

Nuclear Waste Policy Act
(Section 113)

Section 8.5

S

Consultation Draft

**MILESTONES,
DECISION POINTS
AND SCHEDULE**



Site Characterization Plan

**Yucca Mountain Site, Nevada Research
and Development Area, Nevada**

Volume VII

January 1988

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

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8.5 MILESTONES, DECISION POINTS, AND SCHEDULE

This section presents the milestones, decision points, and summary schedule information established for the site characterization program for the Yucca Mountain site through the submittal of the license application to the Nuclear Regulatory Commission (NRC). This information represents a summary of the schedule information provided in Section 8.3, which includes the sequencing, interrelationships, and relative durations of the studies and activities described in each site investigation and performance assessment or design information need. Specific durations, and start and finish dates for the studies and activities are being developed as part of ongoing planning efforts, and improved information should be available at the time the SCP is issued. Schedule information will then be updated, as appropriate, in subsequent semiannual progress reports. No specific dates or absolute timelines have been specified in this section except in Table 8.5-1 in Section 8.5.6.

Section 8.5.1 presents summary schedule and milestone information related to the site programs described in Section 8.3.1 and includes an exploratory shaft logic diagram showing the relative duration and sequencing of construction- and testing-related activities. Section 8.5.2 presents summary schedule and milestone information for preclosure and postclosure performance assessment issues. Summary schedule information for both preclosure and postclosure repository design issues and for the seal design issue are presented in Section 8.5.3. Section 8.5.4 presents summary schedule information associated with waste package design issues while Section 8.5.5 provides a list of the major decision points and presents a simplified flow diagram showing the interfaces among these decision points. Section 8.5.6 presents a summary schedule for the program elements covered in Sections 8.5.1 through 8.5.4.

The points shown on the timelines presented in Sections 8.5.1 through 8.5.4 represent major events or important summary milestones associated with the investigations or information needs presented in Section 8.3. The milestones selected for presentation in Section 8.5.6 are the major integration products from the activities presented in Sections 8.5.1 through 8.5.4. Regulatory and institutional milestones have been added, as appropriate, to complete the schedule.

The information provided in this section should be viewed as a snapshot in time with regard to planned site characterization activities and the schedule for those activities. The site characterization program will undergo a series of refinements, beginning with changes resulting from review of the consultative draft of the SCP by the State, Tribes, and the NRC. The opportunity to preliminarily review and comment on the SCP and interact with the Department of Energy (DOE) on substantive technical issues prior to final production of the SCP may result in the need for some revision in the scope of activities and the schedule for these activities. Revisions required as a result of consultations with the State, Tribes, and the NRC would be considered in the ongoing planning efforts, and would be reflected, as appropriate, in the SCP at the time of issuance. Further revisions to the scope of activities and schedules may be required as a consequence of the NRC

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and State review of the document to evaluate the data to be obtained and to assess the adequacy of the planned activities. These revisions would be presented in the semiannual SCP progress reports.

8.5.1 SITE CHARACTERIZATION ACTIVITIES AND MILESTONES

The site programs described in Section 8.3.1 do not directly tie to regulatory requirements in the manner that the performance and design issues do. Instead, site programs have been structured to address acquisition of data on present and expected site characteristics, processes, and events needed to develop site descriptions and to support the resolution of design and performance issues. The performance and design issues were derived from the regulations, thus providing an indirect tie from the site programs to the regulations. The issue resolution strategies presented in Section 8.2 and discussed in greater detail in Sections 8.3.2 through 8.3.5 identified the site data required to support the resolution of the design and performance issues that are tied directly to the NRC (10 CFR Part 60) and other regulatory requirements. This includes data required to support the higher level findings on the DOE general siting guidelines (10 CFR Part 960). On the basis of these strategies, the site testing program has been designed to obtain sufficient data to satisfy these requirements.

The following section, 8.5.1.1, provides summary schedule information associated with the site program. A logic diagram showing the relative duration and sequencing of major exploratory shaft construction- and testing-related activities is provided in Section 8.5.1.2. Section 8.5.1.3 presents the list of site characterization study plans. Study plans will contain schedule and milestone information to supplement that presented in the SCP.

8.5.1.1 Site programs

Summary schedule information for each site program described in Section 8.3.1 is provided in this section in the form of timelines. The schedule information presented in the figures that follow has been grouped by site program as follows:

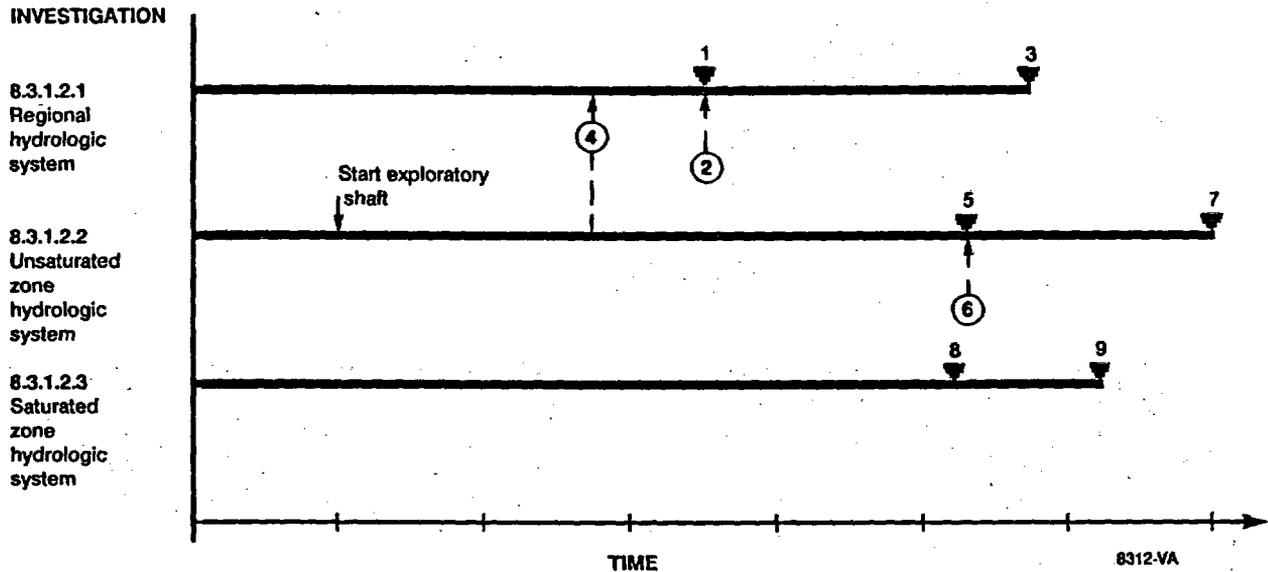
1. Geohydrology program
2. Geochemistry program
3. Rock characteristics program
4. Climatology program
5. Erosion program
6. Postclosure tectonics program
7. Human interference program
8. Meteorology program
9. Offsite installations program
10. Surface characteristics program
11. Thermal and mechanical rock properties program
12. Preclosure hydrology program
13. Preclosure tectonics program

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Each investigation within a site program is represented by a timeline. The length of the timeline representing the investigation is proportional to the investigation duration. Points shown on the timelines represent major events or important milestones associated with the investigation. Solid lines represent investigation durations and dashed lines show interfaces. The data input and output at the interfaces are shown by circles.

**GEOHYDROLOGY PROGRAM
(SECTION 8.3.1.2)**

Results of the studies under this program will be used in the resolution of Issues 1.1 and 1.6 (total system performance and pre-waste-emplacement ground-water travel time, respectively). The activities in this investigation will progress in parallel with the activities necessary to resolve performance and design issues.



The points on the timelines and the data input and output are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z491. Report available on the refinement of the three-dimensional ground-water flow model.
2	Three-dimensional ground-water flow model will be used in the studies of Investigations 8.3.1.5.2 and 8.3.1.8.3 to test the impacts of possible future ground-water developments, tectonic activity, and climatic changes on the saturated hydrologic system.

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- 3 Milestone Q044. Report available on the characterization of the Yucca Mountain regional hydrologic system.

Point
number

Description

- 4 Meteorological and runoff data input to infiltration study.
- 5 Milestone Z483. Issue report on the preliminary hydrologic description of the unsaturated zone at Yucca Mountain.
- 6 Analyses as part of the unsaturated zone flow and transport modeling study and system analysis and integration study will be used toward the resolution of Issues 1.1 (total system performance) through 1.6 (ground-water travel time).
- 7 Milestone M391. Issue report on the hydrologic description of the unsaturated zone at Yucca Mountain.
- 8 Milestone P897. Issue report on the preliminary hydrologic description of the saturated zone for input to the draft environmental impact statement.
- 9 Milestone M389. Issue report on the description of the site saturated zone hydrology at Yucca Mountain.

GEOCHEMISTRY PROGRAM (SECTION 8.3.1.3)

The results of studies under this program will be used in the resolution of Issue 1.1 (total system performance). The geochemical retardation that can be relied upon in the rock units between the repository and the accessible environment is one component of the strategy for meeting the release limits specified in the regulations. The activities in this investigation will progress in parallel with activities supporting resolution of the performance and design issues.

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INVESTIGATION

8.3.1.3.1
Water
chemistry

8.3.1.3.2
Mineralogy,
petrology and rock
chemistry

8.3.1.3.3
Minerals/glass
stability

8.3.1.3.4
Radionuclide
retardation –
sorption
processes

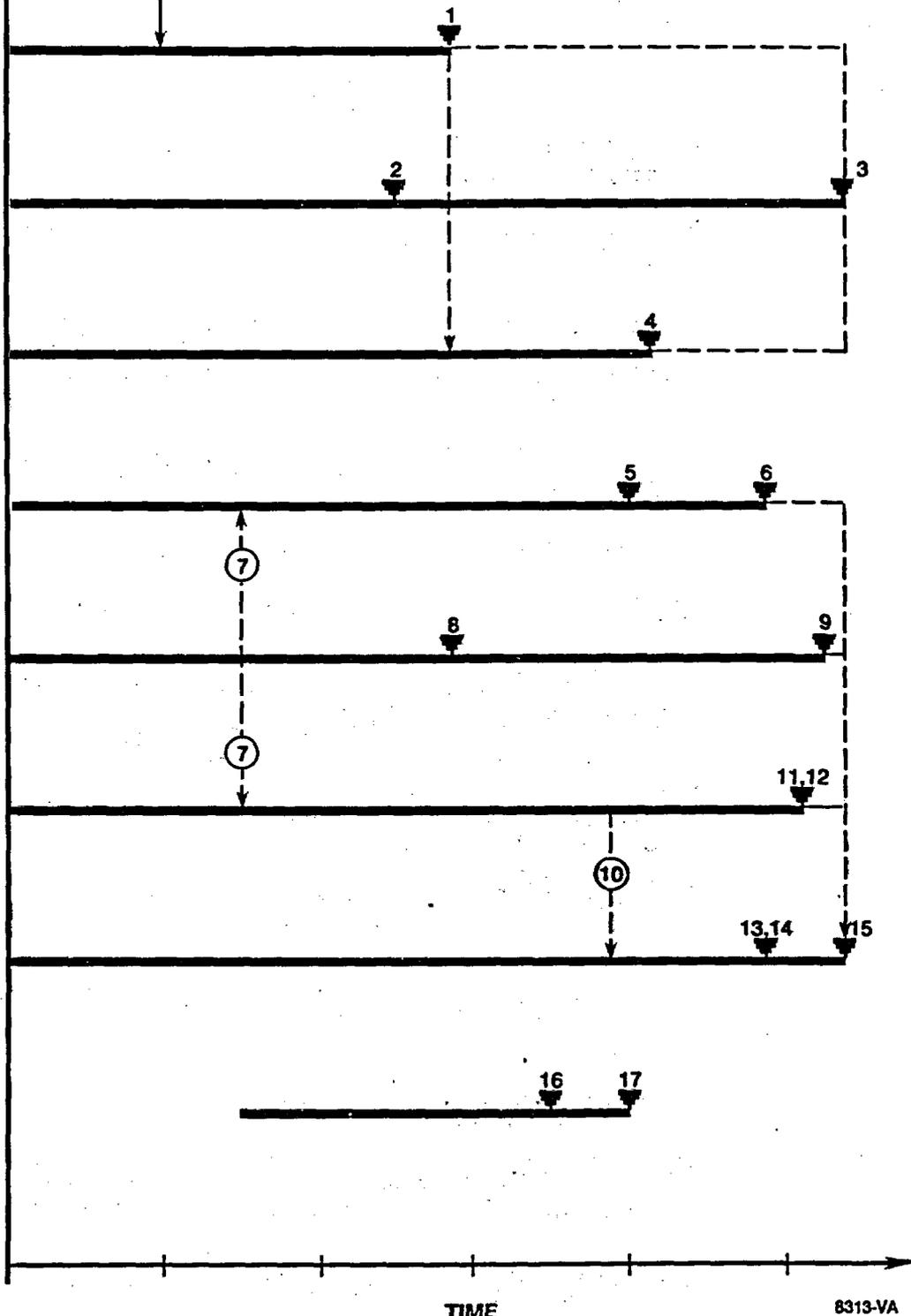
8.3.1.3.5
Radionuclide
retardation –
precipitation
processes

8.3.1.3.6
Radion. retard. –
dispersion, diffu-
sive, and advective
transp. processes

8.3.1.3.7
Radionuclide
retardation –
all processes

8.3.1.3.8
Gaseous
radionuclide
retardation

Start exploratory shaft



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The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone M374. Final report available on ground-water chemistry model.
2	Milestone Q030. Summary report available on alteration history.
3	Milestone Q001. Report available on the summary results defining the geochemical characteristics (mineralogy-petrology, mineral stability, and water chemistry) at Yucca Mountain.
4	Milestone R360. Final report available on conceptual model of mineral evolution at Yucca Mountain.
5	Milestone R385. Sorption model complete.
6	Milestone M376. Final sorption report available.
7	Data input on radionuclide retardation by precipitation processes from Investigation 8.3.1.3.5 to Investigations 8.3.1.3.4 and 8.3.1.3.6 for the interpretation of batch sorption and column tests, respectively.
8	Milestone Z224. Final report available on colloid stability and characterization.
9	Milestone M377. Final report available on the solubility of radionuclides in Yucca Mountain water.
10	Data input on dispersion and diffusion from Investigation 8.3.1.3.6 to Investigation 8.3.1.3.7 for geochemical-geophysical model development.
11	Milestone R340. Final report available on unsaturated flow column experiments.
12	Milestone Q038. Summary report available on radionuclide retardation by diffusive, dispersive, and advective processes.
13	Milestone M390. Final geochemical-geophysical model complete.
14	Milestone P381. Final integrated transport calculations available.
15	Milestone Q002. Report available on the summary of results defining radionuclide retardation at Yucca Mountain.

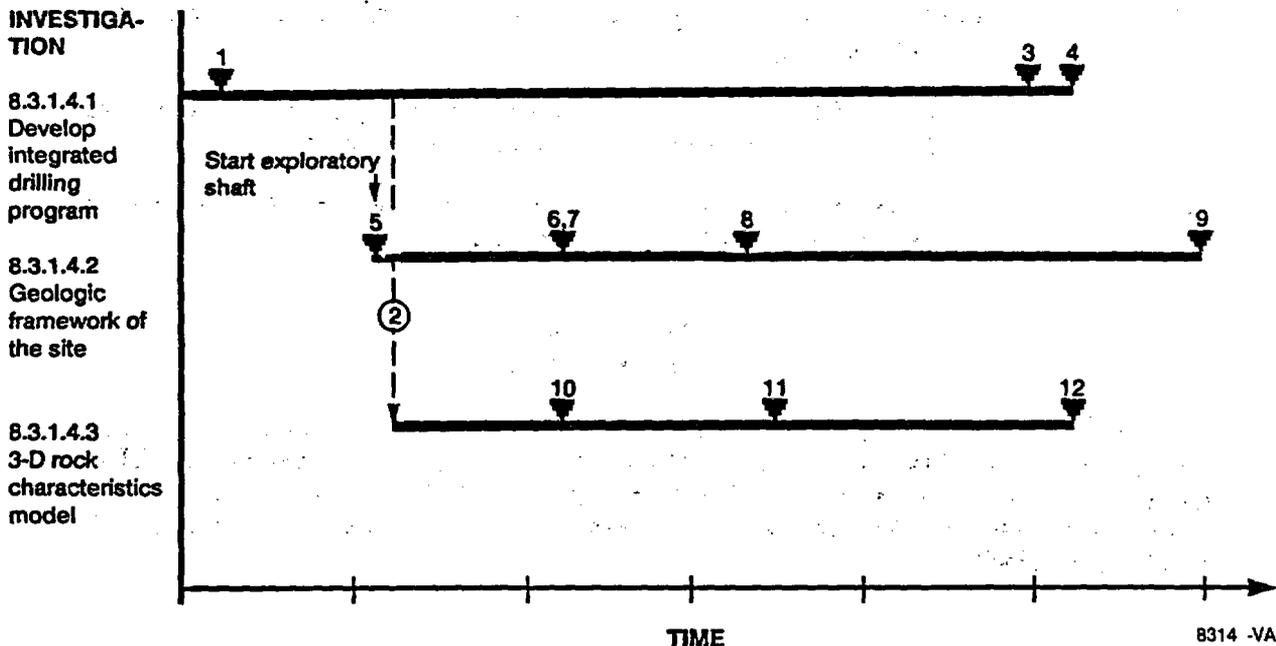
Point number

Description

- 16 Complete assessment as to whether calculated gas transport rates with their associated uncertainties are adequate to assess gaseous radionuclide releases for performance assessment calculations; results of this assessment will determine whether experimental measurements of radionuclide transport rates and retardation processes are needed to verify calculational models.
- 17 Report available on the results of experimental measurements of gaseous transport and retardation rates to verify calculational models (assuming the experimental measurements are necessary).

**ROCK CHARACTERISTICS PROGRAM
(SECTION 8.3.1.4)**

Results of studies in this program will be used to develop an integrated drilling program for the Yucca Mountain site, to better define the geologic framework of the site, and to produce a three-dimensional rock characteristics model for the site. This information will be useful in the resolution of a number of performance and design issues, including Issues 1.1 (total system performance), 1.6 (pre-waste-emplacement ground-water travel time), and 1.11 (configuration of underground facilities).



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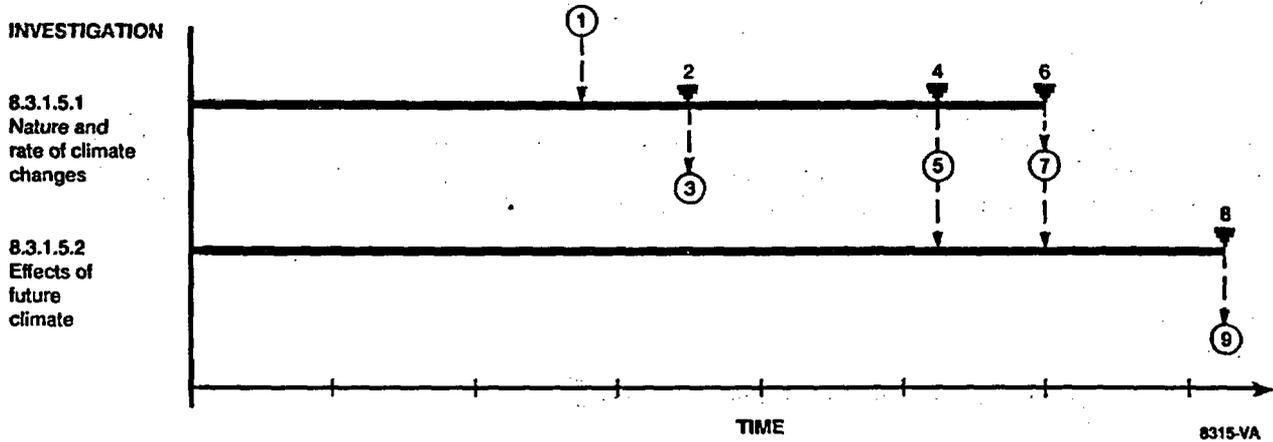
The points on the timeline and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Q085. Produce integrated drilling plan for the first year of site characterization.
2	Results of integrated drilling plan for second year of site characterization available to Investigation 8.3.1.4.3.
3	Milestone Q120. Complete all borehole construction and testing for licensing application.
4	Milestone Q121. Issue final report on integration of site characterization borehole construction.
5	Milestone P780. Issue final geologic map of Yucca Mountain.
6	Milestone R757. Complete alteration and fracture mineralogy studies.
7	Milestone Z263. Complete vertical seismic profiling studies.
8	Milestone Q117. Complete drilling of geologic holes.
9	Milestone M384. Complete final 3-D geologic model of the site area.
10	Milestone Q101. Complete Phase I of performance assessment drilling program.
11	Milestone Q118. Complete Phase II of performance assessment drilling (representative sampling) program.
12	Milestone Q006. Complete final reference model for 3-D rock characteristics of Yucca Mountain.

CLIMATE PROGRAM (SECTION 8.3.1.5)

Results of studies in this program will be used to support the resolution of Issue 1.1 (total system performance). Expected changes in climatic conditions over the next 10,000 yr are important for predicting if releases of radionuclides to the accessible environment are likely to comply with the regulatory limits.

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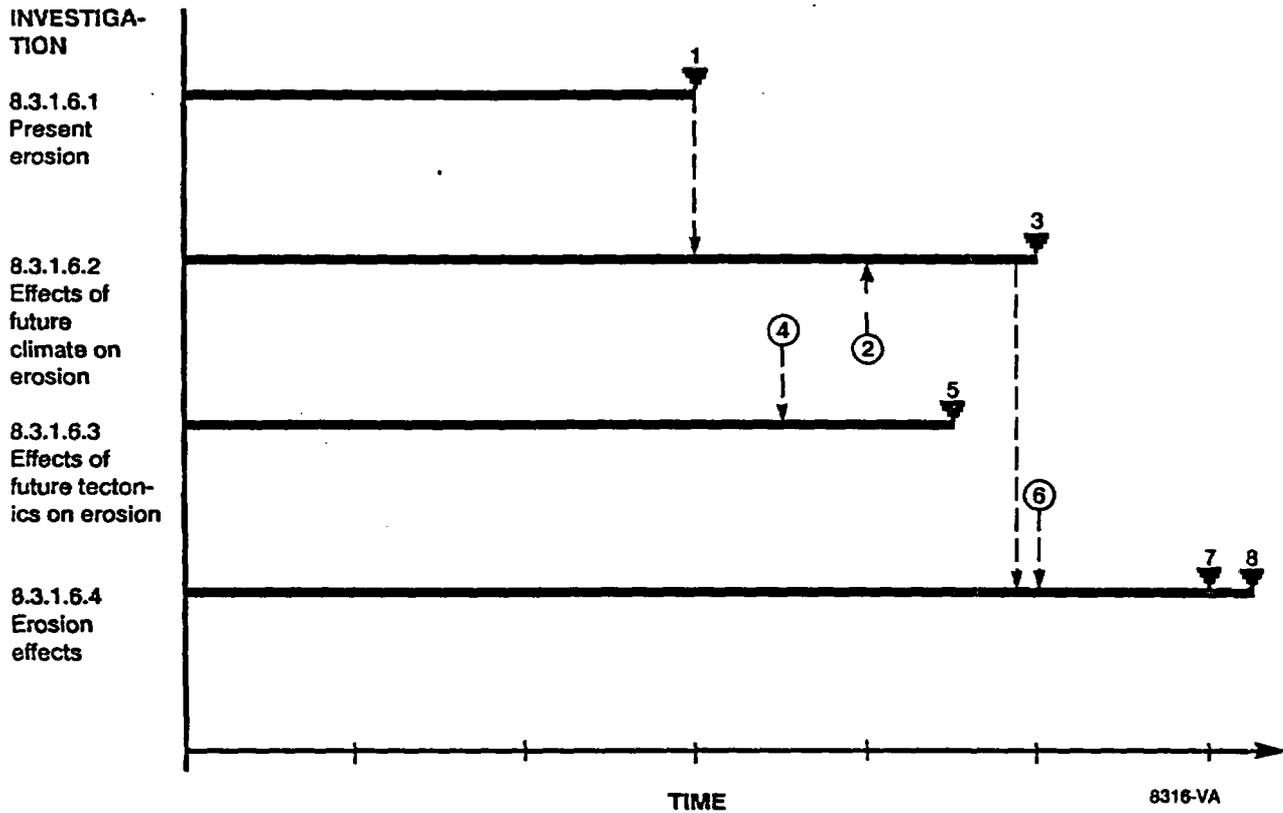
The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Data input from meteorology program (Section 8.3.1.12) and geohydrology program (Section 8.3.1.2).
2	Milestone P101. Report available on characterization of the present regional climate and environment.
3	Input from climate information relevant to Quaternary faulting in the site area to Investigation 8.3.1.17.4 (preclosure tectonics data collection and analysis).
4	Milestone M366. Define Quaternary climate of Yucca Mountain.
5	Conceptual model of calcite-silica deposits available for Issue 1.1 (total system performance, Section 8.3.5.13) and for the postclosure tectonics program (Section 8.3.1.8).
6	Milestone P104. Report available on future climate as predicted from models based on the nature and rates of change in climatic conditions.
7	Final input regarding future climate as predicted from models is available for use in Investigation 8.3.1.5.2.
8	Milestone Q162. Report available on potential effects of future climate conditions on hydrologic characteristics at Yucca Mountain.
9	Final input to Issue 1.1 (total system performance) on effects of future climatic change on the hydrologic system.

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EROSION PROGRAM
(SECTION 8.3.1.6)

Studies in this program will document the predicted impacts of erosion on the performance of a repository at Yucca Mountain. A series of topical reports are planned to demonstrate that the overall impacts of erosion at the Yucca Mountain site are likely to be insignificant.



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z286. Complete development of geomorphic map of Yucca Mountain.
2	Information received from climate investigations 8.3.1.5.1 and 8.3.1.5.2.
3	Milestone Z290. Issue topical report on the evaluation of the impact of future climatic conditions on locations and rates of erosion.

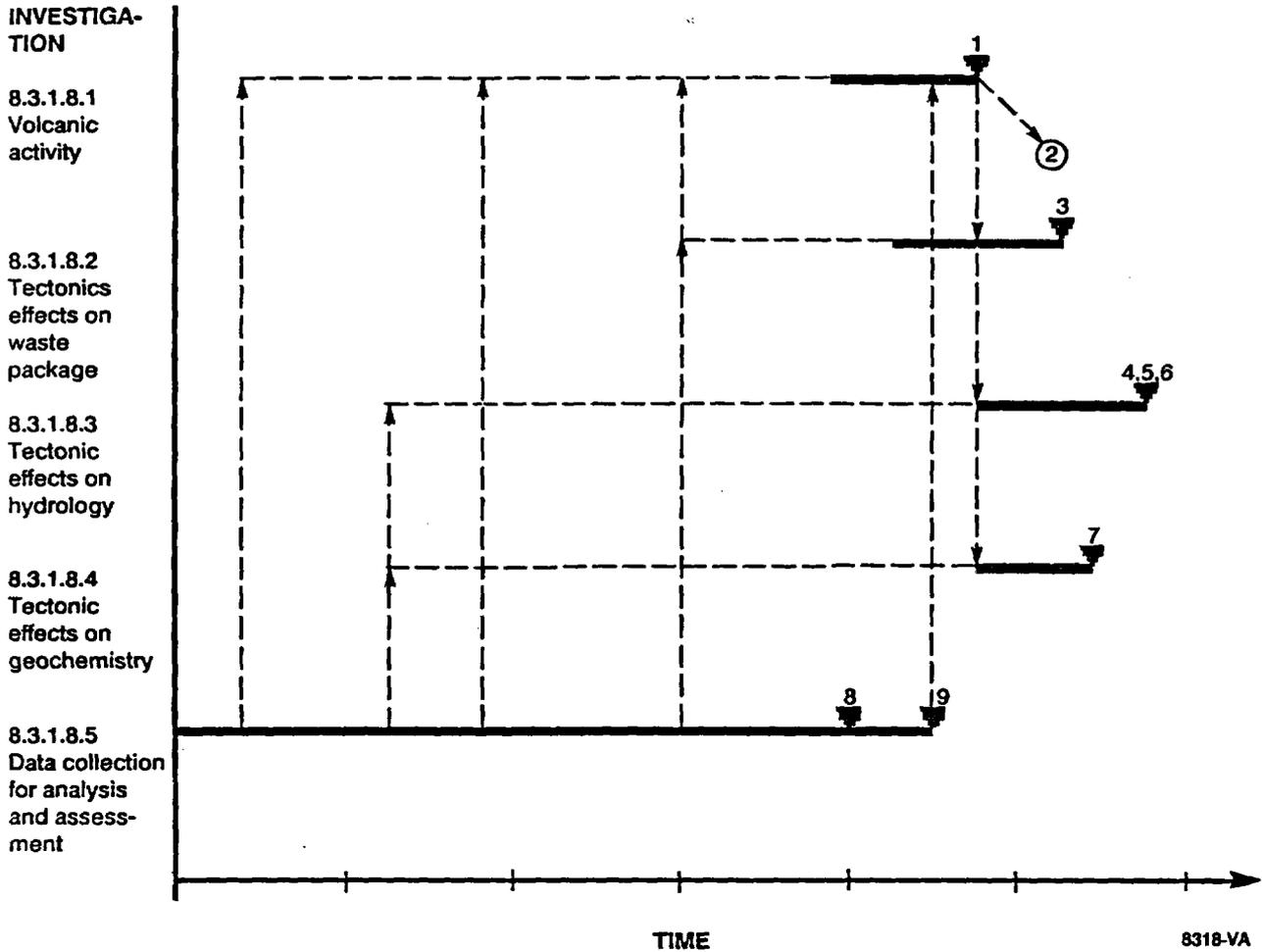
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- 4 Information received from postclosure tectonics (Investigation 8.3.1.8.2).
- 5 Milestone Z292. Issue topical report on the evaluation of the impact of future uplift/subsidence and faulting on erosion at Yucca Mountain and vicinity.
- 6 Information received from the geohydrology, geochemistry, and rock characteristics programs (Sections 8.3.1.2, 8.3.1.3, and 8.3.1.4).
- 7 Milestone Z294. Issue topical report on the evaluation of future erosion on baseline conditions at Yucca Mountain and vicinity.
- 8 Milestone Z498. Issue topical report on the effects of erosion on postclosure containment and isolation at Yucca Mountain.

POSTCLOSURE TECTONICS PROGRAM (SECTION 8.3.1.8)

Results of the studies in this program will be used to support the resolution of a number of performance and design issues, including Issues 1.1 (total system performance), 1.8 (NRC siting criteria), 1.11 (configuration of the underground facilities), and Issue 4.4 (preclosure design and technical feasibility). Scenarios resulting from tectonic processes and events will be considered in the evaluation of the cumulative radionuclide releases over 10,000 yr in Issue 1.1.

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The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z378. Summary report available on effects of igneous and volcanic effects.
2	Probability calculations for risk assessment as well as other results of the investigation input to Issue 1.1 (total system performance).
3	Milestones Z379, Z380, and Z382. A series of reports to be available for use by Issue 1.11 (configuration of underground facilities (postclosure)) assessing the effects of faulting, folding, deformation, and igneous intrusive processes on the waste packages, and on expected repository ground motions during the postclosure period (Milestone Z381).

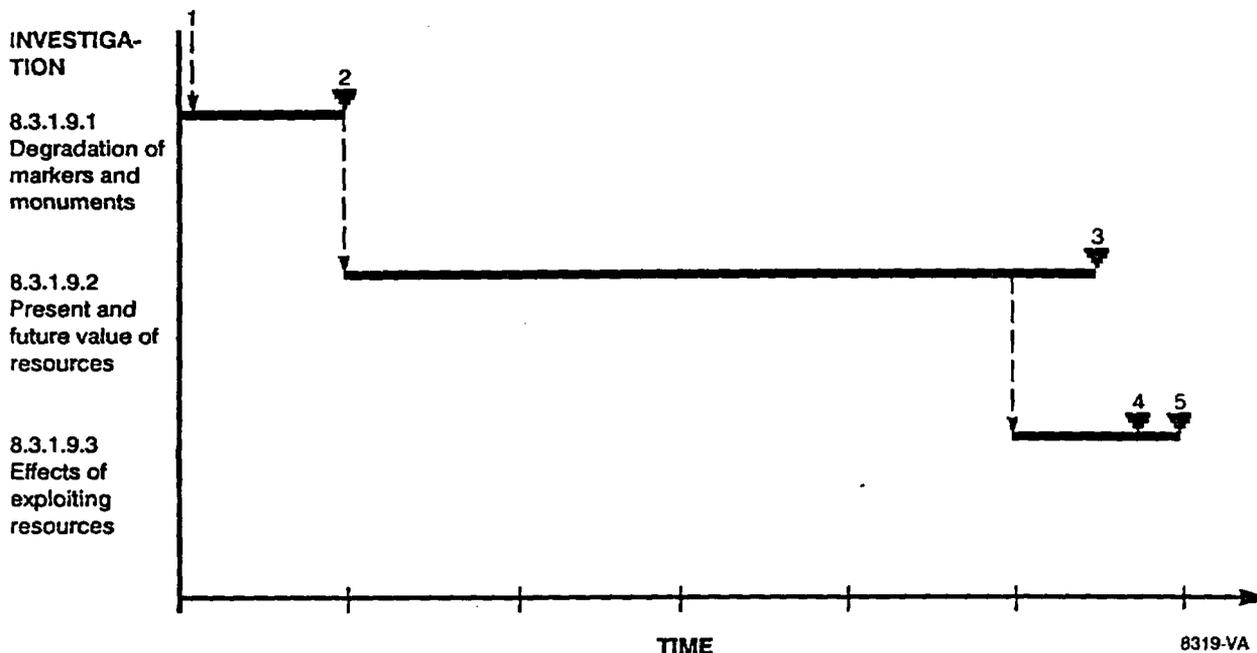
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<u>Point number</u>	<u>Description</u>
4	Milestones Z384, Z383, and Z393. A series of reports is available for use by Issue 1.1 assessing the effects of volcanism, faulting, folding, uplift, and subsidence on flux rates.
5	Milestones Z385, Z386, and Z388. A series of reports is available for use by Issue 1.1 assessing the effects of igneous intrusions, strain changes, faulting, folding, uplift and subsidence on water-table elevations.
6	Milestones Z389, Z390, Z391. A series of reports is available for use by Issue 1.1 assessing the effects of igneous intrusions, faulting, and stress and strain changes on local fracture permeability and effective porosity.
7	Milestones Q149, Z397, Z398, and Z399. A series of reports is available for use by Issue 1.1 assessing the effects of igneous intrusions, faulting, or tectonically induced changes in water-table elevation on rock geochemical properties along likely travel pathways.
8	Milestone Z302. Report available on evaluation of folds in Neogene rocks of the region.
9	Milestone Z409. Report available on geochemical cycles of basalt fields of the Great Basin.

HUMAN INTERFERENCE PROGRAM (SECTION 8.3.1.9)

Results of studies in this program will be used to establish that markers and monuments will remain effective for the time specified in the regulations. The likelihood of human interference related to natural resources will be considered in the calculation of total releases to the accessible environment over 10,000 yr as required for the resolution of Issue 1.1 (total system performance).

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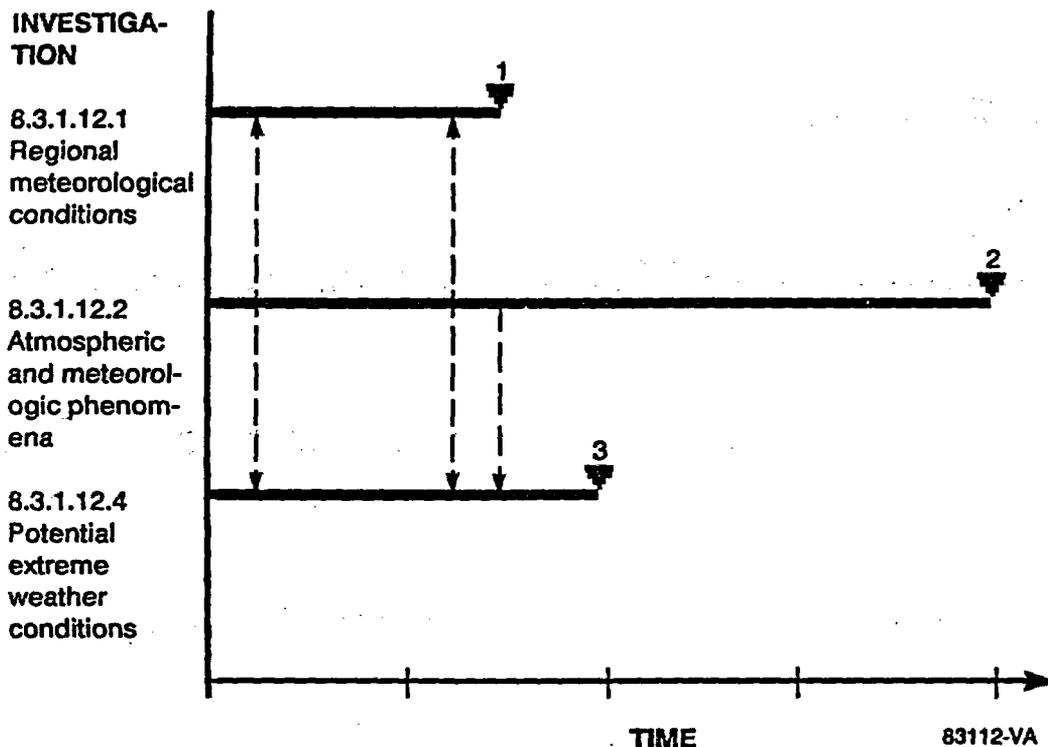
The points on the timeline and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Data input from investigations examining volcanic eruption, repository igneous intrusion, waste package rupture due to tectonic processes and events, and modern regional climate (8.3.1.8.1, 8.3.1.8.2, 8.3.1.8.5 and 8.3.1.5.1) for activities examining tectonic activity and erosion and future climate and erosion (8.3.1.6.3.1.1 and 8.3.1.6.2.1.1).
2	Milestone Z472. Issue report synthesizing the natural processes that could affect marker survivability.
3	Milestone T082. Issue final report on the evaluation of natural resources at Yucca Mountain and vicinity.
4	Milestone R676. Issue report on factors contributing to the likelihood of human interference and intrusion events at Yucca Mountain.
5	Milestones Z473 and Z474. Issue reports on potential effects of exploiting ground water and the assessment of unlikely events of human interference.

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METEOROLOGICAL PROGRAM
(SECTION 8.3.1.12)

Results of the studies and monitoring performed in this program will be used to support issue resolution of a number of preclosure issues concerned with radiological safety, including Issues 2.1 (public radiological exposures--normal conditions), 2.2 (worker radiological safety--normal conditions), 2.3 (accidental radiological releases), and 2.7 (repository design criteria for radiological safety). The activities in this program will proceed in parallel with the performance and design activities.



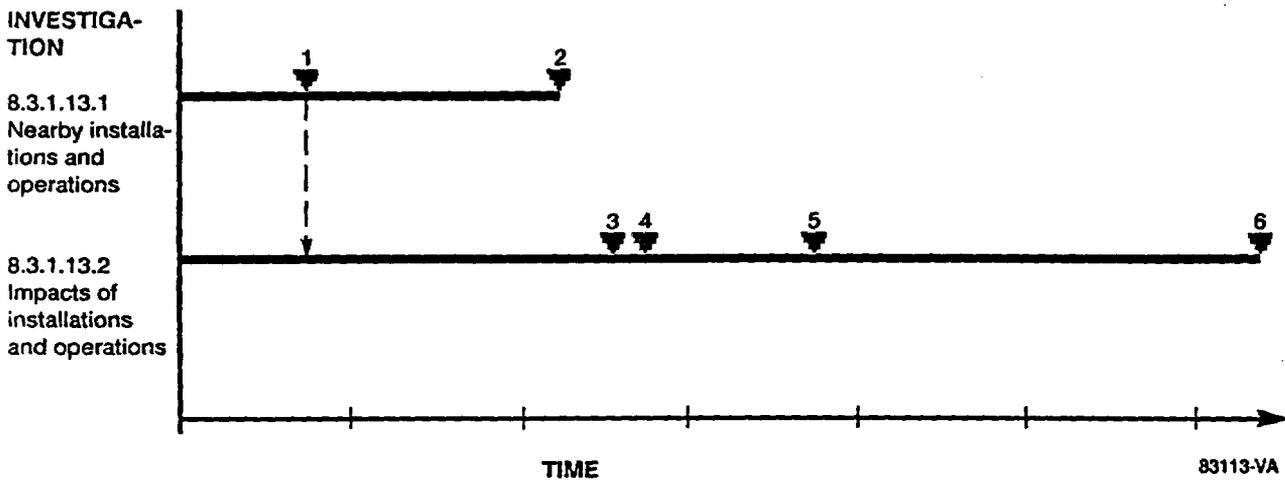
The points on the timelines are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Q032. Issue report on regional meteorological conditions.
2	Milestone M393. Issue five-year summary report on meteorological conditions.
3	Milestone Q033. Issue report on extreme weather phenomena and expected recurrence intervals at Yucca Mountain.

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OFFSITE INSTALLATIONS PROGRAM
(SECTION 8.3.1.13)

Results of the activities of this program will be used to support the resolution of a number of preclosure issues concerned with radiological safety requirements, including Issues 2.1 (public radiological exposures--normal conditions), 2.2 (worker radiological safety--normal conditions), 2.3 (accidental radiological releases), 2.5 (higher level findings--preclosure radiological safety), and 2.7 (repository design criteria for radiological safety). The activities in this program will proceed in parallel with the performance and design activities.



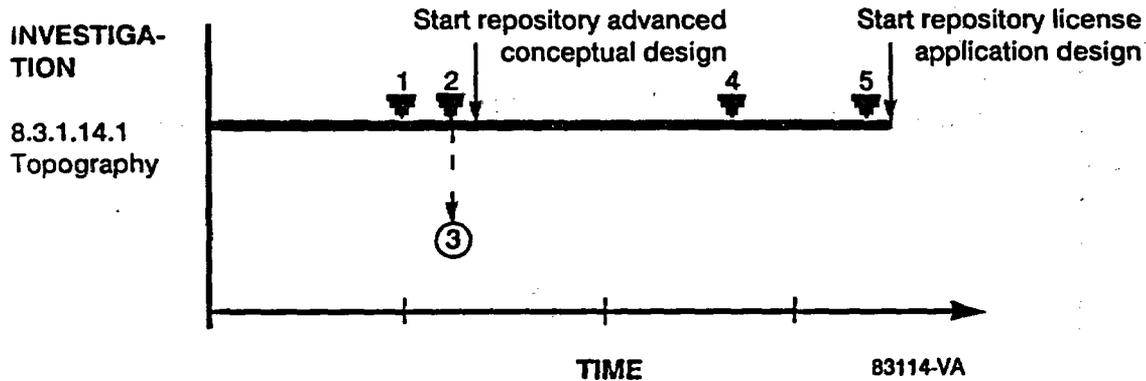
The points on the timelines are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Data collection for the identification of near-site activities is complete.
2	Complete data collection for the identification of all nuclear facilities.
3	Issue report on alternative rail access spur screening.
4	Issue final report on U.S. Air Force overflight impacts.
5	Select rail access route to repository.
6	Milestone N338. Issue report on the characterization of the existing radiological environment.

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SURFACE CHARACTERISTICS PROGRAM
(SECTION 8.3.1.14)

Results of the studies in this program will be used in the design and siting of surface repository facilities at the Yucca Mountain site. The principle issue concerned with surface-facility design is Issue 4.4 (preclosure design and technical feasibility). This program will proceed in parallel with the activities supporting resolution of the performance and design issues.



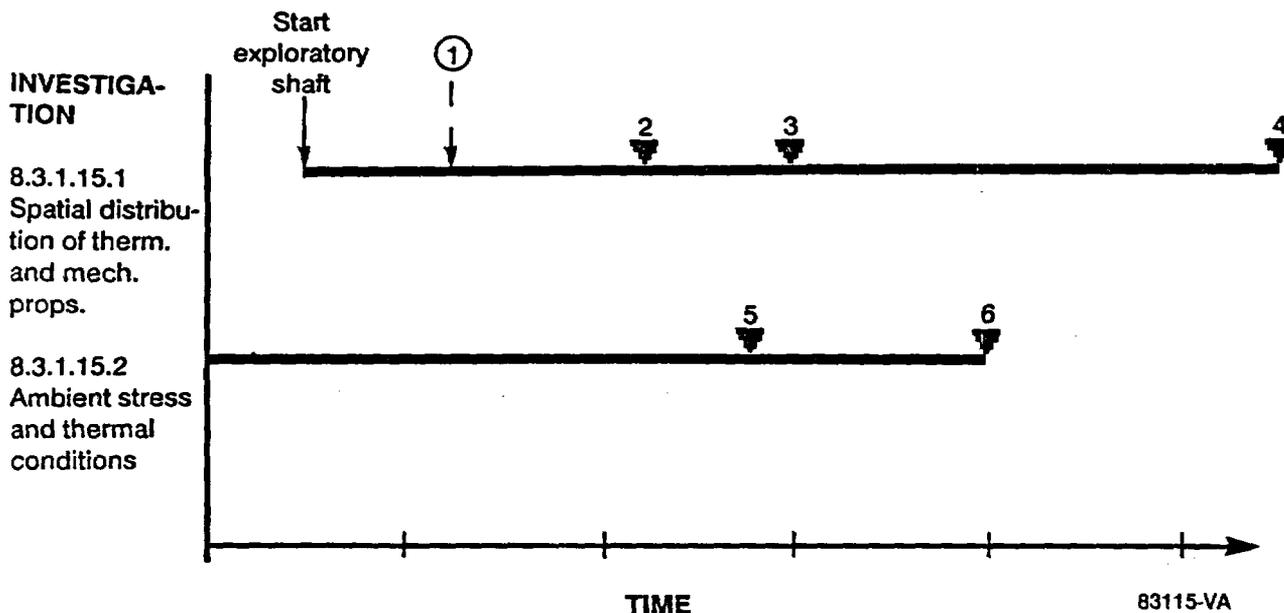
The points on the timeline and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z413. Issue report on the results of the geotechnical exploration program for surface-facility advanced conceptual design (ACD) at Yucca Mountain.
2	Milestone Z415. Issue report on the results of geotechnical field tests and characterization measurements for surface-facility ACD at Yucca Mountain.
3	Material property and geophysical field measurement data available to Investigation 8.3.1.17.3 (vibratory ground motion).
4	Milestone Z417. Issue update report on the results of geotechnical laboratory tests and material property measurements for surface-facility ACD at Yucca Mountain.
5	Milestone Q150. Issue summary report on rock and soil properties at the reference conceptual site.

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THERMAL AND MECHANICAL ROCK PROPERTIES PROGRAM
(SECTION 8.3.1.15)

Results of the studies in this program will be used in the design of the underground repository facilities. Issue 1.11 (configuration of underground facilities) will use the stratigraphic data, the information on geologic structure, and information on thermal and mechanical rock properties to develop appropriate layouts for the underground repository facilities.



The points on the timelines and the data input and output at the interfaces are described in the following table:

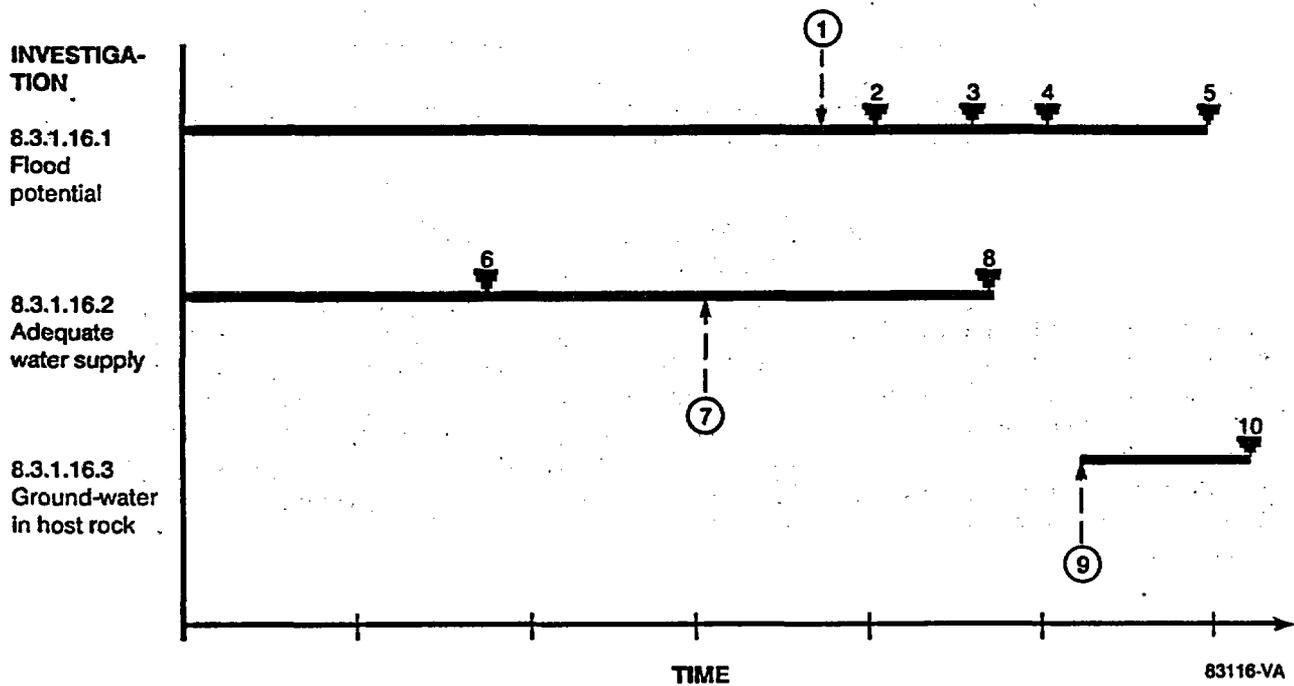
<u>Point number</u>	<u>Description</u>
1	Input of Phase I performance assessment drilling results from Investigation 8.3.1.4.3 (development of 3-D models of rock characteristics at the repository site).
2	Milestone M058. Issue final report on the thermal, thermo-mechanical, and mechanical properties of material from shaft construction.
3	Milestone M445. Update document on thermomechanical properties for license application.
4	Milestone M691. Issue report on the results of the canister-scale heater experiments in the ESF.

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<u>Point number</u>	<u>Description</u>
5	Milestone M687. Issue report on overcore stress experiments.
6	Issue summary report on the results of in situ studies in the site vicinity.

**PRECLOSURE HYDROLOGY PROGRAM
(SECTION 8.3.1.16)**

Results of studies in this program will be used to support resolution of Issue 4.4 (preclosure design and technical feasibility). Potential flooding hazards will be considered in the design and placement of surface facilities. This program will provide input to the plans being developed for obtaining the water necessary to support repository-related activities.



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Data input from Sections 8.3.1.2 (geohydrology program), 8.3.1.5 (climate program), 8.3.1.12 (meteorology program), and 8.3.1.14 (surface characteristics program).

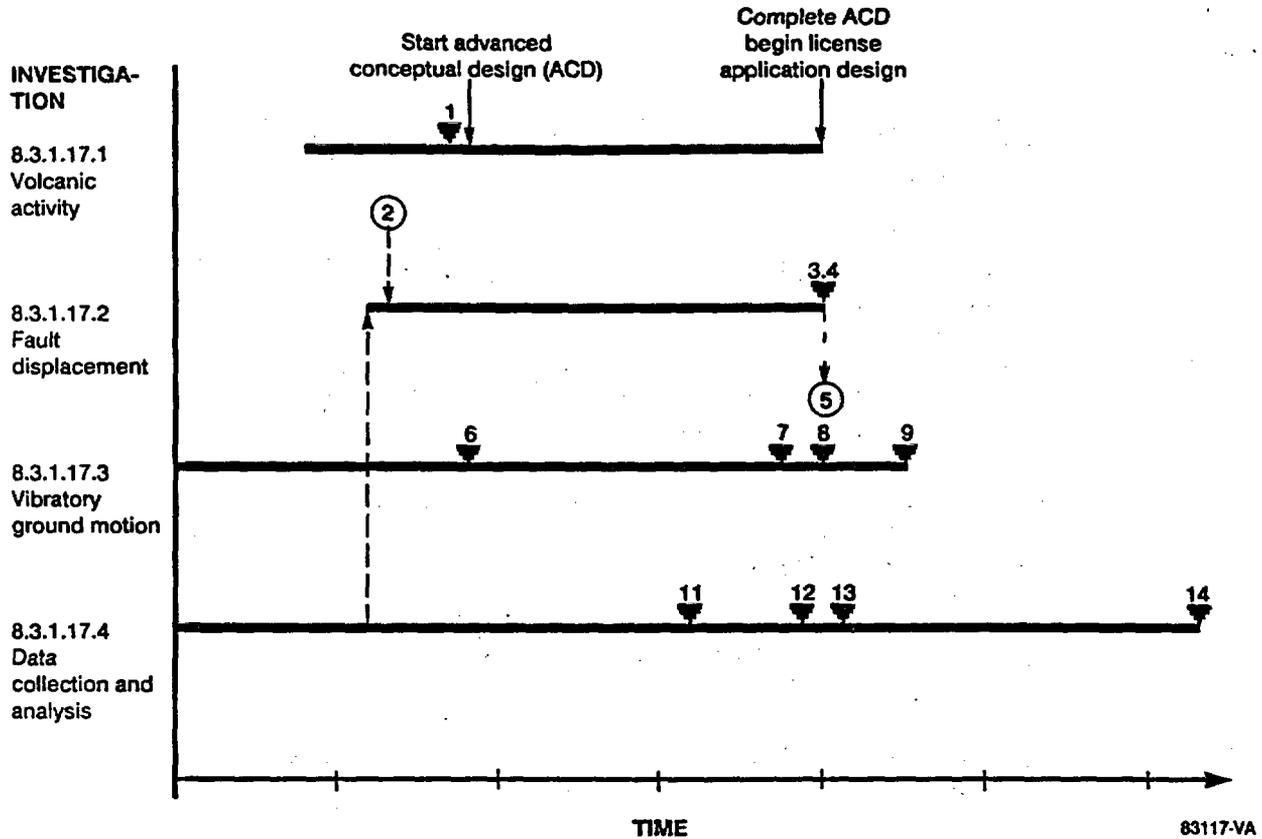
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- 2 Milestone P923. Issue report summarizing prehistoric flooding at Yucca Mountain.
- 3 Milestone P935. Issue report summarizing modern flooding events and debris transport.
- 4 Milestone P787. Issue report on predictions of future flooding and debris movement due to climate changes.
- 5 Milestone Z494. Issue report on characterization of runoff and streamflow for Yucca Mountain and vicinity.
- 6 Milestone Z246. Issue report on repository-related water supply alternatives.
- 7 Data input from Section 8.3.1.2 (geohydrology program) and advanced conceptual design.
- 8 Milestone T040. Issue final report on the potential effects of water withdrawals on the local flow system.
- 9 Data input from Section 8.3.1.2 (geohydrology program).
- 10 Milestone Q124. Issue report on ground-water conditions within and above the potential host rock.

PRECLOSURE TECTONICS PROGRAM (SECTION 8.3.1.17)

Results of the studies in this program will be used to support the resolution of Issue 4.4 (preclosure design and technical feasibility). Designs of the surface and underground facilities will account for all aspects of the seismic hazards recognized at the Yucca Mountain site. Hazards due to volcanic activity and to both vibratory ground motion and surface faulting will be identified through activities in this program. Repository design activities will continue in parallel with the studies in this program.

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The points on the timelines and the data input and output at the interfaces are shown in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Q144. Report on volcanic ash-fall potential at the site. This information will be considered in both the advanced conceptual and license application designs of the surface and underground ventilation systems.
2	Initiation of investigation requires: information from Investigation 8.3.1.17.4 (data collection and analysis); preliminary results from trenching in Midway Valley; preliminary interpretation of tectonic interrelationships between local faults; preliminary information on fault-zone widths and recurrence of movement on potentially significant faults within 5 km of proposed sites for surface facilities that are potentially important to safety; preliminary identification of faults in or near the repository block with 1 m offset of Quaternary materials, 100 m offset of Tertiary rocks, or Quaternary slip rates ≥ 0.005 mm/yr; preliminary information on the regional spacing and rate of Quaternary faulting; and tectonic relationships between local faults.

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<u>Point number</u>	<u>Description</u>
3	Milestone Q147. Final report on the assessment of the potential for faulting at the sites of prospective surface facilities.
4	Milestone Q148. Final report on the assessment of the potential for displacement on faults that intersect underground facilities.
5	Input to license application design on assessment of the potential for displacement on faults that intersect underground facilities.
6	Description available of strong ground motion to be considered in the advanced conceptual design of a high-level nuclear waste repository at Yucca Mountain.
7	Milestone Q165. Final report available on earthquake ground motion (attenuation) models appropriate for the Yucca Mountain site.
8	Milestone Q167. Final report available on probabilistic seismic hazard analysis of the Yucca Mountain site.
9	Milestone Q169. Report available on the description of strong ground motion to be considered in the license application design of a high-level nuclear waste repository at Yucca Mountain.
10	Milestone P701. Complete preliminary regional tectonic model.
11	Milestone P880. Issue report on Quaternary geology and faults of Yucca Mountain.
12	Milestone P879. Issue summary report on detachment faults at or proximal to Yucca Mountain.
13	Report available on historical and current lateral crustal movement in the Yucca Mountain region.
14	Milestone M383. Issue report on the final tectonic model.

8.5.1.2 Exploratory shaft

The following table presents a list of milestones related to the construction of, and testing in, the exploratory shaft (ES). A logic diagram for these activities is presented in Figure 8.5-1. The diagram has been included to illustrate the sequence of activities planned and the relationships of the various activities to the construction schedule and to each

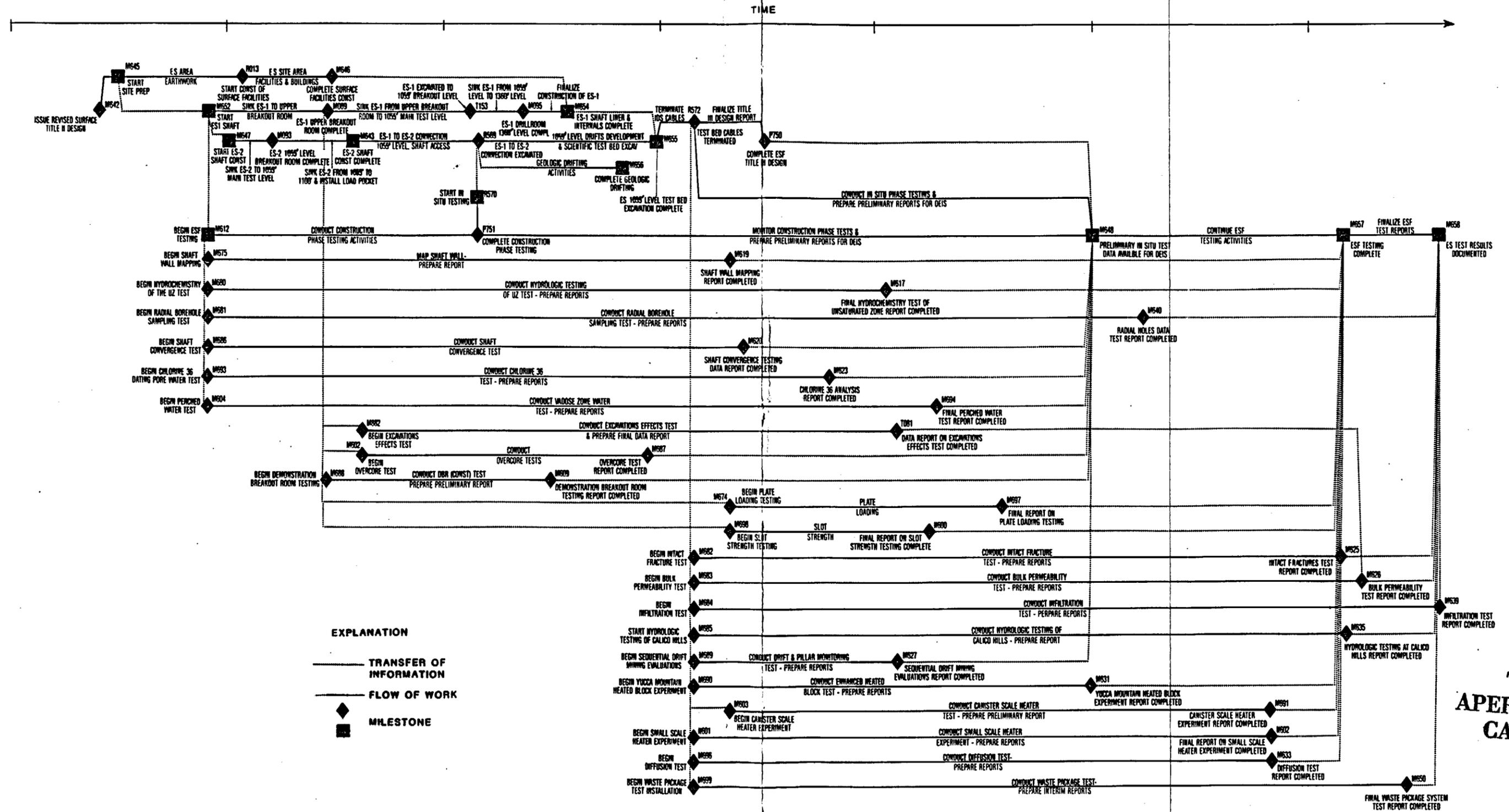


Figure 8.5-1. Logic diagram for the exploratory shaft.

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CONSULTATION DRAFT

other. It should be recognized that certain in situ tests will be continued for confirmatory purposes after the license application has been submitted.

Milestone number	Related SCP section	Milestone description
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CONSTRUCTION-RELATED ACTIVITIES AND MILESTONES

M642	NA ^a	Issue revised surface Title II design
M645	8.4.1	Start exploratory shaft (ES) site preparation
M652	8.4.2.1	Start ES-1 shaft construction
R013	8.4.1	Start construction of surface facilities
M647	8.4.2.2	Start ES-2 shaft construction
M089	8.4.2.1	Complete ES-1 upper break-out room (600-ft level)
M646	8.4.1	Complete surface facility construction
M093	8.4.2.2	Complete ES-2 1,055-ft level breakout room
T153	8.4.2.1	Complete ES-1 excavation to 1,020-ft breakout level
M643	8.4.2.2	Complete ES-2 shaft construction
M095	8.4.2.1	Complete ES-1 drillroom 1,360-ft level
M654	8.4.2.1	Complete ES-1 shaft liner and internals
R569	8.4.2.2.2	Complete connection of ES-1 to ES-2
R572	NA	Test bed cables terminated
M656	8.4.2.4	Complete geologic drifting
M655	8.4.2.2	Complete ES-2 1,055-ft level testbed excavation
P750	NA	Complete ESF Title III design

TESTING-RELATED ACTIVITIES AND MILESTONES

M612	NA	Start ES construction phase testing
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CONSULTATION DRAFT

Milestone number	Related SCP section	Milestone description
TESTING-RELATED ACTIVITIES AND MILESTONES (continued)		
P751	NA	Complete construction phase testing
R570	NA	Start in situ phase testing
M688	8.3.1.15.1.5.2	Begin demonstration breakout room testing
M609	8.3.1.15.1.5.2	Complete report on demonstration breakout room testing
M686	8.3.1.15.1.5.1	Begin shaft convergence test
M620	8.3.1.15.1.5.1	Complete shaft convergence testing data report
M602	8.3.1.15.2.1.2	Begin overcore stress experiments
M687	8.3.1.15.2.1.2	Complete report on overcore stress experiments
M689	8.3.1.15.1.5.3	Begin sequential drift mining evaluations
M627	8.3.1.15.1.5.3	Complete sequential drift mining evaluations report
M675	8.3.1.4.2.2.4	Begin shaft wall mapping
M619	8.3.1.4.2.2.4	Complete shaft wall mapping report
M693	8.3.1.2.2.2.1	Begin chlorine-36 dating pore water test
M623	8.3.1.2.2.2.1	Complete chlorine-36 analysis report
N601	8.3.1.15.1.6.1	Begin small scale heater experiment
N602	8.3.1.15.1.6.1	Complete final report on small scale heater experiment results
M674	8.3.1.15.1.7.1	Begin plate loading testing
M697	8.3.1.15.1.7.1	Complete final report on plate loading testing
M882	8.3.1.2.2.4.5	Begin excavation effects test
T081	8.3.1.2.2.4.5	Complete report on the results of the excavations effects test
M604	8.3.1.2.2.4.7	Begin perched-water test

CONSULTATION DRAFT

Milestone number	Related SCP section	Milestone description
TESTING-RELATED ACTIVITIES AND MILESTONES (continued)		
M694	8.3.1.2.2.4.7	Complete report on the results of the perched-water test
M698	8.3.1.15.1.7.2	Begin slot strength testing
N600	8.3.1.15.1.7.2	Complete final report on slot strength testing
M690	8.3.1.15.1.6.3	Begin Yucca Mountain heated block experiment
M631	8.3.1.15.1.6.3	Complete report on the results of the Yucca Mountain heated block experiment
M680	8.3.1.2.2.4.8	Begin hydrochemistry tests
M617	8.3.1.2.2.4.8	Complete final report on the results of hydrochemistry tests
M648	NA	Preliminary in situ test data available for draft environmental impact statement (DEIS)
M603	8.3.1.15.1.6.2	Begin canister scale heater experiments
M691	8.3.1.15.1.6.2	Complete report on the results of canister scale heater experiments
M696	8.3.1.2.2.5.1	Begin diffusion test
M633	8.3.1.2.2.5.1	Complete final report on the results of diffusion tests
M681	8.3.1.2.2.4.4	Begin radial borehole tests
M640	8.3.1.2.2.4.4	Complete report on the results of the radial borehole tests
M657	NA	ESF testing complete
M682	8.3.1.2.2.4.1	Begin intact fracture tests
M625	8.3.1.2.2.4.1	Complete report on the results of intact fracture tests
M683	8.3.1.2.2.4.3	Begin bulk-permeability tests

CONSULTATION DRAFT

Milestone number	Related SCP section	Milestone description
TESTING-RELATED ACTIVITIES AND MILESTONES (continued)		
M626	8.3.1.2.2.4.3	Complete report on the results of the bulk-permeability test
M685	8.3.1.2.2.4.6	Start hydrologic testing of the Calico Hills
M635	8.3.1.2.2.4.6	Complete report on the hydrologic testing of the Calico Hills
M699	8.3.4.2.4.4	Begin waste package system test
M650	8.3.4.2.4.4	Complete final report on the results of the waste package system test
M684	8.3.1.2.2.4.2	Begin infiltration test
M639	8.3.1.2.2.4.2	Complete report on the results of the infiltration test
M658	NA	Complete documentation of ES test results for license application (LA)

^aNA = not applicable

8.5.1.3 Site characterization study plans

The following table provides a list of site characterization study plans which will present details of site-related studies, tests, and analyses and the schedule for those activities as a supplement to the information in this document. Preparation and review of study plans will be staggered depending on when the studies are to commence. The availability of new or updated study plans will be reported in the semiannual SCP progress reports.

Study plans are being prepared to be consistent with agreements between the DOE and the NRC. Detailed technical and compliance reviews will be completed by the DOE. Following these reviews, study plans will then be submitted to the NRC for review and comment and to the State and affected Indian tribes for their information.

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

GEOHYDROLOGY PROGRAM

- 8.3.1.2.1.1 Characterization of Meteorology for Regional Hydrology
- 8.3.1.2.1.2 Characterization of Runoff and Streamflow
- 8.3.1.2.1.3 Characterization of the Regional Ground-Water Flow System
- 8.3.1.2.1.4 Regional Hydrologic System Synthesis and Modeling
- 8.3.1.2.2.1 Characterization of Unsaturated Zone Infiltration
- 8.3.1.2.2.2 Water Movement Tracer Tests Using Chloride and Chlorine-36 Measurements of Infiltration at Yucca Mountain
- 8.3.1.2.2.3 Characterization of Percolation in the Unsaturated Zone - Surface-Based Study
- 8.3.1.2.2.4 Characterization of Yucca Mountain Percolation in the Unsaturated Zone - Exploratory Shaft Facility Investigations
- 8.3.1.2.2.5 Diffusion Tests in the Exploratory Shaft Facility
- 8.3.1.2.2.6 Characterization of Flux within the Paintbrush Nonwelded Unit in the vicinity of the Ghost Dance Fault
- 8.3.1.2.2.7 Characterization of Gaseous-Phase Movement in the Unsaturated Zone
- 8.3.1.2.2.8 Hydrochemical Characterization of the Unsaturated Zone
- 8.3.1.2.2.9 Unsaturated Zone Flow and Transport Modeling
- 8.3.1.2.2.10 Unsaturated Zone System Analysis and Integration
- 8.3.1.2.3.1 Characterization of the Site Saturated Zone Ground-Water Flow System
- 8.3.1.2.3.2 Characterization of the Site Saturated Zone Hydrochemistry
- 8.3.1.2.3.3 Saturated Zone Hydrologic System Synthesis and Modeling

GEOCHEMISTRY PROGRAM

- 8.3.1.3.1.1 Ground-Water Chemistry Model

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

GEOCHEMISTRY PROGRAM (continued)

- 8.3.1.3.2.1 Three-Dimensional Mineral Distribution at Yucca Mountain
- 8.3.1.3.2.2 History of Mineralogic and Geochemical Alteration of Yucca Mountain
- 8.3.1.3.3.1 Natural Analog of Hydrothermal Systems in Tuff
- 8.3.1.3.3.2 Kinetics and Thermodynamics of Mineral Evolution
- 8.3.1.3.3.3 Conceptual Model of Mineral Evolution
- 8.3.1.3.4.1 Batch Sorption Studies
- 8.3.1.3.4.2 Biological Sorption and Transport
- 8.3.1.3.4.3 Development of Sorption Models (Isotherms)
- 8.3.1.3.5.1 Dissolved Species Concentration Limits
- 8.3.1.3.5.2 Colloid Behavior
- 8.3.1.3.6.1 Dynamic Transport Column Experiments
- 8.3.1.3.6.2 Diffusion
- 8.3.1.3.7.1 Retardation Sensitivity Analysis
- 8.3.1.3.7.2 Demonstration of Applicability of Laboratory Data to Repository Transport Calculations
- 8.3.1.3.8.1 Gaseous Radionuclide Transport Calculations and Measurements

ROCK CHARACTERISTICS PROGRAM (POSTCLOSURE)

- 8.3.1.4.2.1 Characterization of the Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area
- 8.3.1.4.2.2 Characterization of the Structural features within the Site Area
- 8.3.1.4.2.3 Three-Dimensional Geologic Model
- 8.3.1.4.3.1 Systematic Acquisition of Site-Specific Subsurface Information

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

ROCK CHARACTERISTICS PROGRAM (POSTCLOSURE) PROGRAM (continued)

8.3.1.4.3.2 Three-Dimensional Rock Characteristics Models

CLIMATE PROGRAM

8.3.1.5.1.1 Characterization of Modern Regional Climate

8.3.1.5.1.2 Paleoclimate Study: Lake, Playa, Marsh Deposits

8.3.1.5.1.3 Climate Implications of Terrestrial Paleoecology

8.3.1.5.1.4 Analysis of the Paleoenvironmental History of the Yucca Mountain Region

8.3.1.5.1.5 Paleoclimate-Paleoenvironment Synthesis

8.3.1.5.1.6 Characterization of the Future Regional Climate and Environments

8.3.1.5.2.1 Characterization of the Quaternary Regional Hydrology

8.3.1.5.2.2 Characterization of the Future Regional Hydrology due to Climate Changes

EROSION PROGRAM

8.3.1.6.1.1 Distribution and Characteristics of Present and Past Erosion

8.3.1.6.2.1 Influence of Future Climatic Conditions on Locations and Rates of Erosion

8.3.1.6.3.1 Evaluation of the Effects of Future Tectonic Activity on Erosion at Yucca Mountain

8.3.1.6.4.1 Development of a Topical Report to Address the Effects of Erosion on the Hydrologic, Geochemical, and Rock Characteristics at Yucca Mountain

TECTONICS PROGRAM (POSTCLOSURE)

8.3.1.8.1.1 Probability of a Volcanic Eruption Penetrating the Repository

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

TECTONICS PROGRAM (POSTCLOSURE) (continued)

- 8.3.1.8.1.2 Effects of Volcanic Eruption Penetrating the Repository
- 8.3.1.8.2.1 Analysis of Waste Package Rupture due to Tectonic Processes and Events
- 8.3.1.8.3.1 Analysis of the Effects of Tectonic Processes and Events on Average Percolation Flux Rates Over the Repository
- 8.3.1.8.3.2 Analysis of the Effects of Tectonic Processes and Events on Changes in Water-table Altitude
- 8.3.1.8.3.3 Analysis of the Effects of Tectonic Processes and Events on Local Fracture Permeability and Effective Porosity
- 8.3.1.8.4.1 Analysis of the Effects of Tectonic Processes and Events on Rock Geochemical Properties
- 8.3.1.8.5.1 Characterization of Volcanic Features
- 8.3.1.8.5.2 Characterization of Igneous Intrusive Features
- 8.3.1.8.5.3 Investigation of Folds in Miocene and Younger Rocks of the Region

HUMAN INTERFERENCE PROGRAM

- 8.3.1.9.1.1 An Evaluation of Natural Processes That Could Affect the Long-Term Survivability of the Surface Marker System at Yucca Mountain
- 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nevada
- 8.3.1.9.2.2 Water Resource Assessment of Yucca Mountain, Nevada
- 8.3.1.9.3.1 Evaluation of Data Needed to Support an Assessment of the Likelihood of Future Inadvertent Human Intrusion at Yucca Mountain as a Result of Exploration and/or Extraction of Natural Resources
- 8.3.1.9.3.2 An Evaluation of the Potential Effects of Exploiting Natural Resources on the Hydrologic Characteristics at Yucca Mountain

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

METEOROLOGICAL PROGRAM

8.3.1.12.2.1 Meteorological Data Collection at the Yucca Mountain Site

SURFACE CHARACTERISTICS PROGRAM

8.3.1.14.2.1 Exploration Program

8.3.1.14.2.2 Laboratory Tests and Material Property Measurements

8.3.1.14.2.3 Field Tests and Characterization Measurements

ROCK CHARACTERISTICS PROGRAM (PRECLOSURE)

8.3.1.15.1.1 Laboratory Thermal Properties

8.3.1.15.1.2 Laboratory Thermal Expansion Testing

8.3.1.15.1.3 Laboratory Determination of Mechanical Properties of
Intact Rock

8.3.1.15.1.4 Laboratory Determination of the Mechanical Properties of
Fractures

8.3.1.15.1.5 Excavation Investigations

8.3.1.15.1.6 In Situ Thermomechanical Properties

8.3.1.15.1.7 In Situ Mechanical Properties

8.3.1.15.1.8 In Situ Design Verification

8.3.1.15.2.1 Characterization of the Site Ambient Stress Conditions

8.3.1.15.2.2 Characterization of the Site Ambient Thermal Conditions

PRECLOSURE HYDROLOGY PROGRAM

8.3.1.16.1.1 Characterization of Flood Potential of the Yucca Mountain
Site

8.3.1.16.2.1 Location of Adequate Water Supply for Construction,
Operation, Closure, and Decommissioning of a Mined
Geologic Disposal System at Yucca Mountain, Nevada

CONSULTATION DRAFT

Study plan number ^a	Study plan title ^b
	PRECLOSURE HYDROLOGY PROGRAM (continued)
8.3.1.16.3.1	Determination of Preclosure Hydrologic Conditions of the Unsaturated Zone at Yucca Mountain, Nevada
	TECTONICS PROGRAM (PRECLOSURE)
8.3.1.17.1.1	Potential for Ash Fall at the Site
8.3.1.17.2.1	Faulting Potential at the Repository
8.3.1.17.3.1	Relevant Earthquake Sources
8.3.1.17.3.2	Underground Nuclear Explosion Sources
8.3.1.17.3.3	Ground Motion from Regional Earthquakes and Underground Nuclear Explosions
8.3.1.17.3.4	Effects of Local Site Geology on Surface and Subsurface Motions
8.3.1.17.3.5	Ground Motion at the Site from Controlling Seismic Events
8.3.1.17.3.6	Probabilistic Seismic Hazards Analyses
8.3.1.17.4.1	Historical and Current Seismicity
8.3.1.17.4.2	Location and Recency of Faulting Near Prospective Surface Facilities
8.3.1.17.4.3	Quaternary Faulting within 100 km of Yucca Mountain, Including the Walker Lane
8.3.1.17.4.4	Quaternary Faulting proximal to Site within Northeast-Trending Fault Zones
8.3.1.17.4.5	Detachment Faults at or proximal to Yucca Mountain
8.3.1.17.4.6	Quaternary Faulting within the Site Area
8.3.1.17.4.7	Subsurface Geometry and Concealed Extensions of Quaternary Faults at Yucca Mountain
8.3.1.17.4.8	Stress Field within and proximal to the Site Area
8.3.1.17.4.9	Tectonic Geomorphology of the Yucca Mountain Region

CONSULTATION DRAFT

Study plan
number^a

Study plan title^b

TECTONICS PROGRAM (PRECLOSURE) (continued)

- 8.3.1.17.4.10 Geodetic Leveling
- 8.3.1.17.4.11 Characterization of Regional Lateral Crustal Movement
- 8.3.1.17.4.12 Tectonic Models and Synthesis

SHAFT AND BOREHOLE SEAL CHARACTERISTICS

- 8.3.3.2.2.1 Seal Material Properties Development

WASTE PACKAGE CHARACTERISTICS

- 8.3.4.2.4.1 Characterize Chemical and Mineralogic Changes in the Postemplacement Environment
- 8.3.4.2.4.2 Hydrologic Properties of Waste Package Environment
- 8.3.4.2.4.3 Thermal and Mechanical Attributes of the Waste Package Environment
- 8.3.4.2.4.4 Engineered Barrier System Field Tests
-

^aStudy plan number corresponds to the SCP section number under which a discussion of the study is provided.

^bStudy plan title corresponds to the appropriate SCP section title.

8.5.2 PERFORMANCE ASSESSMENT ACTIVITIES AND MILESTONES

The elements of performance assessment for a high-level radioactive waste repository can be categorized into calculations covering two distinctly different time periods. The first time period, referred to as the preclosure period, covers the period during repository operation, closure and decommissioning. Calculations must demonstrate compliance with the radiation exposure and radioactive material release limits for the unrestricted area and the exposure limits for repository workers during the period of waste emplacement and until final closure and decommissioning of the repository. The preclosure radiological safety requirements are summarized in Section 8.3.5.1.

The second time period covered by performance assessment calculations is termed the postclosure period which represents the time following

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permanent closure of the repository. Calculated releases from the repository must meet the limits specified by the NRC in 10 CFR Part 60. The postclosure performance requirements are summarized in Section 8.3.5.8. Performance requirements apply to the overall geologic repository, the engineered barrier system, the geologic setting (natural barriers), and the waste package.

The following sections provide summary schedule information associated with the performance assessment issues presented in Section 8.3.5. Preclosure and postclosure performance assessment schedule information is treated separately in Sections 8.5.2.1 and 8.5.2.2, respectively.

8.5.2.1 Preclosure performance assessment

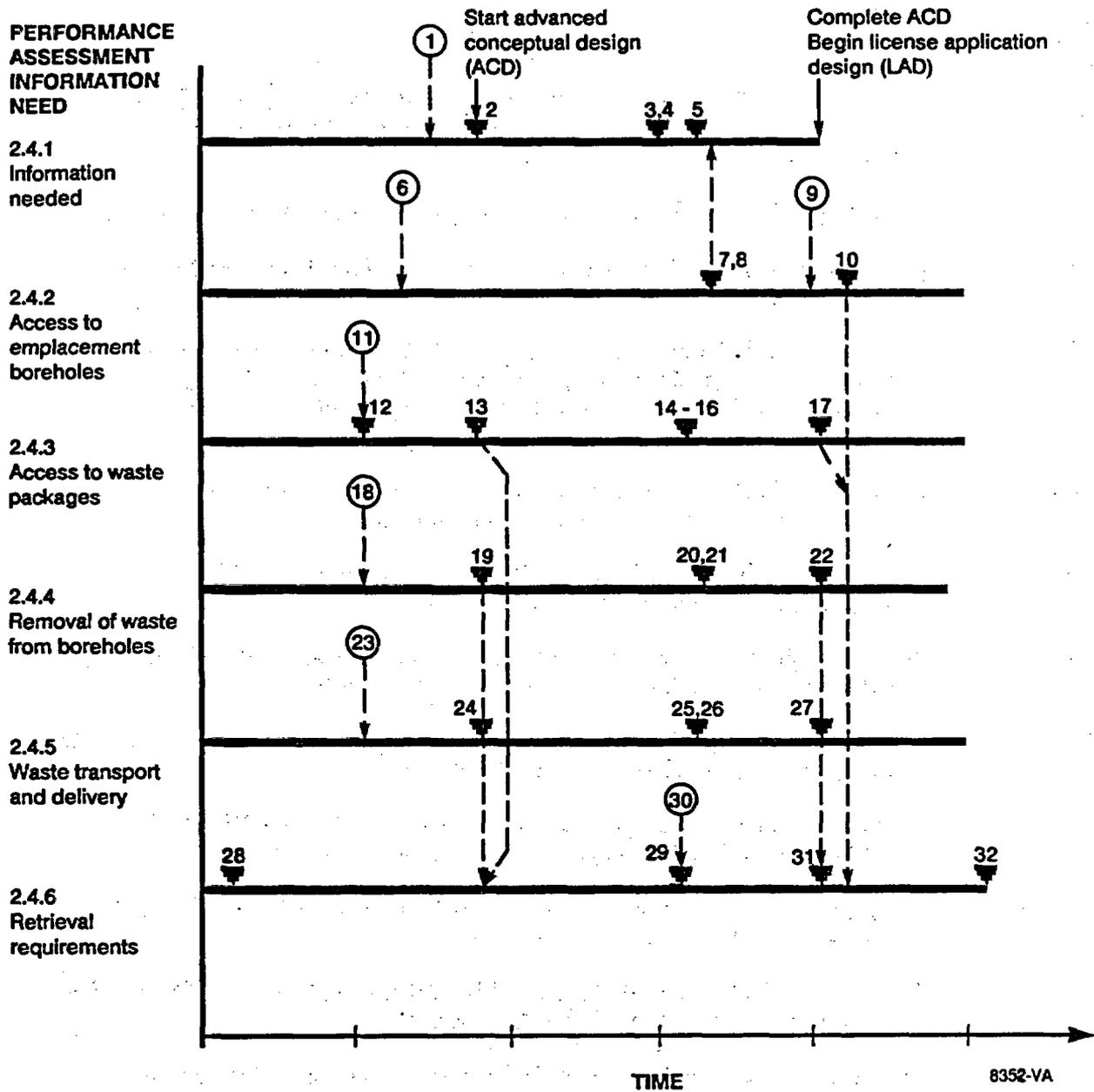
Preclosure performance assessment activities and milestones address the requirements for determination of radiation exposures and release of radioactive material. Radiation exposure and airborne concentration limits for workers and the public are established by 10 CFR Part 20. Repository preclosure activities must also comply with certain EPA standards according to 10 CFR Part 60.

Summary schedule information, in the form of timelines, for each preclosure performance assessment issue described in Sections 8.3.5.2 through 8.3.5.5 is given in this section. Information needs within an issue are presented as appropriate. The length of the timeline representing the information need is proportional to the duration of the activities described in the information need. Points shown on the timelines represent major events or important milestones associated with the investigation. Solid lines represent information need activity durations and dashed lines show interfaces. The data input and output at the interfaces are shown by circles.

WASTE RETRIEVABILITY (ISSUE 2.4, SECTION 8.3.5.2)

The activities described in this issue are those addressing the requirement that the repository design, construction, operation, and maintenance must ensure that any or all of the emplaced waste can be retrieved starting at any time up to 50 yr after waste emplacement operations have begun. Activities planned to support resolution of this issue include design analyses and documentation of retrieval conditions for access to waste emplacement boreholes, access to waste containers, borehole access for waste removal, and for transport of retrieved waste to the surface facilities. As with all preclosure design issues, Issue 4.4 (preclosure design and technical feasibility) integrates the requirements for maintaining the retrieval option from Issue 2.4 with other constraints on repository design addressed in other issues to produce reference designs.

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The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Receive and compile requests for input items and information for information needs within this issue (2.4).
2	Milestone Z153. Preliminary report compiling retrieval conditions and performance goals.

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<u>Point number</u>	<u>Description</u>
3	Milestone Z122. Receive design requirements list for license application design (LAD) from Issue 4.4 (technical feasibility).
4	Milestone Z154. Final report compiling retrieval conditions.
5	Milestone Z441. Compile final request for input items from Issue 4.4.
6	Receive final input items on borehole access from Information Needs 4.4.5 (reference preclosure repository design), 4.4.7 (design analyses), and 4.4.9 (underground facility technology).
7	Milestone Z126. Final report on retrieval conditions for access to waste emplacement boreholes.
8	List of final input items related to access to waste emplacement boreholes is available.
9	Receive preliminary input items for compliance analysis from Information Needs 4.4.5, 4.4.7, and 4.4.9.
10	Milestone Z128. Input completed for final report on compliance analysis for retrieval requirements.
11	Receive input items on access to waste containers from Information Needs 4.4.5, 4.4.7, and 4.4.9.
12	Receive advanced conceptual design (ACD) requirements for access to waste containers.
13	Milestone Z134. Input to preliminary report on compliance analysis for retrieval requirements.
14	Receive LAD requirements for access to waste containers.
15	Milestone Z133. Final report on retrieval conditions for access to waste containers.
16	List of final input items related to access to waste containers available for LAD.
17	Milestone Z135. Input to final report on compliance analysis for retrieval requirements.
18	Receive final input on borehole access for waste removal from Information Needs 4.4.5, 4.4.7, and 4.4.9.
19	Milestone Z141. Provide input to preliminary report on compliance analysis for retrieval requirements.

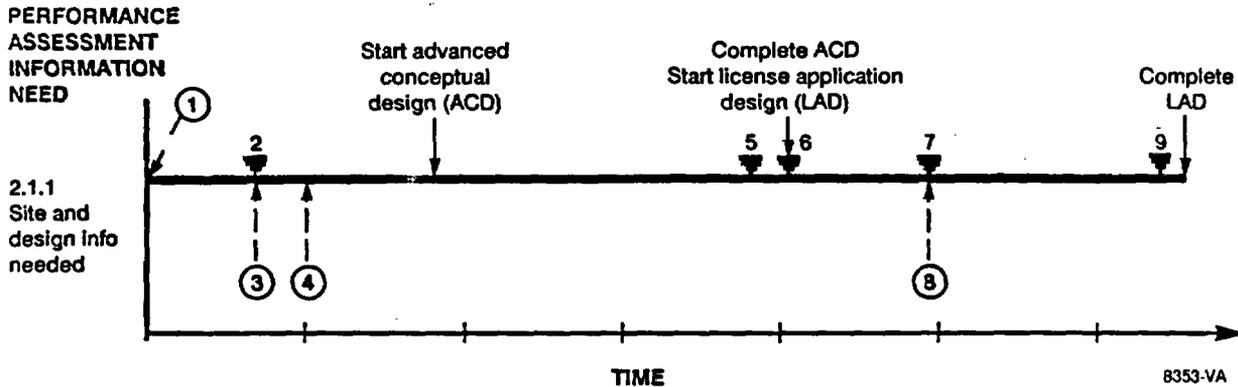
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<u>Point number</u>	<u>Description</u>
20	Milestone Z140. Final report on retrieval conditions for waste removal from emplacement boreholes.
21	List of final input items relative to access for waste removal from emplacement boreholes available.
22	Milestone Z142. Provide input to final report on compliance analysis for retrieval requirements.
23	Receive final input items on retrieved waste transport from Information Needs 4.4.5, 4.4.7, and 4.4.9.
24	Milestone Z148. Input to preliminary report on compliance analysis for retrieval requirements.
25	Milestone Z147. Final report on retrieval conditions for transport of waste to surface facilities.
26	List of final input items related to transport of retrieved waste to surface facilities available.
27	Milestone Z149. Input to final report on compliance analysis for retrieval requirements available.
28	Milestone Z157. Retrievability strategy report.
29	Milestone Z160. Compile LAD requirements for retrievability using reasonably available technology.
30	Receive input items related to reasonably available technology from Information Needs 4.4.3 (plans for repository operation) and 4.4.5 through 4.4.9.
31	List of final items related to retrievability using reasonably available technologies is available.
32	Milestone Z156. Final report on compliance analysis for retrieval requirements available.

PUBLIC RADIOLOGICAL EXPOSURES - NORMAL CONDITIONS (ISSUE 2.1, SECTION 8.3.5.3)

The activities planned to support resolution of this issue address the requirements that radiation exposure to the general public associated with normal conditions during operation, closure, and decommissioning of the repository meet the exposure limits in 10 CFR Part 20 and 40 CFR 191, Subpart A. The activities performed under this issue involve repetitive examination of an evolving design to ensure that the final design meets the established criteria.

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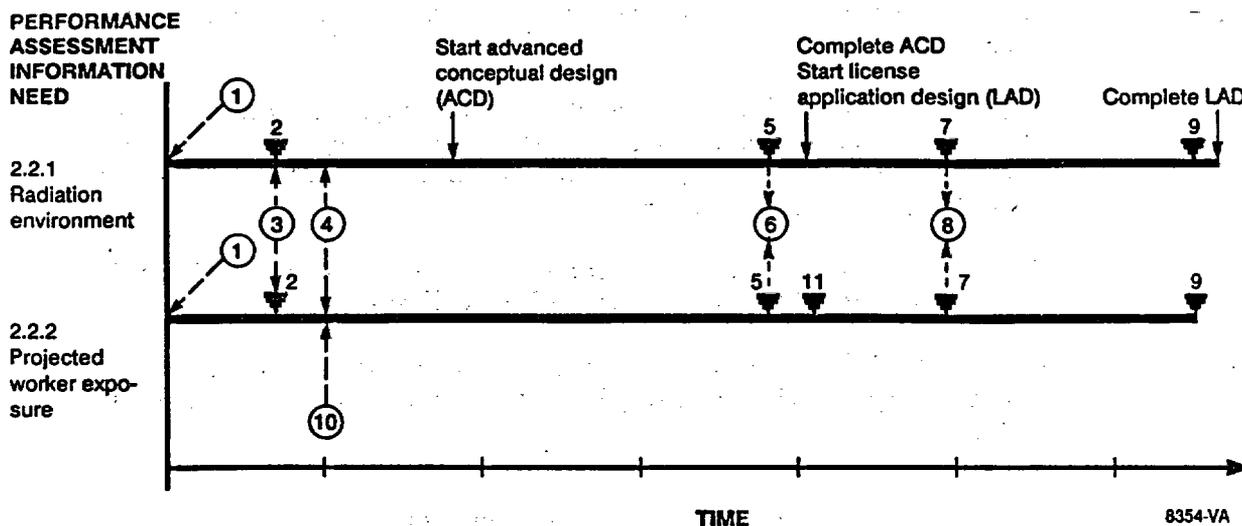
The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Input from Milestone P159. Radiological safety analysis for normal repository conditions--advanced conceptual design (ACD) guidance from Issues 2.1 and 2.2.
2	Milestone N464. List of normal conditions, accident scenarios, and source terms for preclosure safety analysis.
3	Input information from site programs 8.3.1.3 (geochemistry), 8.3.1.10 (population density), 8.3.1.12 (meteorology), 8.3.1.13 (offsite installations), and 8.3.1.15 (thermal and mechanical rock properties).
4	Input data/information from preclosure risk assessment methodology: lists of required parameters for preclosure safety analysis.
5	Milestone R784. ACD preclosure safety analysis report.
6	Milestone Z458. Complete development of activities for assessing public radiological safety for license application design.
7	Milestone Z496. Provide preliminary preclosure performance assessment input (radiological safety) in support of the draft environmental impact statement (DEIS).
8	Output radiological safety information to the DEIS.
9	Milestone R780. Issue updated report on radiological safety assessment report to support the final environmental impact statement and license application (includes update of design evaluation if necessary).

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WORKER RADIOLOGICAL SAFETY - NORMAL CONDITIONS
(ISSUE 2.2, SECTION 8.3.5.4)

The activities planned to support resolution of this issue include those necessary to demonstrate that the radiological safety of workers during normal operations is guaranteed. The activities performed under this issue will show that the mined geologic disposal system will limit the normal radiation doses to workers during construction, operation, closure, and decommissioning of the repository to less than the limits specified in 10 CFR Part 20.



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Input from Milestone P159. Radiological safety analysis for normal repository conditions. Advanced conceptual design (ACD) guidance from Issues 2.1 and 2.2.
2	Milestone N464. List of normal conditions, accident scenarios, and source terms for preclosure safety analysis.
3	Receive input data/information from site programs 8.3.1.3 (geochemistry), 8.3.1.10 (population density), 8.3.1.12 (meteorology), 8.3.1.13 (offsite installations), and 8.3.1.15 (rock characteristics).
4	Provide radiological safety analysis for normal conditions to Issue 2.7 (repository design criteria for radiological safety).

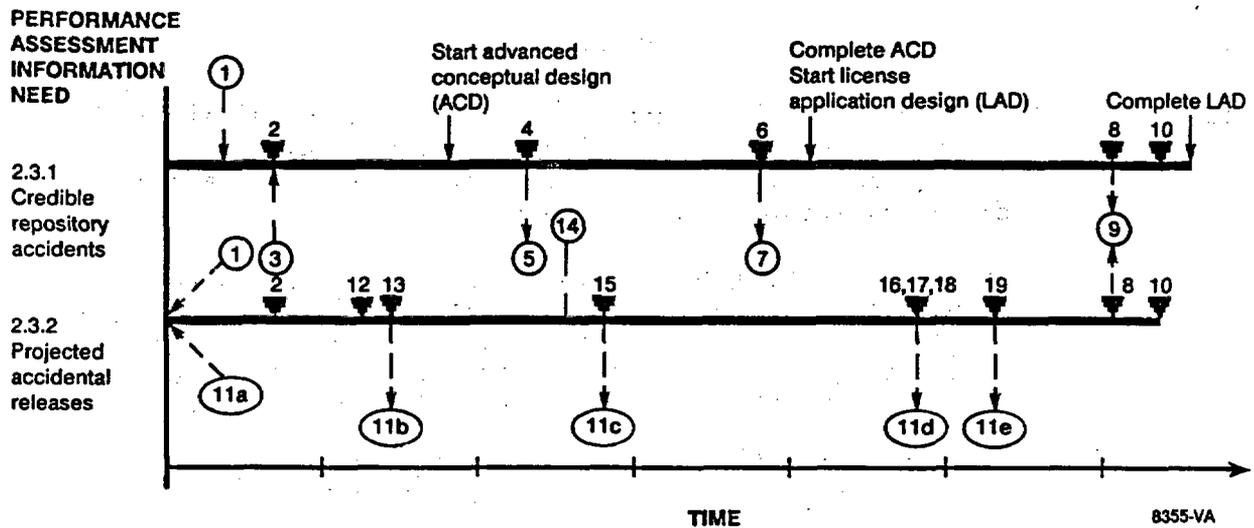
CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
5	ACD preclosure safety analysis report completed (Milestone R784).
6	Provide information/data on safety analysis report to Issue 2.7 (repository design criteria for radiological safety).
7	Milestone Z496. Preliminary preclosure performance assessment input (radiological safety) available in support of the draft environmental impact statement (DEIS).
8	Provide information/data on radiological safety assessment to the DEIS.
9	Milestone R780. Update report on radiological safety assessment to support the final environmental impact statement (FEIS) and license application (includes update of design evaluation, if necessary).
10	Input information from preclosure risk assessment methodology: lists of required parameters for analyses.
11	Milestone Z458. Complete development of activities for assessing public radiological safety for license application design.

ACCIDENTAL RADIOLOGICAL RELEASES (ISSUE 2.3, SECTION 8.3.5.5)

The activities planned to support resolution of this issue include those necessary to show that radiation exposure to the general public and repository workers under credible accident conditions during construction, operation, closure and decommissioning will be kept at safe levels. The activities to be conducted will show that the structures, systems, and components of the repository provide for prevention of accidents and mitigation of consequences. The three approaches that will be used to protect the health and safety of the general public and repository workers are to provide locations that assist in limiting potential radiation exposure from accidents; provide prevention, containment, and mitigation of accident consequences; and provide assurance that repository workers are safe from the effects of offsite accidents.

CONSULTATION DRAFT



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Radiological safety analysis for accident conditions available (Milestone P160).
2	Milestone N464. List of normal conditions, accident scenarios, and source terms for use in preclosure safety analysis.
3	Receive data/information from site programs 8.3.1.12 (meteorology), 8.3.1.13 (offsite installations), and 8.3.1.16 (preclosure hydrology).
4	Milestone Z478. List of credible accidents completed.
5	Provide list of credible accidents to Issue 2.7 (radiological design criteria).
6	Advanced conceptual design (ACD) preclosure safety analysis report available (Milestone R784).
7	Provide safety analysis information/data to Issue 2.7 (radiological design criteria).
8	Milestone R777. Update preclosure performance assessment input (radiological safety).
9	Provide updated information/data on preclosure performance assessment to FEIS and license application.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
10	Milestone R780. Issue updated report on radiological safety assessment to support the final environmental impact statement (FEIS) and license application (includes update of design evaluation, if necessary).
11	Provide information/data on radiological safety analysis (a), sensitivity and importance analysis (b), advanced conceptual design (ACD) safety analysis (c), credible and design basis accidents (d), consequence analyses of event trees (d), and preclosure performance assessment (c) to Issue 2.7.
12	Milestone Z461. Issue report on results of consequence analysis of event trees for preliminary ACD.
13	Milestone Z479. Issue report on results of preliminary ACD sensitivity and importance analysis.
14	Receive data/information from site programs 8.3.1.12 (meteorology), 8.3.1.13 (offsite installations), 8.3.1.14 (surface characteristics), 8.3.1.16 (preclosure hydrology) and 8.3.1.17 (preclosure tectonics), and Information Need 4.2.1.
15	Milestone R784. ACD preclosure safety analysis report.
16	Milestone Z482. License application design (LAD) event trees for credible accidents and design basis accidents.
17	Milestone Z462. Issue report on results of consequence analysis of event trees for LAD.
18	Milestone Z480. Issue report on results of LAD sensitivity and importance analysis.
19	Milestone M068. Preclosure performance assessment input for enclosure in license application.

8.5.2.2 Postclosure performance assessment

This section presents summary schedule information for each postclosure performance assessment issue described in Sections 8.3.5.9 through 8.3.5.15. The information presented has been grouped by the principal elements of postclosure performance assessment: overall system performance of the geologic repository, performance of the engineered barrier system and the waste packages, and performance of the geologic setting (natural barriers). These elements represent the primary barriers for which the NRC established performance objectives in 10 CFR 60.112 and 60.113.

CONSULTATION DRAFT

Overall geologic repository system performance

The requirement for performance of the overall geologic repository system after permanent closure is established in 10 CFR 60.112. This requirement states that the geologic setting shall be selected and the engineered barrier system and the shafts, boreholes, and their seals shall be designed to ensure that releases of radioactive materials to the accessible environment conform to environmental standards for radioactive material release established by the EPA. The EPA has specified limits for total cumulative release of radionuclides over 10,000 yr. Performance assessment calculations will be used to show that releases resulting from both expected (undisturbed) conditions and processes and from potentially disruptive conditions and processes will be within the allowable limits.

Engineered barrier system and waste package performance

The engineered barrier system (EBS) is to be designed so that releases of radionuclides are gradual, resulting in small fractional releases to the geologic setting over long periods of time. The release rate is specified to be not greater than one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 yr after permanent closure of the repository. The EBS is also to be designed so that containment of high level waste will be substantially complete during the period when radiation and thermal conditions are dominated by fission product decay. The waste package is to be designed to provide substantially complete containment of the high level waste for 300 to 1,000 yr after permanent closure of the geologic repository. The product milestones associated with the EBS and waste package performance issues (Sections 8.3.5.9 and 8.3.5.10) represent the results of evaluations of releases from various components of the EBS, and reports that document the performance of the waste package in compliance with the requirements previously specified.

Performance of the geologic setting

The performance requirements specified by the NRC in 10 CFR 60.113(a)(ii)(B)(2) for the geologic setting state that the geologic repository should be located so that pre-waste-emplacement ground-water travel time (GWTT) along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment will be at least 1,000 yr. Although this regulation addresses the pre-waste-emplacement ground-water travel time, the calculations for ground-water flow (Section 8.3.5.12) are the same ones used to predict radionuclide migration in the total system performance assessment (Section 8.3.5.13). Therefore, the activities and milestones completed for this component of the performance assessment program serve a dual role although they are more focused toward the assessment of ground-water travel times.

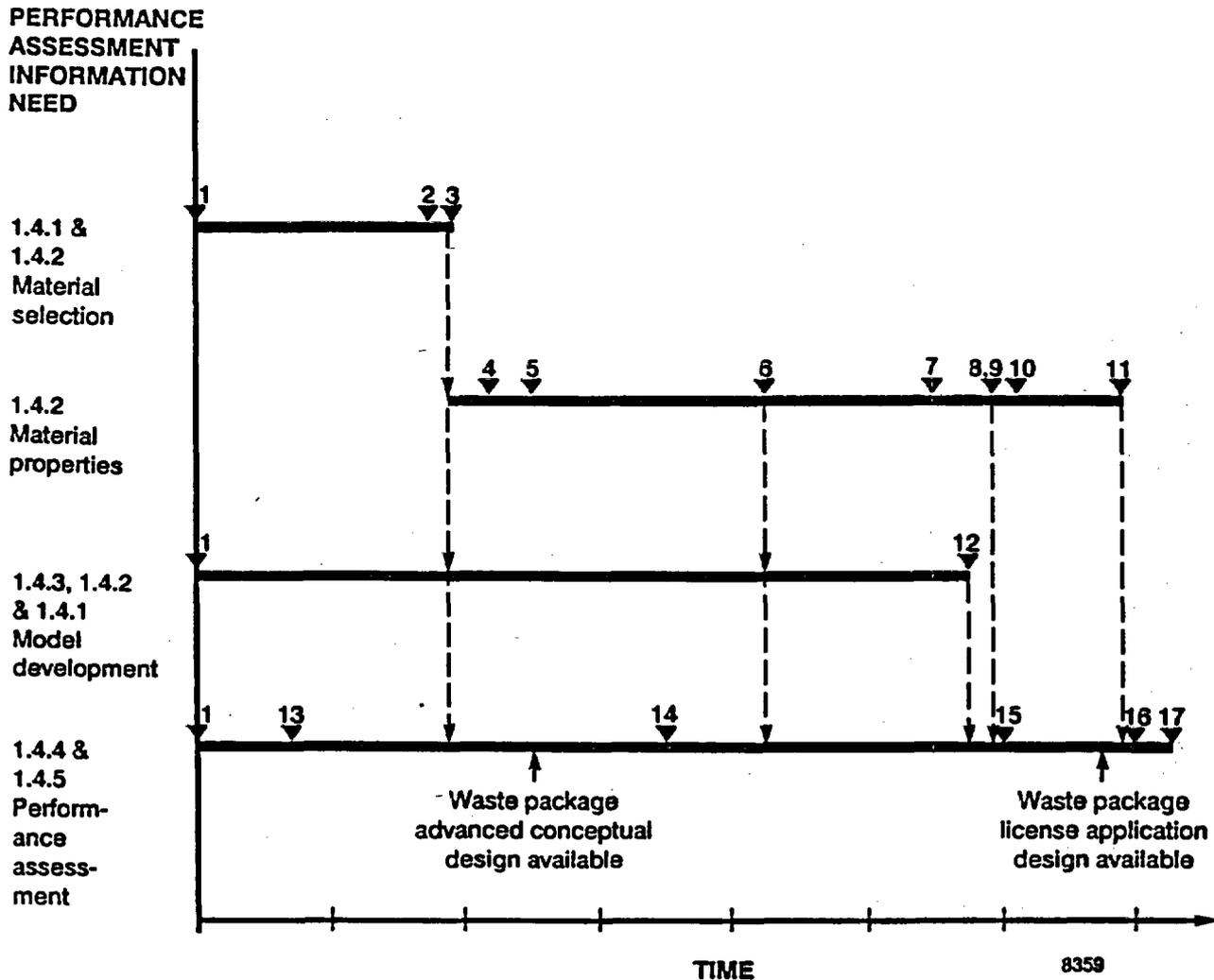
The schedule information for the issues associated with the principal elements of postclosure performance assessment is given in this section in the form of timelines. Information needs within an issue are represented as appropriate. The length of the timeline representing the information need is proportional to the duration of the activities described in the information need. Points shown on the timeline represent major events or important milestones associated with the issue. Solid lines represent information need

CONSULTATION DRAFT

durations and dashed lines show interfaces. The data input and output at the interfaces are shown by circles.

**CONTAINMENT BY WASTE PACKAGE
(ISSUE 1.4, SECTION 8.3.5.9)**

The activities planned to support resolution of this issue include those necessary to show that the set of waste packages meet the NRC requirement for substantially complete containment for 300 to 1,000 yr. These activities will produce information that allows prediction of both the degree of containment and the duration of containment. The results derived from activities in this issue provide important input to Issue 1.5 (engineered barrier system release rates) and Issue 1.1 (total system performance).



CONSULTATION DRAFT

The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Barrier material selection, model development, and performance assessment are ongoing, parallel efforts.
2	Milestone P265. Complete feasibility evaluation of ceramic-lined waste package as an alternative design approach.
3	Milestone M265. Metal barrier material selected.
4	Milestone P259. Issue test plan for metal barrier data acquisition in support of license application.
5	Milestone P260. Initiate license application testing for metal barriers.
6	Milestone Z036. Issue final data base for container material performance in license application.
7	Milestone P261. Complete data acquisition to support the draft environmental impact statement (DEIS) performance calculations.
8	Milestone P262. Provide input on metal barrier to waste package performance assessment to support the DEIS.
9	Milestone P268. Provide input on other materials to waste package performance assessment to support the DEIS.
10	Milestone P200. Complete documentation of the results of other materials testing to support the DEIS.
11	Milestone P040. Issue final report on oxidation/corrosion performance of selected container material.
12	Milestone T075. Complete and document waste package performance analysis codes.
13	Milestone M260. Issue report on preliminary long-term waste package performance assessments for waste package conceptual design.
14	Milestone M263. Complete waste package performance assessment for advanced conceptual design.
15	Milestone Z489. Initiate waste package performance assessment to support the DEIS.
16	Milestone M268. Complete waste package performance assessment for license application design.

CONSULTATION DRAFT

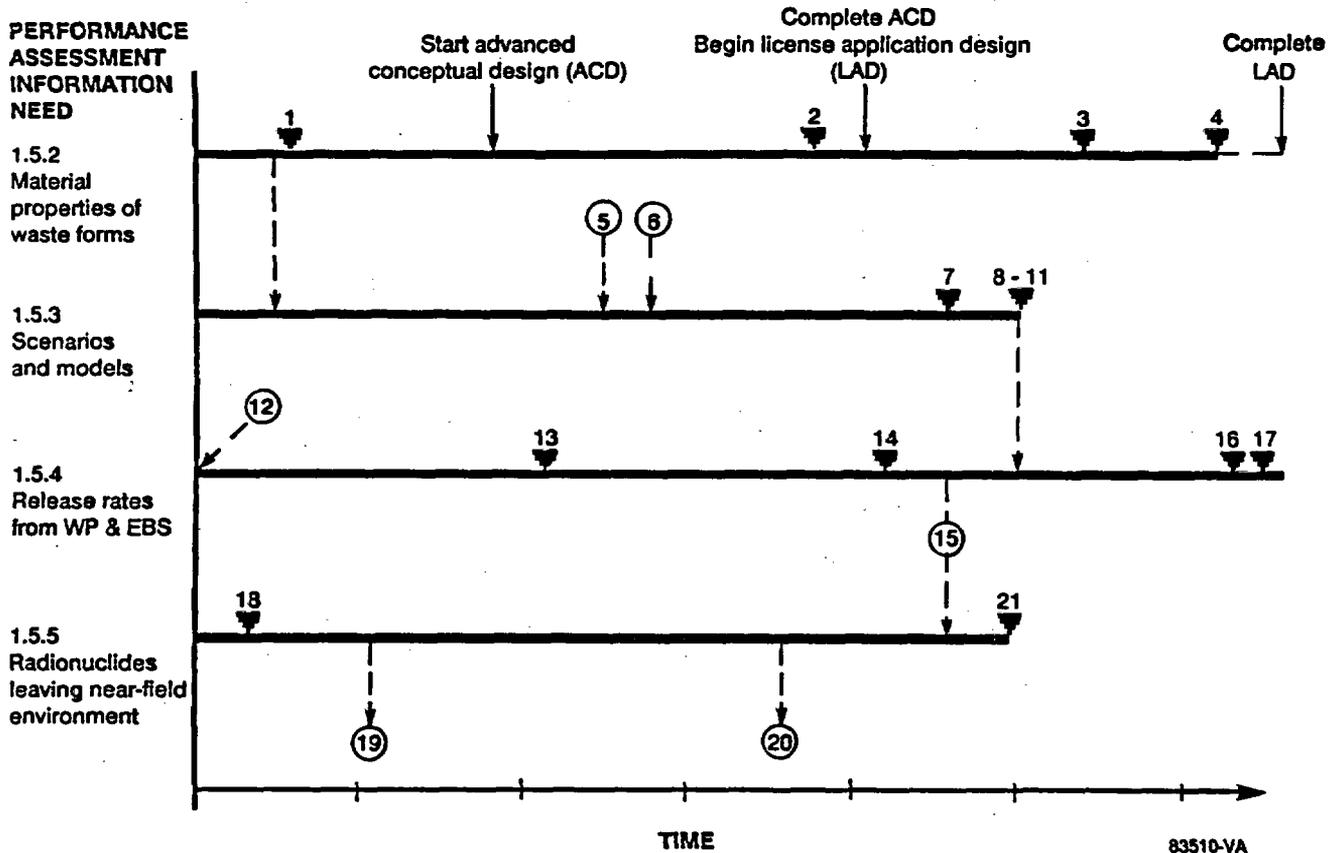
Point number

Description

17 Milestone M273. Issue final report on license application design waste package performance assessment, regulatory performance of aggregate of waste packages, and reliability in meeting regulatory requirements, and waste package radionuclide source term.

**ENGINEERED BARRIER SYSTEM RELEASE RATES
(ISSUE 1.5, SECTION 8.3.5.10)**

The activities conducted under this issue will support demonstrations of compliance with the requirements of the Nuclear Regulatory Commission that the engineered barrier system should limit the release rate of any radionuclide after the containment period so that no greater than one part in 100,000 of the 1,000 yr inventory of that nuclide shall be released per year. The activities that will be performed under this issue include waste form testing, waste package performance assessment, and scenario analysis to provide near-field radionuclide source terms to Issue 1.1 (total system performance).



CONSULTATION DRAFT

The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone M269. Complete spent fuel waste form testing for design.
2	Milestone Z066. Complete studies of alteration of glass.
3	Milestone Z069. Complete confirmatory testing of spent fuel waste forms.
4	Complete documentation of waste form testing results for license application.
5	Input received from Information Need 1.4.5 (substantially complete containment of waste) on time of container failure.
6	Scenarios supplied from total system calculations by Information Need 1.1.2.
7	Milestone P334. Issue final EQ3/6 data base.
8	Milestone M012. Complete modeling of expected long-term performance of spent fuel waste forms under repository conditions to support the draft environmental impact statement (DEIS).
9	Complete modeling of expected long-term performance of glass waste forms under repository conditions to support the DEIS.
10	Milestone T065. Complete and document waste package performance analysis codes.
11	Milestone T076. Complete waste package performance assessment code verification and validation.
12	Report on preliminary long-term waste package performance assessment for waste package conceptual designs is available.
13	Milestone M263. Complete waste package performance assessments for advanced conceptual design (ACD).
14	Milestone M268. Complete waste package performance assessments for license application design.
15	Output release calculations to Issue 1.4 (containment by waste package), Information Need 1.5.5 (radionuclides leaving near-field of waste package), and Issue 1.1 for total system release calculations.

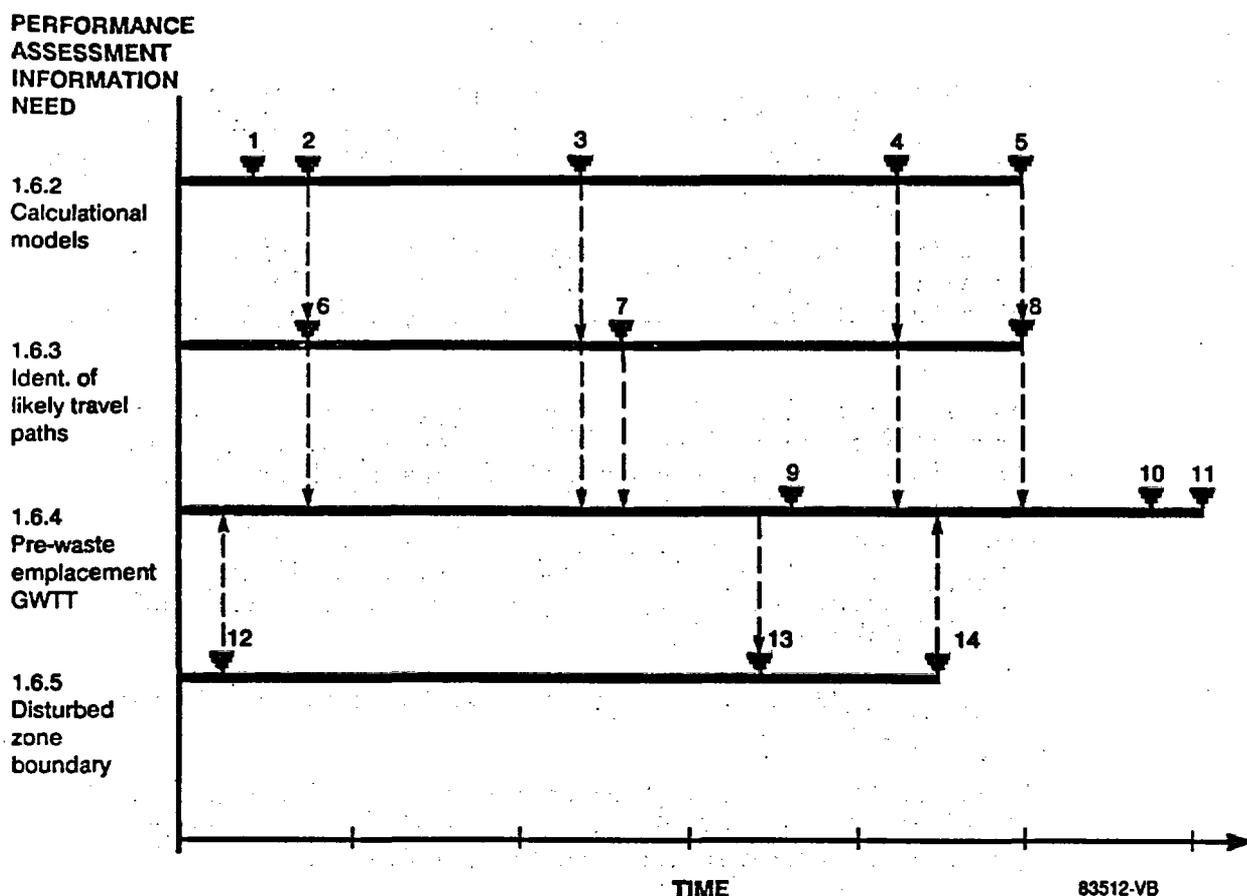
CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
16	Milestone M273. Issue final report on license application design waste package performance assessment, regulatory performance of aggregate of waste packages, and reliability in meeting repository requirements and waste package radionuclide source term.
17	Milestone IRO2. Preliminary issue resolution report addressing the performance objective for controlled radionuclide release by the engineered barrier system.
18	Milestone W260. Complete local flow and transport model.
19	Provide input to unsaturated flow studies in Information Need 1.10.4 (Section 8.3.4.2.4).
20	Output preliminary information on source term to Information Need 1.5.3 and to Issue 1.1 for total system release calculations.
21	Milestone P204. Issue final report on near-field radionuclide source term.

GROUND-WATER TRAVEL TIME (ISSUE 1.6, SECTION 8.3.5.12)

The activities planned to support resolution of this issue are those required to demonstrate that the pre-waste-emplacement ground-water travel time from the disturbed zone to the accessible environment will be at least 1,000 yr. Because the repository at the Yucca Mountain site would be situated in the unsaturated zone, many of the activities are focused on understanding the dynamics and mechanisms of flow under unsaturated conditions. The NRC regulation responsible for this issue requires that the travel time be calculated along the fastest path of likely radionuclide travel, resulting in some activities to identify the fastest path. This issue also requires a definition of the starting point for the travel-time calculation, i.e., the disturbed zone. Activities necessary to identify the disturbed zone are also included under this issue.

CONSULTATION DRAFT



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone R073. Development of verification and validation strategies.
2	Milestone P650. Issue report on concepts of flow in partially saturated tuff.
3	Update of conceptual, mathematical, and numerical models (codes) for use in identification of fastest flow path (Information Need 1.6.3) and calculation of ground-water travel time (GWTT) (Information Need 1.6.4). Activity to be reported in Milestone M183, Information Need 1.6.4.
4	Final codes and models developed and selected for use in calculations of GWTT for the DEIS and license application. Activity to be reported in Milestone P652, Information Need 1.6.4.

CONSULTATION DRAFT

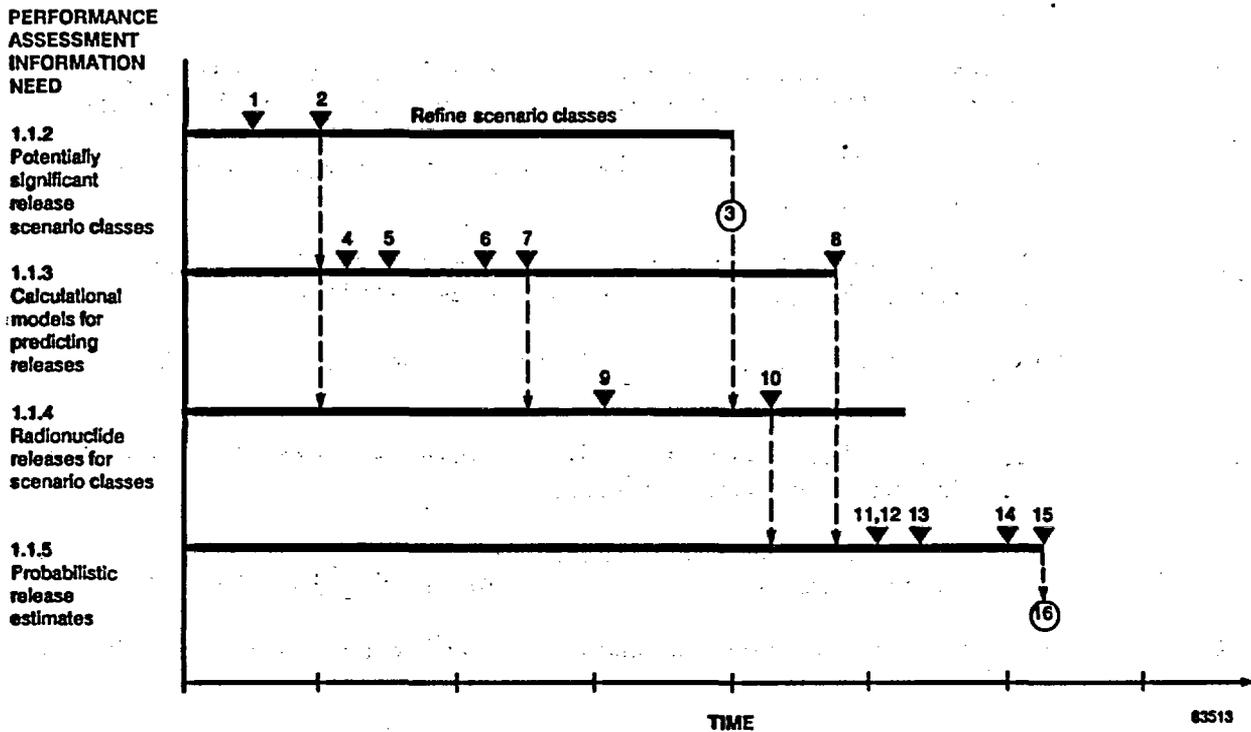
<u>Point number</u>	<u>Description</u>
5	Milestone P227. Verification of codes and validation of models used for identification of fastest path and calculation of GWTT for the draft environmental impact statement (DEIS) and license application.
6	Identification of the fastest path of likely radionuclide travel for use in preliminary calculation of pre-waste emplacement GWTT. Activity to be reported in Milestone M181, Information Need 1.6.4.
7	Update of identification of fastest path of likely radionuclide travel for use in interim calculation of GWTT. Activity to be reported in Milestone M183, Information Need 1.6.4.
8	Identification of fastest path of likely radionuclide travel for use in calculation of GWTT for DEIS and license application. Activity to be reported in Milestone P652, Information Need 1.6.4.
9	Milestone M183. Issue report on GWTT based on interim site characterization data.
10	Milestone P652. Calculation of pre-waste-emplacement GWTT in support of the DEIS and calculation of post-emplacement ground-water travel time (Activity 1.6.5.1).
11	Update of GWTT calculations for the final environmental impact statement (FEIS) and license application.
12	Milestone M107. Issue report on the preliminary definition of the disturbed zone.
13	Milestone M188. Issue report on the detailed analysis of the effect of heat and excavation on water flow in the vicinity of the waste package.
14	Milestone Z090. Issue report on the definition of the disturbed zone.

TOTAL SYSTEM PERFORMANCE (ISSUE 1.1, SECTION 8.3.5.13)

The activities planned to support resolution of this issue are those necessary to show that total repository system releases over 10,000 yr will comply with the cumulative release limits specified in 40 CFR Part 191. The contribution to total radionuclide releases to the accessible environment for the scenarios that are likely to occur, as well as those scenarios that are unlikely, yet sufficiently credible, will be determined. This issue relies on Issue 1.6 (pre-waste-emplacement ground-water travel time) for transport

CONSULTATION DRAFT

models, and on Issue 1.5 (engineered barrier system releases) for radionuclide source terms. It also draws information from a variety of site programs, such as the climate program (Section 8.3.1.5) and the postclosure tectonics program (Section 8.3.1.8) to establish the range of expected conditions and processes over the next 10,000 yr at the Yucca Mountain site.



The points on the timelines and the data input and output at the interfaces are shown in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone M126. Report on the NNWSI Project data priority study.
2	Milestone P654. Report on the description of preliminary scenario classes to be screened against consequences.
3	Input refined scenario classes to Information Need 1.1.4.
4	Milestone M125. Report on preliminary models of releases through volcanism and human intrusion.
5	Milestone P655. Report on preliminary models of gas-phase releases.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
6	Milestone P086. Report on preliminary systems models of releases through water pathways.
7	Milestone M193. Report on a refined source term model using exploratory shaft and waste package advanced conceptual design information.
8	Complete validation of models and verification of codes in support of the draft environmental impact statement (DEIS).
9	Milestones Z043 and Z075. Reports on the results of screening scenario class models.
10	Milestone Z077. Report on final computationally efficient models to be used in the total system simulator.
11	Milestone Z078. Report on structure of the total system simulator.
12	Milestone Z079. Report on joint probability distributions used in the total system simulator.
13	Milestone N121. Complete interim probability analysis of performance of the total system for input into the DEIS.
14	Output of performance assessment calculations in support of the DEIS.
15	Update of DEIS performance assessment calculations in support of the final environmental impact statement (FEIS) and license application.

INDIVIDUAL PROTECTION (ISSUE 1.2, SECTION 8.3.5.14)

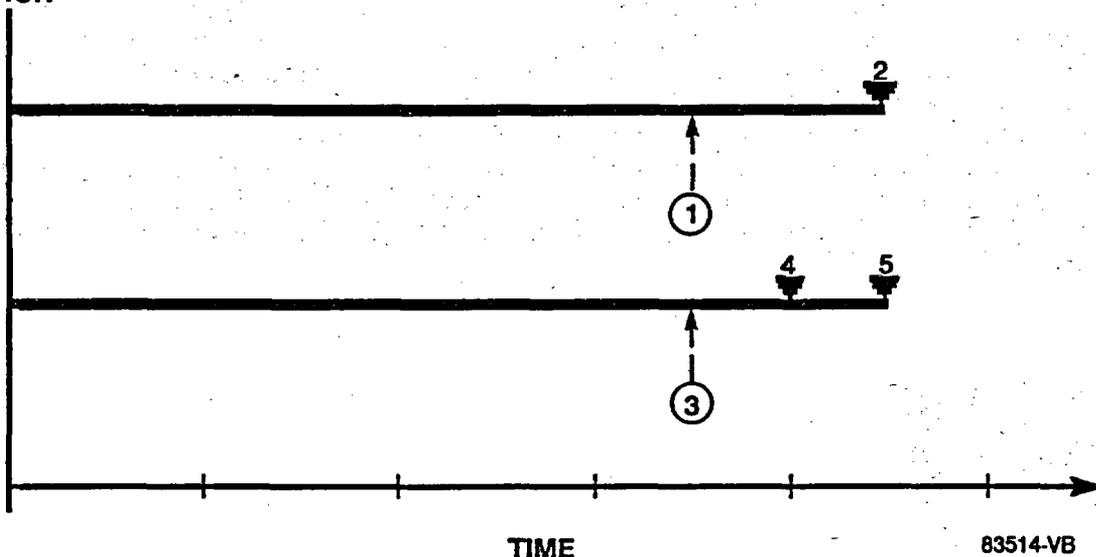
The activities planned to support resolution of this issue address the EPA requirements limiting the annual dose equivalent from the repository system to any member of the public in the accessible environment following permanent closure. Two transport mechanisms must be considered at the Yucca Mountain site: ground-water transport and gas-phase transport. The activities planned under this issue will determine if any exposure to the public will occur during the 1,000-yr period following permanent closure.

CONSULTATION DRAFT

PERFORMANCE
ASSESSMENT
INFORMATION
NEED

1.2.1
Public
doses—
ground-
water
transport

1.2.2
Public
doses—
gaseous
pathways



The points on the timelines and the data input and output at the interfaces are described in the following table:

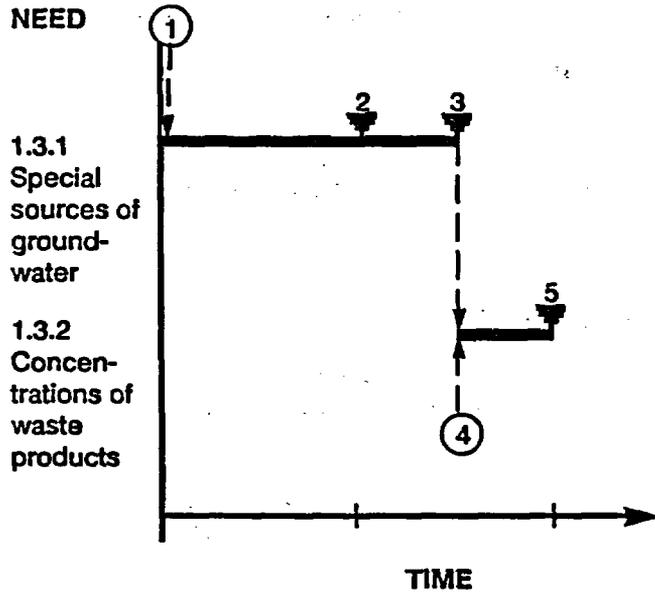
<u>Point number</u>	<u>Description</u>
1	Information received from Issue 1.6 (ground-water travel time, Section 8.3.5.12) and the geochemistry program (Section 8.3.1.3).
2	Milestone Z456. Issue report on the determination of doses to the public in the accessible environment through the ground-water pathways.
3	Information received from Issue 1.5 (engineered barrier system release rates, Section 8.3.5.10), Issue 1.1 (total system performance, Section 8.3.5.13), and the meteorology program (Section 8.3.5.12).
4	Initial calculation of gaseous transport time of carbon-14 dioxide through overburden complete. If the confidence levels are adequate, prepare report on gaseous transport time (Milestone Z457). If the confidence levels are not adequate, initiate next activity to evaluate upper-bound internal and external doses.
5	Milestone Z457. Issue report on the determination of doses to the public in the accessible environment through gas-phase transport.

CONSULTATION DRAFT

**GROUND-WATER PROTECTION
(ISSUE 1.3, SECTION 8.3.5.15)**

The activities planned to support resolution of this issue are those necessary to demonstrate that concentrations of radioactive waste products in special sources of ground water will meet the limits specified in 40 CFR 191.16. To comply with this requirement, the first approach to be used is to demonstrate that no special sources of ground water exist in the vicinity of the site. If special sources of ground water are found to be present, the second approach is to show that concentrations of radionuclides in any ground-water sources during the first 1,000 yr after disposal will not exceed the limits.

**PERFORMANCE
ASSESSMENT
INFORMATION
NEED**



83515-VB

The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Analysis begins with information received from Investigations 8.3.1.2.1 (regional hydrology system), 8.3.1.2.3 (site saturated zone hydrologic system), and 8.3.1.9.2 (value of resources).
2	Milestone Z454. Issue report on evaluation of the potential for special sources of ground water at Yucca Mountain.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
3	Milestone Z360. Complete evaluation of the potential for special sources of ground water at Yucca Mountain.
4	Analysis begins with decision that analysis is needed based on results of evaluation of the potential for special sources of ground water from 8.3.5.1.5.1.1; information is also passed from Investigation 8.3.1.2.3 (site saturated hydrologic system) and Section 8.3.5.13 (total system performance).
5	Milestone Z455. Issue report on the calculations to determine concentration of waste products in special source aquifers over the first 1,000 yr after disposal.

8.5.3 REPOSITORY DESIGN ACTIVITIES AND MILESTONES

The repository design must address regulatory requirements for both the preclosure and postclosure periods. The design must ensure radiological safety, as described in Section 8.5.2.1. For the preclosure period, 10 CFR 60.131-133 specify general design criteria for the geologic repository operations area and additional design criteria for the surface and underground facilities. A DOE requirement (10 CFR Part 960) also specifies that the designs should be feasible on the basis of reasonably available technology. For postclosure, a general criterion for the underground facility requires that the orientation, geometry, layout and depth of the facility, and the design of engineered barriers should contribute to the containment and isolation of radionuclides (10 CFR 60.133(a)(1)). The engineered barriers are also to be designed to assist the geologic setting in meeting the performance objectives. Other postclosure requirements on the repository design specify that it must allow the performance objectives to be met under the predicted postclosure conditions (10 CFR 60.133(h)). Another postclosure requirement placed on the geologic repository operations area, and combined with the repository design milestones for purposes of this section, is the requirement for the development of seals for shafts and boreholes (10 CFR 60.134).

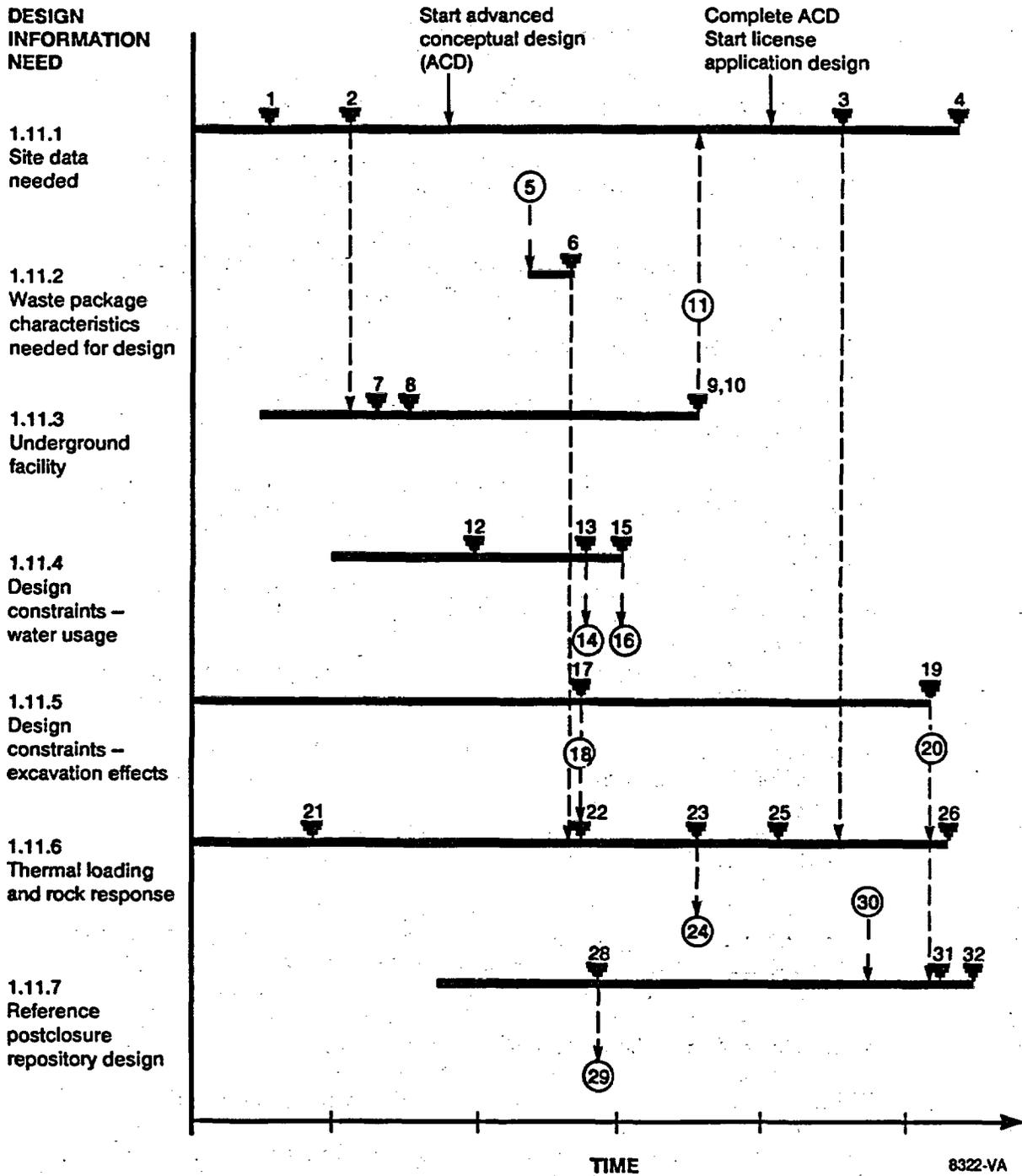
Summary schedule information, in the form of timelines, for each preclosure and postclosure repository design issue presented in Sections 8.3.2.2 through 8.3.2.5 and the seal design issue presented in Section 8.3.3.2 is given in this section. Each information need is represented as appropriate. The length of the timeline representing the information need is proportional to the activity durations. Points shown on the timelines represent major events or important milestones associated with the information need. Solid lines represent the information need activity durations and dashed lines show interfaces. The data input and output at the interfaces are shown by circles.

CONSULTATION DRAFT

CONFIGURATION OF UNDERGROUND FACILITIES (POSTCLOSURE) (ISSUE 1.11, SECTION 8.3.2.2)

The activities planned to support resolution of this issue are those related to aspects of the underground facility design that have implications for the postclosure behavior of the repository. The requirements addressed by the issue state that the underground facility and the engineered barrier system shall contribute to the containment and isolation of radionuclides, incorporate sufficient flexibility to accommodate site specific conditions, and assist the geologic setting in meeting the postclosure performance objectives. Major considerations in addressing the requirements covered by this issue include the potential excavation effects on performance, the rock response to the thermal loads induced by the emplaced waste, and the availability of adequate usable host rock for the underground facility. Data from site programs are required for resolution of this issue, including information on stratigraphy and structure and on the thermal and mechanical properties of the host rock.

CONSULTATION DRAFT



The points on the timelines and the data input and output at the interfaces are described in the following table:

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
1	Milestone M444. Report available updating reference thermo-mechanical properties for advanced conceptual design (ACD).
2	Initial report available describing the three-dimensional thermal and mechanical stratigraphy of Yucca Mountain.
3	Milestone M445. Report available updating reference thermo-mechanical properties for license application design (LAD).
4	Milestone Z094. Complete the determination of the adequacy of existing data needed for postclosure repository design.
5	Input waste package data required to resolve this issue from Issue 1.10.
6	Milestone Z097. Complete determination and compilation of waste package information required for design of the underground facility.
7	Milestone Z103. Complete evaluation of usable area and flexibility for ACD.
8	Milestone M466. Vertical or horizontal emplacement option selected.
9	Milestone P584. Report available on usable area and flexibility for LAD.
10	Milestone P588. Underground facility contingency plan available.
11	Data/information on usable area and flexibility to Issue 4.4 (preclosure design and technical feasibility) and Information Need 1.11.1 (site characteristics needed for design).
12	Milestone Z098. Report available on the potential effects of construction materials on geochemistry.
13	Milestone P586. Water usage criteria report available.
14	Output water usage criteria to information needs on significant release scenarios, repository design, and equipment development (Information Needs 1.1.2, 4.4.4, and 4.4.6).
15	Milestone P587. Underground facility material inventory criteria.
16	Output underground facility material inventory criteria to information needs on release estimates, waste package design, repository design, and equipment development (Information Needs 1.1.5, 1.10.4, 4.4.4, and 4.4.6, respectively).

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
17	Milestone P585. Complete definition of underground facility excavation methods criteria.
18	Output excavations criteria to Information Needs 1.11.6 (thermal loading and thermomechanical rock response) and 4.4.4 (repository design requirements).
19	Milestone Z023. Issue long-term subsidence control strategy report.
20	Output long-term subsidence control information to Information Needs 1.11.6, 1.11.7 (reference postclosure underground designs), and 4.4.7 (design analyses).
21	Milestone P573. Complete strategy for underground facility ACD considerations to enhance containment.
22	Milestones P576 and P577. Complete ACD far-field and near-field reference design analysis calculations.
23	Milestone P583. Complete determination of allowable far-field areal power density for LAD.
24	Output information on far-field areal power density to Information Needs 1.1.2 (potentially significant release scenario classes) and 4.4.7 (design analyses).
25	Milestone Z106. Complete strategy for underground facility LAD considerations to enhance containment.
26	Milestone Z107. Complete LAD reference design calculations.
27	Output near-field sensitivity information to Information Need 4.4.7 (design analyses); reference design calculations to Information Needs 1.1.3 (models for release scenarios), 1.6.5 (disturbed zone boundary), and 1.10.4 (near-field environment).
28	Milestone P581. Complete reference postclosure design for ACD.
29	Output reference conceptual design to Information Need 1.1.2 (potentially significant release scenario classes).
30	Input information on potentially significant scenario classes (Information Need 1.1.2) and design analyses (Information Need 4.4.7).
31	Milestone M063. Issue design analysis report to support license application.

CONSULTATION DRAFT

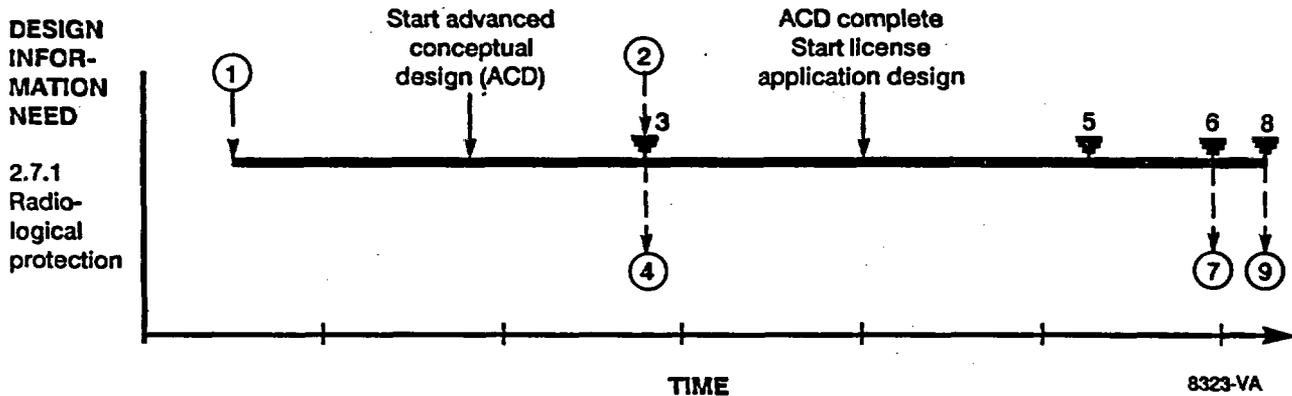
Point number

Description

32 Milestone Z439. Complete reference postclosure design confirmation for the LAD.

**REPOSITORY DESIGN CRITERIA FOR RADIOLOGICAL SAFETY
(ISSUE 2.7, SECTION 8.3.2.3)**

The activities performed under this issue will provide radiological safety design analyses to support resolution of Issue 4.4 (preclosure design and technical feasibility). Data from a variety of site programs, such as Meteorology (Section 8.3.1.12) and Preclosure tectonics (8.3.1.17) will be used to determine the site-specific conditions that must be considered in designing a repository facility that will protect the health and safety of repository workers and the public.



The points on the timelines and the data input and output at the interfaces are described in the following table:

Point number

Description

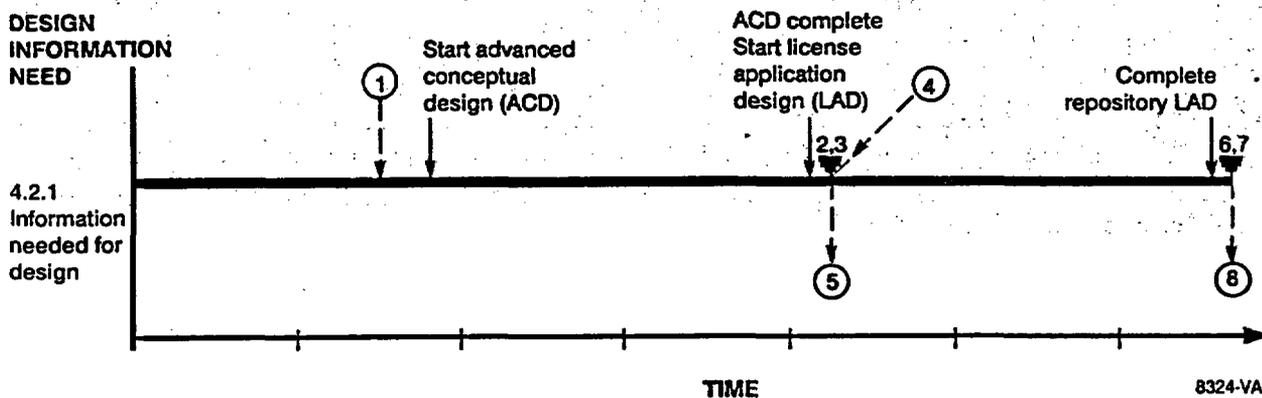
- 1 Receive site characterization data from site programs 8.3.1.3 (geochemistry), 8.3.1.12 (meteorology), 8.3.1.13 (offsite installations), 8.3.1.14 (surface characteristics), 8.3.1.15 (rock properties), 8.3.1.16 (preclosure hydrology), and 8.3.1.17 (preclosure tectonics), and data/information from Information Need 2.3.1 (credible accident sequences, Section 8.3.5.5.1).
- 2 Receive site characterization data from site Investigations 8.3.1.3, 8.3.1.12, 8.3.1.13, 8.3.1.14, 8.3.1.15, 8.3.1.16, and 8.3.1.17 and data/information from Information Need 2.3.1. (See point 1 description for investigation names.)

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
3	Milestone R784. Advanced conceptual design (ACD) preclosure safety analysis report.
4	Output radiological safety design analyses to Issue 4.4 (preclosure design and technical feasibility).
5	Milestone M068. Preclosure performance assessment input for enclosure in license application.
6	Milestone R777. Update preclosure performance assessment report in support of draft environmental impact statement (DEIS) preparation.
7	Output preclosure performance assessment information/data to DEIS.
8	Milestone R780. Update preclosure performance assessment report in support of final environmental impact statement (FEIS) and license application.
9	Output preclosure radiological safety assessment to FEIS and license application.

**NONRADIOLOGICAL HEALTH AND SAFETY
(ISSUE 4.2, SECTION 8.3.2.4)**

The activities planned to support resolution of this issue are those necessary to demonstrate that repository designs and operating procedures will protect the nonradiological health and safety of repository workers. General areas of concern for nonradiological health and safety include stability of drifts and boreholes, adequate ventilation, and temperatures in the underground facility.



CONSULTATION DRAFT

The points on the timelines and the data input and output at the interfaces are described in the following table:

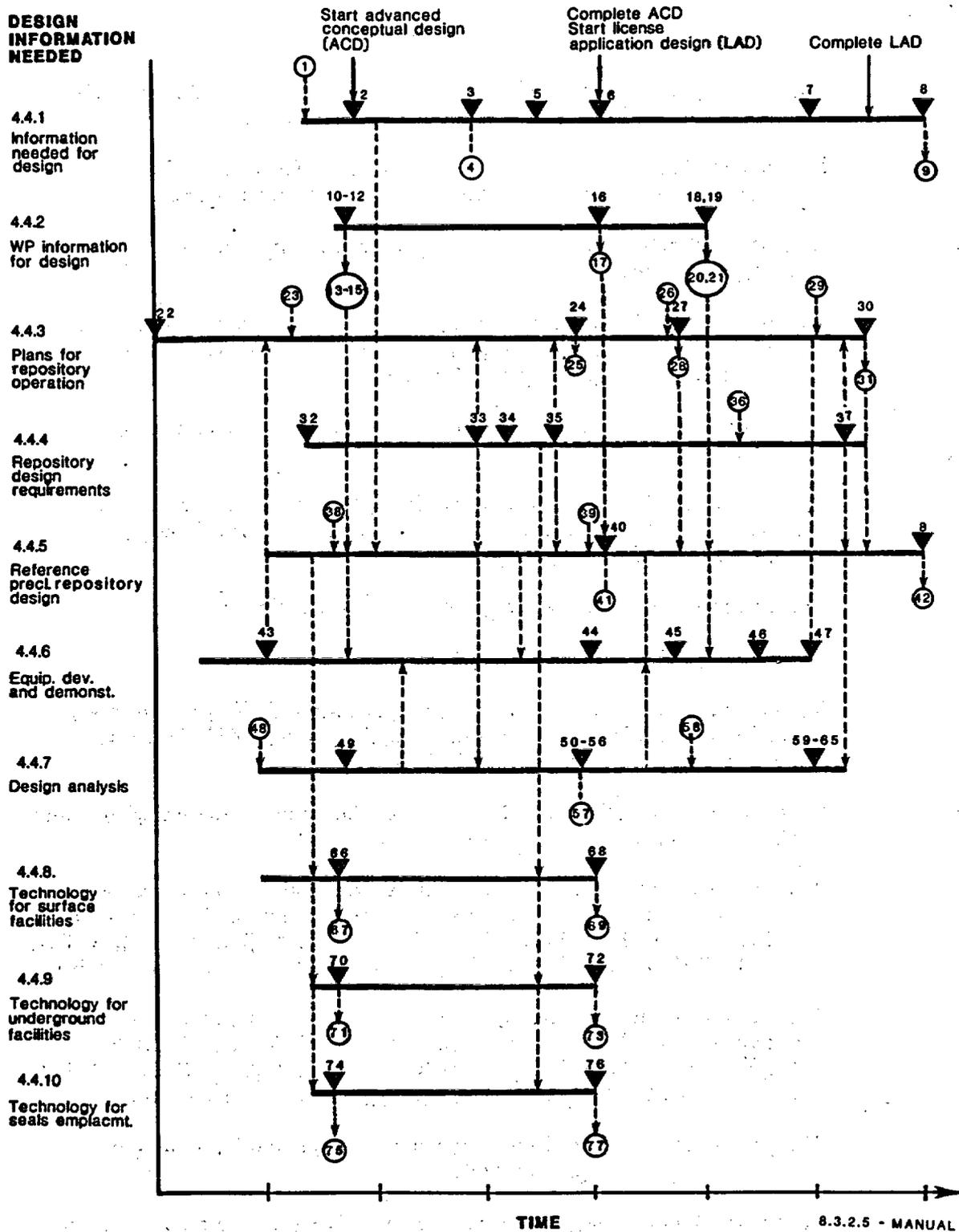
<u>Point number</u>	<u>Description</u>
1	Input reference designs and design analyses from Information Needs 4.4.5 (reference preclosure repository design) and 4.4.7 (design analyses).
2	Milestone Z161. Advanced conceptual design (ACD) and analyses of repository accesses and drifts.
3	Milestone Z163. ACD and analysis of repository ventilation system.
4	Input reference designs and design analyses from Information Needs 4.4.5 and 4.4.7.
5	Output design and analyses to support worker nonradiological safety to ACD report.
6	Milestone Z162. License application design (LAD) and analysis of repository accesses and drifts.
7	Milestone Z164. LAD and analysis of repository ventilation system.
8	Output information/data on design and analysis of repository accesses and drifts to LAD report.

PRECLOSURE DESIGN AND TECHNICAL FEASIBILITY (ISSUE 4.4, SECTION 8.3.2.5)

The activities supporting resolution of this issue are those necessary to demonstrate that the repository can be designed, constructed, operated, and closed using reasonably available or proven technology. This issue is also the focus for repository design requirements addressed under other issues. Because of this role, the activities performed under this issue must address a variety of design requirements, such as the ability to retrieve the waste, the quantities and types of waste to be emplaced, the waste package designs, the waste handling and emplacement systems, the stability of boreholes, the seismic design of surface facilities, and the mine ventilation systems. Activities under this issue will provide updated designs that meet design criteria, taking into account the various requirements placed on the preclosure repository facilities.

CONSULTATION DRAFT

DESIGN INFORMATION NEEDED



The points on the timelines and the data input and output interfaces are described in the following table:

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
1	Input technical feasibility information for pre-ACD studies from Information Needs 4.4.8, 4.4.9, and 4.4.10.
2	Milestone Z444. Issue updated set of reference values of geotechnical properties to support repository ACD.
3	Milestone R770. Repository advanced conceptual design (ACD) design freeze.
4	Output design information for completion of reports on conformance with ACD requirements (Milestone Q140) in waste retrievability (Section 8.3.5.2).
5	Milestone P007. Complete ACD of surface waste handling facilities.
6	Milestone Z445. Issue updated set of reference values of geotechnical properties to support repository license application design (LAD).
7	Milestone T120. Repository LAD configuration freeze.
8	Milestone M459. Issue repository LAD report.
9	Output design information for completion of final reports on conformance with requirements (Milestone Q141) in waste retrievability (Section 8.3.5.2).
10	Milestone Z165. Issue report on waste types, quantities, and characteristics for repository ACD.
11	Output information on waste quantities and characteristics to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.
12	Output preliminary waste package design information to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.
13	Milestone Z169. Obtain preliminary waste package design information needed for ACD.
14	Milestone Z171. Issue report on preliminary design basis for waste handling and emplacement systems in repository ACD.
15	Output information on waste handling and emplacement systems to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
16	Milestone Z172. Issue report on final design basis for waste handling and emplacement systems in repository LAD.
17	Output final design for waste handling and emplacement systems to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.
18	Milestone Z166. Issue report on waste types, quantities, and characteristics for repository LAD.
19	Milestone Z170. Obtain final waste package design information needed for LAD.
20	Output information on waste quantities and characteristics to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.
21	Output final waste package design information to other design-related information needs, specifically 1.10.2, 1.10.3, 1.10.4, 1.11.2, 1.11.6, 1.11.7, 2.2.2, 2.3.2, 2.3.3, 2.3.4, 2.4.4, 2.6.3, 2.7.2, 2.7.6, 4.4.5, 4.4.6, and 4.5.1.
22	Milestone N242. Issue pre-ACD operations plan.
23	Input information from other design-related information needs, specifically 1.11.4, 1.11.5, 1.11.7, 1.12.3, 2.7.5, 2.7.6, 2.7.8, and 4.4.5.
24	Milestone Z006. Issue repository ACD operations plan.
25	Output operations planning information to other design-related information needs, specifically 1.1.5, 2.1.2, 2.2.2, 2.3.1, 2.7.3, 2.7.4, 3.2.2, 3.2.4, 3.2.6, 3.2.7, 3.2.8, 3.2.9, 3.2.10, 3.3.1, 3.3.3, 3.3.4, 3.7.1, 3.8.4, 3.8.5, 4.2.2, and 4.4.5.
26	Input planning-related information from Information Needs 1.11.4, 1.11.5, 1.11.7, 1.12.3, 2.7.5, 2.7.6, 2.7.8, 4.4.2, 4.4.4, and 4.4.5.
27	Milestone Z173. Issue repository LAD operations plan.
28	Output operations planning information to other design-related information needs, specifically 1.1.5, 2.1.2, 2.2.2, 2.3.1, 2.7.3, 2.7.4, 3.2.2, 3.2.4, 3.2.6, 3.2.7, 3.2.8, 3.2.9, 3.2.10, 3.3.1, 3.3.3, 3.3.4, 3.7.1, 3.8.4, 3.8.5, 4.2.2, and 4.4.5.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
29	Input information related to planning from Information Needs 1.11.4, 1.11.5, 1.11.7, 1.12.3, 2.7.5, 2.7.6, 2.7.8, 4.4.2, 4.4.4, and 4.4.5.
30	Milestone Z174. Final procurement and construction design (FP&CD) operations plan.
31	Output final operations planning information to Information Needs 1.1.5, 2.1.2, 2.2.2, 2.3.1, 2.7.3, 2.7.4, 3.2.2, 3.2.4, 3.2.6, 3.2.7, 3.2.8, 3.2.9, 3.2.10, 3.3.1, 3.3.3, 3.3.4, 3.7.1, 3.8.4, 3.8.5, 4.2.2, and 4.4.5.
32	Milestone N546. Issue preliminary report on preliminary design requirements document.
33	Milestone M456. Issue updated repository design requirements document with changes resulting from ACD review.
34	Input information on design requirements from other design-related information needs, specifically 1.11.4, 1.11.5, 1.11.6, 1.12.2, 1.12.3, 2.6.1, 2.6.2, 2.6.3, 2.7.6, 2.7.7, 2.7.8, 2.10.2, 2.10.4, 4.2.3, and 4.4.2.
35	Milestone M042. Complete repository design requirements document for LAD.
36	Input information on design requirements from other design-related information needs, specifically 1.11.4, 1.11.5, 1.11.6, 1.12.2, 1.12.3, 2.6.1, 2.6.2, 2.6.3, 2.7.6, 2.7.7, 2.7.8, 2.10.2, 2.10.4, 4.2.3, and 4.4.2.
37	Milestone R781. Update subsystem design requirements for the final procurement and construction design.
38	Input information from the rock characteristics (8.3.1.4), surface characteristics (8.3.1.14), thermal and mechanical properties (8.3.1.15), and preclosure tectonics (8.3.1.17) programs; other design-related documents; and repository operations plans (Information Need 4.4.3).
39	Input updated information from the rock characteristics (8.3.1.4), surface characteristics (8.3.1.14), thermal and mechanical properties (8.3.1.15), and preclosure tectonics (8.3.1.17) programs; other design-related documents; and repository operations plans (Information Need 4.4.3).
40	Milestone M468. Issue repository ACD report.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
41	Output ACD to other design-related information needs, specifically 1.11.3, 2.1.1, 2.2.2, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.7.3, 2.7.4, 2.7.5, 2.7.6, 2.7.7, 2.7.8, 4.4.7, 4.4.8, 4.4.9, 4.4.10, and 4.5.2.
42	Output LAD to other design-related information needs, specifically 1.11.3, 2.1.1, 2.2.2, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.7.3, 2.7.4, 2.7.5, 2.7.6, 2.7.7, 2.7.8, 4.4.7, 4.4.8, 4.4.9, 4.4.10, and 4.5.2.
43	Milestone Z175. Complete repository equipment list.
44	Milestone R269. Issue report on detailed design of emplacement and retrieval equipment.
45	Milestone R271. Complete fabrication of emplacement and retrieval equipment for demonstration.
46	Milestone R273. Complete demonstration of emplacement and retrieval equipment.
47	Milestone R274. Complete documentation of emplacement results for support of the license application.
48	Input site characterization data from the surface characteristics (8.3.1.14), thermal and mechanical properties (8.3.1.15), preclosure hydrology (8.3.1.16), and preclosure tectonics (8.3.1.17) programs.
49	Issue report on Benchmarking I, preliminary verification analyses of thermal and mechanical models.
50	Milestone Z176. Issue report on repository access analysis for incorporation into ACD report.
51	Milestone Z177. Issue report on repository opening analysis for incorporation into ACD report.
52	Milestone Z178. Issue report on borehole analysis for incorporation into ACD report.
53	Milestone Z180. Issue report on mine ventilation design for incorporation into ACD report.
54	Milestone Z448. Issue report on surface facility design analysis for incorporation into ACD report.
55	Milestone Z449. Issue report on seismic design of surface facilities for incorporation into ACD report.

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<u>Point number</u>	<u>Description</u>
56	Milestone Z450. Report on design of surface facilities for wind, tornados, and flooding for ACD report.
57	Output design analysis information to information needs associated with waste retrievability, nonradiological safety, and technical feasibility, specifically 2.4.2, 2.4.3, 2.4.4, 2.4.5, 4.2.3, 4.4.4, and 4.4.5.
58	Input site characterization data from the surface characteristics (8.3.1.14), thermal and mechanical properties (8.3.1.15), preclosure hydrology (8.3.1.16), and preclosure tectonics (8.3.1.17) programs.
59	Milestone Q156. Issue report on repository access analysis report for incorporation into LAD report.
60	Milestone Q157. Issue report on repository opening analysis for incorporation into LAD report.
61	Milestone Q154. Issue report on borehole analysis for incorporation into LAD report.
62	Milestone Q155. Issue report on mine ventilation design for incorporation into LAD report.
63	Milestone Z181. Issue report on surface facility design analysis for LAD report.
64	Milestone Z182. Issue report on seismic design of surface facilities for incorporation into LAD report.
65	Milestone Z183. Report on design of surface facilities for wind, tornados, and flooding for LAD report.
66	Milestone Z451. Issue report on technology requirements for repository surface facilities and systems for incorporation into ACD.
67	Output technology requirements for surface facilities to Information Need 4.5.3 (plans for repository operation).
68	Milestone Z184. Issue report on technology requirements for repository surface facilities and systems for incorporation into LAD.
69	Output technology requirements for surface facilities to Information Need 4.5.3 (plans for repository operation).

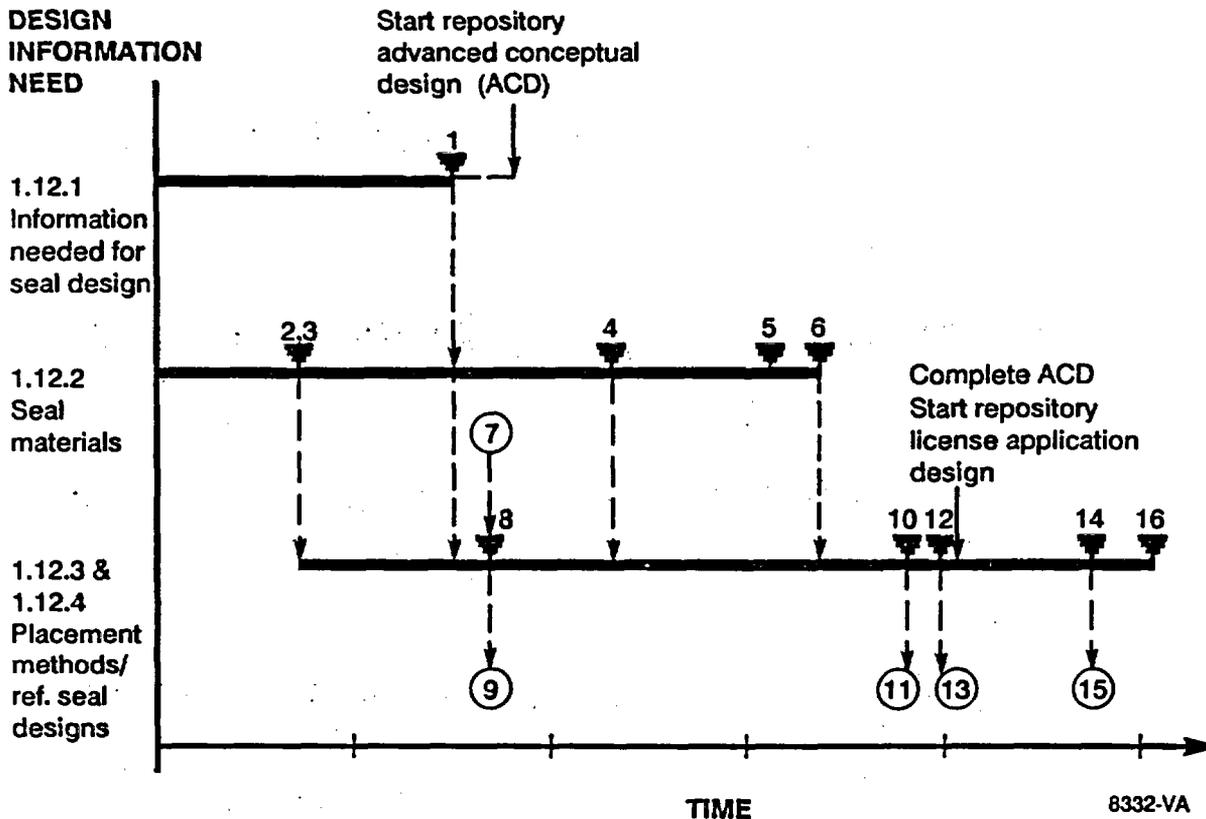
CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
70	Milestone Z452. Issue report on technology requirements for repository underground facilities and systems for incorporation into ACD.
71	Output requirements for underground facilities to Information Need 4.5.3 (plans for repository operation).
72	Milestone Z185. Issue report on technology requirements for repository underground facilities and systems for incorporation into LAD.
73	Output requirements for underground facilities to Information Need 4.5.3 (plans for repository operation).
74	Milestone Z453. Issue report on technology requirements for seal design, material, and emplacement for incorporation into ACD.
75	Output seals technology requirements to Information Need 4.5.3 (plans for repository operation).
76	Milestone Z186. Issue report on technology requirements for seal design, material, and emplacement for incorporation into LAD.
77	Output seals technology requirements to Information Need 4.5.3 (plans for repository operation).

SEAL CHARACTERISTICS (ISSUE 1.12, SECTION 8.3.3.2)

The activities planned to support resolution of this issue include those necessary to develop designs and evaluate performance of seals to be placed in the shafts, ramps, and boreholes associated with the development and closure of the repository. Data from a number of site programs, such as geohydrology (Section 8.3.1.2) and rock properties (Section 8.3.1.15), will be used to ensure that shafts and boreholes are adequately sealed so that after closure, they do not become pathways that compromise the ability of the geologic repository to meet the postclosure performance objectives.

CONSULTATION DRAFT



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z108. List of information needed for seal design completed.
2	Milestone R280. Issue detailed test plan for longevity testing.
3	Issue report on development of a degradation model for cementitious sealing materials.
4	Milestone R283. Complete Phase I testing associated with longevity testing.
5	Milestone R281. Issue report on the results of pipe restraint tests.
6	Milestones R282 and R286. Issue reports on the results of crushed tuff properties test and Phase II seal materials longevity testing.

CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
7	Input site characterization data from site programs 8.3.1.2 (geohydrology), 8.3.1.3 (geochemistry), 8.3.1.5 (climate), 8.3.1.6 (erosion), 8.3.1.8 (postclosure tectonics), 8.3.1.14 (surface characteristics), 8.3.1.15 (rock properties), 8.3.1.16 (preclosure hydrology), and 8.3.1.17 (preclosure tectonics); input data/information from Information Needs 1.11.6 (thermal loading), 1.12.2 (seal characteristics), and 4.4.7 (design analyses).
8	Milestone M461. Sealing conceptual design for incorporation into advanced conceptual design (ACD) report.
9	Output sealing conceptual designs information/data to Information Need 4.4.7 (design analyses).
10	Milestone R276. Recommendations for materials for LAD and performance assessment studies.
11	Output information/data on seal material recommendations to Design Activity 1.12.4.2 (development of LAD for sealing) and Information Needs 1.11.7 (reference postclosure repository design), 4.4.5 (reference preclosure repository design) and 4.4.10 (seal technology).
12	Milestone M492. License application design (LAD) sealing criteria incorporated into repository design requirements.
13	Output information/data on sealing criteria to Information Need 4.4.3 (repository operations plan).
14	Milestone M449. Report on sealing subsystem performance assessment.
15	Output information/data on seal performance assessment to Information Need 1.1.6 (estimates of total system releases).
16	Milestone Z186. Issue report on technology requirements for seal design, materials, and emplacement for repository LAD.

8.5.4 WASTE PACKAGE DESIGN ACTIVITIES AND MILESTONES

The waste package design requirements address the preclosure and post-closure time periods in a manner similar to the repository design requirements covered by the milestones presented in Section 8.5.3. Detailed discussions of the waste package preclosure and postclosure design requirements are provided in Section 8.3.4. The primary requirements placed on the waste package for the preclosure time period cover such concerns as control

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of criticality, limits on reactive materials and free liquids, and the availability of production technologies for fabrication, closure, and inspection of the waste package.

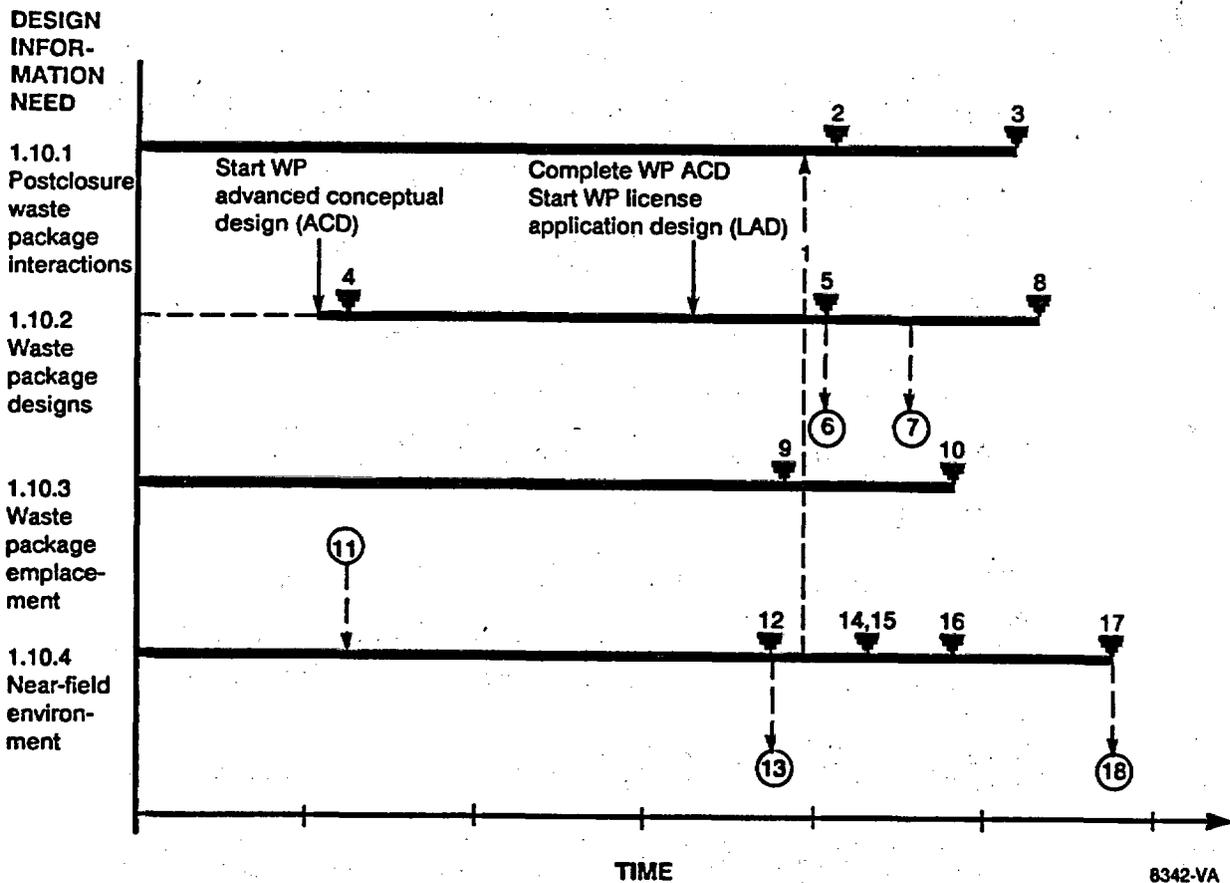
For the postclosure time period, the waste package requirements address the need for considerations of potential interactions between the waste package and its environment that could compromise the function of the packages or the performance of the underground facility or the geologic setting.

Summary schedule information, in the form of timelines, for design-oriented waste package issues presented in Sections 8.3.4.2 through 8.3.4.4 is given in this section. Summary schedule information related to waste package performance assessment issues was presented in Section 8.5.2. Each information need is represented as appropriate. The length of the timeline representing the information need is proportional to the duration of the activities in the information need. Points shown on the timelines represent major events or important milestones associated with the information need. Solid lines represent the information need durations and dashed lines show interfaces. The data input and output at the interfaces are shown by circles.

WASTE PACKAGE CHARACTERISTICS (POSTCLOSURE) (ISSUE 1.10, SECTION 8.3.4.2)

The activities planned to support resolution of this issue are those required to demonstrate that interactions of the waste package with the emplacement environment do not compromise the function of the package or the performance of the underground facility or the geologic setting. The principal characteristics of high-level waste that must be considered are the high levels of radiation and the heat generated within the waste form. To understand the effects of the waste package on the emplacement environment, it is necessary, first, to understand ambient conditions at the repository horizon and the way those conditions will be altered by repository construction and operation. The activities displayed in this section are those necessary to show that the waste package design will meet the requirements addressed by this issue.

CONSULTATION DRAFT



The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Data input from Information Need 1.10.4 (near-field environment).
2	Milestone M264. Complete development of models for integrated testing of waste forms with ground water and container material.
3	Milestone IR21. Issue preliminary report on waste package design criteria considering its interaction with the environment.
4	Milestone T073. Complete waste package design requirements document for advanced conceptual design (ACD).
5	Milestone P267. Final waste package environment definition provided to waste package performance assessment.
6	Output to repository license application design (LAD).

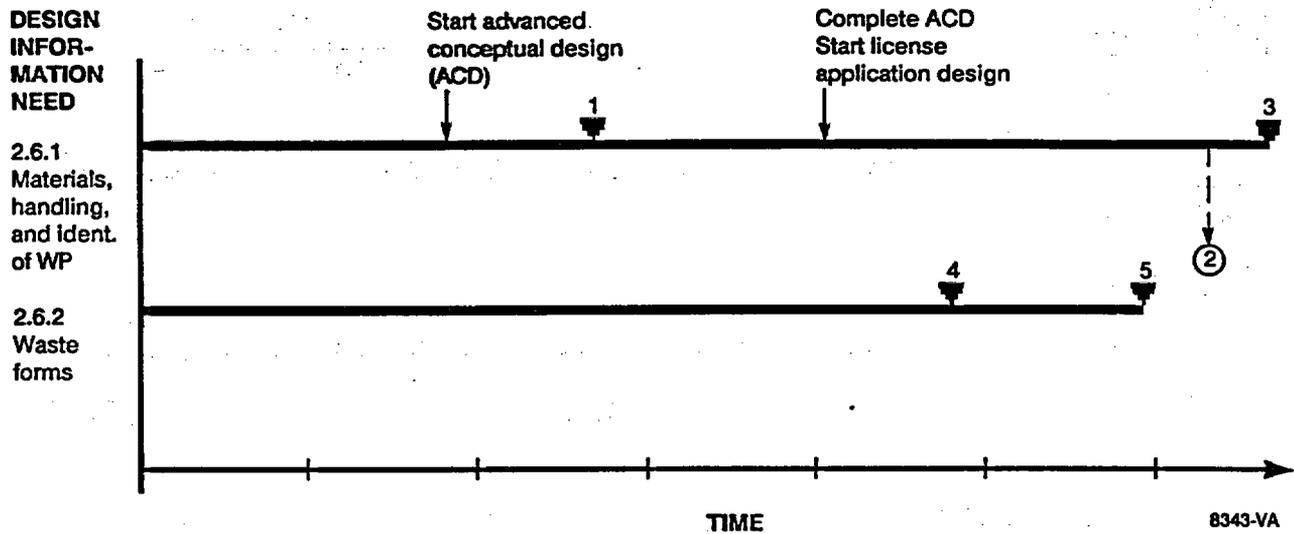
CONSULTATION DRAFT

<u>Point number</u>	<u>Description</u>
7	Output to Issues 1.4 and 1.5, (containment by waste package and engineered barrier system release rates, respectively).
8	Milestone M274. Issue waste package LAD report.
9	Milestone M468. Issue repository ACD report.
10	Milestone M459. Issue repository LAD report.
11	Input results of prototype testing.
12	Milestone M007. Issue report on effects of grout on ground-water chemistry and grout-affected water on waste form dissolution.
13	Data output to Issue 1.5, waste form dissolution.
14	Milestone Z464. Issue report on characterization of potential chemical and mineralogical changes in the post-emplacment environment.
15	Milestone P204. Issue final report on radionuclide source term.
16	Milestone Z466. Issue report summarizing the thermal and mechanical attributes of the waste package environment.
17	Milestone M650. Complete final report on the results of the waste package system test.
18	Data output to Issues 1.4 and 1.5 (containment by waste package and engineered barrier system release rates, Sections 8.3.5.9 and 8.3.5.10, respectively) and Information Need 1.10.1 (waste package design information, Section 8.3.4.2.1).

WASTE PACKAGE CHARACTERISTICS (PRECLOSURE) (ISSUE 2.6, SECTION 8.3.4.3)

The activities planned to support resolution of this issue are related to development of the waste package designs and the integration of the designs into the repository system. Requirements and constraints are placed on the waste form, the container, and the waste package assembly during the preclosure period. It is also important that the waste form and container are not subjected to conditions that could impact their performance during the postclosure period. The requirements derived through this issue are combined with those from the postclosure waste package design issue (Issue 1.10, Section 8.3.4.2) to develop a consolidated design.

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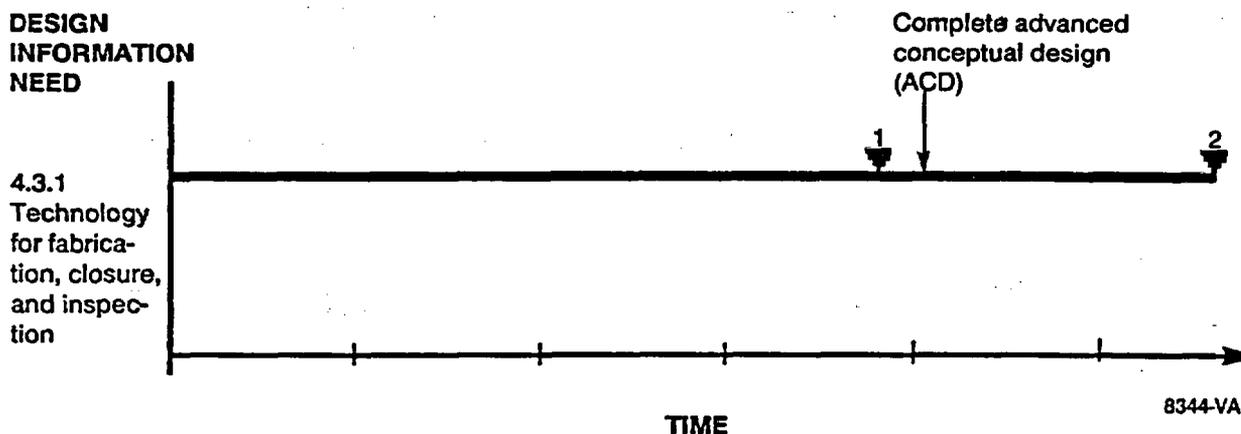
The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone M259. Issue waste package advanced conceptual design report.
2	Data output to Issues 2.1 through 2.4 (Sections 8.3.5.2 through 8.3.5.5).
3	Milestone M274. Issue waste package license application design report.
4	Milestone Z468. Issue report on the comparison of waste form acceptance specifications with regulatory criteria.
5	Milestone P258. Complete documentation of the results of waste form testing to support the draft environmental impact statement.

**WASTE PACKAGE PRODUCTION TECHNOLOGIES
(ISSUE 4.3, SECTION 8.3.4.4)**

The activities planned to support resolution of this issue are those related to the DOE requirements that the repository operations shall be demonstrated to be feasible on the basis of reasonably available technology. Rather than differentiate among various aspects of the production process, all production-related requirements are addressed in this issue. Activities to be performed under this issue include process criteria definition, process identification, process testing and evaluation, and prototype fabrication and testing.

CONSULTATION DRAFT



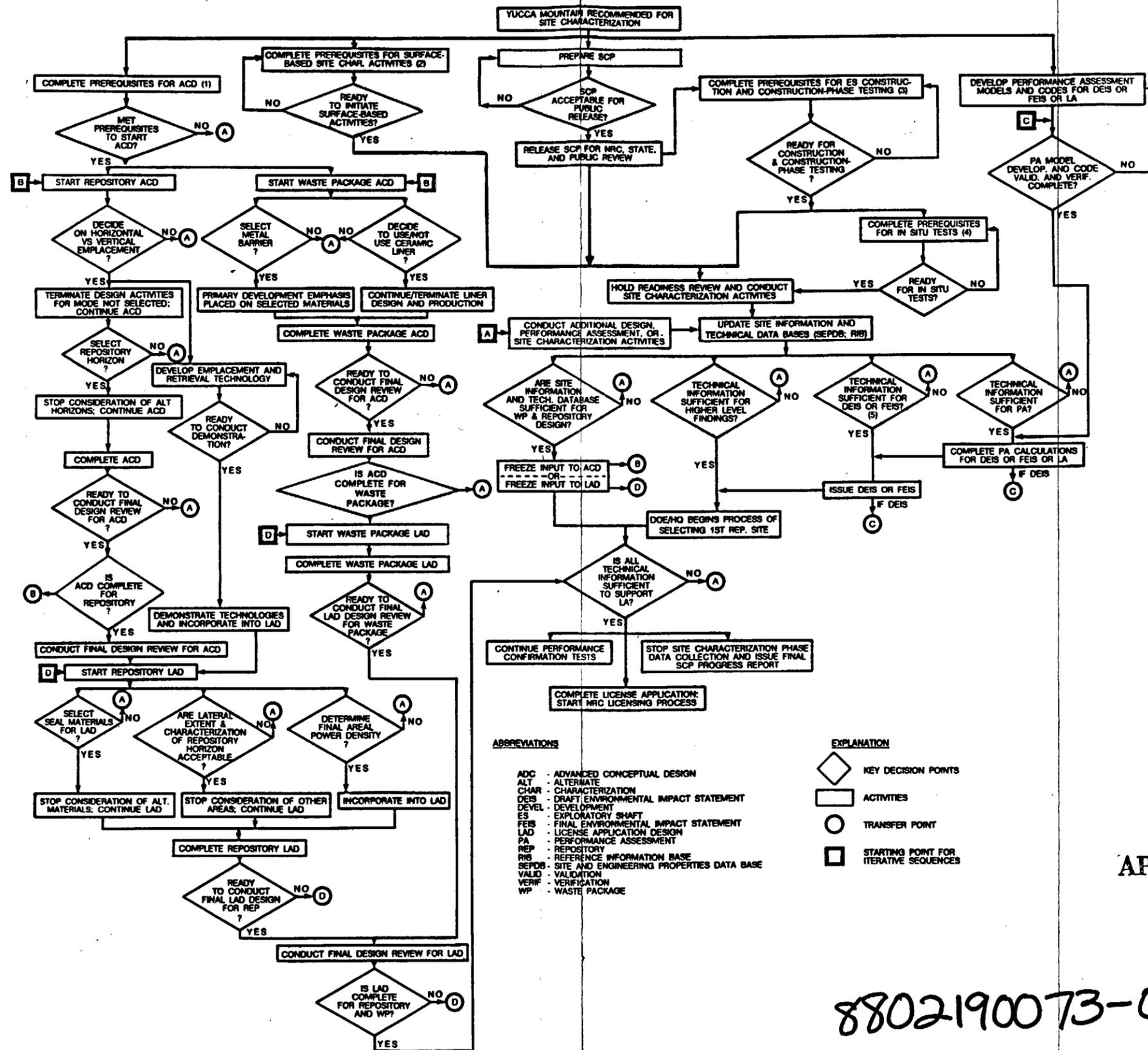
The points on the timelines and the data input and output at the interfaces are described in the following table:

<u>Point number</u>	<u>Description</u>
1	Milestone Z054. Issue report on prototype closure joints and closure process for license application design.
2	Milestone P203. Document prototype waste package testing results.

8.5.5 MAJOR DECISION POINTS FOR THE NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS (NNWSI) PROJECT

This section presents the major decision points currently recognized by the NNWSI Project. A logic diagram, shown in Figure 8.5-2, illustrates the interfaces among the major program elements affected by the decisions.

The timing of some of the highest level decision points is closely tied to critical milestones in the Mission Plan for the Civilian Radioactive Waste Management Program. Decision points for the NNWSI Project are generally related to the provision of site information required by the performance and design elements of the Project to address licensing and other regulatory requirements. This information consists of the technical data bases and supporting information that will allow an evaluation of compliance with regulatory requirements. Preliminary design and performance assessment analyses and calculations, such as those presented in the environmental assessment (DOE, 1986b), were completed on the basis of limited site information. If new site information collected during site characterization raises questions about earlier models and hypotheses, then certain design or performance strategies and approaches may require revision. If, at any time, new site data present evidence that a disqualifying condition exists or that a qualifying condition of any system or technical guideline cannot be met, 10 CFR 960.3-1-5 requires that the site be disqualified. Revised design or



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Figure 8.5-2. General logic diagram for major decision points in site characterization program.

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performance strategies may also result in the need for additional site information.

Some of the major decision points covered in this section do not rely on site information. Decision points may be determined by the activities of other Federal agencies, such as the publication of the Site Characterization Analyses by the NRC. Other decision points will be reached by the systematic progress of design activities from preliminary conceptual to advanced conceptual design (ACD), and ultimately to the final design suitable for inclusion in the license application. The expected dates presented here for the actions resulting from each decision point are the best estimates available at this time. It should be recognized that factors beyond the DOE's control may impact these dates.

The following table lists major decision points, describes their likely outcome, and provides expected dates for the outcomes.

Decision point	Likely outcome
Is the SCP acceptable for public release?	Release SCP for NRC, State, and public review
Have all prerequisites been met to start ACD? ^a	Conduct waste package and repository ACD
Is Project prepared to initiate surface-based activities? ^b	Complete readiness review and begin surface-based activities
Is the Project ready for exploratory shaft (ES) construction and ES construction-phase testing? ^c	Complete readiness review and start ES construction and ES construction-phase testing
Can the metal barrier be selected for the waste package?	Primary emphases placed on selected materials
Can the decision be made to use or not use a ceramic liner for waste packages?	Continue or terminate liner design and production
Is the ACD adequate and complete?	Conduct final design review for ACD; complete all required design documents; start license application design (LAD)
Is the Project prepared to conduct ES in situ testing? ^d	Complete readiness review and start in situ test phase
Can the decision be made on horizontal versus vertical waste emplacement?	Stop all design and analyses of emplacement mode not selected; continue ACD

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Decision point	Likely outcome
Can the repository horizon be selected?	Stop consideration of alternative horizons and continue LAD
Can the decision on final areal power density be made?	Incorporate final areal power density into LAD
Is the lateral extent sufficient and are the characteristics of repository horizon acceptable?	Stop consideration of extension areas; continue LAD
Can the reference sealing material for LAD be selected?	Stop consideration of alternative materials; continue LAD
Is the Project prepared to conduct the demonstration of waste emplacement and retrieval technologies?	Demonstrate the technologies and incorporate into LAD
Are site information and the technical data base for sufficient for waste package and repository design?	Freeze input to ACD; continue data collection for LAD or Freeze input to LAD
Is the Project ready to hold the final LAD design review for waste package?	Conduct the final LAD design review and activities for waste package design
Is the Project ready to hold the final LAD design review for repository?	Conduct the final LAD design review and terminate LAD activities for repository design
Are performance assessment model development and code validation and verification complete?	Complete performance assessment calculations for draft environmental impact statement (DEIS), final environmental impact statement (FEIS) or license application (LA)
Are site information and the technical data base sufficient for performance assessment calculations?	Complete performance assessment calculations for DEIS, FEIS, or LA
Is all technical information adequate to issue DEIS?	Issue DEIS
Is all technical information sufficient to support higher level findings on DOE siting guidelines?	DOE/HQ begins process of selecting first repository site

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Decision point	Likely outcome
Is all technical information sufficient for LA?	Issue final SCP progress report supporting LA; complete LA; start NRC licensing process

^aPrerequisites for ACD

- systems requirements document published
- repository design requirements document published
- waste package design requirements document published
- reference information base data available
- Waste package postclosure compliance strategy developed

^bRequirements for readiness review prior to initiation of surface-based activities:

- land access agreements in place
- environmental permits obtained
- appropriate study plans reviewed by NRC
- test procedures and quality assurance (QA) level assignments completed and approved

^cRequirements for ES construction and ES construction-phase testing readiness review:

- environmental permits obtained
- construction-phase study plans reviewed by NRC
- test procedures and QA level assignments completed and approved

^dRequirements for ES in situ testing readiness review:

- in situ phase study plans reviewed by NRC
- test procedures and QA level assignments completed and approved

8.5.6 SUMMARY SCHEDULE

The following sections provide information useful for developing an overall understanding of the structure of the site characterization program, together with the repository and waste package design and the performance assessment programs. The summary schedule presented in Section 8.5.6.1 portrays the evolution of the major elements of the program from the present time through the license application to the Nuclear Regulatory Commission (NRC). Table 8.5-1 provides a list of the major NNWSI Project Mission Plan Amendment milestones and the scheduled completion date for each milestone. A schematic figure, presented in Section 8.5.6.2, and the text describing preliminary plans for regulatory and institutional activities and milestones provide an overview of the general approach that will be used to document the results of site characterization and important design and performance assessment products.

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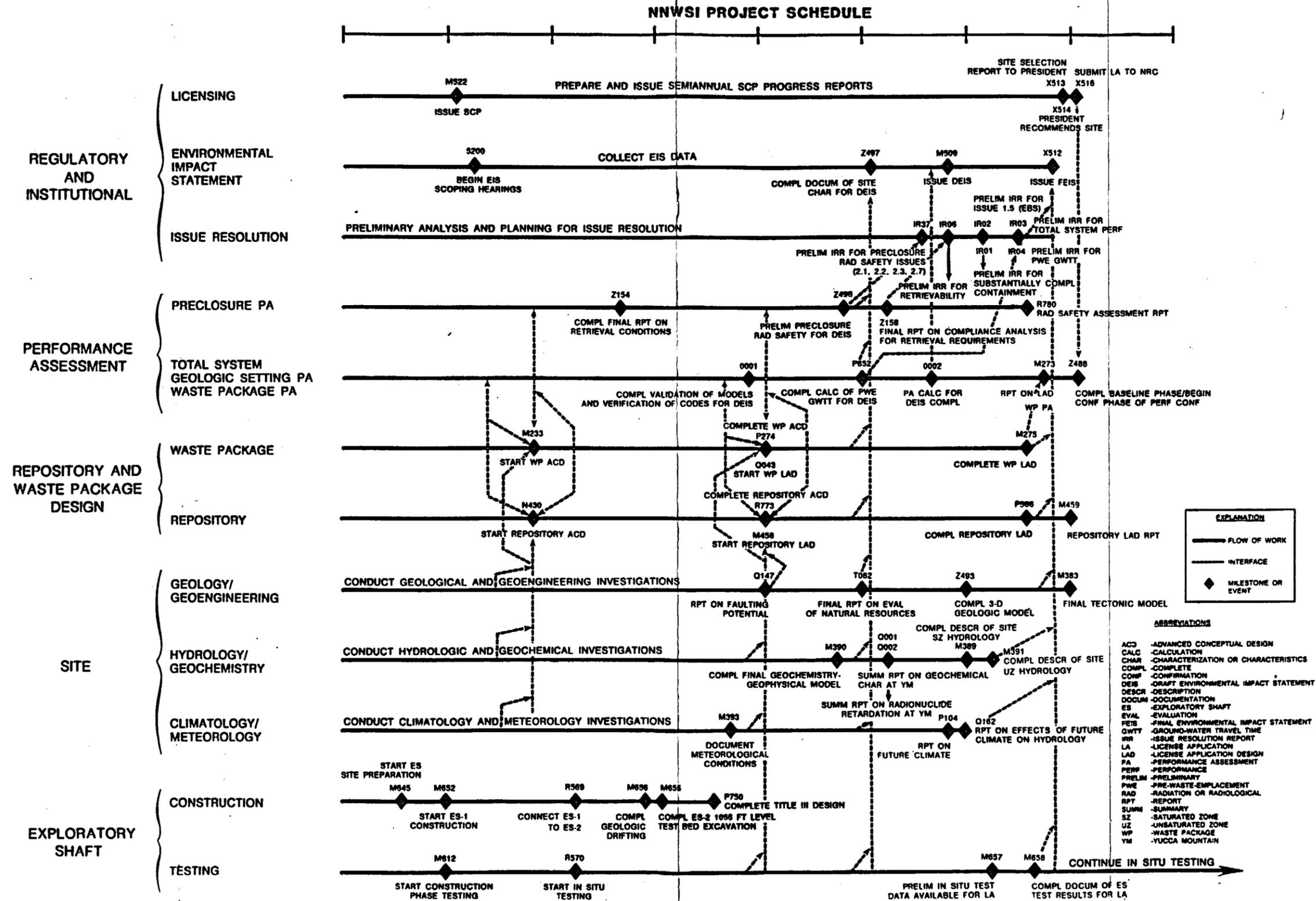
8.5.6.1 Presentation of summary schedule for the Yucca Mountain site

Figure 8.5-3 provides a summary schedule for the site characterization program planned at the Yucca Mountain site. The schedule should be viewed as an aid to understanding the overall structure of the site characterization program. A list of the major NNWSI Project Mission Plan Amendment milestones and the scheduled completion date for these milestones is provided in Table 8.5-1. These milestones are a subset of the milestones shown on the summary schedule. All milestones shown on the summary schedule in Figure 8.5-3 are listed in the following table.

The major program elements represented include regulatory and institutional, performance assessment, repository and waste package design, site investigations, and exploratory shaft.

Table 8.5-1. Major NNWSI Project Mission Plan Amendment milestones

Milestone	Current Schedule
Start Exploratory Shaft Construction	Fourth quarter
Start Waste Package ACD	10/89
Start Repository ACD	10/89
Complete Exploratory Shaft Connection	Second quarter
Complete Waste Package ACD	1/92
Complete Repository ACD	1/92
Start Waste Package LAD	1/92
Start Repository LAD	1/92
Complete Waste Package LAD	1/94
Issue DEIS	10/93
Complete Repository LAD	7/94
Issue FEIS	10/94
Issue Site Selection Report	11/94
Issue Record of Decision	11/94
Submit LA	1/95



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Figure 8.5-3. Summary schedule for the site characterization program at Yucca Mountain.

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Milestone number	Related SCP section	Milestone description
REGULATORY AND INSTITUTIONAL MILESTONES		
M522	NA ^a	DOE/HQ issues SCP to public
5200	NA	Begin environmental impact statement (EIS) scoping hearings
Z497	NA	Complete documentation of site characterization program results to support the draft environmental impact statement (DEIS)
M509	NA	Issue DEIS
X512	NA	Issue final environmental impact statement (FEIS)
X513	NA	Issue site selection report to President
X514	NA	President recommends first repository site
X516	NA	Submit license application to the NRC
IR37	2.1 & 2.2; 8.3.5.3, 8.3.5.4; 10 CFR 60.111; 2.3 & 2.7; 8.3.5.5, 8.3.2.3; 10 CFR 60.131, 60.132, 60.133	Preliminary issue resolution report addressing the performance objective for protection against radiation exposures and releases of radioactive materials
IR06	2.4; 8.3.5.2; 10 CFR 60.111(b)	Preliminary issue resolution report addressing the performance objective for preserving the option of waste retrievability
IR01	1.4; 8.3.5.9; 10 CFR 60.113	Preliminary issue resolution report for the performance objective for substantially complete containment by the waste package

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Milestone number	Related SCP section	Milestone description
IR02	1.5; 8.3.5.10; 10 CFR 60.113	Preliminary issue resolution report addressing the performance objective for controlled radionuclide release by the engineered barrier system
IR04	1.6; 8.3.5.12; 10 CFR 60.113	Preliminary issue resolution report addressing the performance objective for pre-waste-emplacment ground-water travel time
IR03	1.1; 8.3.5.13; 10 CFR 60.112	Preliminary issue resolution report addressing the performance objective for overall system performance
PERFORMANCE ASSESSMENT		
Z154	8.3.5.2	Complete final report on retrieval conditions
Z496	8.3.2.3 8.3.5.3 8.3.5.4 8.3.5.5	Provide preliminary preclosure performance assessment input (radiological safety) in support of the DEIS
Z156	8.3.5.2	Issue final report on compliance analysis for retrieval requirements
R780	8.3.2.3 8.3.5.3 8.3.5.4 8.3.5.5	Issue update report on preclosure radiological safety assessment to support the FEIS and license application
0001	8.3.5.13	Complete validation of models and verification of performance assessment codes for DEIS
P652	8.3.5.12.4	Complete calculations of pre-waste-emplacment ground-water travel time for DEIS
0002	8.3.5.13	Complete performance assessment calculations for DEIS
M273	8.3.5.9 8.3.5.10	Issue final report on waste package license application design (LAD) performance assessment
Z488	8.3.5.16	Complete baseline phase and begin confirmation phase of performance confirmation

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Milestone number	Related SCP section	Milestone description
REPOSITORY AND WASTE PACKAGE DESIGN		
M233	8.3.4.2 8.3.4.3	Start waste package advanced conceptual design (ACD)
P274	8.3.4.2 8.3.4.3	Complete waste package ACD
Q043	8.3.4.2 8.3.4.3	Start waste package license application design (LAD)
M275	8.3.4.2 8.3.4.3	Complete waste package LAD drawings and specifications
N430	8.3.2.2 8.3.2.5	Start repository ACD
R773	8.3.2.2 8.3.2.5	Complete repository ACD
M458	8.3.2.2 8.3.2.5	Start repository LAD
P566	8.3.2.2 8.3.2.5	Complete repository LAD
M459	8.3.2.2 8.3.2.5	Issue repository LAD report
SITE		
Q147	8.3.1.17.2	Issue report on the assessment of the potential for faulting at the sites of prospective surface facilities
T082	8.3.1.9.2	Issue final report on evaluation of natural resources at Yucca Mountain and vicinity
Z493	8.3.1.4.2	Complete final three-dimensional geologic model of the site area
M383	8.3.1.17.4	Issue report on final tectonic model
M390	8.3.1.3.7	Complete final geochemical-geophysical model

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Milestone number	Related SCP section	Milestone description
SITE (continued)		
Q001	8.3.1.3.1 8.3.1.3.2 8.3.1.3.3 8.3.1.3.4	Issue report on the summary of results defining the geochemical characteristics (mineralogy-petrology, mineral stability, and water chemistry) at Yucca Mountain
Q002	8.3.1.3.4 8.3.1.3.5 8.3.1.3.6 8.3.1.3.7	Issue report on the summary of results defining radionuclide retardation at Yucca Mountain
M389	8.3.1.2.3	Issue report on the description of the site saturated zone hydrology at Yucca Mountain
M391	8.3.1.2.2	Issue report on the hydrologic description of the unsaturated zone at Yucca Mountain
M393	8.3.1.12.2	Issue five-year summary report on meteorological conditions at Yucca Mountain
P104	8.3.1.5.1	Issue report on future climate as predicted from models based on the nature and rates of change in climatic conditions
Q162	8.3.1.5.2	Issue report on potential effects of future climate conditions on hydrologic characteristics at Yucca Mountain and vicinity
EXPLORATORY SHAFT^a		
M645	8.4.1	Start exploratory shaft (ES) site preparation
M652	8.4.2.1	Start ES-1 shaft construction
R569	8.4.2.2.2	Complete connection of ES-1 to ES-2
M655	8.4.2.2	Complete ES-2 1,055-ft level testbed excavation
P750	NA ^b	Complete exploratory shaft facility Title III design
M612	NA	Start ES construction phase testing

Milestone number	Related SCP section	Milestone description
EXPLORATORY SHAFT^a (continued)		
R570	NA	Start in situ phase testing
M657	NA	Preliminary in situ test data available for license application
M658	NA	Complete documentation of ES test results for license application

^aSee Section 8.5.1.2

^bNot applicable

8.5.6.2 Regulatory and institutional activities and milestones

As shown in Figure 8.5-3, the principal milestones for regulatory and institutional activities include issuance of the SCP and the semiannual progress reports, as well as those documents and activities that support the site selection process eventually leading to issuance of the environmental impact statement, repository site recommendation, and submittal of the license application.

Because regulatory and institutional milestones were not included in Sections 8.5.1 through 8.5.4, a brief discussion of the preliminary planning basis for regulatory and institutional activities is provided here. The manner in which site information will be utilized in performance and design activities and, finally, in the preparation of regulatory documents is schematically displayed in Figure 8.5-4. Throughout the site characterization program, a series of reports will be prepared to document the DOE position on regulatory requirements and technical issues, as shown in the figure. For purposes of this document, two different types of reports have been defined. Topical reports will be developed by assimilation and compilation of information from published reports documenting the results of site program activities and analyses, performance assessment activities, and the design of the waste package and repository. Many of the reports shown on the timelines in Sections 8.5.1 through 8.5.4, including some reports published by DOE contractors, will be used as input to topical reports or may be directly used as topical reports. Some topical reports may also be used as one component of a larger compiled topical report. This is especially true in the case of those reports that document implementation of the issue resolution strategies for performance and design issues, called issue resolution (IR) reports in this document. Preliminary milestones for the IR reports identified to date are presented below. The need for additional

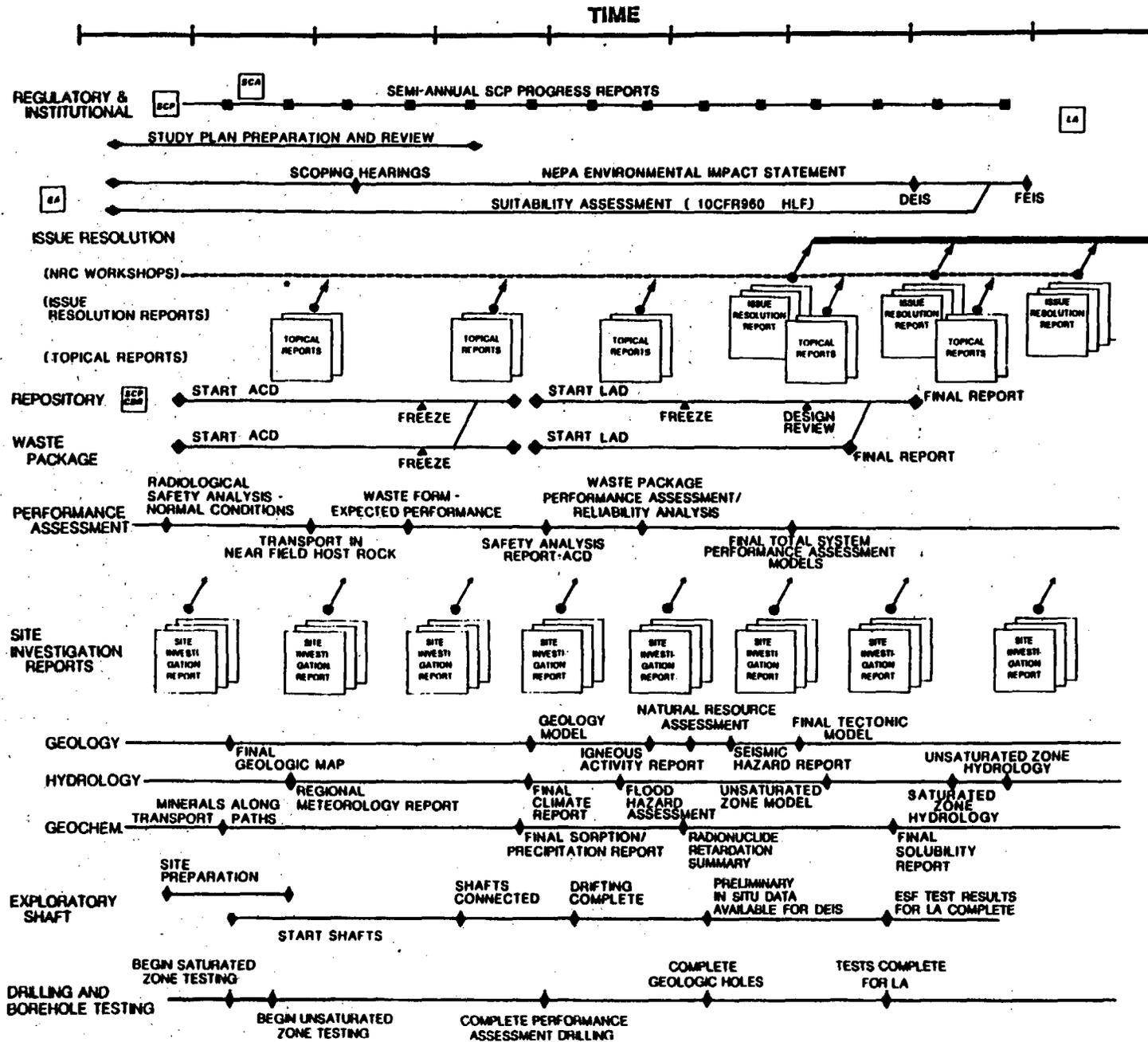


Figure 8.5-4. Schematic diagram showing utilization of site data by performance assessment and design, and for preparation of regulatory documents.

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topical and IR reports is likely to be recognized during site characterization. Titles of new reports will be provided in the semiannual progress reports.

Specific plans have not yet been developed for the process through which the DOE and NRC will reach concurrence on technical issues and regulatory requirements. However, it is expected that some of the topical and IR reports may be used as the basis for interaction with the NRC.

Issue resolution reports

Issue resolution (IR) reports are intended to provide preliminary documentation of the implementation of the issue resolution strategies defined for performance and design issues in Sections 8.3.2 through 8.3.5. These reports may also be used to present preliminary DOE positions on other technical issues of concern to the NRC, State, or public, such as an assessment of the seismic hazards at the Yucca Mountain site or the significance of calcite-silica deposits in faults near the site.

Three of the earliest IR reports to be issued will be related to the higher level findings required by the DOE general siting guidelines (10 CFR 960, Appendix III) at the time of selection of the first repository.

Topical reports

Topical reports will be used to document the DOE's developing positions on regulatory requirements and technical issues (Figure 8.5-4). As new design, performance, and site information becomes available, the DOE will incorporate this information into topical reports. Topical reports will serve as a vehicle through which the DOE establishes and communicates its developing technical information base. Specific plans have not yet been developed for the process through which the DOE and the NRC will reach concurrence on technical issues and requirements for regulatory compliance. However, preliminary plans are to use topical reports as the basis for interactions between the DOE and NRC, allowing the NRC to have early input into the DOE's developing positions. Some reports published by DOE contractors may be directly usable by the DOE as topical reports, while others will be used as one component of a larger compiled topical report. As various site models are tested and revised, and design and performance analyses proceed to a mature stage, the topical reports will provide the record of the development of DOE positions on the technical issues and regulatory requirements.

The timelines presented in Sections 8.5.1 through 8.5.4 include associated milestones, some of which are reports that will serve as topical reports or input to topical reports. The need for additional topical reports is likely to be recognized during site characterization, and titles of new reports will be provided in SCP progress reports.

The following table provides a list of preliminary issue resolution reports, the corresponding issue and regulatory requirement addressed by the IR report, and the corresponding SCP section number.

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Report number	Corresponding issue, SCP section, and regulation	Report description
ISSUE RESOLUTION REPORT DESCRIPTIONS		
IR11	1.3; 8.3.5.15; 40 CFR 191.16	Preliminary issue resolution report addressing the requirement for protection of special sources of ground water
IR23	1.12; 8.3.3.2; 10 CFR 60.134	Preliminary issue resolution report addressing the design criteria for the shaft and borehole seals
IR25	2.7; 8.3.2.3; 10 CFR 60.131	Preliminary issue resolution report addressing the general design criteria for the geologic repository operations area
IR26	2.7; 8.3.2.3; 10 CFR 60.132	Preliminary issue resolution report addressing the additional design criteria for surface facilities in the geologic repository operations area
IR27	2.7; 8.3.2.3; 10 CFR 60.133	Preliminary issue resolution report addressing the additional design criteria for the underground facility
IR28	4.2; 8.3.2.4; 10 CFR 60.131	Preliminary issue resolution report for the nonradiological health and safety requirements for repository workers
IR29	4.3; 8.3.4.4; 10 CFR 60.135	Preliminary issue resolution report addressing final production technologies for fabrication, closure, and inspection of the waste package
IR30	4.4; 8.3.2.5; 10 CFR 960.5-1	Preliminary issue resolution report addressing reasonable availability of technologies for repository construction, operation, closure and decommissioning
IR31	4.5; 8.2.2.3; 10 CFR 960.5-1	Preliminary issue resolution report addressing estimated life-cycle costs of the reference and alternate total system designs and analysis of cost effectiveness of reference and alternate total system designs
IR14	2.3; 8.3.5.5; 10 CFR 960.5-1	Preliminary issue resolution report addressing radiation exposure, radiation levels, and releases of radioactive material to the repository workers and the public under accidental conditions

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Report number	Corresponding issue, SCP section, and regulation	Report description
ISSUE RESOLUTION REPORT DESCRIPTIONS (continued)		
IR24	2.6; 8.3.4.3; 10 CFR 60.135	Preliminary issue resolution report addressing the design criteria for the waste package and its components
IR22	1.11; 8.3.2.2; 10 CFR 60.133	Preliminary issue resolution report addressing the additional design criteria for the underground facility
IR36	1.2; 8.3.5.14; 40 CFR 191.15	Preliminary issue resolution report addressing the requirement for limiting individual doses in the accessible environment
IR37	2.1 & 2.2; 8.3.5.3 & 8.3.5.4; 10 CFR 60.111; 2.3 & 2.7; 8.3.5.5 & 8.3.2.3; 10 CFR 60.131, 60.132, 60.133	Preliminary issue resolution report addressing the performance objective for protection against radiation exposures and releases of radioactive materials
IR12	2.1; 8.3.5.3; 10 CFR 60.111	Preliminary issue resolution report addressing radiation exposures, radiation levels, and releases of radioactive material to the public under normal conditions
IR13	2.2; 8.3.5.4 10 CFR 960.5-1	Preliminary issue resolution report addressing radiation exposures, radiation levels, and releases of radioactive material to repository workers under normal conditions
IR06	2.4; 8.3.5.2; 10 CFR 60.111(b)	Preliminary issue resolution report addressing the performance objective for preserving the option of waste retrievability
IR15	1.8; 8.3.5.17; 10 CFR 60.122	Preliminary issue resolution report for the evaluation of the Yucca Mountain site against the favorable and potentially adverse conditions of 10 CFR 60.122
IR05	1.8; 8.3.5.17; 10 CFR 60.122	Preliminary issue resolution report for the NRC Siting Criteria

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Report number	Corresponding issue, SCP section, and regulation	Report description
ISSUE RESOLUTION REPORT DESCRIPTIONS (continued)		
IR21	1.10; 8.3.4.2; 10 CFR 60.135	Preliminary issue resolution report addressing the design criteria for the waste package considering its interactions with the emplacement environment
IRO1	1.4; 8.3.5.9; 10 CFR 60.113	Preliminary issue resolution report for the performance objective for substantially complete containment by the waste package
IRO2	1.5; 8.3.5.10; 10 CFR 60.113	Preliminary issue resolution report addressing the performance objective for controlled radionuclide release by the engineered barrier system
IRO4	1.6; 8.3.5.12; 10 CFR 60.113	Preliminary issue resolution report addressing the performance objective for pre-waste-emplacement ground-water travel time
IRO3	1.1; 8.3.5.13; 10 CFR 60.112	Preliminary issue resolution report addressing the performance objective for overall system performance
IR16	1.9; 8.3.5.18; 10 CFR 960.3	Preliminary issue resolution report documenting higher level findings on the qualifying and disqualifying conditions for the postclosure system and technical guidelines
IR17	1.9; 8.3.5.18; 10 CFR 960.3	Preliminary issue resolution report for the prediction of cumulative radionuclide releases over 100,000 years
IR18	2.5; 8.3.5.6; 10 CFR 960.5	Preliminary issue resolution report documenting higher level findings on the qualifying and disqualifying conditions for the preclosure radiological safety system and technical guidelines
IR19	4.1; 8.3.5.7; 10 CFR 960.5	Preliminary issue resolution report documenting higher level findings on the qualifying and disqualifying conditions for the preclosure system and technical guidelines on ease and cost of siting, construction, operation, and closure

CONSULTATION DRAFT

Report number	Corresponding issue, SCP section, and regulation	Report description
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ISSUE RESOLUTION REPORT DESCRIPTIONS (continued)

IR20	1.7; 8.3.5.16; 10 CFR 60.137	Preliminary issue resolution report for the requirements for performance confirmation
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**ISSUE RESOLUTION OR TOPICAL REPORT DESCRIPTIONS
ADDRESSING BROADER TECHNICAL AND REGULATORY ISSUES**

IR09	NA ^a	Evaluation of potential hazards at the Yucca Mountain site resulting from underground nuclear explosions at the Nevada Test Site
IR35	NA	Mode of origin of calcite-silica deposits and the potential effects on repository performance
IR34	NA	Final assessment of volcanic hazards at the site
IR08	NA	Assessment of potential hazards at the site due to faulting and vibratory ground motion
IR33	NA	Evaluation of potential impacts at the site due to natural resource extraction
IR32	NA	Potential for coupling of tectonic and hydrologic processes and events

^aNA = not applicable.

The following table lists other major regulatory and institutional milestones included on the summary schedules in Figure 8.5-3.

Milestone number	Related SCP section	Milestone description
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OTHER REGULATORY AND INSTITUTIONAL MILESTONES

M522	NA ^a	DOE/HQ issues SCP to public
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CONSULTATION DRAFT

Milestone number	Related SCP section	Milestone description
OTHER REGULATORY AND INSTITUTIONAL MILESTONES (continued)		
5200	NA	Begin environmental impact statement (EIS) scoping hearings
Z497	NA	Complete documentation of site characterization program results to support the draft environmental impact statement (DEIS)
M509	NA	Issue DEIS
X512	NA	Issue final environmental impact statement
X513	NA	Issue site selection report to President
X514	NA	President recommends first repository site
X516	NA	Submit license application to NRC

^aNA = not applicable.