter values must exist for the data to be employed for either of these purposes. The approaches to data collection selected for the present study have been chosen to minimize uncertainty in parameter values and in the understanding of parameter interrelations, within the constraints of available resources. Where possible, multiple approaches within an activity are directed toward evaluating the value of a parameter by different means. The combined effect of using multiple approaches (or tasks) will be to increase the level of confidence in the parameter, because reliance will not be placed exclusively in one approach. Within a particular activity, some approaches may provide only partial information, while others will provide extensive information necessary for determination of a hydrologic parameter. By combining the task results and studying their relations, a greater understanding and confidence of any particular parameter can be achieved.

Table 2.1-1 Association of activity parameters with characterization parameters

Activity	Site-Characterization Parameter	Activity Parameters Associated with Site-Characterization Parameter
Site flood and debris-transport studies (8.3.1.16.1.1)	Potential for future flooding: magnitude and frequency of flooding at specific locations	Frequencies and recurrence intervals of potential future floods
		Magnitudes of potential future floods
	Potential for future flooding: potential hazards of debris transported by flood flows	Quantity and characteristics of debris transported by potential future floods
		Sediment component of potential future floods
		Debris-transport triggering mechanisms
Surface-water runoff monitoring (8.3.1.2.1.2.1, from SP 8.3.1.2.1.2)	Runoff and streamflow: temporal, spatial, and physical characteristics	Precipitation, quantity and timing
		Air temperature
		Geographic extent of runoff
		Runoff frequencies in specific and general areas
		Runoff rates at specific sites
		Durations of individual runoff events
		Runoff quantities at specific sites for specific events
		Sediment component of runoff
		Relations of runoff to weather conditions
		Chemical and isotopic characteristics of streamflow

Table 2.1-1 Association of activity parameters with characterization parameters--Continued

Activity	Site-Characterization Parameter	Activity Parameters Associated with Site-Characterization Parameter
Transport of debris by severe runoff (8.3.1.2.1.2.2, from SP 8.3.1.2.1.2)	Debris transport: locations, quantities, and characteristics	Hillslope and channel erosion: location and areal extent Hillslope and channel erosion: timing Flood debris: physical characteristics Sediment deposits: location and areal extent

The possibility that one or more tasks may fail in achieving the desired objectives is recognized. The use of multiple approaches for determining parameters increases confidence that the failure or the partial failure of one or more tasks will not severely inhibit the ability of the characterization activities in providing the required information.

2.2 Constraints on the study

2.2.1 Representativeness of repository scale and correlation to repository conditions

The calculational methods for estimating frequency and magnitude of future flooding described in Section 3 will be performed using streamflow data collected from drainages at, and peripheral to, the Yucca Mountain site, and also from streamflow estimates inferred from paleoflood evidence collected in the same area. For this reason, the resulting estimates of potential future flood magnitudes and recurrence intervals can be considered to correlate with and simulate the surface hydrology of the repository area and its surroundings.

2.2.2 Accuracy and precision of methods

Selected and alternate methods for the tasks in the flood and debris-hazards activity are summarized in Table 3.1-1. The interpretive methods for this study will be selected on the basis of applicability to the surface-water regime at Yucca Mountain. The accuracy and precision of data collection methods supporting this study are discussed in other study plans and in the technical procedures referenced by this study.

2.2.3 Potential impacts of activities on the site

Field activity required for this study is restricted to surveying channel and floodplain geometries. Off-road travel will be by foot, and the only impact to the site will be placement of stakes used for survey reference points.

2.2.4 Time required versus time available

Section 5.1 describes a proposed schedule for the activity described in Section 3. Because the methods in the activity are mostly analytical, it is expected that they can be accomplished within the time scheduled for them. However, the data upon which the analyses of this study are based, notably runoff and streamflow data and data on debris transport by severe runoff from SP 8.3.1.2.1.2, require ample time for collection. This time required is in excess of the time available. Thus, regional data, paleoflood data, and surface-water models must be included to assure the best possible results. The reliability of flood-potential calculations is dependent upon the quantity and ranges of surface hydrological data collected, and on other regional data and knowledge that may be available.

The primary reason that not enough data will be available is that the confidence that can be assigned to estimates of discharge with a given exceedance probability is inversely related to the length of the record. Current timelines call for 4 additional years of surface-water data collection. Fortunately, 6 years of record already exist. Estimates of discharges with given exceedance probabilities will therefore have large confidence intervals. For example, when a hypothetical flood-frequency distribution has a logarithmic mean of 3.0,

standard deviation of 0.25, and skewness of 0.20, when the discharge with an exceedance probability of 0.01 (the 100-year flood) is calculated from 50 years of record, its confidence interval is 0.24 log units (58 percent); when it is calculated from 10 years of record, the confidence interval is 0.63 log units (200 percent); when it is calculated from 5 years of record, the confidence interval is 1.18 log units (750 percent); (Interagency Advisory Committee on Water Data, 1982, p. 9-2 to 9-5). Furthermore, many sites at Yucca Mountain receive no flow for several years at a time.

2.2.5 Limits of analytical methods

Many of the analytical methods that will be examined for characterizing potential future flooding are documented in the hydrological and engineering literature. Each of the methods has its unique limitations, but it is expected that a comparison of flow predictions resulting from applications of the various techniques can yield a credible projection of future-flooding potential.

2.2.6 Potential for interference among activities

The selected tasks of this study will have no interference with tests of other activities.

3 DESCRIPTION OF ACTIVITY

This study contains one activity:

- 8.3.1.16.1.1 - Site flood and debris hazards studies

The plans for this activity are described in Section 3.1.

3.1 Site flood and debris hazards studies

3.1.1 Objectives

The objective of this activity is to assess the flood and debris hazards at and near the potential locations of the repository surface facilities, to allow adequate design of the facilities to prevent or reduce hazards to an acceptable level.

3.1.2 Rationale for activity selection

Local convective storms and regional storms, coupled with the rugged terrain at Yucca Mountain, can cause sporadic and intense flash flooding in washes that drain the mountain. SCP Section 3.2 (U.S. Department of Energy, 1988) summarizes the current information regarding flood history, the potential for future flooding, current and future studies of flood and debris hazards, and flood protection. The meteorology and climatology of the Yucca Mountain site and the region are discussed further in SCP Section 5.1. Flood-protection-design considerations are discussed in SCP Sections 6.2.4 and 3.10.2.

Further evaluation of the flood potential of these washes is necessary to adequately design the surface facilities. In addition, the activity addressed in this study is designed to assemble information that is useful and pertinent to ensure both the safety of workers and surface facilities.

3.1.3 General approach and summary of tasks and analyses

This activity will incorporate four tasks: flood and debris-transport characterization, hydrologic modeling, analysis of Yucca Mountain flood data, and assessment of potential future flooding and debris transport (Figures 3.1-1 and 3.1-2). The first task originates in Study 8.3.1.2.1.2 (Characterization of the Yucca Mountain regional surface-water runoff and streamflow). The estimation of the magnitude and duration of runoff (assuming hypothetical meteorological events) by hydrologic modeling, which is part of the second task, originates in Study 8.3.1.5.2.2 (Effects of future climate on hydrology). These contributions from other studies are restated in this document because of their critical contributions to the present study.

Much of the data to be used in this investigation will be collected by other site-characterization activities; however, some supplementary peak-flow data on floods, as they occur, will also be collected as part of this activity. Current surface-water monitoring will be conducted as part of Activities 8.3.1.2.1.2.1 (Surface-water runoff monitoring) and 8.3.1.2.1.3.3 (Fortymile Wash recharge study), and will be supplemented by other regional data collected since the 1960's as part of the U.S. Geological Survey and Nevada Department of Transportation (USGS-NDOT) flood-study program (Schroer and Moosburner, 1978). Current meteorologic monitoring will be conducted as part of Activity 8.3.1.2.1.1.1 (Characterization of meteorology for site and regional hydrology). The relations between meteorologic input and runoff will be

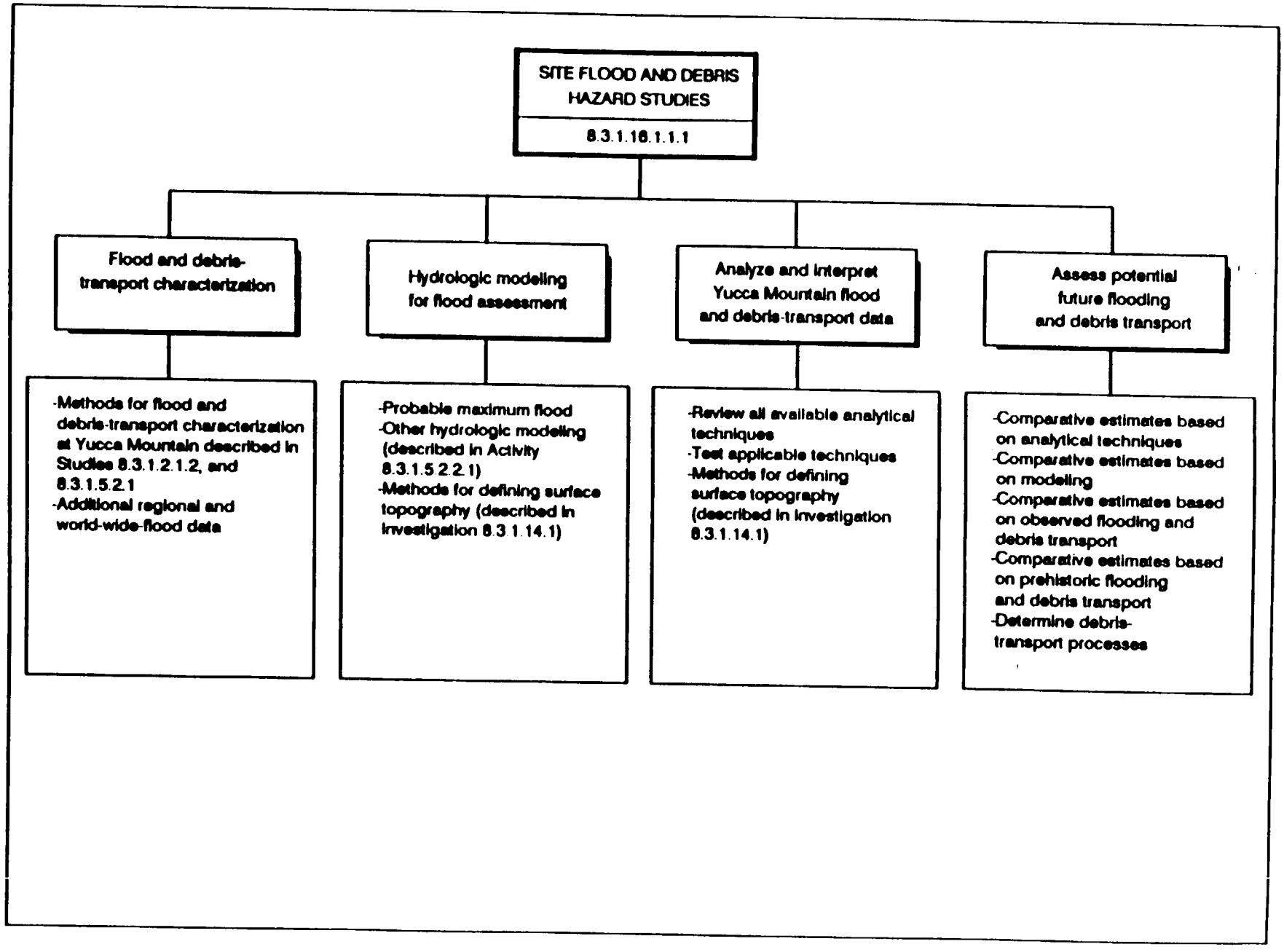

Figure 3.1-1. Diagram of site flood and debris hazards activity showing tasks, analyses, and methods.

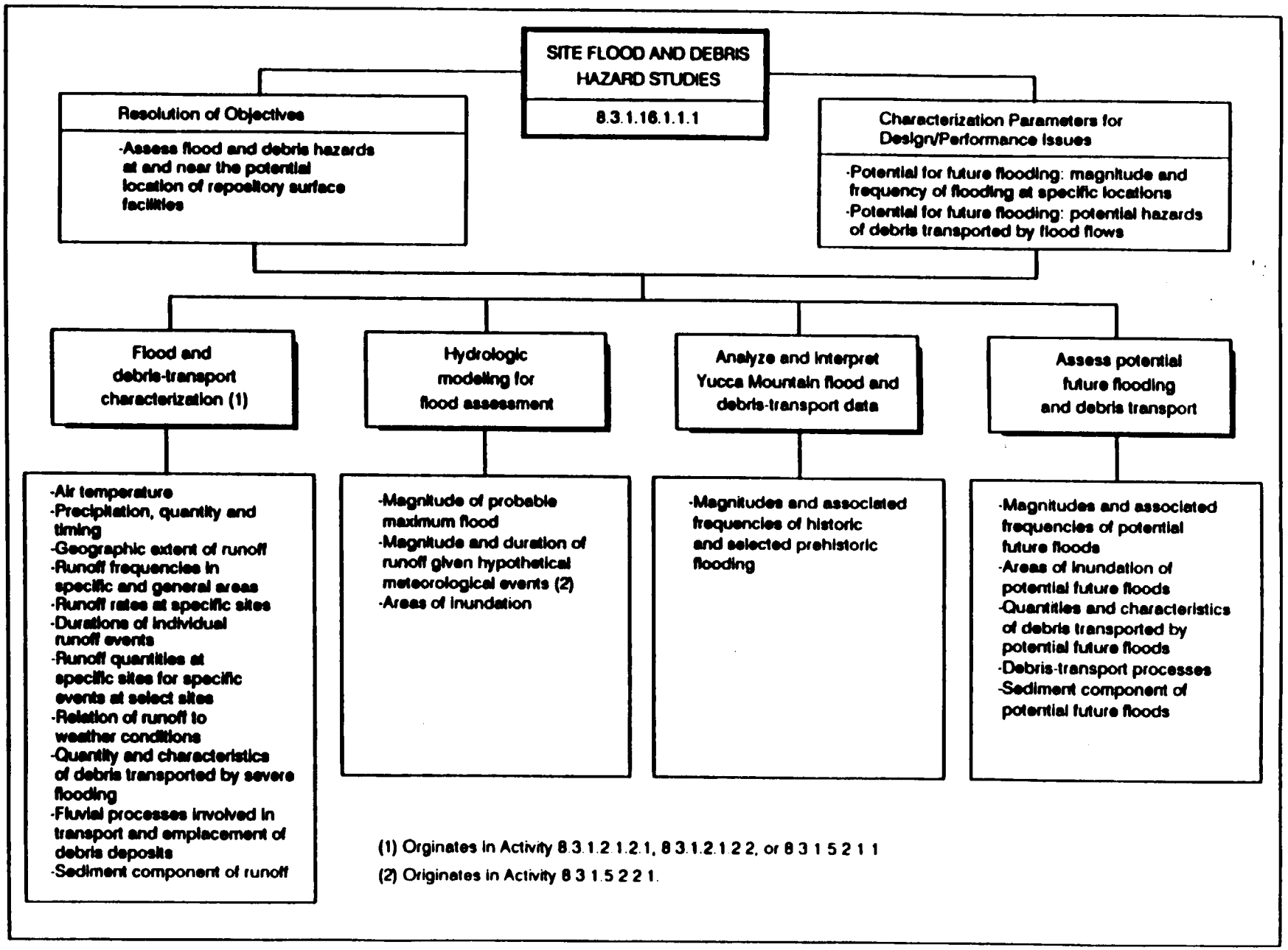

Figure 3.1-2. Diagram of site flood and debris hazards activity showing tasks, analyses, and activity parameters.

assessed by Activities 8.3.1.2.1.2.1 (Surface-water runoff monitoring) and 8.3.1.5.2.2.1 (Analysis of future surface hydrology due to climate changes). Quantities and characteristics of debris transport in current flows will be monitored by Activity 8.3.1.2.1.2.2 (Transport of debris by severe runoff). Prehistoric flows will be assessed in terms of both the magnitude of flow and the character of debris transported by the flow by Activity 8.3.1.5.2.1.1 (Regional paleoflood evaluation). Site flood potential studies will also utilize data from Investigation 8.3.1.14.1 (Topographic characteristics of surface facility locations).

This activity will analyze data collected by the activities listed above and through this activity itself to develop predictive capabilities for assessing flood and debris hazards for selected sites and drainages at and near Yucca Mountain. Data collected by Activities 8.3.1.2.1.2.1, 8.3.1.2.1.3.3, 8.3.1.2.1.1.1, 8.3.1.5.2.2.1, and 8.3.1.5.2.1.1, and the USGS-NDOT flood-study program will be analyzed to assess the potential for future flooding. Data collected by Activities 8.3.1.5.2.2.1, 8.3.1.2.1.2.2, and 8.3.1.5.2.1.1 will be used in conjunction with the flood-potential assessment to assess the potential for future debris movement.

3.1.3.1 Investigative strategy

The unique physio-hydrologic nature of the Yucca Mountain area requires a somewhat non-standard approach to assessing the flood- and debris-hazard potential of the area. A lack of perennially flowing streams throughout the region, and the resultant paucity of historical streamflow data, renders normal streamflow and floodflow analytical techniques as largely inapplicable for this remote and arid region. Therefore, parts of this activity will include necessary research regarding the existence of applicable knowledge and techniques available to perform the needed analyses, study and sorting of the available technology, possibly the modification of available techniques or the development of new techniques, and finally, the application of those techniques deemed most acceptable through the study, development, and sorting process. This phase of techniques research will be done concurrently with a streamflow-data-collection activity that will provide data needed for the analytical and interpretive techniques that are selected. The assessment of quantitative uncertainties of flood analyses will not be possible until analytical techniques have been selected, and until streamflow data for analyses have been collected.

A preliminary stepwise strategy to research, sort, select, and apply the analytical techniques is, as follows:

1. Streamflow and debris transport data are being collected at the site and throughout the region by Activities 8.3.1.2.1.2.1, 8.3.1.2.1.2.2, and 8.3.1.16.1.1, (within a 200-mi radius of Yucca Mountain) when runoff occurs. This data collection will continue throughout the duration of this activity. Collection of these data has been ongoing since 1983; the data will be combined with the few

historical data available, and with data that will be collected through the regional paleoflood investigation (Activity 8.3.1.5.2.1.1), to form the Yucca Mountain Project streamflow and flood-peak data base. These activities (8.3.1.2.1.2 and 8.3.1.5.2.1.1) will provide aerial photography and interpretation of aerial photographs used in this (8.3.1.16.1.1) study.

The streamflow-measurement study also collects data on the hazardous movement of debris by severe runoff. These data will also be utilized in the analyses and predictions of site flood and debris hazards. Semi-quantitative and (or) qualitative data on past floods will be collected through the regional paleoflood evaluation activity (8.3.1.5.2.1.1). Because of the semi-quantitative (at best) nature of these paleoflood data and many of the debris data, they will have only marginal value to the quantitative schemes that will be used to analyze and predict flooding. However, they will be very useful in maintaining a sense of realism when climate-change scenarios are imposed on precipitation-runoff models in an attempt to predict changes in flood- and debris-hazards potentials caused by climate changes. Precipitation data from throughout the Yucca Mountain region will also be utilized in the analyses of present and future flood-hazard potentials to the YMP.

2. The first stage of flood analysis and prediction will be an assessment of the probable maximum flood (PMF) potential for select drainages at and peripheral to Yucca Mountain. This task will provide peak-flow magnitudes and zones of inundation (by channelized flow and sheet flow along drainages) where needed for the design of surface facilities. It will encourage a conservative (safe) design of most facilities to withstand severe flood hazards, and will also comply with American Nuclear Society requirements (ANSI/ANS, 1981) that PMF design be incorporated into planning and construction. This task will be performed by the U.S. Bureau of Reclamation as contractors for the U.S. Geological Survey. PMF computations utilize a relatively simple precipitation-runoff model that is based on the unit hydrograph concept of streamflow. Even though PMF calculations based on PMP (probable maximum precipitation) estimates do not account for debris movement by these unique floods, there are no known examples at this time of flood peaks that have exceeded predicted PMF flow rates using current methodology (Bullard, Kenneth L., 1986 and oral communication, 1990). The data collected on debris movement by severe floods, through the streamflow-measurement program, will be used in conjunction with general knowledge of the volumetric magnitudes of the sediment component of flood flows, to adjust PMF flows to include the estimated effects of entrained sediment loads.

3. A literature review will provide a thorough, but not necessarily exhaustive, assessment of the various flood analytical and prediction techniques that might be applied to the Yucca Mountain area and region. This review may also include communications with known experts on arid-lands flooding (local and international) to include the personal wisdom of these experts on analytical strategies that they may utilize, but have not yet published. This task will produce an assemblage of techniques that can be examined, tested, and compared. The techniques will include purely statistical as well as empirical engineering techniques. They will include those that require local site data and regional data, as well as those that need no specific streamflow data from the site or the surrounding region.

4. Individual techniques of the assemblage produced by step 3 above will be studied, tested, and compared to select the best techniques available to analyze the data that accrue under step 1 above. The study, testing, and comparisons will not only attempt to select the best available analytical techniques but will also evaluate the particular strengths and weaknesses of the individual techniques when they are applied to the Yucca Mountain situation. This step will select several of the best-rated techniques available for application, using the available data and knowledge specific to the Yucca Mountain terrain.

5. The techniques selected under step 4, above, will be applied using the available local data, where applicable, from the data base; results will be used to help predict flood-magnitude potentials at recurrence intervals of 10, 25, 50, 100, and 500 years. Those results will also be compared with the estimated PMF to add perspective to the reasonableness and degree of conservatism of the PMF estimates.

6. Results of step 5 will be further compared to note the ranges in flood potentials as estimated by the various techniques. The preferred results can then be used to predict flood-hazard potentials on the basis of specific design needs and safety tolerances. Results of these techniques applications, particularly those utilizing locally collected data, can be compared with results of the PMF calculations of step 2 to assess the reliability of PMF predictions regarding the safety of facilities. Estimates of potential floods and measured flood flows that accrue through this activity can be utilized and evaluated by the precipitation-runoff modeling exercises that will be part of the future surface hydrology activity (8.3.1.5.2.2.1). This task will provide peak-flow magnitudes and zones of inundation (by channelized flow and sheet flow along drainages) where needed for the design of surface-facilities.

Figure 3.1-1 summarizes the organization of the site flood- and debris-hazards tasks. A descriptive heading for each task and analysis appears in the shadowed boxes of the second row. Below each task/analysis are the individual methods that will be used during the process. Figure 3.1-2 summarizes the objectives of the activity, the characterization parameters which are addressed by the activity, and the activity parameters measured during the investigative process. These appear in the boxes in the top left side, top right side, and below the task/analysis boxes, respectively, in Figure 3.1-2.

The two figures summarize the overall structure of the planned activity in terms of methods to be employed and measurements to be made. The descriptions of the following sections are organized on the basis of these diagrams. Methodology and parameter information are tabulated as a means of summarizing the pertinent relations among (1) the activity parameters to be determined, (2) the information needs of the performance and design issues, (3) the technical objectives of the activity, and (4) the methods to be used.

3.1.3.1.1 Flood and debris transport characterization

The streamflow data that will be available for use in this activity will come from several sources that are discussed in the following text. (1) Data are being collected as part of Activity 8.3.1.2.1.2.1 (Surface-water runoff monitoring). Data collection for that activity began in 1983, and has included all known and important runoff near Yucca Mountain and all severe runoff within a 200-mi radius of Yucca Mountain since that time (Figure 3.1-3). These streamflow data include quantitative estimates of peak flows for a variety of runoff conditions. Some peak-flow data are also being collected as part of this site flood and debris hazards activity (8.3.1.16.1.1.1). (2) Some, but not many, historic (pre-1983) peak-streamflow data, and a very few continuous records of streamflow, are available for specific sites within the 200-mi radius of Yucca Mountain. These data will be combined with those being currently collected, as described above, to form the YMP, peak-streamflow data base. (3) Qualitative and semi-quantitative data on previously unmeasured, and heretofore unknown, floods within the 200-mi radius of Yucca Mountain will accrue through the investigative activity of a regional paleoflood evaluation (Activity 8.3.1.5.2.1.1). Although semi-quantitative in nature, at best, these data will add perspective to regional flooding characteristics, particularly with regard to the debris-transport characteristics of paleofloods. They will also help characterize the variability of flooding over long time periods and as the result of different climatic influences. (4) Streamflow data from outside of the Yucca Mountain region will also be utilized, when deemed appropriate, for analyses of flood potential at Yucca Mountain. As an example, peak-flow data

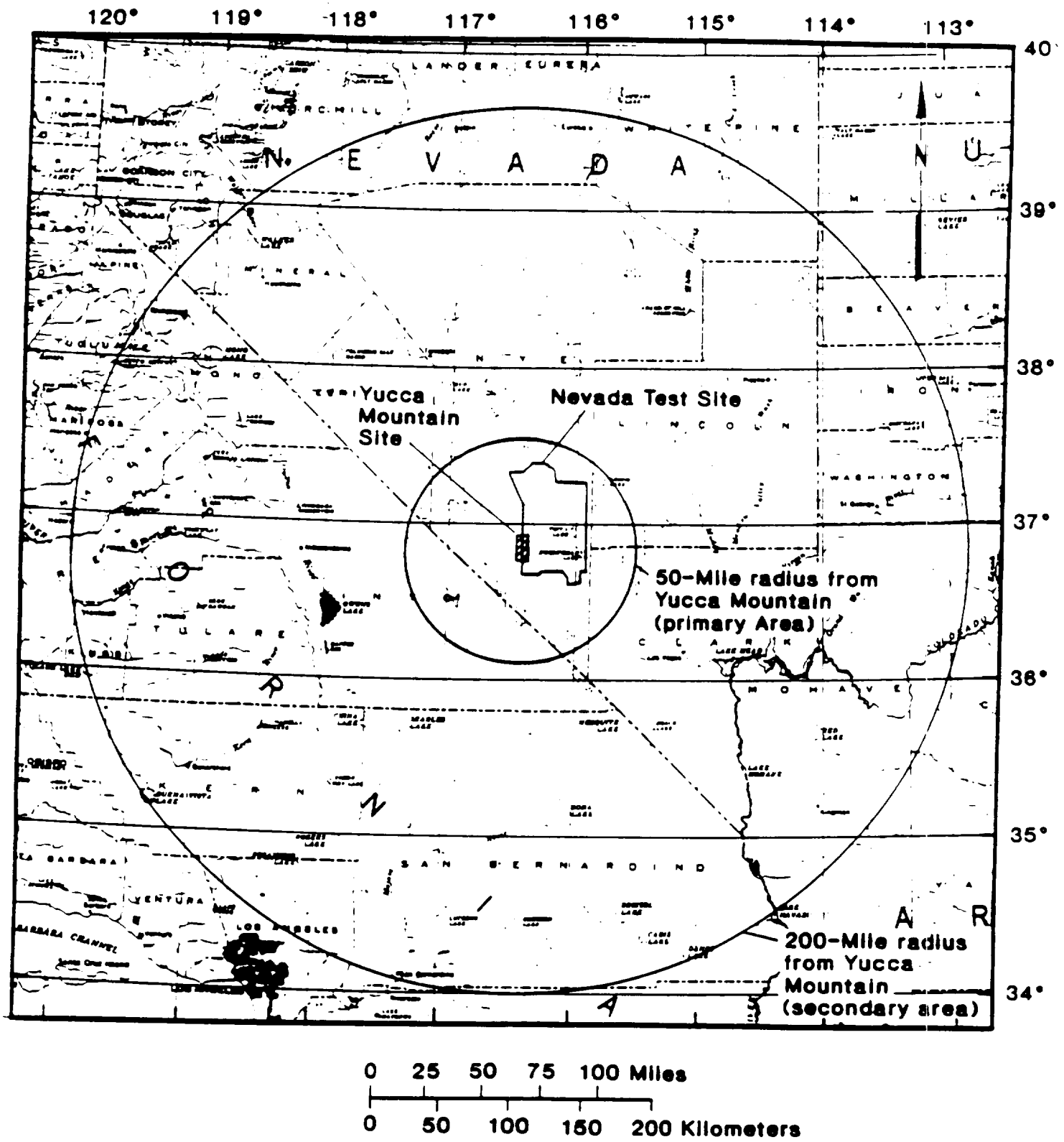

Figure 3.1-3. Primary and secondary areas for streamflow and debris transport data collection.

obtained from studies of major floods throughout the United States help formulate envelope curves that depict the more severe floods known during historic times. (5) Precipitation data collected by, or supplemental to, the regional meteorology study (8.3.1.2.1.1) will also be used to interpret land-surface response to precipitation of varying amounts and intensities. The resultant precipitation-runoff relations will be used in some of the predictions of flooding potentials, including modeling exercises (Activity 8.3.1.5.2.2.1) that will predict runoff responses to different types of storms and climatic change. (6) Data pertaining to the hazardous transport of debris by floods will be collected. These data are described in detail in YMP-USGS-SP 8.3.1.2.1.2 (Characterization of the Yucca Mountain regional surface-water runoff and streamflow), and the forthcoming study plan for Activity 8.3.1.5.2.1.1 (Regional paleoflood evaluation). The data on debris transport will provide a realistic perspective to the potential hazards of flooding and flood-related processes that is uncommon to most flood analyses, but is critically important to flood-hazard prediction for the YMP.

Under the best of field conditions, the number of factors controlling sedimentation (erosion, sediment transport, and deposition) is large, and the number of possible combinations of these factors makes accurate predictions of sedimentation impossible with current knowledge. However, with the current state of knowledge and given adequate field data on specific sites, the general responses of hillslopes and stream channels to precipitation can be predicted; hazard zones can be qualitatively established and general probabilities of various processes occurring in those zones can be estimated. These zones and probabilities are based on a combination of deterministic and probabilistic criteria, neither of which can be specified until additional field work is completed. Probability categories may be as broad as "likely during a 100-year event" or "unlikely during a 100-year event". Much of the debris-hazard assessment is experimental at this time, and more precise investigative plans cannot be formalized until local experience accrues with regard to debris movement caused by flooding.

Relevant information from the regional paleoflood evaluation activity (8.3.1.5.2.1.1) will be transferred to the present study for use in enhancing the characterization of flood and debris hazards. The surface character of selected channel and floodplain deposits (paleo-deposits) in the numerous ephemeral drainages in and around the proposed storage site will be field-examined in attempts to determine the fluvial processes involved in the emplacement of the deposits. Selection will be based on surficial characteristics of the deposits, character of the drainage that produced them, and relations of the drainages to planned site facilities. These investigations will be mainly conducted as part of Activity 8.3.1.5.2.1.1 (Regional paleoflood

evaluation). Investigative strategies are better described in that study plan. Reconnaissance investigations will be part of the paleoflood activity and of this activity. If this reconnaissance discloses a variety of processes or significant variations within any process, an attempt will be made to differentiate the processes and degrees of differences. The results of this effort may then determine whether the variations in the characteristics of the deposits can or should be shown on surficial-deposit maps of the drainages. This approach is experimental and results are currently unpredictable.

The cumulative data on peak streamflows, both historic and prehistoric, and knowledge of the behavior of these flows as influenced by entrained debris, and relations between precipitation and runoff will be utilized in the prediction of future flooding and debris hazards.

After a reasonable amount of experience and data are gained through field investigations, laboratory experiments would seem to be the next logical step in the study process. However, laboratory efforts are not planned at this time. Scaling problems associated with laboratory models may be insurmountable, and the current (1990) technology of physical modeling of debris movement is not sufficiently advanced to be a reliable alternative or supplement to the planned activities.

3.1.3.1.2 Probable maximum flood analysis

The design of safe surface facilities that is necessary for successful waste-repository construction cannot be delayed while flood data are collected and analyzed throughout a period of a decade or longer. Therefore, some facilities will have to be designed using a type of flood analysis that does not require local precipitation and streamflow data. The probable maximum flood (PMF) technique was chosen for two reasons: (1) this technique complies with ANSI requirements that PMF technology be used in the design of nuclear-related facilities (ANSI/ANS, 1981), and (2) the PMF analysis has become a commonly used technology to predict a "worst possible case" flood scenario.

In spite of its engineering attractiveness, the frequently used PMF technology has several scientific shortcomings. It estimates the magnitude of the upper limit of flooding that can occur under present climatic conditions, thus it inherently has no recurrence interval. Its accuracy depends on the accuracy of determining the routing of flood flows within the drainage basin, and the accuracy of estimates of probable maximum precipitation (PMP) that are subject to change with the expansion of the regional precipitation data base and an improved understanding of atmospheric processes. The probable maximum flood only takes into account the water component of streamflow and does not address the entrained sediment component of streamflows; it therefore, may grossly underestimate the

magnitude and hazard potential of this unusual-size flood. The PMF calculation does not address the possibility of climatic change over time which could become a reality during the projected life of high-level waste storage (10,000 years, or longer). However, there are no known examples of flood peaks that have exceeded predictions of PMF flow rates (Bullard, Kenneth L., 1986, and oral communication, 1990).

The determinations of PMF magnitudes necessary for preliminary engineering design of surface facilities at Yucca Mountain will be done by the U.S. Bureau of Reclamation. They were selected as contractors by the U.S. Geological Survey because of their extensive experience and success throughout the western United States in PMF analyses for the design of hydraulic structures. Their task will include the estimation of PMF magnitudes for stream channels that impinge on shaft sites and facilities associated with the proposed repository block; it will also include the mapping of the PMF-inundation zones (by channelized flow and sheet flow along drainages), where required, that are expected to result from PMF flows. Figure 3.1-4 is a preliminary map showing drainages where PMF analyses are now planned. PMF analyses can produce predictions of flooding for which a safe design may be very costly; however, the severe hazards associated with long-term disposal of high-level nuclear wastes and consequences of inundating the site require a degree of design safety that far exceeds normal economic restraints.

The PMF estimates will be used as a basis for defining the areal extent of flooding. Detailed topographic maps with 1- or 2-ft contour intervals or surveyed cross sections will be needed for each water course studied. These maps or cross sections must cover the entire area that would be inundated during the PMF. Channel and floodplain roughness coefficients will be estimated. This will require field reconnaissance as well as the use of standard engineering guidance on selection of roughness coefficients.

The Standard Step Method, incorporating the Bernoulli Energy Equation, will be used to compute water surface profiles for each water course studied. These computations may be made by hand or with software such as the industry-wide standard U.S. Army Corps of Engineers HEC-2 Water Surface Profiles Program.

The perceived shortcomings of PMF analysis in this data-deficient terrain, as described above, and the abnormally long period requiring a secure level of safety, may require a new approach to flood analyses and predictions for the YMP beyond the standard techniques commonly used. Therefore, long-term collection of hydrologic data is necessary to verify, validate, or modify the PMF predictions. These data should also assist in the recognition and understanding of any special local hazards and thereby provide for long-term protection from the hazards.

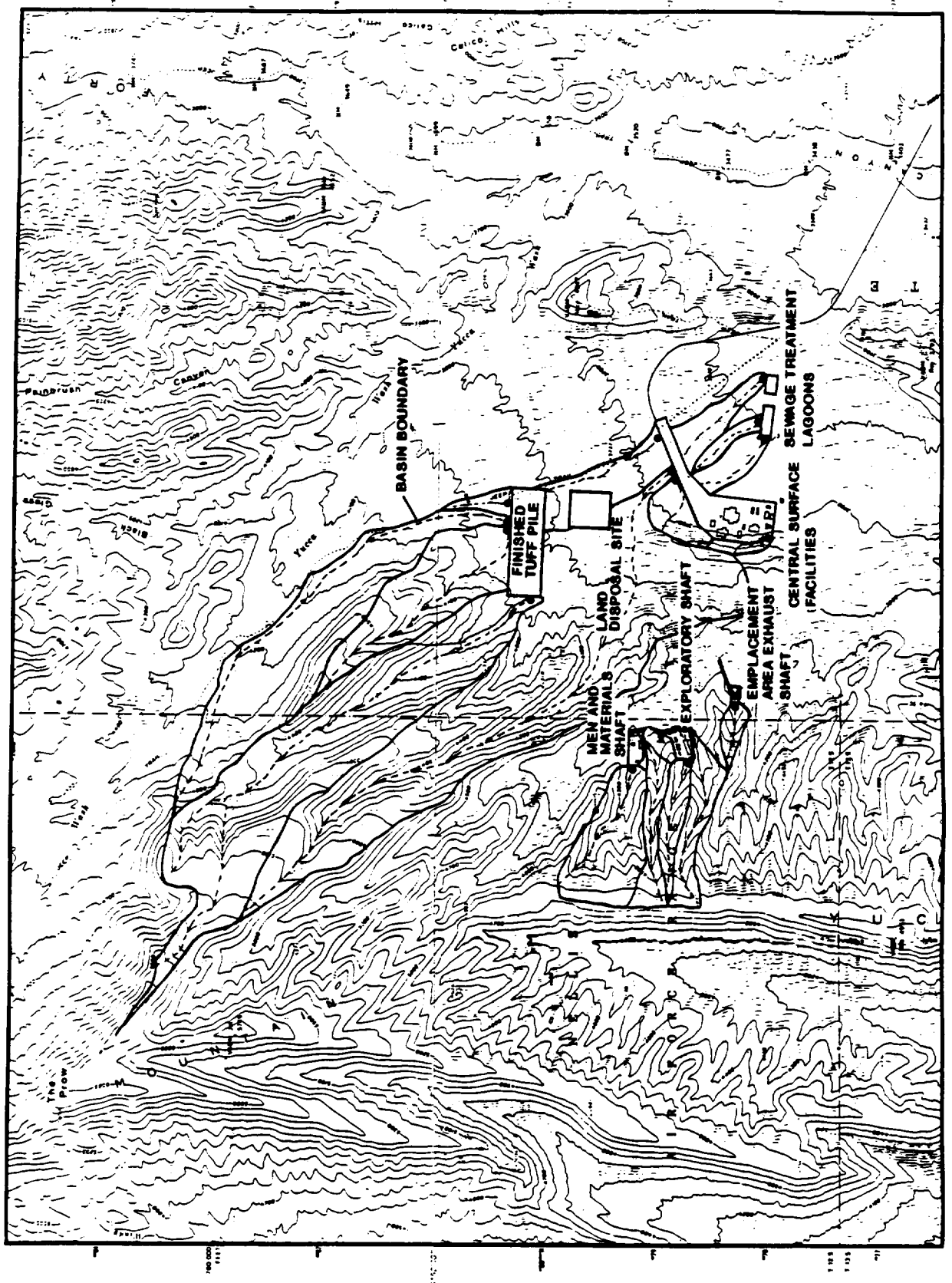

FIGURE 3.1-4.
PRELIMINARY MAP OF PROPOSED SURFACE FACILITIES
BASIN BOUNDARIES FOR PMF CALCULATIONS

Thus, the PMF analysis is considered a necessary, but only preliminary, phase of the site flood and debris hazards study.

3.1.3.1.3 Assessment of the potential for future flooding and debris transport

Flood magnitude and frequency prediction for the Yucca Mountain region is a formidable challenge. The general nature of flooding in the Great Basin, which includes much of the Yucca Mountain region, is described by Burkham (1988). Floods are most often caused by severe storms that affect only small localized areas rather than the entire region at any given time. Areally extensive storm systems move across the region within a few days, particularly during winter months. However, severe flooding caused by these storm systems is often localized because cells of intense precipitation can be widely scattered within the regional weather systems. Collectively, these cells of intense precipitation and resultant flooding affect only minor parts of the area encompassed by the regional storm systems. Summer convective storms are equally or even more restricted areally, even though the masses of atmospheric moisture that enable the intense convective storms encompass wide geographic areas, somewhat similarly to the broad areal expanses included by regional winter storms. The regionally extensive presence of moist air during the summer is usually caused by tropical storms or the northerly influx of monsoonal systems, mainly from the Gulf of California, and more rarely from the Gulf of Mexico. In contrast to the tropical storms which usually move across the region in a few days, the monsoonal air masses can linger for days, weeks, or months. The usual net effects of these differing weather systems is a seemingly random scattering of intense precipitation cells and resultant floods; the apparent random character of the intense rainfall and flooding is both areal and temporal in nature.

The weather characteristics described above cause relatively frequent flooding within the region, but floods are infrequent within any given drainage or at any specific site. If the drainage is intermediate-to-large in size (tens or hundreds of mi^2) the infrequent floods generally occur within only a part of the drainage at any given time. As a result, flood prediction at any specific site, or within any given drainage, is very uncertain. The paucity of long-term runoff records for specific sites and the, as yet, unpredictable nature of intense storms, precludes the likelihood that site-specific flood magnitude-and-frequency determinations can be done with a great degree of precision now or in the near future.

The difficulties of understanding and predicting flood hazards do not diminish the requirements of the YMP for the needed knowledge and answers. The problems, although immediate in nature, will probably be of long-term duration. Therefore, the following strategy is proposed to cope with the challenges

of flood prediction. The strategy has both short-term and long-term objectives; therefore, it is both a short-term and long-term strategy.

Flood assessment for the YMP has been an ongoing activity for over a decade. The first published product was a study of Topopah Wash, an Amargosa River tributary that drains part of Jackass Flats just east of the Fortymile Wash drainage (Christensen and Spahr, 1982). That study was followed by an assessment of the flood potential of Fortymile Wash, and its principal tributaries from the Yucca Mountain area (Squires and Young, 1984). These analyses were not based on streamflow data collected in the vicinity of Yucca Mountain; they were largely based on some historic data collected within the YMP region (within 200 mi of Yucca Mountain), many data collected outside the YMP region, but within the Great Basin and adjacent Mohave Desert, and some analyses were based on severe floods that ranged throughout the conterminous United States (Crippen and Bue, 1977). The results of these studies represented the best estimates possible at the time they were made, but the estimates were based on few local data.

Statistical characteristics of streamflow, based on available streamflow data, for the Yucca Mountain region and surrounding areas have been published (Jorgensen and others, 1971, and Schroer and Moosburner, 1978) but these characteristics have not been updated in recent years. Some major floods in the region have also been documented (Glancy and Harmsen, 1975, Katzer and other, 1976, National Weather Service, 1982, and Randerson, 1986).

The next attempt at flood prediction for the YMP was a preliminary assessment of the probable maximum flood potential for the proposed nuclear waste repository area on the east-facing flanks of Yucca Mountain (Bullard, 1986). This technique did not use local streamflow data. It was based on estimates of the probable maximum precipitation (PMP) for the Colorado River and Great Basin Region (Hansen and others, 1977). The PMP estimates utilized historic, regional precipitation data, although the data-collection sites were few, widely separated, and records usually consisted of less than 50 years of continuous data at any site.

A site-specific analysis of flood potential for Coyote Wash, near the site of the proposed exploratory shaft, has been in preparation for several years (Glancy, in preparation). However, this analysis is based on a combination of paleoflood data from Coyote Wash, regional envelope curves of maximum measured flood peaks, and a local PMF analysis; it also does not utilize any local streamflow data. Data developed by this study were utilized by Fernandez (1987). Initial trench studies suggest that paleoflood techniques may not be adequate to fully assess flood and debris hazards because of the lack of datable

materials (e.g., organics, tephra, and soils) and incomplete stratigraphic records.

The history of flood studies for the YMP is characterized by a persistent theme that is common to all attempts at flood analysis made thus far -- local data are either absent or very scarce; when available, they usually comprise only a short period of record. Confidence in the results of these analyses is necessarily lowered by this lack of local data to calibrate the analytical schemes. The long duration proposed for waste storage and the potentially serious impacts that might result from unsafe storage require that studies of flooding potentials be designed to alleviate this chronic shortage of local data. The obvious answer to this dilemma is to enact an adequate data-collection program to improve the calibration of predictive models and thereby increase confidence in the results. This data-collection phase of the flood-prediction strategy is discussed above in Section 3.1.3.1.1.

The data that are and will be collected for this flood- and debris-hazards activity must then be competently analyzed to fulfill the requirements of an acceptable flood-analysis strategy. A fundamental challenge to competent data analysis is the selection of the best available technique, or techniques, for the analytical process. The unusual nature of runoff in this arid area raises concerns about the validity of applying flood-analysis techniques that were developed and proven valid for use in strikingly different hydrologic terrains. For example, the log-Pearson, type-III-distribution analysis recommended as a standard analysis by the National Water Resources Council (Interagency Advisory Committee on Water Data, 1982), may not serve flood-prediction requirements for the YMP; its accuracy and dependability improves as the length of streamflow record for a specific site increases. The short duration of most streamflow records in the YMP region currently precludes accurate long-term flood prediction using this method. Also, the intermittent character of streamflow in the region may lower confidence that the Pearson type III statistical distribution adequately represents the true statistical distribution of flood data from this unusual hydrological environment. As streamflow data accumulate, the applicability of this technique can be verified better. Until a sufficient quantity of data accumulate for specific streamflow-measurement sites, the best approach may be to incorporate available data into regional analytical schemes. Thus, the analytical strategy will evolve with time as data accumulate, and predictive results should also be expected to change correspondingly with time.

A major part of the flood- and debris-hazards investigation will be a literature review. This review will result in a discovery and compilation of the existing techniques to analyze the available data for flood-prediction purposes. Prominent experts on arid-lands flooding will also be consulted regarding

unpublished techniques and strategies for flood analysis as an adjunct to the literature review. This consultation will include international as well as national experts. The search for available technology will not be exhaustive, but will be comprehensive enough to avoid overlooking any prominent analytical techniques. This compilation of techniques will be ongoing throughout the period of data collection to prevent any oversight of new and important methodology.

The techniques that accrue through this review and discovery process will be examined and tested for their utility and validity when applied to YMP data and hydrologic conditions. Some techniques may need to be re-evaluated as data accumulate, or modified to better suit local hydrologic conditions. Through this ongoing sorting and testing process, a technique or group of techniques will be applied to the specific flood-prediction needs and data of the YMP to assure that the best available technology can be used to predict both long-term and short-term flood and debris hazards. If no acceptable techniques are discovered, effort will be made to develop an acceptable methodology.

Data that accrue through the streamflow and meteorologic measurement programs will be used to develop the flood predictions, and will also be used to validate, enhance, or reject preliminary flood predictions that were, of necessity, done without the benefit of adequate local data.

Activity 8.3.1.5.2.2.1 (Analysis of future surface hydrology due to climate changes) will apply detailed watershed models to the prediction of the impact of changes in climate on streamflow. Although similar in overall approach to the PMF unit hydrograph approach, these watershed models will more accurately represent soil moisture, the effects of antecedent precipitation, timing and seasonality of storms, and the hydraulics and routing of the resulting flows. As part of this analysis, a wide range of precipitation distributions and other climatic scenarios will be analyzed to determine the probable resulting streamflow in terms of peak and mean discharge. Among these climatic scenarios, precipitation distributions matching those conceivable under present conditions, or believed likely in the foreseeable future, will be analyzed. These analyses will provide estimates of frequency and magnitude of streamflow either under conditions typical of current climates, or of possible and foreseeable future climates.

Table 3.1-1 shows a preliminary listing of analytical and prediction techniques that will be tested to evaluate their applicability to and acceptability for flood prediction for the YMP. The number and diversity of methods is expected to increase as the literature review and consultation phases of this activity are conducted. Figure 3.1-5 shows a preliminary concept of sites where flood-and-debris-hazards assessments will

Table 3.1-1 A preliminary list of flood analysis and prediction techniques

Method of type of technique	Remarks
Probable maximum flood analysis	No recurrence interval, no local streamflow data, sediment component of flow not included, does not account for climate change; uses precipitation data for the local area, is the best available technology for determining the upper limit of potential flooding under present climate.
Log-Pearson Type III, or other statistical distributions, analysis	Requires long-duration data at a site, includes sediment components of flow.
Regional Envelope Curves (including those of Crippen and Bue, 1977)	Can be updated with new local data, includes sediment component of flow, can include climate change.
National Envelope Curves (including that of Matthai, 1969)	Can be updated with new data (including local data), includes sediment component of flow, can include climate change.
Regional Statistical Analyses (including those of Christensen and Spahr, 1980, and Squires and Young, 1985)	Expected to change with accumulating data, includes sediment component of flow, depends on local data, does not specifically include climate change.
Statistical and deterministic watershed models	May be calibrated with local data, calibration includes sediment component of flow, can be programmed to predict responses to climate change.

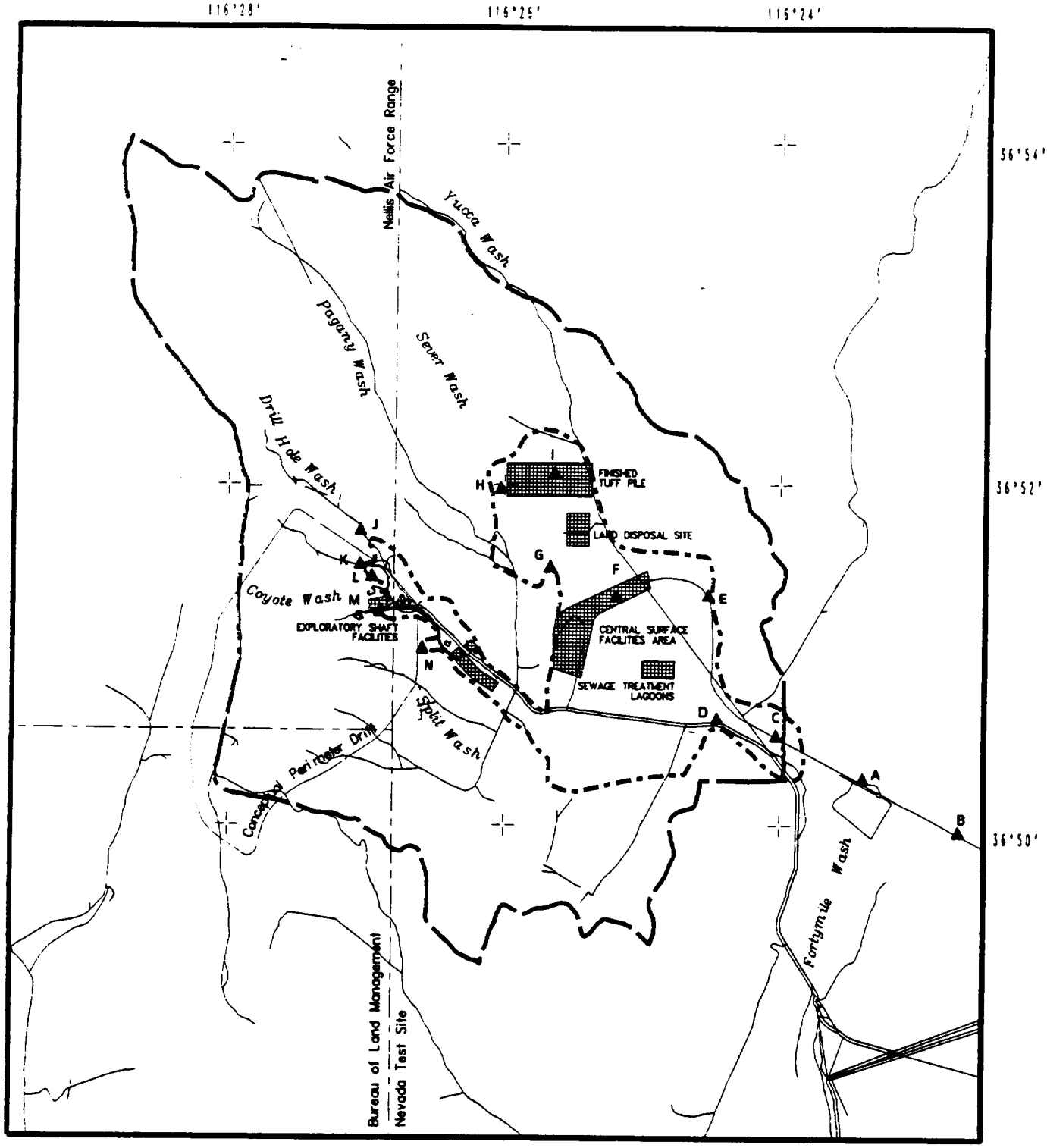

Figure 3.1-5. Preliminary flood and debris hazard assessment sites.

be done as part of this activity. Table 3.1-2 lists the sites and (or) drainages of Figure 3.1-5 and explains the need for hazards information. These sites were selected by authors of this study plan because of the proximity of drainages to planned surface facilities, as they are currently known. The number and location of sites is subject to future change when flood- and debris-hazards activities are coordinated with the specific needs of surface-facilities designers.

Using the estimated magnitudes of potential future flood events, in conjunction with relations developed between debris transport quantities and processes and flood magnitudes in modern and ancient flood events, it may be possible to estimate the debris-transport potential of future severe floods.

With current technology, it is impossible to accurately predict the quantity of debris associated with various magnitudes of flooding. However, qualitative assessments of the types of hazards that might be expected in different areas during "severe flooding" will be included with flood inundation maps. These assessments cannot include recurrence intervals or probabilities for various types of debris hazards.

Alternatives to the above approach are to ignore the hazards posed by debris transport, or to guess at the risk. These alternatives were not selected because they have too high a level of uncertainty.

3.1.3.2 Methods summary

The activity parameters to be determined by the tasks and analyses described in the above sections are summarized in Table 3.1-3. Also listed are the selected methods for determining the parameters and the current estimate of the parameter-value range. Potential alternate methods will be identified during the literature review and outside consultation. In some cases, there are additional approaches to conducting the task. In those cases, only the most common methods are included in the tables. The selected methods in Table 3.1-3 were chosen wholly or in part on the basis of accuracy, precision, duration of methods, expected range, and lack of interference with other tasks and analyses.

The USGS investigators have selected methods which they believe are suitable to provide accurate data within the expected range of the activity parameters. Models and analytical techniques have been or will be developed to be consistent with test results. The expected ranges of the activity parameters have been bracketed by previous data collection and are shown in Table 3.1-3.

3.1.4 Technical procedures and quality-assurance levels

The USGS quality-assurance program plan for the YMP (USGS, 1986) requires assignment, justification, and documentation of quality levels

Table 3.1-2 Locations of sites to be investigated for flood and debris hazards

Site	Location	Reason
A	Fortymile Wash at proposed bridge	Road
B	Unnamed tributary to Fortymile Wash, 3,800 ft east of proposed bridge	Road
C	Unnamed tributary to Fortymile Wash, 3,400 ft west of proposed bridge	Road
D	Drillhole Wash at northern end of Fran Ridge	Road
E	Unnamed tributary to Sever Wash, 3,100 ft north of mouth, west of Alice Ridge	Road
F	Sever Wash	Central surface facilities
G	Pagany Wash	Land disposal site
H	Sever Wash	Finished tuff pile
I	Unnamed tributary to Sever Wash	Finished tuff pile
J	Drillhole Wash	Men and materials shaft
K	Wren Wash	Men and materials shaft
L	Unnamed tributary to Wren Wash, north of Dead Yucca Ridge	Men and materials shaft
M	Coyote Wash	Exploratory shaft
N	Unnamed tributary to Drillhole Wash, at east end of Live Yucca Ridge	Emplacement area exhaust shaft

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Table 3.1-3. Summary of tasks and methods for the flood and debris hazards activity (SCP 8.3.1.16.1.1)
[Note: Dashes (--) indicate information is not available and to be determined

Methods (selected and alternate)	Activity parameter	Expected range
	Flood and debris-transport characterization	
Methods for flood and debris-transport characterization at Yucca Mountain (Studies 8.3.1.2.1.2, 8.3.1.5.2.1, and 8.3.1.2.1.1) (selected)	Air temperature	For overall study area, -23°C to +49°C
"	Durations of individual runoff events	Minutes to several days
"	Fluvial processes involved in transport and emplacement of debris deposits	Not applicable
"	Geographic extent of runoff	Depends on extent and intensity of storms
"	Precipitation, quantity and timing	Per storm, up to 0.6 m and 0 to several days
"	Quantity and characteristics of debris transported by severe runoff	Per feature, quantity 0 to 1.2 x 10^6 m^3 characteristics indeterminate
"	Relation of runoff to weather conditions	Not applicable
"	Runoff frequencies in specific and general areas	Depends on extent and intensity of storms
"	Runoff quantities at specific sites for specific events at select sites	Per storm, up to 61 x 10^6 m^3
"	Runoff rates at specific sites	0 to 2,830 m^3/sec
"	Sediment component of runoff	0-90% of flow
Collection of additional regional and world-wide flood data (selected)	(Same as for flood and debris-transport characterization at Yucca Mountain.)	(Same as for flood and debris-transport characterization at Yucca Mountain.)

Table 3.1-3. Summary of tasks and methods for the flood and debris hazards activity (SCP 8.3.1.16.1.1)--Continued

Methods (selected and alternate)	Activity parameter	Expected range
Hydrologic modeling for flood assessment		
Calculation of probable maximum flood (PMF) (selected)	Magnitude of probable maximum flood (PMF)	--
Other hydrologic modeling (Activity 8.3.1.5.2.2.1) (selected)	Magnitude and duration of runoff given hypothetical meteorological events (Activity 8.3.1.5.2.2.1)	--
Methods for defining surface topography (Investigation 8.3.1.14.1) (selected)	Areas of inundation	--
Analyze and interpret Yucca Mountain flood and debris-transport data		
Review all available analytical techniques (selected)	(Does not directly generate activity parameters)	Not applicable
Test applicable analytical techniques (selected)	"	"
Apply chosen analytical techniques (selected)	Magnitudes and associated frequencies of historic and selected prehistoric flooding	--
Methods for defining surface topography (selected)	(Does not directly generate activity parameters)	--
Assess potential future flooding and debris transport		
Comparative estimates based on analytical techniques (selected)	Areas of inundation of potential future floods	--
"	Magnitudes and associated frequencies of potential future floods	--

Table 3.1-3. Summary of tasks and methods for the flood and debris hazards activity (SCP 8.3.1.16.1.1)--Continued

Methods (selected and alternate)	Activity parameter	Expected range
Assess potential future flooding and debris transport		
Comparative estimates based on analytical techniques (selected)	Quantities and characteristics of debris transported by potential future floods	--
"	Sediment component of potential future floods	--
Comparative estimates based on modeling (selected)	Areas of inundation of potential future floods	--
"	Magnitudes and associated frequencies of potential future floods	--
"	Quantities and characteristics of debris transported by potential future floods	--
"	Sediment component of potential future floods	--
Comparative estimates based on observed flooding and debris transport (selected)	Areas of inundation of potential future floods	--
"	Magnitudes and associated frequencies of potential future floods	--
"	Quantities and characteristics of debris transported by potential future floods	--
"	Sediment component of potential future floods	--

Table 3.1-3. Summary of tasks and methods for the flood and debris hazards activity (SCP 8.3.1.16.1.1)--Continued

Methods (selected and alternate)	Activity parameter	Expected range
	Assess potential future flooding and debris transport	
Comparative estimates based on prehistoric flooding and debris transport (selected)	Areas of inundation of potential future floods	--
"	Magnitudes and associated frequencies of potential future floods	--
"	Quantities and characteristics of debris transported by potential future floods	--
"	Sediment component of potential future floods	--
Determine debris-transport processes (selected)	Debris-transport processes	Not applicable

to activities that affect quality, and documentation of technical procedures for all technical activities that require quality assurance.

Table 3.1-4 provides a complete tabulation of quality-assurance level-assignment (YMP-QALA-) numbers and technical procedures applicable to this activity. Approved procedures are identified with a USGS number and the effective beginning date of the procedure implementation. Procedures that still require preparation do not yet have procedure numbers.

Procedures that are identified as "needed" in the table will be completed and available before the associated testing is started. Many of the needed technical procedures depend on the results of ongoing prototype testing and cannot be completed until work is done.

Completed quality-assurance level assignments are presented in Appendix 7.1.

Equipment requirements and instrument calibration are described in the technical procedures. Lists of equipment and stepwise procedures for the use and calibration of equipment, limits, accuracy, handling, and calibration needs, quantitative or qualitative acceptance criteria of results, description of data documentation, identification, treatment and control of samples, and records requirements are also included in these documents.

Page 1

Table 3.1-4. Technical procedures and quality-assurance level assignments for flood and debris hazards activity (SCP Activity 8.3.1.16.1.1)
[Dashes (--) indicate information is not available and to be determined. Quality-assurance level assignment numbers are listed with test/analysis title.]

Technical- procedure number (NWM-USGS-)	Technical-procedure	Effective date
	Debris transport characterization	
	3310G-01-07,R0, 3310G-01-08,R0, 3310G-01-09,R0	
TBD	Techniques for differentiating fluvial deposits on the basis of their physical characteristics	--
HP-174,R1	Techniques for measuring severe stream-channel or hillslope erosion and (or) resultant sediment deposits	01/08/90
	Assess potential future flooding	
	--	
Needed	Flood inundation mapping	

4 APPLICATION OF STUDY RESULTS

4.1 Application of results to resolution of design and performance issues

The results of this study will be used in the resolution of YMP design and performance issues concerned with the aspects of surface hydrology related to flood and debris hazards. Principal applications addressed in this study will be in repository seal characteristics (Issue 1.12), technical feasibility (Issue 4.4), repository design criteria for radiological safety (Issue 2.7), accidental radiological releases (Issue 2.3), total system performance (Issue 1.1), and NRC siting criteria (Issue 1.8).

The application of site information from this study to design and performance parameter needs, required for the resolution of design and performance issues, is addressed in Section 1.3. Appendix 7.2 provides additional detailed parameter relations.

4.2 Application of results to support other site-characterization investigations and studies

Data obtained as a result of this study may also be used in studies in the following investigations:

- o 8.3.1.2.1 - Studies to provide a description of the regional hydrologic system
- o 8.3.1.5.2 - Studies to provide the information required on potential effects of future climatic conditions on hydrologic characteristics
- o 8.3.1.6.1 - Studies to determine present locations and rates of surface erosion
- o 8.3.1.9.1 - Studies to provide the information required on natural phenomena and human activities that might degrade surface markers and monuments.

In Investigation 8.3.1.2.1, Study 8.3.1.2.1.2 (Characterization of runoff and streamflow), which mainly provides surface hydrologic data to the present study, may also receive some site-characterization data as part of original field work planned for the flood and debris hazards studies, and may possibly employ data on potential future flooding (such as frequency, magnitudes, and areas of inundation) calculated in the present study. In Study 8.3.1.2.1.3 (Characterization of the regional ground-water system), in the Fortymile Wash recharge study (Activity 8.3.1.2.1.3.3), frequencies and magnitudes of potential future flooding generated in this study may assist addressing the potential of streamflow in Fortymile Wash to act as a recharge mechanism.

In Investigation 8.3.1.5.2, Study 8.3.1.5.2.1 (Characterization of the Quaternary regional hydrology) includes a regional paleoflood evaluation (Activity 8.3.1.5.2.1.1), where paleoflood evidence will be compared with magnitudes and frequencies of historic floods collected in Study 8.3.1.2.1.2 (Characterization of runoff and streamflow). Because the data on historic flooding is expected to be sparse, it may be desirable to compare frequencies and magnitudes of potential future flooding (as calculated from the present study) with paleoflood evidence. A result of such a comparison could be an assessment of whether characteristics of potential future floods in the preclosure period are reasonably predicted in the light of paleoflood data.

In Investigation 8.3.1.6.1, Study 8.3.1.6.1.1 (Distribution and characteristics of present and past erosion), some of the original field work performed in this study (e.g. channel morphology), as well as calculations of frequencies and magnitudes and debris transport characteristics of potential future floods (from the present study) may be employed in the characterization of erosion potential at the various shafts and along roads and bridge locations, and in identifying low-erosion and low-deposition locations for surface markers.

In Investigation 8.3.1.9.1 (Natural phenomena and human activities that might degrade surface markers and monuments), Study 8.3.1.9.1.1 (Evaluation of natural processes that could affect the long-term survivability of the surface marker system at Yucca Mountain), the calculations from this study on frequency and magnitudes of future flood events, and their debris transport characteristics, may be used to identify optimum locations of surface markers.

5 SCHEDULES AND MILESTONES

5.1 Schedules

The proposed schedule presented in Figure 5.1-1 summarizes the logic network and reports for the flood potential and debris hazards study. This figure represents a summary of the schedule information which includes the sequencing, interrelations, and relative durations of the activities described in this study. Specific durations and start and finish dates for the activities are being developed as part of ongoing planning efforts. The development of the schedule for the present study has taken into account how the study will be affected by contributions of data from other studies, and also how the present study will contribute to or may interfere with other studies. Milestones shown on the schedule include the major milestones cited in SCP Table 8.3.1.16-3 (Major events and planned completion dates for studies in the Preclosure Hydrology program). Figure 5.1-1 reflects the most recent available project participant schedule.

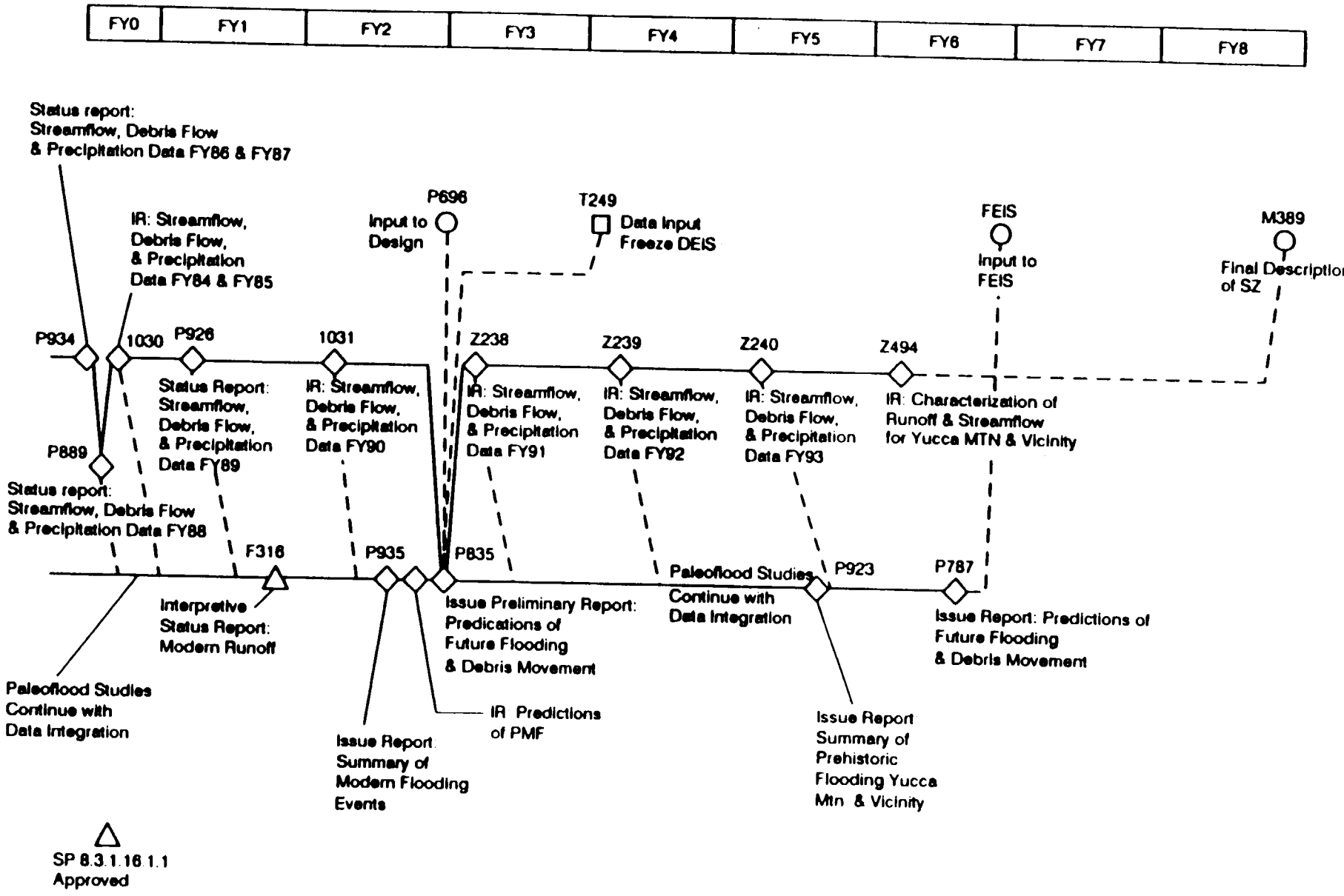

Figure 5.1-1. Summary network for flood-potential and debris-transport study, and runoff and streamflow study.

5.2 Milestones

The milestone numbers, titles, levels, and corresponding work breakdown structure (WBS) numbers associated with the flood and debris hazards activity are summarized in Table 5.2-1.

The information presented in Table 5.2-1 represents major events or important summary milestones associated with the activity presented in this study plan as shown in Figure 5.1-1. Specific dates for the milestones are not included in the tables, as these dates are subject to change due to ongoing planning efforts.

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Table 5.2-1. Milestone list for work-breakdown structure number-1.2.3.3.2.1 (SCP 8.3.1.16.1.1)

[Milestone dates are unavailable at this time.]

Milestone number	Milestone	Milestone level
Site flood and debris hazards studies: 8.3.1.16.1.1		
	Input to report on modern flooding events	
P794	Issue report on the potential for severe floods in Coyote Wash	2
3835	Issue PR: Predictions of probable maximum flood (U.S. Bureau of Reclamation)	2
3834	Work authorization (site flood and debris hazard studies)	3
P787	Issue Report: Predictions of future flooding and debris movement	3
P835	Issue PR: Predictions of future flooding and debris movement	3
P923	Issue Report: Summary of prehistoric flooding, Yucca Mountain and vicinity	3
3K47	Submit study plan 8.3.1.16.1.1 for DOE audit review	4
8M02	Submit study plan 8.3.1.16.1.1 to NRC	4
8M03	Prepare record package for Coyote Wash report	4

6 REFERENCES

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7 APPENDICES

7.1 Quality-assurance requirements matrix and quality-assurance level assignment sheets for the activity in present revision of study plan

7.1.1 Quality-assurance requirements matrix

Quality-assurance requirements

The activities of Study 8.3.1.2.1.2, and also Activity 8.3.1.5.2.1.1, which are critical contributors to the present study, have been restated in the present study plan. They have been assigned as Quality Level I in accordance with procedure USGS QMP-3.02. These data may be used in the license application in assessing ground-water travel times and ground-water flow rates which have a direct bearing on site assessments concerning waste isolation to be used in the license application. The applicable criteria from NQA-1 that apply to this study are shown below, along with the procedures and other documents that will satisfy these criteria.

The QALAs included in this appendix were approved in 1987 and are not completely consistent with the following list of NQA-1 criteria. Revised QALAs for this study plan are currently being developed using procedures that implement NUREG 1318. When the revised QALAs are approved, they will supersede the 1987 QALAs and will be provided through controlled distribution as a revision to the study plan.

Applicable NQA-1 criteria for Study 8.3.1.16.1.1 and how they will be satisfied

NQA-1 Criteria #	Documents addressing these requirements
1. Organization and interfaces	The organization of the OCRWM program is described in the Mission Plan (DOE/RW-005, June 1985) and further described in Section 8.6 of the SCP. Organization of the USGS-YMP is described in the following: QMP-1.01 (Organization Procedure)
2. Quality assurance program	The Quality-Assurance Programs for the OCRWM are described in YMP-QA Plan-88-9, and OGR/83, for the Project Office and HQ, respectively. The USGS QA Program is described in the following: QMP-2.01 (Management Assessment of the YMP-USGS Quality-Assurance Program)

	QMP-2.02 (USGS Personnel Qualification and Training) QMP-2.05 (Qualification of Audit and Surveillance Personnel) QMP-2.07 (Training Development and Documentation) QMP-2.08 (Contractor Personnel Qualification and Training) Each of these QA programs contains Quality Implementing Procedures further defining the program requirements. An overall description of the QA Program for site characterization activities is described in Section 8.6 of the SCP.
3. Scientific investigation design and control	This study is a scientific investigation. The following QA implementing procedures apply: QMP-3.02 (USGS QA Levels Assignment [QALA]) QMP-3.03 (Software Quality Assurance) QMP-3.04 (Technical Review, Approval and Distribution of YMP-USGS Publications) QMP-3.05 (Work Request for NTS Contractor Services [Criteria Letter]) QMP-3.06 (Scientific Investigation Plan) QMP-3.07 (YMP-USGS Review Procedure) QMP-3.10 (Verification of Scientific Investigations) QMP-3.11 (Peer Review) QMP-3.13 (Design Input) QMP-3.14 (Software Configuration Management System)
4. Administrative operations and procurement	QMP-4.01 (Procurement Document Control) QMP-4.02 (Control of Intra-USGS Acquisitions)

5.	Instructions, procedures, plans, and drawings	The activities in this study are performed according to the technical procedures listed in Section 3 of this study plan, and the QA administrative procedures referenced in this table for criterion 3. QMP-5.01 (Preparation of Technical Procedures) QMP-5.02 (Preparation and Control of Drawings and Sketches) QMP-5.03 (Development and Maintenance of Quality Management Procedures) QMP-5.04 (Preparation and Control of the USGS Quality Assurance Program Plan) QMP-5.05 (Scientific Notebook Control of Technical Activities)
6.	Document control	QMP-6.01 (Document Control)
7.	Control of purchased items and services	QMP-7.01 (Control of Purchased Items and Services)
8.	Identification and control of items, samples, and data	QMP-8.01 (Identification and Control of Samples) QMP-8.03 (Identification, Control, and Transmittal of Technical Data)
9.	Control of processes	Not applicable
10.	Inspection	Not applicable
11.	Test control	Not applicable
12.	Control of measuring and test equipment	QMP-12.01 (Instrument Calibration)
13.	Handling, shipping, and storage	QMP-13.01 (Handling, Storage, and Shipping of Instruments)
14.	Inspection, test, and operating status	Not applicable

15.	Control of nonconforming items	QMP-15.01 (Control of Nonconforming Items)
16.	Corrective action	QMP-16.01 (Control of Corrective Action Reports)
		QMP-16.02 (Control of Stop-Work Orders)
		QMP-16-03 (Trend Analysis)
17.	Records management	QMP-17.01 (YMP-USGS Records Management)
18.	Audits	QMP-18.01 (Audits)
		QMP-18.02 (Surveillances)

NQA-1 requires that tools, gages, instruments, and test equipment used for activities affecting quality shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within the necessary limits. Since this recalibration is not always possible when instruments are permanently sealed into the rock being tested, redundancy and other methods for mitigation are being evaluated and included in experimental design. Instruments and test-equipment calibration are controlled by USGS QMP-12.01 noted above.

Sample management is controlled by USGS QMP-8.01 noted above. More specific procedures for the handling and storage of samples (to ensure sample control and traceability) are being developed for use by the YMP Sample Management Facility and by the USGS in its technical procedures.

7.1.2 Quality-assurance level assignment sheets for the activity in present revision of study plan

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NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Regional and Yucca Mountain Surface-Water Runoff Studies and Monitoring
Method - Design Streamgage Network

NNWSI-QALA-3310G-01-01, RO
Page 1 of 1

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Site reconnaissance	III		Meets none of the attributes of Level I or II. Site reconnaissance is reasonably flexible with regard to acceptable documentation of runoff.
Site selection	I	1,2,3,4,5,6,7,8,10, 12,13,15,16,17,18	Meets Step 5 of the QA Level Checklist wherein hydraulic criteria must be satisfied to collect accurate data. Criteria excluded: Item 9--not a special process; item 11--no tests or research involved; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

Originator Patrick A. Glancy	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI	Date
	6/3/87		6/9/87	for	6/10/87
WHPO Quality Assurance	Date	WHPO Technical	Date		Effective Date
	5/10/87		5-11-87		4/25/88

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Revised QALA

This is a REVISED SHEET

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Regional and Yucca Mountain Surface-Water Runoff Studies and Monitoring
Method - Measure Streamflow

NNWSI-QALA-3310G-01-02, R1
Page 1 of 1

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Measure streamflow	I	1,2,3,4,5,6,7,8,10, 12,13,15,16,17,18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These data are essential to quantification of surface-water runoff. Criteria excluded: Item 9--not a special process; item 11--no tests or research involved; item 14--not part of USGS QA Program.
Prototype testing of flumes and associated equipment for measuring streamflow and sediment concentration	III		Meets none of the attributes of Level I or II. Prototype testing of flumes is purely preliminary and will be conducted to define the range of methods and equipment suitable for incorporating into a more detailed study. No site characterization data will be collected.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

David A. Beck	2-19-88		3/4/88	for		3/4/88
Originator	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI		Date
	5/9/88		3-30-88		4/25/88	
WMPO Qual[illegible] Assurance	Date	WMPO Technical	Date		Effective Date	

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NNWSI - USGS QUALITY LEVELS ASSESSMENT SHEET (QALAS)
Activity - Regional and Yucca Mountain Surface-Water Runoff Studies and Monitoring
Method - Collection of Streamflow Data

NNWSI-QALA-3310G-01-03, RO

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Collect streamflow data	1	1,2,3,4,5,6,7,8,10, 12,13,15,16,17,18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These installations and data are essential to quantification of surface-water runoff. Criteria excluded: Item 9--not a special process; item 11--no tests or research involved; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
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6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

Originator Patrick A. Glancy	Date	Quality Assurance Manager	6/9/87 Date	Chief, Branch of NNWSI for	6/10/87 Date
WMPO Quality Assurance	6/8/87 Date	WMPO Technical	5-12-87 Date	4/25/88 Effective Date	

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Fluvial Transport of Hazardous Debris
Method - Measure Channel or Hillslope Erosion

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Measure channel or hillslope erosion caused by severe flooding	I	1,2,3,4,5,6,7,8,10 11,12,13,15,16,17, 18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These data are essential to the quantification of debris transport by severe flooding. Criteria excluded: Item 9--not a special process; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
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6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

Originator Patrick A. Glancy	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI for	6/10/87 Date
WMPO Quality Assurance	Date	WMPO Technical	Date		4/25/88 Effective Date

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NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Fluvial Transport of Hazardous Debris
Method - Measure Fluvial-sediment Deposition

NNWSI-QALA-3310G-01-08, RO
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Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Measure and characterize sediment deposits emplaced by severe floods	I	1,2,3,4,5,6,7,8,10 11,12,13,15,16,17, 18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These data are essential to the quantification of debris transport by severe flooding. Criteria excluded: Item 9--not a special process; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

Originator: Patrick A. Glancy — Date: June 5, 1987
Quality Assurance Manager — Date: 6/9/87
Chief, Branch of NNWSI (for) — Date: 6/10/87
WMPO Quality Assurance — Date: 6/8/87
WMPO Technical — Date: 6-10-87
Effective Date: 4/25/88

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NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Paleoflood Studies
Method - Measure and Describe Characteristics of Erosion Scars and Sediment Deposits

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Reconnaissance and selection of study sites	III		Meets none of the attributes of Level I or II.
Excavate sediment deposits by trenching	III		Meets none of the attributes of Level I or II.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

Originator
Patrick A. Glancy — Date 6/2/87

Quality Assurance Manager — Date 6/10/87

Chief, Branch of NNWSI for — Date 6/10/87

WMPO Quality Assurance — Date 6/16/87

WMPO Technical — Date 6-22-87

Effective Date 4/25/88

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Paleoflood Studies
Method - Measure and Describe Characteristics of Erosion Scars and Sediment Deposits

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements[2]	Justification of Level & QA Criteria Exceptions
Measure and describe characteristics of erosion scars and (or) sediment deposits	I	1,2,3,4,5,6,7,8,10, 11,12,13,15,16,17, 18	Meets Steps 4 and 5 of the QA Level Checklist wherein data will be used for site characterization. The use of systematic measurement techniques is essential to proper interpretation of erosion scars and sediment deposits. Criteria excluded: Item 9--not a special process; item 14--not part of USGS QA Program.

New QALA

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS)
Activity - Regional Surface-Water Runoff Studies
Method - Collect and Analyze Streamflow Samples for Chemical and Isotopic Content

NNWSI-QALA-3310G-01-10, RO

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Collection and analysis of streamflow samples for chemical and isotopic content	I	1,2,3,4,5,6,7,8,10 12,13,15,16,17,18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These installations and data are essential to characterization of surface-water runoff. Criteria excluded: Item 9--not a special process; item 11--no tests or research involved; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

David A. Beck Originator David A. Beck	2-19-88 Date	[signature] Quality Assurance Manager	3/4/88 Date	[signature] for Chief, Branch of NNWSI	3/4/88 Date
James Blaylock WMPO Quality Assurance	4/25/88 Date	Maxwell Blanchard WMPO Technical	3-30-88 Date	4/25/88 Effective Date	

New QALA

NNWSI - USGS QUALITY LEVELS ASSIGNMENT SHEET (QALAS) NNWSI-QALA-3310G-01-11, RO
Activity - Yucca Mountain Surface Runoff Monitoring
Method - Collect and Analyze Streamflow Samples for Sediment Concentration

Method/Item Breakdown	QA Level	NQA-1 Criteria Requirements*	Justification of Level & QA Criteria Exceptions
Collection and analysis of streamflow samples for sediment concentration	I	1,2,3,4,5,6,7,8,10, 12,13,15,16,17,18	Meets Steps 4 and 5 of the QA Level Checklist wherein data collected will be used for site characterization. These installations and data are essential to quantification of surface-water runoff. Criteria excluded: Item 9--not a special process; item 11--no tests or research involved; item 14--not part of USGS QA Program.

*LEGEND OF 18 QA CRITERIA OF NQA-1

1 ORGANIZATION	7 CONTROL OF PURCHASED MAT'L, EQUIPMENT, SERVICES	13 HANDLING, STORAGE & SHIPPING
2 QA PROGRAM	8 ID & CONTROL OF MATERIALS, PARTS & SAMPLES	14 INSPECTION, TEST, & OP. STATUS
3 DESIGN & SITE INVESTIGATION CONTROL	9 CONTROL OF SPECIAL PROCESSES	15 CONTROL OF NONCONFORMING ITEMS
4 PROCUREMENT DOCUMENT CONTROL	10 INSPECTION (SURVEILLANCE)	16 CORRECTIVE ACTION
5 INSTRUCTIONS, PROCEDURES & DRAWINGS	11 TEST & EXPERIMENT/RESEARCH CONTROL	17 QA RECORDS
6 DOCUMENT CONTROL	12 CONTROL OF MEASURING & TEST EQUIPMENT	18 AUDITS

APPROVALS

David A. Beck	2-19-88	[signature]	2/29/88	[signature] for	3/4/88
Originator David A. Beck	Date	Quality Assurance Manager	Date	Chief, Branch of NNWSI	Date
[signature]	4/25/88	[signature]	3-30-88	4/25/88	
NNPO Quality Assurance	Date	NNPO Technical	Date	Effective Date	

7.2 Relations between the site information to be developed in this study and the design and performance information needs specified in the SCP

This section tabulates in Table 7.2.1 the specific technical information relations between SCP design- and performance-parameters needs and characterization parameters to be determined in this study. The relations were developed using model-based parameter categories (see Figure 2.1-1) that provide common terminology and organization for evaluation of site, design, and performance information relations.

All design and performance issues that obtain data from this study are noted in the table. For each issue, the characterization parameters (from SCP 8.3.1.2 and 8.3.1.16) are related to the design and performance parameters reported in the performance allocation tables (from SCP 8.3.2 - 8.3.5). At the beginning of each issue group, the performance measures addressed by the design or performance parameters for the issue are listed. Parameter categories, as noted above, are used to group the design and performance parameters with the characterization parameters so that comparisons of information requirement (design and performance) with information source (site study) can be made.

For each design and performance parameter noted in the table, the associated goal and confidence (current and needed) and site location are listed. For each parameter category, the associated characterization parameters are listed with information about the site location and the site activity providing the information.

Note - Comparison of the information relations (characterization parameters with design/performance parameters) must be done as sets of parameters in a given parameter category. Line-by-line comparisons from the left side of the table (design/performance parameters) with the right side of the table (site parameters) within a parameter category should <u>not</u> be made.

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 1.1	Will the mined geologic disposal system meet the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13?				(SCP 8.3.5.13)
Performance Measures: EPPM[a], disturbed case C-1, increased water flux through unsaturated zone					
Parameter Category: Surface-water flood and runoff characteristics					
Expected magnitude of local flux change, and quantitative bounds on magnitude of flux change, due to flooding through access shafts (scenario class C-1, local or extensive increases in unsaturated-zone percolation flux)	Shaft locations; Land surface	Goal: Show <25,000 m^3 per yr would pass through access shafts Current: Low Needed: Medium	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1
			Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	"

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 1.12	Have the characteristics and configurations of the shaft and borehole seals been adequately established to (a) show compliance with the postclosure design criteria of 10 CFR 60.134 and (b) provide information for the resolution of the performance issues				(SCP 8.3.3.2)
Performance Measures: Quantity of water Drainage capacity					
Parameter Category: Surface-water flood and runoff characteristics					
Quantity of water due to surface flooding events; 100 and 500 yr flood and probable maximum flood, including area of inundation and debris load of flows	Shaft, ramp, and borehole locations; Land surface	Goal: Inundation maps with elevation of inundated area to within +/- 2 m Current: Low Needed: Medium	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1
"	"	Goal: Determine topography of drainage area using 2 m contours Current: Medium Needed: Medium	Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	"
Magnitude of water entering shafts	ES-1, ES-2, MM and EE shafts;	Goal: <150 m^3/yr per shaft considering anticipated processes Current: Low Needed: Low			

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 1.12	Have the characteristics and configurations of the shaft and borehole seals been adequately established to (a) show compliance with the postclosure design criteria of 10 CFR 60.134 and (b) provide information for the resolution of the performance issues				(SCP 8.3.3.2)
Performance Measures: Quantity of water					
		Parameter Category: Surface-water debris-transport characteristics			
Quantity of water due to surface flooding events; 100 and 500 yr flood & probable maximum flood, including area of inundation and debris load of flows	Shaft, ramp, and borehole locations; Land surface	Goal: Estimates of debris quantity and category Current: Low Needed: Low	Debris transport: locations, quantities, and characteristics (from Study 8.3.1.2.1.2)	Yucca Mountain and surrounding region; Land surface	8.3.1.16.1.1.1
			Potential for future flooding, potential hazards of debris transported by flood flows	Yucca Mountain and vicinity; Land surface	"

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 2.1	During operation, closure, and decommissioning will radiation dose received by public within a highly populated area be less then a small fraction of the allowable limits and in unrestricteed areas are the limits as required by 10 CFR 60.111, 40 CFR 191				(SCP 8.3.5.3)
Performance Measures: Radionuclides concentrations in environmental media and individual doses					
		Parameter Category: Surface-water flood and runoff characteristics			
Volumetric flow of surface water to water bodies	80 km radius; Land surface	Goal: Little or no surface runoff Current: Medium Needed: Medium	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1
			Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	"
Issue 2.3	Can the repository be designed, operated, costructed, closed, and decommissioned in such a way that accidents do not result radiological exposures of the public at the nearest boundry of the area, or workers in the restricted area, in excess of limits?				(SCP 8.3.5.5)
Performance Measures: Consequences of credible site-related accidents Long-term dispersion, diffusion, and bioaccummulation characteristics of the site					
Frequency and magnitudes of repository surface flooding	Repository facilities; Land surface	Goal: PMF (Probable maximum flood) Current: Medium Needed: High	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 2.3	Can the repository be designed, operated, costructed, closed, and decommissioned in such a way that accidents do not result radiological exposures of the public at the nearest boundry of the area, or workers in the restricted area, in excess of limits?				(SCP 8.3.5.5)
Performance Measures: Long-term dispersion, diffusion, and bioaccummulation characteristics of the site					
		Parameter Category: Surface-water flood and runoff characteristics			
Volumetric flow of surface water to water bodies	80-km radius; Land surface	Goal: Little or no surface runoff Current: Medium Needed: Medium	Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	8.3.1.16.1.1.1
Issue 2.7	Have the characteristics and configurations of the repository been adequately established to (a) show compliance with preclosure design (b) provide information for the resolution of performance issues				(SCP 8.3.2.3)
Performance Measures: Ability to detect radioactive materials in repository effluent streams Decontamination factor					
Volumetric flow of surface water to water bodies (80 km radius)	Area within 80 km of site; Land surface	Goal: Little or no surface runoff Current: Medium Needed: Medium	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1
Repository surface flooding (At facility)	Repository area; Land surface	Goal: PMF[o] Current: Medium Needed: High	Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	"

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 4.4	Are the technologies repository construction, operation, closure, and decommissioning adequately established for the resolution of the performance issues				(SCP 8.3.2.5)
Performance Measures: Location relative to floodplain Soil and rock conditions					
		Parameter Category: Surface-water flood and runoff characteristics			
Surface hydrology for 10-, 25-, 50-, 100-, and 500-year flood and probable-maximum flood (PMF);area of inundation - maps with elevation of inundation	Repository area; Land surface	Goal: Inundation maps with elevation of inundation area to within +/- 2 m Current: Low Needed: High	Potential for future flooding, magnitude and frequency of flooding at specific locations	Yucca Mountain and vicinity; Land surface	8.3.1.16.1.1.1
Surface hydrology for 10-, 25-, 50-, 100-, and 500-year flood and probable-maximum flood (PMF): topography of area of inundation and drainage area	"	Goal: Topography of drainage area 2 m contours Current: Medium Needed: Medium	Runoff and streamflow, temporal, spatial, and physical charateristics (from Study 8.3.1.2.1.2)	Yucca Mountain; Land surface	"
Favorable infiltration/runoff ratio	Yucca Mountain, vicinity of surface facilities; Land surface	Goal: See SCP Section 8.3.1.2 (geohydrology) Current: Low Needed: High			

Table 7.2-1 Design and performance issues and parameters supported by results of this study

Design and Performance Parameters	Parameter Location	Parameter Goal and Confidence (Current and Needed)	Site Parameters	Parameter Location	Site Activity
Issue 4.4	Are the technologies repository construction, operation, closure, and decommissioning adequately established for the resolution of the performance issues				(SCP 8.3.2.5)
Performance Measures: Location relative to floodplain					
		Parameter Category: Surface-water debris-transport characteristics			
Surface hydrology for 10-, 25-, 50-, 100-, and 500-year flood and probable-maximum flood (PMF);- area of inundation - debris quantity and category	Repository area; Land surface	Goal: Debris quantity and category Current: Low Needed: Low	Debris transport: locations, quantities, and characteristics (from Study 8.3.1.2.1.2)	Yucca Mountain and surrounding region; Land surface	8.3.1.16.1.1.1
			Potential for future flooding, potential hazards of debris transported by flood flows	Yucca Mountain and vicinity; Land surface	"

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