

MGDS License Application Annotated Outline

Section 3.2 Description of the Anticipated Processes and Events and Unanticipated Processes and Events

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3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60

[This Section provides an analysis of the natural systems of the geologic setting of the site, including the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of Yucca Mountain, Nevada [10 CFR 60, *Disposal of High-Level Radioactive Wastes in Geologic Repositories*, Section 21(c)(1)(ii)(A)]. Analyses of these systems have determined the degree to which favorable and potentially adverse conditions are present and the degree to which each condition influences waste isolation [10 CFR 60.21(c)(1)(ii)(B)]. Sufficient investigations have been presented to assess critical pathways for radionuclide migration from the underground facility to the accessible environment and to analyze the pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment. Natural barriers important to the isolation of waste from the accessible environment including barriers that may not themselves be part of the GROA, have been identified and evaluated for effectiveness against the release of radioactive material to the environment [10 CFR 60.21(c)(1)(ii)(D)]. This Section also describes how the Yucca Mountain site complies with the requirements of 10 CFR 60.122 with respect to the favorable and potentially adverse conditions of the geologic, hydrologic, geochemical, and climatologic and meteorologic systems. Analyses of the affects of these favorable and potentially adverse conditions on the overall system performance are presented in Section 6.5.]

3.3.1 Geologic System

[This subsection describes the analyses that determine which of the favorable and potentially adverse conditions identified in 10 CFR 60.122 that are related to the geologic system are present or absent.

The favorable conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each contributes to waste isolation. Likewise, potentially adverse conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each detracts from waste isolation. Analyses of potentially adverse conditions are also included that demonstrate:

- The condition has been adequately investigated, the extent to which the condition may be undetected, and the degree of resolution achieved by the investigations;
- The effect of the condition has been adequately evaluated and the sensitivity of the analyses to assumptions that tend to underestimate the effects; and
- The condition does not significantly affect the ability of the repository to meet the performance objective and the degree to which the condition is compensated for by favorable conditions or that the condition can be compensated for through engineering design.

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The criteria used to describe whether a condition has a significant adverse effect and the criteria used to determine whether an adverse condition is compensated by one or more favorable conditions are also described.

The models and data used in the analyses are described and the uncertainties in the models and data are fully discussed. Predictions of future conditions and changes in the system are supported using relevant field studies and tests, in situ tests, laboratory tests, monitoring data, and natural analog studies. Computer codes and their model conceptualizations are fully described in references and summarized in this subsection. Documentation of the degree of verification and validation of the codes and where possible of the models is provided. The analyses include a complete sensitivity analysis of the input data, model conceptualizations, and where relevant boundary conditions. Uncertainties in data, their interpretation, conceptual models, and boundary conditions are fully described. References are provided for input and output data and discussions of the analyses that are sufficient to allow an independent analysis of the conditions. Where expert judgment has been used in either analysis of the presence of favorable and potentially adverse conditions or model validation, its use is fully documented.]

3.3.1.1 Favorable Conditions

3.3.1.1.1 Nature and Rates of Tectonic and Geomorphic Processes

The nature and rates of tectonic and geomorphic processes (or any such process) operating within the geologic setting during the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate waste [60.122(b)(1)].

[A complete analysis of this favorable condition is not yet available. Studies planned for site characterization will evaluate process operating in the geologic setting during the Quaternary Period [INN 3.3.1.1.1-1] and the results of these studies will provide a basis to evaluate the extent to which this favorable condition may be present.]

Geomorphic Processes (erosion). Rates of erosion during the Quaternary were relatively low and, if continued into the future, would not disrupt the performance of the repository. Average erosion rates at Yucca Mountain are less than 0.2 cm/ka (DOE, 1993). The maximum rate of down-cutting by stream flow is 222 cm/ka, and average rates are much lower than this. DOE (1993) concluded that during the late Quaternary, stream flow is resulting in accumulation rather than erosion in most stream beds at Yucca Mountain.

Tectonic Effects. There have been infrequent tectonic and volcanic activity during the Quaternary Period. If these conditions were to reoccur in the future, ground-water travel time to the accessible environment could be decreased and subsequently the rate of radionuclide transport increased.

There is a potential for earthquakes to induce changes in the elevation of the water table. These changes are thought to be transient and relatively small at Yucca Mountain, but these effects are not well characterized, because there have been few large earthquakes recorded in

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the area. Three earthquakes reported within a day of each other in Nevada and California in 1992 induced water-level fluctuations in wells in the Yucca Mountain Area (USGS, 1993). These fluctuations consisted of high frequency oscillations that lasted only a short time and sometimes resulted in a change in the stable water level after these oscillations damped out. The changes in water levels were on the order of a meter, which would have an insignificant impact on the performance of the repository.

The first earthquake (May 1992) had a Richter Magnitude of 7.5, and occurred in Landers, California, about 300 miles from Yucca Mountain. The nearest earthquake had a Richter Magnitude of 5.6 about 26 miles away at Little Skull Mountain. The earthquakes caused oscillations in fluid pressure in one well at Yucca Mountain that was the equivalent of over two meters in head. The water level temporarily increased in altitude about 5 to 10 centimeters then decayed to its original value in a few hours in well USW H-6. Another well, UE-25P#1, lost about 1/2 meter of head that took several months to recover. Well USW H-3 increased about 30 centimeters. The water level in Devil's Hole decreased about 25 cm in response to the earthquakes. These changes in the water level were thought to be due to the redistribution of stress after the earthquakes. The impact of very large earthquakes in the Yucca Mountain area is not well known because of the limited amount of data. No large earthquakes have been recorded at Yucca Mountain.

3.3.1.1.2 Minimum Depth of 300 Meters

Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone [60.122(b)(5)].

This favorable condition is not present at the Yucca Mountain site. Within the repository block, not all of the waste could be emplaced at least 300 meters below the ground surface in the densely welded portion of the Topopah Spring, the proposed repository horizon (DOE/RW-0199).

3.3.1.1.3 Low Population Density

A low population density within the geologic setting and a controlled area that is remote from population centers [60.122(b)(6)].

[A complete analysis of this favorable condition is not available yet. The information needed to complete an analysis of this favorable condition [INN 3.3.1.1.3-1] will be identified through environmental scoping hearings and documented in an environmental impact statement.]

3.3.1.2 Potentially Adverse Conditions

The following conditions are potentially adverse if they are characteristic of the controlled area or may affect isolation within the controlled area. [60.122(c)]

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3.3.1.2.1 Evidence of Dissolutioning

Evidence of dissolutioning such as breccia pipes, dissolution cavities, or brine pockets [60.122(c)(10)].

This potentially adverse condition is not present at the Yucca Mountain site. There are no dissolution features such as breccia pipes, dissolution cavities, or brine pockets within the controlled area (DOE/RW-0199).

3.3.1.2.2 Structural Deformation

Structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period [60.122(c)(11)].

[A final analysis of this potentially adverse condition is not yet available. Structural deformation has occurred during the Quaternary within the controlled area of the Yucca Mountain site. Studies planned in the tectonics program for site characterization [INN 3.3.1.2.2-1] will provide additional data to evaluate the extent to which this condition may adversely impact postclosure performance.]

3.3.1.2.3 Historic Earthquakes

Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly [60.122(c)(12)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the tectonics program for site characterization [INN 3.3.1.2.3-1] will provide additional data to evaluate whether or not this adverse condition is present at the Yucca Mountain site.]

3.3.1.2.4 Correlations of Earthquakes and Tectonic Processes

Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase [60.122(c)(13)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the tectonics program for site characterization [INN 3.3.1.2.3-1] will provide additional data to evaluate the extent to which this adverse condition may be present at the Yucca Mountain site.]

3.3.1.2.5 More Frequent and Higher Magnitude Earthquakes

More frequent occurrence of earthquakes of higher magnitude than is typical of the areas in which the geologic setting is located [60.122(c)(14)].

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[A final analysis of this potentially adverse condition is not yet available. Studies planned in the tectonics program for site characterization [INN 3.3.1.2.3-1] will provide additional data to evaluate the extent to which this adverse condition may be present at the Yucca Mountain site.]

3.3.1.2.6 Igneous Activity

Evidence of igneous activity since the start of the Quaternary Period [60.122(c)(15)].

[A final analysis of this potentially adverse condition is not yet available. Because basaltic volcanism has occurred in the vicinity of Yucca Mountain since the start of the Quaternary Period, this condition is present at the Yucca Mountain site. Studies planned in the tectonics program for site characterization [INN 3.3.1.2.6-1] will provide additional data to evaluate the extent to which this condition may have adversely affected postclosure performance.]

3.3.1.2.7 Extreme Erosion

Evidence of extreme erosion during the Quaternary Period. [60.122(c)(16)]

This subsection demonstrates that the potentially adverse condition identified in 10 CFR 60.122(c)(16), evidence of extreme erosion during the Quaternary Period, is absent at Yucca Mountain. This conclusion is supported by and documented in a topical report, YMP/92-41-TPR, *Evaluation of the Potentially Adverse Condition "Evidence of Extreme Erosion During the Quaternary Period" at Yucca Mountain, Nevada.*

This conclusion is based on a regulatory and technical evaluation. The regulatory evaluation provides an assessment of the regulatory requirements and boundaries associated with the determination of whether a potentially adverse condition exists. The technical evaluation provides an assessment of the scientific studies conducted to characterize and quantify the erosion rates in the Yucca Mountain area and compares these rates to erosion rates in other geologic and climate settings in the United States and the world. This comparison was used to establish that the erosion rates at and in the vicinity of Yucca Mountain during the Quaternary are less than or comparable to rates for other climatically and lithologically similar areas and conclude that the Yucca Mountain rates of erosion are not extreme.

The data and analyses used to develop the regulatory conclusion include the assumptions made, representativeness of data, interpretations, data uncertainties, and qualification of data [INN 3.3.1.2.7-1]. The methodologies and references are sufficient to allow an independent analysis of the results.

Low to moderate erosion rates in the United States range from 2 to 50 centimeters per thousand years (cm/ka) in semiarid environments. Long-term average hillslope erosion rates established for Yucca Mountain were determined to be 0.19 cm/ka. The Yucca Mountain rates were established using cation ratio dating of rock varnish on colluvial boulder deposits to establish age control and by measuring hillslope denudation and hillslope channel incision

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marginal to these boulder deposits. [Confirmatory age information for selected boulder deposits, using various cosmogenic age dating methods, is being gathered [INN 3.3.1.2.7-2]. The geologic record examined for Yucca Mountain area hillslopes extends from 170 ka to about 1400 ka, and represents the longest geologic record obtained from hillslopes in the southwestern United States. Recently completed mapping in Midway Valley and Fortymile Wash [INN 3.3.1.2.7-3] provided data to estimate erosion rates for the last 20 ka and confirm that extreme stream incision has not occurred during the last 3 ma. Based upon extensive investigations of the available Quaternary geologic record, no evidence of extreme erosion has been found. In addition, a comparative evaluation of Yucca Mountain hillslope erosion with erosion rates in other analogous geologic and climatic regimes, has shown that extreme erosion has not occurred at Yucca Mountain during the Quaternary Period. Therefore, the potentially adverse condition of evidence of extreme erosion during the Quaternary Period identified in 10 CFR 60.122(c) does not exist at Yucca Mountain.

3.3.1.2.8 Naturally Occurring Materials

The presence of naturally occurring materials, whether identified or undiscovered, within the site, in such form that: (1) economic extraction is currently feasible or potentially feasible during the foreseeable future and (2) such materials have greater gross value or net value than the average for other areas of similar size that are representative of and located within the geologic setting [60.122(c)(17)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the natural resources program for site characterization [INN 3.3.1.2.8-1] will provide additional information to evaluate whether or not this condition is present at the Yucca Mountain site.]

3.3.1.2.9 Subsurface Mining

Evidence of subsurface mining for resources within the site [60.122(c)(19)].

This potentially adverse condition is not present at the Yucca Mountain site. There is no evidence of subsurface mining for resources within 10 km of the site (DOE/RW-0199).

3.3.1.2.10 Evidence of Drilling

Evidence of drilling for any purpose within the site [60.122(c)(19)].

[A final analysis of this potentially adverse condition is not yet available. A total of 184 drillholes within 10 km of the site have been documented (DOE/RW-0199). Additional studies [INN 3.3.1.2.10-1] planned for site characterization will provide additional data to evaluate the extent to which this condition may adversely affect postclosure performance.]

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3.3.1.2.11 Stable Underground Opening

Geomechanical properties that do not permit design of underground opening that will remain stable through permanent closure [60.122(c)(21)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the rock characteristics program for site characterization [INN 3.3.1.2.11-1] will provide additional data to evaluate whether or not this condition is present at the Yucca Mountain site.]

3.3.2 Hydrologic System

[This subsection describes the analyses that determine which of the favorable and potentially adverse conditions identified in 10 CFR 60.122 that are related to the hydrologic system are present or absent.

The favorable conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each contributes to waste isolation. Likewise, potentially adverse conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each detracts from waste isolation. Analyses of potentially adverse conditions are also included that demonstrate that:

- The condition has been adequately investigated, the extent to which the condition may be undetected, and the degree of resolution achieved by the investigations;
- The effect of the condition has been adequately evaluated and the sensitivity of the analyses to assumptions that tend to underestimate the effects; and
- The condition does not significantly affect the ability of the repository to meet the performance objective and the degree to which the condition is compensated for by favorable conditions or that the condition can be compensated for through engineering design.

The criteria used to describe whether a condition has a significant adverse effect and the criteria used to determine whether an adverse condition is compensated by one or more favorable conditions are also described.

The models and data used in the analyses are described and the uncertainties in the models and data are fully discussed. Predictions of future conditions and changes in the system are supported using relevant field studies and tests, in situ tests, laboratory tests, monitoring data, and natural analog studies. Computer codes and their model conceptualizations are fully described in references and summarized in this subsection. Documentation of the degree of verification and validation of the codes and where possible of the models is provided. The analyses include a complete sensitivity analysis of the input data, model conceptualizations, and, where relevant, boundary conditions. Uncertainties in data, their interpretation,

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conceptual models, and boundary conditions are fully described. References are provided for input and output data and discussions of the analyses that are sufficient to allow an independent analysis of the conditions. Where expert judgment has been used in either analysis of the presence of favorable and potentially adverse conditions or model validation, its use is fully documented.]

3.3.2.1 Favorable Conditions

3.3.2.1.1 Nature and Rates of Hydrogeologic Processes

The nature and rates of hydrogeologic processes (or any of such processes) operating within the geologic setting during the Quaternary Period that, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate the waste" 10 CFR 60.122 (b)(1)].

[A complete analysis of this favorable condition is not yet available. Studies planned for site characterization will evaluate geohydrologic processes operating in the geologic setting during the Quaternary Period [INN 3.3.2.1.1-1] and the results of these studies will provide a basis for evaluating the extent to which this favorable condition may be present.

There are several processes operating during the Quaternary that, if projected into the future, will contribute to isolating waste. One of the reasons that this site was chosen for further study was that many of the currently operating conditions were favorable for the isolation of waste. There are, however, some processes that may not contribute to isolating waste, consequently this favorable condition is only partially present. Those processes that, if projected into the future, may not contribute to waste isolation are thought to have a low probability of having a significant adverse impact on the repository.

Hydrologic processes when projected into the future that will have a favorable impact on the ability to isolate waste include: slow groundwater movement, dispersion and retardation of radionuclides, geomorphic processes (particularly erosion), and climate (low rainfall, high evapotranspiration rate).

Slow Groundwater Movement. The velocity of ground water movement in the unsaturated and saturated zones is very slow. The site is considered desirable because these conditions are expected to continue into the future.

Unsaturated Zone Water Movement. The movement of water in the unsaturated zone is thought to be slow because of the very low matrix permeabilities of tuff rocks at partially saturated conditions. Fractures, on the other hand, have permeabilities many orders of magnitude greater than in the matrix. Under steady-state conditions the hydraulic potential in the matrix and fractures are equal. Precipitation is not a steady phenomena. It occurs in infrequent events, so conditions at the surface are not at steady-state. Because of the thickness of the rocks above the repository, it is thought that capillary equilibrium will be established by the time that infiltration reaches the repository level. [include a reference to

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imbibition into the matrix from fractures done by T. Buschek.] This capillary equilibrium condition is not very well demonstrated. There is some evidence of deep infiltration of modern water [report the results of deep occurrences of tritium and ^{36}Cl : [INN 3.3.2.1.1-2]. It is expected that the average rate of water movement in the unsaturated zone will continue to be slow during the post-closure period, so it will continue to contribute to the waste isolation potential. Thermal effects may perturb the local unsaturated zone ground water flow field for part of the 10,000 year life of the repository.

Saturated Zone Water Movement. The water movement in the saturated zone is very slow because the water table gradient below and down gradient from Yucca Mountain is very low. Water level monitoring (Subsection 3.1.2.2.2) shows that the gradient is less than xxx [report the latest map of the area showing water table gradients INN 3.3.2.1.1-3]. More discussion on the rates of ground water movement can be found in Subsections 3.1.2.2.6 and 3.3.5(b). It is expected that the rate of water movement in the saturated zone will continue to be slow during the post-closure period, so it will continue to contribute to the waste isolation potential.

3.3.2.1.2 For Disposal in the Saturated Zone

For disposal in the saturated zone, hydrogeologic conditions that provide: (1) a host rock with low horizontal and vertical permeability, (2) downward or dominantly horizontal hydraulic gradient in the host rock and immediately surrounding hydrogeologic units, and (3) low vertical permeability and low hydraulic gradient between the host rock and the surrounding hydrogeologic units [10 CFR 60.122(b)(2)].

This favorable condition applies only to disposal in the saturated zone and therefore does not apply to the Yucca Mountain site which provides for disposal in the unsaturated zone.

3.3.2.1.3 Pre-Waste-Emplacement Groundwater Travel Time

Pre-waste-emplacment groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years [10 CFR 60.122(b)(7)].

[A complete analysis of this favorable condition is not yet available. Preliminary analysis suggest that for expected conditions and assuming that matrix flow dominates, groundwater travel times are "likely to exceed 1,000 years along paths of likely radionuclide flow" (Yunker, et. al., 1992). Studies planned for site characterization [INN 3.3.2.1.3-1] will provide additional data to characterize potential flow paths, flow rates, and the distribution of infiltration (percolation flux). These data and the results of the calculations and sensitivity analyses [INN 3.3.2.1.3-2 through INN 3.3.2.1.3-12] which are described in general below will be used to evaluate the extent to which this favorable condition is present at the Yucca Mountain site.]

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General Considerations

Groundwater travel time is interpreted to be water particle transport which is equivalent to mass transport where chemical retardation is neglected. The travel time is affected by advection (flow velocity), dispersion, and matrix diffusion all of which influence the distribution of water particle arrival times at the accessible environment. Dispersion is caused by different flow paths, some of which are faster than others. Matrix diffusion is caused by water particles entering the rock matrix where the flow is slower than in the fractures. Here the results will be obtained with and without matrix diffusion to examine the potential effects of colloidal transport. Transport phenomena are present even in a homogeneous medium and in heterogeneous media along the flow paths at Yucca Mountain have a more pronounced effect. In addition, the distribution of arrival times is influenced by both the particle starting location (lateral and vertical extent of the disturbed zone boundary) and the arrival location at the accessible environment. For pre-waste-emplacment groundwater travel time the modeling will be conducted by releasing all of the water particles at the boundary of the disturbed zone at the same time. This is in contrast to performance assessment where water particles (containing radionuclides) would be released at the waste package boundary at the time of waste package failure, and chemical retardation would be considered as an additional transport process along the pathway to the accessible environment.

The pre-waste-emplacment groundwater travel time distribution at the accessible environment defines the likelihood of each water particle reaching the accessible environment at a specific time. The significance of a particular pathway or travel time is related to either the integral of the mass release along that pathway or the peak mass concentration at the end of the pathway (i.e., significance is a function of postclosure performance). The definition of "likely" should be tied to significance (i.e., what portion, if any, of the arrival distribution can be neglected?).

The definition of the disturbed zone is based on postclosure performance assessment. The disturbed zone is defined as that portion of rock where the pre- and postclosure repository effects significantly alter the long-term performance of the repository system (i.e., significantly change the post-closure release to or dose at the accessible environment). The water particle travel time through the disturbed zone is neglected in the calculation of pre-waste-emplacment groundwater travel time (i.e., in the model the water particles are released at the boundary of the disturbed zone and are transported to the accessible environment under pre-waste-emplacment conditions).

[For calculation of travel time through the unsaturated zone the areal extent of the disturbed zone will be considered along with the variability of percolation flux through the repository horizon. The heterogeneous layered sequence between the disturbed zone and the water table and the lateral heterogeneities within hydrostratigraphic units must be considered. The largest uncertainty in the unsaturated zone that must be taken into consideration is the potential nonequilibrium between flow in the fractures and flow in the matrix (i.e., matrix imbibition). Various conceptual flow models will also be considered (i.e., porous media, dual porosity,

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dual permeability, and discrete fracture). Dispersion and matrix diffusion are important in the unsaturated zone and will be considered in the calculations.]

For calculation of groundwater travel time through the saturated zone the areal extent of water particle release points on the water table below the repository is an important consideration (water particles are released in the simulation at points of transition from unsaturated flow to the saturated flow along the total path length from the disturbed zone to the accessible environment). [The heterogeneous nature of the saturated zone between these points of water particle release and the accessible environment is important and will be considered in the calculations. Of particular importance are the boundary conditions for the site-scale model which arise due to different hydrogeologic conceptual models (i.e., different concepts for the steep hydraulic gradient north of the site). Uncertainty in these boundary conditions can have a dramatic effect on flow directions and travel times and changes in these conditions will be considered. In addition, different conceptual flow models will be considered. Both matrix diffusion and dispersion will be considered in the calculation of travel time through the saturated zone.]

General Approach

[The approach to calculation of groundwater travel time requires development of criteria for determination of whether a specific pathway (those less than 1,000 years) or a volume of disturbed rock near the controlled zone is significant (has a significant effect on postclosure performance). The criteria will be developed based on whether a change in a postclosure performance measure (for example, cumulative release or dose) is judged to be significant. The volumes in which transport properties are permanently altered will be determined by conducting thermomechanical modeling, thermohydrological modeling, and estimating the mineralogical changes due to increased temperature (process modeling and expert judgment) to determine the range of property changes caused by repository construction and thermal loading (i.e., pre- and postclosure effects). These volumes and associated property changes will then be used to evaluate the consequences of the changes in properties using postclosure performance assessment. The significance criteria will be applied to the range of consequences to determine a range in the extent of the disturbed zone. Sensitivity analyses will be conducted to determine the effects on the extent of the disturbed zone of uncertainty in parameter distributions, conceptual flow models, boundary conditions, and geometry of stratigraphic and structural features. The results of the sensitivity analyses will be used to determine the overall range of the extent of the disturbed zone for each potential thermal loading of the repository.]

[Qualified data and flow models will be used to determine an expected distribution of groundwater travel times from the edge of the disturbed zone through the unsaturated zone to the water table. Sensitivity analyses will be conducted to determine the effects of uncertainty in percolation flux, hydraulic properties, extent of the disturbed zone, alternate conceptual flow models, matrix diffusion, and dispersion on groundwater travel time through the unsaturated zone.]

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[Qualified data and flow models will be used to determine an expected distribution of groundwater travel times from the water table below the repository through the saturated zone to the accessible environment. Sensitivity analyses will be conducted to determine the effects of uncertainty in hydraulic properties, boundary conditions, conceptual flow models, matrix diffusion, and dispersion on groundwater travel time through the unsaturated zone.]

[The two groundwater travel time distributions that result from the sensitivity analyses for the saturated and unsaturated zones will be convolved. Convolution of travel-time distributions will consider conceptual flow models, parameter variability/uncertainty, correlation among parameters, and location of the pathway intersection with the water table. The resulting travel time distributions, from the disturbed zone to the accessible environment, will be compared to the single value of 1,000 years, and the significance of any travel times that are less than 1,000 years will be determined. The determination of significance will be based on significance criteria described above (i.e., an evaluation of the effects of these pathways on long-term release to or dose at the accessible environment).]

3.3.2.1.4 Disposal in the Unsaturated Zone

For disposal in the unsaturated zone, hydrogeologic conditions that provide [10 CFR 60.122(b)(8)(i)-(iv)]:

- i. Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units;
- ii. A water table sufficiently below the underground facility such that fully saturated voids contiguous with the water table do not encounter the underground facility;
- iii. A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility; or
- iv. A host rock that provides for free drainage;

[A complete analysis of this favorable condition is not yet available. Studies planned in the geohydrology program and the climatic program [INN 3.3.2.1.4-1] will evaluate the hydrologic characteristics of the unsaturated zone and the climatic regime at the site. The results of these studies and the results of the calculation of pre-waste-emplacement groundwater travel time will provide a basis for evaluating the extent to which this favorable condition may be present at the Yucca Mountain site.]

The first condition is: "Low moisture flux in the host rock and in the overlying and underlying units." The moisture flux is expected to be highly variable with infrequent episodes of storm infiltration into fractured areas at the surface. Some of this storm moisture will be stored near the surface in rock pores, and unconsolidated surface materials (alluvium, aeolean sand, etc) for later evaporation and transpiration by vegetation. Some of the moisture

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will flow in fractures to depths below the evapotranspiration depth. For the average summer storm, the fracture flow will be imbibed into the rock matrix after reaching a depth of xxx meters [INN: 3.3.2.1.4-2 - report the results of studies on imbibition from fractures into rock matrix].

The second condition is: "A water table sufficiently below the underground facility such that fully saturated voids contiguous with the water table do not encounter the underground facility." According to the current design (M&O, 1994), the altitude of the drifts at the north end of the elevation repository is above 1000 meters. The water table is at about 730 meters (Ervin et al., 1994), so the repository is nearly 300 meters above the water table. Details of the design are likely to have small changes in the future, but these changes are not expected to result in construction of the repository below the levels where saturated conditions would be encountered. Perched water in wells on or near the repository block is at least 100 meters below the repository. Thus the repository level is well above strata where saturated conditions are known to exist. Water saturation at the repository level is [INN: 3.3.2.1.4-3 Report on the saturation at the repository level].

The third condition is: "A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility." Permeability of rock is a function of water saturation. Under partially saturated steady-state flow there is no water in the fractures, and all water flow occurs in the matrix. The maximum permeability of the matrix occurs when the pores are saturated. The following table lists average saturated matrix hydraulic conductivity and permeability in well USW G-4, in several rock units above the repository horizon (conductivity taken from: M&O, 1994b):

Unit	conductivity	permeability
TCw -	4.3×10^{-12} m/sec	4.39×10^{-15} cm ²
PTn -	5.0×10^{-10} m/sec	5.10×10^{-13} cm ²
TSw1 -	2.9×10^{-12} m/sec	2.96×10^{-15} cm ²

The values for permeability listed in this table are considered to be low. These units over lie the entire repository block [INN: 3.3.2.1.4-4: include a map that shows the areal extent of each of the listed units]. Because of these low permeability rocks and the steep terrain most of the precipitation that falls on Yucca Mountain flows down drainage channels and is diverted away from the mountain. [INN: 3.3.2.1.4-5: Include a discussion of climate, runoff, and evapotranspiration at Yucca Mountain].

The fourth condition is: "A host rock that provides for free drainage." [INN: 3.3.2.1.4-6: provide a discussion of fracture permeability in the host rock. Include discussion of saturations, which indicate that the rock drains freely].

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3.3.2.2 Potentially Adverse Conditions

The following conditions are potentially adverse if they are characteristic of the controlled area or may affect isolation within the controlled area [60.122(c)].

3.3.2.2.1 Potential for Flooding

Potential for flooding of the underground facility, whether resulting from the occupancy and modification of floodplains or from the failure of existing or planned man-made surface water impoundments [60.122(c)(1)].

The roads and pads for surface facilities are located such that they do not form impoundments or alter significant natural flood channels. After the repository is closed, the openings will be sealed and the surface will be restored to the original contours. The sealed repository openings have been designed to be above the flood plains even after the original contours have been restored. The only scenario that needs to be considered is flooding in the vicinity of the repository openings during the pre-closure period that results in water entering these openings. These openings are the North and South Ramps, and other optional ventilation and access shafts and drifts. The pre-closure period is expected to last on the order of one hundred years, so it is sufficient to show that there is a low probability of a flood occurring that would be high enough to enter these openings.

[A final analysis of this potentially adverse condition is not yet available. Design analyses that take into account the probable maximum flood [INN 3.3.2.2.1-1] will provide the basis to evaluate the extent to which this potentially adverse condition is present. Drawings of the surface facilities as-built at the entrances to the North and South Ramps, and ventilation and other access shafts and drifts [INN 3.3.2.2.1-2] will be compared with detailed topographic maps [INN 3.3.2.2.1-3] and the probable maximum flood levels to determine the likelihood of surface flood waters entering the repository openings.]

The analysis of potential for flooding required information on design of surface facilities, topography, erosion, climate and climate projections, human activity, and repository sealing programs. The flood history, flood potential, and description of the site as it relates to flooding are discussed in more detail in Subsections 3.1.2.1.4, and 3.1.2.1.5. This PAC is addressed by design of the systems that take into account the probable maximum flood. The repository design was based on the probable maximum flood (PMF) flows and levels, determined in accordance with ANSI/ANS 2.8 (1981). This method took into account site-specific characteristics, including terrain, soil, and rock conditions of the drainage basins that could have an impact on repository openings. It is used by the U.S. Army Corps of Engineers for dam design and by the nuclear power industry for the protection of safety-related facilities.

A regional maximum flood analysis, reported by Squires and Young (1984), shows that the 100 year flood does not exceed the banks of the incised channels. Since surface facilities have been designed to be out of the incised channels, no flood waters are expected to enter

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repository openings from the anticipated 100 year flood. The regional maximum flood, reported by Squires and Young, also did not have an adverse impact the proposed design. As built surface elevations of pads and surface facilities are needed to verify that these items were constructed as designed. The PMF method is more site-specific and severe than the regional maximum flood analyses.

The Bureau of Reclamation (Bullard, 1986) did a preliminary PMF analysis. After this study there were changes in the planned locations of some of the surface facilities and more stringent requirements for software documentation were put in place, so the study was updated in 1991 (Bullard, 1991). Further work was reported by Blanton (1992). [More work is needed. Specifically, drawings of the surface facilities as-built at the entrances to the North and South Ramps, and ventilation and other access shafts and drifts [INN 3.3.2.2.1-2] will be compared with detailed topographic maps [INN 3.3.2.2.1-3] and the probable maximum flood levels to determine the likelihood of surface flood waters entering the repository openings.] [Studies planned in the geohydrology program and the climatic program [INN 3.3.2.1.4-1] will evaluate the hydrologic characteristics of the climatic regime at the site.]

Two main types of storms occur in the vicinity of Yucca Mountain. These are relatively low intensity regional storms, usually in the winter months, and potentially very high intensity, infrequent, local thunderstorms during the summer months. Flooding potential is highest during the local summer storms. Bullard used data from the NWS to determine the maximum rainfall from a local storm (10.3 inches of rain in one hour) and calculated clear water volume flow rates in the washes at Yucca Mountain near the locations of surface facilities. These flow rates were compared with measured maximum stream flow rates from several drainage basins where the USGS had measured peak flows (Squires and Young, 1984). The flows were also compared with peak flows measured in large local storms reported in desert areas of the states of California, Utah, Arizona, New Mexico, and other areas of Nevada. The flows from these storms were all less than the flows that would have been calculated using the NWS data. Thus, Bullard's approach is thought to be conservative. Bullard did not account for the effects of debris flow in his analyses.

Blanton (1992) increased the flows calculated by Bullard by a factor of two to account for air, sediment and debris transport. The cross-sections of the stream beds were measured and used to determine flood inundation areas of the stream beds in the vicinity of the North and South Portals, and the optional ventilation shaft. The proposed repository openings were well above the maximum extent of flooding in each case. [As built drawings are needed to verify that the repository openings were indeed located above the maximum extent of flooding. [INN 3.3.2.2.1-2.]

3.3.2.2.2 Human Activity

Potential for foreseeable human activity to adversely affect the groundwater flow system, such as ground withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activity or construction of large scale surface water impoundments [60.122(c)(2)].

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[A final analysis of this potentially adverse condition is not yet available. Studies that address future human activities that could affect postclosure performance will be completed as part of the overall system performance assessment and are discussed in Sections 6.2 and 6.3.]

3.3.2.2.3 Natural Phenomena

Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large scale surface water impoundments could be created that could change the regional groundwater flow system and thereby adversely affect the performance of the geologic repository [60.122(c)(3)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned for site characterization [INN 3.3.2.2.3-1] will provide additional data to evaluate the extent to which this condition may be present.]

3.3.2.2.4 Structural Deformation

Structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional groundwater flow system [60.122(c)(4)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the tectonics program for site characterization [INN 3.3.2.2.4-1] will provide additional data that will provide a basis to evaluate the extent to which this condition may be present.]

3.3.2.2.5 Changes in Hydrologic Conditions

Potential for changes in hydrologic conditions that would affect the migration of radionuclides to the accessible environment, such as changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points [60.122(c)(5)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned to assess tectonics, climate, and future human activities during site characterization [INN 3.3.2.2.5-1] will provide additional data to evaluate the extent to which this condition may be present.]

3.3.2.2.6 Complex Engineering Measures

Rock or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts [60.122(c)(20)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in rock characteristics and geohydrology for site characterization [INN 3.3.2.2.6-1] will provide

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additional data to evaluate whether or not this condition is present at the Yucca Mountain site.]

3.3.2.2.7 Water Table Rise

Potential for the water table to rise sufficiently so as to cause saturation of an underground facility located in the unsaturated zone [60.122(c)(22)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the geohydrology, tectonics, geochemistry and climate programs for site characterization [INN 3.3.2.2.7-1] will provide additional data to evaluate whether or not this condition is present at the Yucca Mountain site.]

This potential condition is concerned with the saturation of an underground facility initially located in the unsaturated zone. A water table rise that would flood an underground facility could result from climatic conditions (Subsection 3.3.4.2), human activity (Subsection 3.3.2.2.2), or tectonic processes or events (Subsections 3.3.2.2.3 and 3.3.2.2.5).

Three lines of evidence point to the possibility that the water table may have been as much as 85 meters higher than it currently is. This higher water table appears to be related to the past climate.

- Calcites deposited in the vadose zone are different than those deposited in the saturated zone. Strontium isotope ratios in calcite fracture fillings above and below the water table suggest that some of these calcites could have been formed when the water table was as much as 100 meters higher than at present (Peterman, et al, 1992).
- Alteration of minerals in tuff to zeolite is enhanced below the water table, so zeolite minerals can be interpreted as indications of historic water table elevations.[Evidence of higher water table elevation by alteration to zeolite INN: 3.3.2.2.7-1]
- Evidence of a higher water table can be seen in past ground water discharge in Crater Flat. Szabo et al (1981) examined evidence of ground water discharge at the south end of Crater Flat. From spring deposits near Lathrop Wells, Quade (1994) concluded that the maximum elevation of the water table during the last half of the Quaternary was less than 115 meters above the current levels. Paces examined paleo discharge deposits and concluded that the water table elevation could have been as much as xxx [INN 3.3.2.2.7-2: Final Report on Crater Flat ground-water discharge.

Climate change, human activities, structural deformation, and igneous activity are all possible at the site. The effects of these processes are not, however, expected to produce a water-table rise high enough to saturate the underground repository.

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3.3.2.2.8 Perched Water

Potential for existing or future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment [60.122(c)(23)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the geohydrology and program for site characterization [INN 3.3.2.2.8-1] will provide additional data to evaluate whether or not this condition is present at the Yucca Mountain site.]

3.3.3 Geochemical System

[This subsection describes the analyses that determine which of the favorable and potentially adverse conditions identified in 10 CFR 60.122 that are related to the geochemical system are present or absent.

The favorable conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each contributes to waste isolation. Likewise, potentially adverse conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each detracts from waste isolation. Analyses of potentially adverse conditions are also included that demonstrate that:

- The condition has been adequately investigated, the extent to which the condition may be undetected, and the degree of resolution achieved by the investigations;
- The effect of the condition has been adequately evaluated and the sensitivity of the analyses to assumptions that tend to underestimate the effects; and
- The condition does not significantly affect the ability of the repository to meet the performance objective and the degree to which the condition is compensated for by favorable conditions or that the condition can be compensated for through engineering design.

The criteria used to describe whether a condition has a significant adverse effect and the criteria used to determine whether an adverse condition is compensated by one or more favorable conditions are also described.

The models and data used in the analyses are described and the uncertainties in the models and data are fully discussed. Predictions of future conditions and changes in the system are supported using relevant field studies and tests, in situ tests, laboratory tests, monitoring data, and natural analog studies. Computer codes and their model conceptualizations are fully described in references and summarized in this subsection. Documentation of the degree of verification and validation of the codes and where possible of the models is provided. The analyses include a complete sensitivity analysis of the input data, model conceptualizations,

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and where relevant boundary conditions. Uncertainties in data, their interpretation, conceptual models, and boundary conditions are fully described. References are provided for input and output data and discussions of the analyses that are sufficient to allow an independent analysis of the conditions. Where expert judgment has been used in either analysis of the presence of favorable and potentially adverse conditions or model validation, its use is fully documented.]

3.3.3.1 Favorable Conditions

3.3.3.1.1 Nature and Rates of Processes

The nature and rates of geochemical processes (or any such process) operating within the geologic setting during the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate waste [60.122(b)(1)].

[A complete analysis of this favorable condition is not yet available. Studies planned for site characterization will evaluate process operating in the geologic setting during the Quaternary Period [INN 3.3.3.1.1-1] and the results of these studies will provide a basis to evaluate the extent to which this favorable condition may be present.]

3.3.3.1.2 Geochemical Conditions

Geochemical conditions that: (1) promote precipitation or sorption of radionuclides, (2) inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides, and (3) inhibit the transport of radionuclides of particulates, colloids, and complexes [60.122(b)(3)].

[A complete analysis of this favorable condition is not yet available. Studies planned in the geochemistry program for site characterization [INN 3.3.3.1.2-1] will evaluate the geochemical conditions at the Yucca Mountain site and the results of these studies will provide a basis to evaluate the extent to which this favorable condition may be present.]

3.3.3.1.3 Mineral Assemblages

Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration [60.122(b)(4)].

[A complete analysis of this favorable condition is not yet available. Studies planned in the geochemistry program for site characterization [INN 3.3.3.1.3-1] will provide information needed to evaluate the extent this favorable condition may be present, given the anticipated thermal load [INN 3.3.3.1.3-1].]

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3.3.3.2 Potentially Adverse Conditions

The following conditions are potentially adverse if they are characteristic of the controlled area or may affect isolation within the controlled area [60.122(c)].

3.3.3.2.1 Groundwater Conditions

Groundwater conditions in the host rock, including chemical composition, high ionic strength or ranges of Eh-pH, that could increase the solubility or chemical reactivity of the engineered barrier system [60.122(c)(7)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the geochemistry program for site characterization [INN 3.3.3.2.1-1] will provide additional data to evaluate the extent to which this adverse condition may be present.]

3.3.3.2.2 Geochemical Processes

Geochemical processes that would reduce sorption of the radionuclides, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system [60.122(c)(8)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned in the geochemistry program for site characterization [INN 3.3.3.2.2-1] will provide additional data to evaluate the extent to which this potentially adverse condition may be present.]

3.3.3.2.3 Absence of Reducing Conditions

Groundwater conditions in the host rock that are not reducing. [60.122(c)(9)]

[A final analysis of this potentially adverse condition is not yet available. Because the water in the Topopah Spring unit is oxidizing, this potentially adverse condition is present at the Yucca Mountain site. Studies planned in the geochemistry program for site characterization [INN 3.3.3.2.3-1] will provide additional data to evaluate the extent to which this condition may adversely affect postclosure performance.]

3.3.3.2.4 Gaseous Radionuclide Migration

Potential for the movement of radionuclides in a gaseous state through air-filled pore spaces on an unsaturated geologic medium to the accessible environment [60.122(c)(24)].

[A final analysis of this potentially adverse condition is not yet available. Analyses of performance indicate that this condition is present at the Yucca Mountain site (Chapter 6, Sections 6.3 and 6.4). Additional analyses are required to evaluate the extent to which this condition may adversely effect repository performance [INN 3.3.3.2.4-1 and INN 3.3.3.2.4-2].]

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3.3.4 Climatological and Meteorological Systems

[This subsection describes analyses that determine which of the favorable and potentially adverse conditions are identified in 10 CFR 60.122 that are related to the climatological and meteorological systems are present or absent.

The favorable conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each contributes to waste isolation. Likewise, potentially adverse conditions found to be present are analyzed to demonstrate the degree to which each has been characterized and the extent to which each detracts from waste isolation. Analyses of potentially adverse conditions are also included that demonstrate:

- The condition has been adequately investigated, the extent to which the condition may be undetected, and the degree of resolution achieved by the investigations;
- The effect of the condition has been adequately evaluated using analyses that are sensitive to the potentially adverse condition, and using assumptions that are not likely to underestimate the condition's effects.
- The condition does not significantly affect the ability of the repository to meet the performance objective and the degree to which the condition is compensated for by favorable conditions or that the condition can be compensated for through engineering design.

The criteria used to determine that the potentially adverse condition is compensated by the presence of one or more favorable conditions or that the condition can be remedied are described.

This subsection also provides an explanation of measures supporting the models used to perform analyses. Supporting analyses and models used to predict future conditions and changes in the system are justified by using an appropriate combination of the following methods:

- Field tests
- In-situ tests
- Laboratory tests representing field conditions
- Monitoring data
- Natural analog studies

Regarding data used in the analyses, this subsection includes:

- Discussions of variability and uncertainty of data and the propagation of errors
- Discussions of evaluations of data representativeness and uncertainties associated with extrapolation of data

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Discussions of the conceptualizations and the documentation and validation of codes and models are provided with respect to:

- Uncertainties related to the data on which the model is based
- Applicability of specific models
- Appropriateness of assumptions used in modelling
- Sensitivity of model results to the uncertainty of the input data.

Input and output data and interpretations, with the bases for the interpretations are provided. Sufficient detail is included to allow independent analysis of results. The role of expert judgment, when used is documented.]

3.3.4.1 Favorable Conditions

A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration [60.122(b)(8)(v)].

[A final analysis of this favorable condition is not yet available. The historic average annual precipitation data are presented and discussed along with relevant paleoclimatic interpretations to demonstrate that precipitation is and has been in the past a small fraction of average annual potential evapotranspiration. Studies planned to evaluate present and future climate and precipitation [INN 3.3.4.1-1] will provide data to evaluate the extent to which this favorable condition is present.]

3.3.4.2 Potentially Adverse Conditions

According to 10 CFR 60.122(c), the following condition is potentially adverse if it is characteristic of the controlled area or may effect isolation within the controlled area:

Potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes. [60.122(c)(6)].

[A final analysis of this potentially adverse condition is not yet available. Studies planned to evaluate the potential for reasonably foreseeable climate changes to change the hydrologic conditions at the site [INN 3.3.2.1.1-1 and INN 3.3.4.1-1] will provide additional data to evaluate the extent to which this condition may be present.]

3.3.5 Assessment of Compliance with Performance Objective

[This subsection provides an assessment of compliance with performance objectives of 10 CFR 60.113(a)(2), 10 CFR 60.113(b), and 10 CFR 60.122(a)(1). In particular it demonstrates how the geologic setting complies with the pre-waste-emplacement groundwater travel time requirement. The general approach to these calculations has been provided in Subsection 3.3.2.1, and the results of those analyses will be used to demonstrate the presence of the favorable condition of travel times that are greater then 1,000 years and a

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demonstration of compliance with the groundwater travel time requirement. This subsection provides a complete documentation of the models used in the analyses, input and output data used, sensitivity and uncertainty analyses, criteria for determination of significance of travel times that are less than 1,000 years, and expert judgment used to support the validity of the models used in the analyses.]

3.3.5.1 Disturbed Zone

[The assessment that follows describes and justifies the selection of the boundaries of the disturbed zone, the criteria used to select the boundary, and the sensitivity of performance to the boundary selection. Data and calculations to support these analyses are described in INN 3.3.2.1.1-1, INN 3.3.1.2.11-1, and INN 3.3.5.1-1.]

3.3.5.2 Groundwater Travel Time

[A complete analysis of pre-waste-emplacment is not yet available. Studies planned for site characterization will evaluate processes operating in the geologic setting during the Quaternary Period [INN 3.3.2.1.1-1, INN 3.3.2.1.3-1, and INN 3.3.5.1-1] and the results of these studies will provide a basis for evaluating groundwater travel time]

3.3.6 Effectiveness of Natural Barriers Against the Release of Radioactive Material to the Environment

[This subsection identifies natural barriers that may not themselves be part of the GROA that are important to isolating waste from the accessible environment. Also a determination of the effectiveness of these barriers against the release of radioactive material to the environment is included considering background information that is presented in Section 3.1, and Subsections 3.3.1, 3.3.4, and 3.3.5. In addition, other applicable analyses discussed in the performance assessments in Chapter 6 and sensitivity analyses are included by reference.]

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10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories

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MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.1.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of the site characterization programs for tectonics and geomorphology.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	TBD
Information Source Description:	Data, interpretations of data, figures, and tables supporting the interpretations.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.1.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Population density.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Environmental Impact Statement
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.2-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Structural Deformation During the Quaternary
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.17.3.1 (Relevant Earthquake Sources) Study Plan 8.3.1.17.3.3 (Ground Motion from Regional Earthquakes and UNEs) Study Plan 8.3.1.17.3.4 (Effect of Local Site Geology on Surface and Subsurface Motions) Study Plan 8.3.1.17.3.5 (Ground Motion from Controlling Seismic Events) Study Plan 8.3.1.17.3.6 (Probabilistic Seismic Hazard) Study Plan 8.3.1.17.4.1 (Historic and Current Seismicity) Study Play 8.3.1.17.4.6 (Quaternary Faulting Within the Site Area) Study Plan 8.3.1.17.4.8 (Stress Field Within and Proximal to the Site) Study Plan 8.3.1.17.4.9 (Tectonic Geomorphology) Study Plan 8.3.1.17.4.12 (Tectonic Models and Synthesis) INN 3.3.2.2.3-1 and 3.3.2.2.4-1 INN 6.5-002
Information Source Description:	Structural Deformation During the Quaternary
Does the supporting data need to be QA?	

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Evaluation of historical earthquakes.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.17.3.1 (Relevant Earthquake Sources) Study Plan 8.3.1.17.3.3 (Ground Motion from Regional Earthquakes and UNEs) Study Plan 8.3.1.17.3.4 (Effect of Local Site Geology on Surface and Subsurface Motions) Study Plan 8.3.1.17.3.5 (Ground Motion from Controlling Seismic Events) Study Plan 8.3.1.17.3.6 (Probabilistic Seismic Hazard) Study Plan 8.3.1.17.4.1 (Historic and Current Seismicity) INN 6.5-002
Information Source Description:	Earthquake catalog
Does the supporting data need to be QA?	

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

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MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.6-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Probability and consequences of an igneous intrusion penetrating the repository history; and of igneous activity during the Quaternary.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.8.1.1 (Probability of Magmatic Eruption Penetrating the Repository) Study Plan 8.3.1.8.1.2 (Physical Processes of Magmatism and Effects) Study Plan 8.3.1.8.5.1 (Characterization of Volcanic Feature) Study Plan 8.3.1.8.5.2 (Characterization of Igneous Intrusive Features) Study Plan 8.3.1.17.4.12 (Tectonic Models and Synthesis)
Information Source Description:	TBD
Does the supporting data need to be QA?	

Date: 03/31/95

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.7-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Data supporting the Extreme Erosion topical report must be qualified. This information was evaluated as suitable and recommended for qualification. But the data has not been qualified.
Information will be used to support:	LAO section 3.3.1.2.7, paragraph 4 specifies that qualified data supports the regulatory conclusion that the potentially adverse condition, "evidence of extreme erosion during the Quaternary Period," does not exist at Yucca Mountain. The supporting data has not yet been qualified.
The Information is needed by/for (date or event):	Rev. 1 of the LAO and for resolution of NRC staff comments on the Extreme Erosion topical report YMP/92-41 TPR
Most likely source of the Information:	Study Plans 8.3.1.5.1.4, Paleoenvironmental History of Yucca Mountain, and 8.3.1.17.4.6, Quaternary Faulting Within the Site Area, existing LANL varnish cation ratio dating information as specified in the topical report and in the report: Technical Assessment Qualification of Data, Erosion Rates at Yucca Mountain LV.SC.BWD.10/92-099 (WBS 1.2.5.2.4), and the data from detailed USGS mapping on and near Yucca Mountain.
Information Source Description:	TBD
Does the supporting data need to be QA?	Yes

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.7-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of beryllium 10 dating from Study Plan 8.3.1.5.1.4 and aluminum 26 dating from Study Plan 8.3.1.17.4.6
Information will be used to support:	Paragraph 5 of this subsection. Information is expected to verify and validate results of varnish cation dating and confirm age estimates used in calculation of erosion rates.
The Information is needed by/for (date or event):	Rev. 1 of LAAO and to support resolution of comments on topical report YMP/92-41-TPR.
Most likely source of the Information:	Study Plan 8.3.1.5.1.4 and Study Plan 5.3.1.17.4.6
Information Source Description:	TBD
Does the supporting data need to be QA?	Yes

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

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MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.7-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of USGS mapping in Forymile Wash (Lundstrom and Warren, 1994) and Midway Valley (Lundstrom and others, in review).
Information will be used to support:	Paragraph 5 of this subsection
The Information is needed by/for (date or event):	Rev. 1 of LAAO and to support resolution of NRC staff comments on topical report YMP/92-41-TPR
Most likely source of the Information:	Study Plans 8.3.1.5.1.4 and 8.3.1.17.4.2
Information Source Description:	TBD
Does the supporting data need to be QA?	Yes

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

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MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.8-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Natural resources within the site that may be economically extracted within the foreseeable future or that have greater or net value than the average for other areas of similar size that are representative of and located in the geologic setting.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.9.2.1 (Natural Resource Assessment at the Yucca Mountain Site) Study Plan 8.3.1.9.2.2 (Water Resource Assessment at the Yucca Mountain Site) Study Plan 8.3.1.9.3.1 (Data Needed to Support the Assessment of the Likelihood of Future Inadvertent Human Intrusion for Exploration/Extraction of Natural Resources) Study Plan 8.3.1.9.3.2 (Evaluation of the Potential Effect of Exploitation of Natural Resources)
Information Source Description:	TBD
Does the supporting data need to be QA?	

Date: 03/31/95

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.10-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Evidence of drilling.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Borehole Catalog
Information Source Description:	Borehole catalog
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.1.2.11-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Geomechanical properties that do not permit design of stable underground openings through permanent closure.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.4.2.2 (Structural Features Within the Site Area) Study Plan 8.3.1.15 (Thermal and Mechanical Properties)
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	<p>Results of the site characterization programs for geohydrology.</p> <p>Additional information is needed on processes which projected into the future that may or may not have a favorable impact on the ability to isolate.</p> <p>Technical evaluations that are needed to support this analysis are varied, because of the broad nature of this requirement this analysis will draw data from many site characterization activities. Many of the studies in section 8.3 of the SCP will be used.</p> <p>(iii) Extrapolation of the processes mentioned in (i) and (ii) for the next 10,000 years, and performance calculations to determine the impact on the ability of the repository to isolate waste.</p>
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	<p>Technical Reports Site Suitability Report INN 6.5-001 SCP 8.3.1.2.1 Studies to provide a description of the regional hydrologic system. SCP 8.3.1.2.1.1 Study: Characterization of the meteorology for regional hydrology SCP 8.3.1.2.1.3 Study: Characterization of the regional groundwater flow system (particularly 8.3.1.2.1.3.1 Assessment of the regional hydrogeologic data needs in the saturated zone) SCP 8.3.1.2.2.1 SCP 8.3.1.2.2.3 SCP 8.3.1.2.2.4 SCP 8.3.1.2.2.6</p>

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Information Source Description:	Data, interpretations of data, figures, and tables supporting the interpretations.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.1-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	There is some evidence of deep infiltration of modern water that can be seen from the detection of short lived isotopes such as tritium and ³⁶ Cl. The results of investigations of deep occurrences of these isotopes need to be published in a report. Preliminary results have been reported in several places but no final position has been developed. More data need to be acquired.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Final report on deep occurrences of tritium and ³⁶ Cl. This information might include results published in the following articles (which have not been reviewed at this time): Lehmann B.E., Davis S.N., and Fabryka-Martin J.T., 1993. Atmospheric and subsurface sources of stable and radioactive nuclides used for groundwater dating. Water Resources Research, 29:2027-2040. Andrews J.N., Davis S.N., Fabryka-Martin J.T., Fontes J-Ch., Lehmann B.E., Loosli H.H., Michelot J.L., Moser H., Smith B., and Wolf M., 1989. The in situ production of radioisotopes in rock matrices with particular reference to the Stripa granite. Geochimica et Cosmochimica Acta, 53:1803-1815.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.1-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Map of the area showing water table gradients. Water level monitoring (Subsection 3.1.2.2.2) shows that the gradient is less than xxx.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Data for calculation of groundwater travel time. Description of hydrogeologic conceptual models and associated hydrostratigraphic units for both the unsaturated and saturated zones. Distribution of flow and transport parameters for each hydrostratigraphic unit (porosity, hydraulic conductivity, distribution of fractures, geometry, coefficient of diffusion, heterogeneity in both lateral and vertical directions). Flow parameters for each conceptual flow model (porous media, dual porosity, dual permeability, discrete fracture). Distribution of percolation flux. Location, properties, and geometry of major faults.
Information will be used to support:	
The Information is needed by/for (date or event):	1997
Most likely source of the Information:	Results of: Study Plan 8.3.1.2.2.1 (Characterization of Unsaturated Zone Infiltration) Study Plan 8.3.1.2.2.2 (Water Movement Test) Study Plan 8.3.1.2.2.3 (Characterization of Percolation in the Unsaturated Zone-Surface Based Studies) Study Plan 8.3.1.2.2.4 (Characterization of the Unsaturated Zone-ESF) Study Plan 8.3.1.2.2.5 (Diffusion) Study Plan 8.3.1.2.2.6 (Characterization of Gas-Phase Movement) Study Plan 8.3.1.2.2.8 (Fluid Flow in the Unsaturated Zone) Study Plan 8.3.1.2.2.9 (Site Saturated Zone Synthesis and Modeling) Site Suitability Report INN 3.3.1.2.11-1 INN 3.3.5.1-1

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Does the supporting data need to be QA?	
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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Documentation and qualification of models. Documentation and Qualification of: geostatistical models; upscaling models; unsaturated site-scale model; saturated zone regional model; saturated zone site-scale model; and one- and two-dimensional stochastic models.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	Individual model documentation and qualification reports.
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of site-scale modeling in the unsaturated zone. Documentation of site-scale model based on TOUGH2 including sensitivity analyses of flow to hydrostratigraphic unit flow parameters, fault properties, and percolation flux distribution.
Information will be used to support:	
The Information is needed by/for (date or event):	1998.
Most likely source of the Information:	Reports on development and evaluation of the site-scale model.
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-4
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of regional modeling in the saturated zone. Documentation of the development and results of regional modeling. This documentation should be sufficient to serve as a source of boundary conditions for the site-scale saturated zone model for each hydrogeologic conceptual model of regional flow.
Information will be used to support:	
The Information is needed by/for (date or event):	1997
Most likely source of the Information:	Reports on regional modeling
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-5
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Results of site-scale modeling in the saturated zone. Documentation of the development and results of the saturated zone site-scale modeling. This documentation should be sufficient to show the effects of different boundary conditions on flow. Additional documentation should be provided on the sensitivity of the site scale model to a range of flow parameters including fault properties.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	Reports of site-scaling modeling
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-6
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	<p>Criteria for evaluation of significance.</p> <p>Specific criteria for evaluation of the significance of the consequences altered transport parameters that define the disturbed zone and are used to evaluate the significance of travel times that are found to be less than 1,000 years. These criteria will define what change in a postclosure performance measure (for example, cumulative release or dose) is considered to be significant (i.e., has a significant effect on radionuclide release). The development of these criteria will likely be based on expert judgment, and the sensitivity of performance assessment tools used to evaluate the consequences of alteration that defines the disturbed zone and travel-time pathways that are less than 1,000 years must be taken into consideration.</p>
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	
Information Source Description:	
Does the supporting data need to be QA?	

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-7
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	<p>Definition of the disturbed zone.</p> <p>Definition of processes that result in permanent changes in transport parameters (i.e., hydraulic conductivity or retardation) and the associated rock volumes of altered parameters for alternative repository thermal loadings. The evaluation of altered volumes should be defined by modeling where applicable and by expert judgment to extent the results of geochemical laboratory analyses to the disturbed volumes. Performance assessment results to analyze the consequences of these volumes of altered transport parameters and application of significance criteria to define a range of extent of the disturbed zone. Sensitivity and uncertainty analyses to ensure that the largest extent of the disturbed zone has been evaluated for each thermal loading.</p>
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	
Information Source Description:	TBD
Does the supporting data need to be QA?	

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Date: 03/31/95

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-8
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Procedure to expert judgement elicitation. This procedure must be a formalized QA procedure that is flexible enough to cover the expert judgement aspects of the development of the disturbed zone and significance criteria, and other Programmatic applications (i.e., volcanism and seismic hazards).
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	Quality Assurance Procedures
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-9
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Documentation and qualification of performance assessment models. Documentation and Qualification of: flow models; transport models; waste package release models, and dose models used in performance assessment necessary to define the disturbed zone and to determine the consequences of travel time pathways that are less than 1,000 years.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	TBD
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-10
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Documentation and qualification of models used in definition of the disturbed zone. Documentation and Qualification of: mechanical; thermal; thermomechanical; hydrothermal; and geochemical models used to define volumes of altered transport parameters that are used in the definition of the disturbed zone.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	TBD
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-11
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Calculations of groundwater travel time. Documentation of the calculations, assumptions, and data used for each iteration of groundwater travel time.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	TBD
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.3-12
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Sensitivity/Uncertainty analyses. Documentation of the sensitivity/uncertainty for each iteration of groundwater travel time calculations. These analyses should include sensitivity to parameter ranges, correlation among parameters, geometry, boundary conditions including distribution of percolation flux, conceptual flow models, and calculational methods and assumptions.
Information will be used to support:	
The Information is needed by/for (date or event):	1998
Most likely source of the Information:	TBD
Information Source Description:	
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	An evaluation of the hydrologic characteristics of the unsaturated zone and the climatic regime at the site. The results of these studies and the results of the calculation of pre-waste-emplacment ground-water travel time will provide a basis for evaluating the extent to which this favorable condition may be present at the Yucca Mountain site.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	The results of studies on imbibition of water from fractures into rock matrix. Some moisture will flow in fractures to depths below the evapotranspiration depth. For the average summer storm, calculations are needed that show the depth that fracture flow will go before it is imbibed into the rock matrix. The moisture flux is low because the repository meets the performance goal of 10 CFR 60.113 (a)(2) relating to groundwater travel time along the fastest path of likely radionuclide travel to the accessible environment. More discussion on this subject can be found in Section 3.3.5 (b).
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Report the results of studies on imbibition of water from fractures.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Report showing that the repository level is well above strata where saturated conditions are known to exist.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Report showing well log data, core analysis and modeling results which indicate that the repository saturation is below 100%.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-4
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Include a map that shows the areal extent of each of the listed units.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Results of geologic mapping of each of the units present at Yucca Mountain. Most of this work will be reported in investigation 8.3.1.4.2.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-5
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	A report showing climate, runoff, and evapotranspiration at Yucca Mountain.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Because of these low permeability rocks and the steep terrain most of the precipitation that falls on Yucca Mountain flows down drainage channels and is diverted away from the mountain. Much of this work will come from the following studies: 8.3.1.2, 8.3.1.12, and 8.3.1.5. Some of the discussion can be extracted from Chapter 5 of the SCP.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.1.4-6
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Provide a discussion of fracture permeability in the host rock, and include a discussion of saturations, which indicate that the rock drains freely.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	This information need will get information from the following SCP investigations: 8.3.1.2.2.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Probable maximum flood.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	<p>SCP 8.3.1.16.1 Investigation: "Flood recurrence intervals and levels at potential locations of surface facilities" will supply information needed here. Additional input for this analysis has been discussed or was developed from the activities under the following SCP sections:</p> <ul style="list-style-type: none"> SCP 8.3.1.6 Overview of the Erosion Program SCP 8.3.1.12 Overview of the Meteorology Program SCP 8.3.1.2 Overview of the Geohydrology Program <ul style="list-style-type: none"> SCP 8.3.1.2.1.1 Precipitation quantities and rates SCP 8.3.1.2.1.2 Streamflow rates, quantities, and durations. <ul style="list-style-type: none"> Study Plan 8.3.1.2.1.2.1: "Surface-water runoff monitoring" Study Plan 8.3.1.2.1.2.2: "Transport of debris by severe runoff" SCP 8.3.1.5 Overview of the Climate Program SCP 6.1.2.6 Flood Characteristics SCP 6.1.2.5 Hydrologic considerations SCP 8.4 Planned site characterization activities and potential performance impact
Information Source Description:	TBD
Does the supporting data need to be QA?	

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.1-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith M. Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	As-built configurations of the entrances to the North and South ramps, and ventilation and other access shafts and ramps.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	As-built surveys will be made of the surface facilities as part of the design activities. Since modifications of the existing pads and surface facilities are likely to occur, this information need may need to be satisfied using interim as-built drawings and institutional controls that ensure that changes will not adversely impact flood drainage patterns.
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.1-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith M. Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Detailed topographic maps in the vicinity of North and South Ramps, and ventilation and other access shafts and drifts.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	SCP Investigation 8.3.1.14.1 provides initial mapping of surface topography. Subsequent surveys have refined these initial measurements. The SCP states that topographic maps at one-foot contours will be prepared. This has not been done, but EG&G reports that they have prepared maps with a two-foot contour interval. [reference will be provided.]
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Potential for natural phenomena to create surface water impoundments that could change the regional groundwater system.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.2.1.2 (Characterization of Runoff and Stream Flow) Study Plan 8.3.1.5.2.2 (Characterization of Future Regional Hydrology Due to Climate Change) Study Plan 8.3.1.8.1.1 (Probability of Magmatic Eruption Penetrating the Repository) Study Plan 8.3.1.8.1.2 (Physical Processes of Magmatism and Effects) Study Plan 8.3.1.17.4.6 (Quaternary Faulting Within the Site Area) Study Plan 8.3.1.17.4.7 (Subsurface Geometry and Concealed Extension of Quaternary Faults) Study Plan 8.3.1.17.4.12 (Tectonic Models and Synthesis)
Information Source Description:	Rates of Vertical Slip and Tilting Locations of Faults and Recurrence Intervals Probability of a Volcanic Event Runoff Estimates
Does the supporting data need to be QA?	

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Date: 03/31/95

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.4-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Structural deformation that could affect the regional groundwater system.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.8.3.1 (Analysis of the Effects of Tectonic Processes and Events on Average Percolation Flux Rates Over the Repository) Study Plan 8.3.1.8.3.2 (Analysis of the Effects of Tectonic Processes and Events on Changes in the Water Table Elevation) Study Plan 8.3.1.8.3.3 (Analysis of the Effects of Tectonic Processes and Events on Local Fracture Permeability)
Information Source Description:	Location of Quaternary Faults and recurrence intervals of Quaternary Faults. Effect of faulting on permeability and porosity and effects of faulting on groundwater flux.
Does the supporting data need to be QA?	

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Date: 03/31/95

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.5-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Effects of tectonic processes, climate change, and human activities on hydrologic conditions.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.5.2.2 (Characterization of Future Regional Hydrology Due to Climate Change) Study Plan 8.3.1.9.3.2 (Evaluation of Potential Effects of the Exploitation of Natural Resources on the Hydrologic Characteristics of Yucca Mountain) INN 3.3.2.2.4-1
Information Source Description:	Radionuclide retardation by sorption processes Radionuclide retardation by precipitation processes Radionuclide dispersion, diffusion, and advection Radionuclide retardation by all processes
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.6-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Rock or groundwater conditions that require complex engineering measures for design and construction of the underground facility or in sealing of boreholes and shafts.
Information will be used to support:	Rock Characteristics Unsaturated Zone Hydrologic Characteristics
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.2.2.1 (Characterization of Unsaturated-Zone Infiltration) Study Plan 8.3.1.2.2.3 (Characterization of Percolation in the Unsaturated Zone-Surface-Based Study) Study Plan 8.3.1.2.2.4 (Characterization of the Yucca Mountain Unsaturated Zone Percolation-ESF) Study Plan 8.3.1.4.2.2 (Characterization of Structural Features in the Site Area) Investigation 8.3.1.15 (Thermal and Mechanical Properties)
Information Source Description:	TBD
Does the supporting data need to be QA?	

SKELETON TEXT

Date: 03/31/95

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.7-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Potential for the water table to rise and saturate the potential repository.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	The strategy for showing compliance is presented in SCP Section 8.3.5.17. The potential cause of water table rise could be from climatic conditions, human activity, or tectonic processes or events. The scenarios to be considered are shown in SCP table 8.3.5.17-14. Information will also come from Study Plan 8.3.1.2.2.9 (Site Saturated Zone Synthesis and Modeling)
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.7-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Report on evidence of higher water table elevation by alteration to zeolite.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Report on evidence of higher water table elevation by alteration to zeolite
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.7-3
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 Keith Kersch (702) 794-5323
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Evidence of a higher water table can be seen in past groundwater discharge in Crater Flat. Paces examined paleo discharge deposits and concluded that the water table elevation could have been as much as xxx meters higher that at present during the Quaternary.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	
Information Source Description:	Final report on Crater Flat ground-water discharge.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.2.2.8-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the needed information:	Potential for existing or future perched water bodies that may saturate the underground facility or provide a faster flow path to the accessible environment.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.2.2.1 (Characterization of Infiltration in the Unsaturated Zone) Study Plan 8.3.1.2.2.2 (Water Movement Test) Study Plan 8.3.1.2.2.3 (Characterization of Yucca Mountain Percolation in the Unsaturated Zone-Surface-Based Studies) Study Plan 8.3.1.2.2.4 (Characterization of Yucca Mountain Percolation in the Unsaturated Zone-ESF) Study Plan 8.3.1.2.2.8 (Fluid Flow in Unsaturated Rock) Study Plan 8.3.1.2.2.9 (Site Unsaturated Zone Modeling and Synthesis)
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.1.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Results of the site characterization program for geochemistry.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	TBD
Information Source Description:	Data, interpretations of data, figures, and tables supporting the interpretations.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.1.2-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Results of studies of radionuclide sorption and solubility.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.3.4.1 (Batch Sorption) Study Plan 8.3.1.3.4.2 (Biological Sorption and Transport) Study Plan 8.3.1.3.4.3 (Development of Sorption Models) Study Plan 8.3.1.3.5.1 (Dissolved Species Concentration Limits) Study Plan 8.3.1.3.5.2 (Colloid Behavior) Study Plan 8.3.1.3.6.1 (Diffusion) Study Plan 8.3.1.3.7.1 (Retardation Sensitivity Analysis)
Information Source Description:	Radionuclide retardation by sorption processes Radionuclide retardation by precipitation processes Radionuclide dispersion, diffusion, and advection Radionuclide retardation by all processes
Does the supporting data need to be QA?	

Date: 03/31/95

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.1.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	
Explicit description of the need information:	Anticipated thermal load, water chemistry, and mineralogy, petrology, and rock chemistry.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Repository LAD Study Plan 8.3.1.3.1.1 (Groundwater geochemistry model) Study Plan 8.3.1.3.2.2 (Alteration History) Study Plan 8.3.1.3.3.1 (Natural Analogs of Hydrothermal Systems in Tuff) Study Plan 8.3.1.3.3.2 (Kinetics and Thermodynamic of Mineral Evolution) Study Plan 8.3.1.3.3.3 (Conceptual Model of Mineral Evolution)
Information Source Description:	TBD
Does the supporting data need to be QA?	

Date: 03/31/95

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.2.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Groundwater condition that could increase the solubility or chemical reactivity of the engineered barrier system.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.3.1.1 (Groundwater Chemistry Model) Study Plan 8.3.1.3.2.1 (Mineralogy, Petrology, and Chemistry along Transport Pathways) Study Plan 8.3.1.3.2.2 (History of Geochemical Alteration) Study Plan 8.3.1.3.4.1 (Batch Sorption Studies) Study Plan 8.3.1.3.4.2 (Biological Sorption and Transport) Study Plan 8.3.1.3.4.3 (Development of Sorption Models) Study Plan 8.3.1.3.5.1 (Dissolved Species Concentration Limits) Study Plan 8.3.1.3.5.2 (Colloid Behavior) Study Plan 8.3.1.3.6.1 (Dynamic Transport Column Experiments) Study Plan 8.3.1.3.6.2 (Diffusion) Study Plan 8.3.1.3.7.1 (Retardation Sensitivity Analysis)
Information Source Description:	TBD
Does the supporting data need to be QA?	

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Date: 03/31/95

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INTEGRATOR (PMO):	
Date information will be available:	
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Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.2.2-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Anticipated thermal load, tectonic processes, and human activities that significantly change the groundwater composition.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Repository LAD Study Plan 8.3.4.2.4.5 (Effects of Man-Made Materials on Groundwater Chemistry) Study Plan 8.3.1.2.2.7 (Hydrochemical Characterization of the Unsaturated Zone) INN 3.3.3.2.1-1
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.2.3-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Groundwater conditions in the host rock that are not reducing.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.2.2.7 (Hydrochemical Characterization of the Unsaturated Zone)
Information Source Description:	Groundwater conditions in the host rock.
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.2.4-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Potential for movement of radionuclides in a gaseous state through the unsaturated zone.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	TBD
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.3.2.4-2
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Effects of gaseous transport on repository performance.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Total system performance assessment for the Safety Analysis Report
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

Date: 03/31/95

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.4.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Effects of future climate change on hydrologic conditions
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Study Plan 8.3.1.5.1.6 (Characterization of Future Regional Climate and Environments) Study Plan 8.3.1.5.2.2 (Characterization of Future Regional Hydrology Due to Climate Change)
Information Source Description:	TBD
Does the supporting data need to be QA?	

INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	

MGDS LA Annotated Outline Form A: Information Need	
Information Need Number:	INN 3.3.5.1-1
Section Number and Title:	3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60
Lead Author/Support Author and Phone:	Martha Pendleton (702) 794-1828 James Duguid (703) 204-8851
Primary LA AO Table or Figure INN supports (if applicable):	N/A
Explicit description of the need information:	Calculations of the extent of the disturbed zone from both hydrologic and geochemical analyses; a description of the criteria used to select this boundary; an analysis of the significance of the boundary based on total system performance; documentation of the models, data, and expert judgment used to support these analyses; and information on the validation and calibration of the models used in the analysis.
Information will be used to support:	
The Information is needed by/for (date or event):	
Most likely source of the Information:	Results of: Report on calculation of pre-waste emplacement groundwater travel time Site Suitability Report INN 3.3.1.2.11-1 INN 3.3.2.1.3-1
Information Source Description:	TBD
Does the supporting data need to be QA?	

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INTEGRATOR (PMO):	
Date information will be available:	
Deliverable providing information:	
If the data needed is QA, then the QA source document number is:	