COMPLIANCE DETERMINATION STRATEGY

RRT 3.2.4.1 FAVORABLE CONDITION: PRECIPITATION IS A SMALL PERCENTAGE OF EVAPOTRANSPIRATION

APPLICABLE REGULATORY REQUIREMENTS:

60.122(b)(8)(v)
60.21(c)(1)(i)(D)
60.21(c)(1)(ii)(A)
60.21(c)(1)(ii)(B)
60.21(c)(1)(ii)(F)

TYPES OF REVIEW:

Acceptance Review (Type 1)
Safety Review (Type 3)

RATIONALE FOR TYPES OF REVIEW:

Acceptance Review (Type 1) Rationale:

This regulatory requirement topic is license application-related because, as specified in 10 CFR 60.31(a)(1)(i), it is information that the Commission shall consider in determining if there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area without unreasonable risk to the health and safety of the public. As presented in the license application content requirements of 10 CFR 60.21(c) referenced above and Section 3.2.4.1 of regulatory guide "Format and Content for the License Application for the High-Level Waste Repository (FCRG)," it must be addressed by the U.S. Department of Energy (DOE) in its license application. Therefore, the staff will conduct an Acceptance Review of the license application for this regulatory requirement topic.

Safety Review (Type 3) Rationale:

This regulatory requirement topic is related to containment and waste isolation. It is a requirement for which compliance is necessary to make a safety determination for construction authorization as defined in 10 CFR 60.31(a) (i.e., regulatory requirements in Subparts E, G, H, and I). Therefore, the staff will conduct a Safety Review of the license application to determine compliance with this regulatory requirement topic.

This regulatory requirement topic focuses on whether the site is located in a climatic regime where the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration (PE). This is one of the favorable conditions in 10 CFR 60.122(b). For regulatory purposes, the staff considers the term "historic" to refer to the relatively recent period for which precipitation and temperature records are available for the site and its vicinity. Moreover, the staff interprets the expression "small percentage" to refer to precipitation amounts of less than 25% of PE. The techniques to determine PE and the historical precipitation record are well-established and are not known to contain any key technical uncertainties with respect to this favorable condition. DOE should be able to make the appropriate calculation and comparison of precipitation to evapotranspiration (ET) and present the results in numerical and graphical form in the license application. It is known that PE

significantly exceeds precipitation at the Yucca Mountain site (see preliminary estimates given below), but details of this relationship for the Yucca Mountain site are not currently well-documented and would be the primary compliance demonstration information to be presented by DOE in the License Application.

Linsley et al. (1982, p. 154) shows generalized estimates of mean annual evaporation from shallow lakes in the United States. Their estimates, considered sufficiently reliable for preliminary studies, are based on the evaporation maps of Kohler et al., 1959. Values for southern Nevada range from 130 to over 160 cm/year. The staff considers that, even though these values represent only evaporation estimates, this range provides a reasonable first approximation of average annual ET and PE for the region. DOE (1991) cites French's (1986) analysis of the relationship between precipitation and topographic elevation in southern Nevada. French used a linear regression model and a sample of 63 precipitation stations to calculate a gradient of 28 mm of average annual precipitation per 1000 vertical ft. For a sample of 12 stations on the Nevada Test Site with data records covering 10 years or more, French (1986) calculated a gradient of 38 mm/1000 ft.

Considering the generalized data presented above, it is possible to roughly estimate precipitation as a percentage of average annual PE for the Yucca Mountain site. It is assumed that estimated mean annual evaporation from shallow lakes in the region is a reasonable first approximation of mean annual PE. Data values and ranges can be used in a way that conservatively emphasizes the upper range of mean annual precipitation. Topographic elevations at the site range from about 4000-4950 ft. Using French's (1986) 10-year precipitation data from the Nevada Test Site (38mm/1000 ft) and an elevation of 5000 ft yields an average yearly precipitation of 190 mm, or 19.0 cm. Now we can compare the estimate of average yearly precipitation to the reported range of mean annual evaporation from shallow lakes in southern Nevada (Linsley et al., 1982). We find that the precipitation varies from about 10% to 15% of the estimated lake evaporation amounts.

DOE (1988, p. 3-8) reported an annual average potential evaporation in the range of 1500 to 1700 mm/yr for the region that includes Yucca Mountain. An average annual precipitation of about 150 mm was also reported. Based on these numbers, the average annual precipitation is about 10% of the annual average potential evaporation, a number comparable to the estimate calculated above.

Various studies of ET have been conducted in the southern Great Basin. Robinson (1957) presented data on the annual rates of water use by common species of phreatophytes in the western U.S. The focus of that paper was on the "salvaging" of water that is "consumptively wasted" by phreatophytes. Czarnecki (1990) documented an extensive program of field investigations at Franklin Lake playa between June 1983 and April 1984. He concluded that the most reasonable and representative estimates of ET at Franklin Lake Playa were obtained using the energy-balance eddy correlation technique. The following data were obtained from Table 22 of Czarnecki, 1990 (p. 79):

SUMMARY OF EVAPOTRANSPIRATION ESTIMATES FROM ALL TECHNIQUES USED (STUDY AT FRANKLIN LAKE PLAYA)

EVAPOTRANSPIRATION TECHNIQUE	ESTIMATE (cm/day)
Energy-balance eddy correlation	0.1 to 0.3
Empirical potential evapotranspiration relations:	
Lower range (January)	0.1 to 0.5
Upper range (July)	0.5 to 1.7
Temporal changes in soil-moisture content in the unsaturated zone	Inconclusive -0.07 to 0.1
Evapotranspiration by phreatophytes (Robinson, 1958[1], measurements made in climatically similar Owens Valley and Santa Ana, California, along with other locations)	0.09 to 0.34
Temperature profiles	Inconclusive
Saturated-zone vertical gradients	0.06 to 0.5
One-dimensional finite-difference model	0.06

{[1] Reference believed to be Robinson, 1957.}

The data in the above table can be compared to an estimate for annual rainfall at Franklin Lake Playa. Czarnecki (1990, p. 46) cites Winograd and Thordarson (1975) in estimating a rainfall of 5 cm/yr at the playa. Then, using the data from the method (eddy correlation) that Czarnecki (1990) considered to be most representative, the 5 cm/yr annual rainfall at Franklin Lake Playa would be a relatively small percentage (4% - 14%) of the ET values determined at Franklin Lake Playa (35 to 110 cm/yr).

In addressing the presence or absence of this favorable condition, DOE will need to do substantially more than document recent precipitation and other meteorologic data. For example, it will be necessary to address the effect on the historic data base of the recent prolonged drought in the southwestern U.S. According to DOE (1991), this drought was entering its third year as of the end of 1989. This is recognized in the "Study Plan for Characterization of Meteorology for Regional Hydrology (DOE, 1991)." As stated in DOE (1991, p. 3.1-32), "The region has experienced much wetter periods in the recent past, and this drought period is an anomaly in the recent climatology of the region. To determine the actual extent of the drought, past records (40-50 years) of the region will be statistically analyzed using time-series and spectral analyses in order to relate past and present conditions." Important questions to be answered include whether the data base is long enough to truly represent long-term

precipitation averages, or whether it may be biased toward the lower end by the recent drought. According to DOE (1988, p. 5-47), precipitation data exist for weather stations scattered throughout the western U.S., with record lengths of up to 100 years.

The following assumptions have been made in developing this rationale and assigning a Type 3 level of review (Safety Review) to this review plan topic:

1. No key technical uncertainties have been identified with regard to this favorable condition. It is expected that DOE can evaluate the presence or absence of this condition in a straightforward way by documenting current and historical meteorological conditions in the vicinity of Yucca Mountain.

2. Estimated ranges of mean annual evaporation from shallow lakes in southern Nevada provide a reasonable first approximation of mean annual evapotranspiration for the region.

3. Based on previous studies in the region, average yearly precipitation at Yucca Mountain (based on a 10-year record) appears to be a small percentage (10% to 15%) of mean annual evaporation from shallow lakes in southern Nevada.

REVIEW STRATEGY:

Acceptance Review:

In conducting the acceptance review of this favorable condition regarding precipitation and PE at Yucca Mountain, the reviewer should determine if the content of the license application is complete in technical breadth and depth with respect to the information requested by Section 3.2.4.1 of regulatory guide "Format and Content of the License Application for the High-Level Waste Repository (FCRG). The reviewer should determine whether the license application contains all appropriate information that the staff needs to support the safety review (described below) and total system and subsystem performance assessments.

The information presented in the license application should be presented in such a way that the assumptions, data, and logic lead to a clear demonstration of compliance with the requirements. The reviewer should not be required to conduct extensive analyses or literature searches. The reviewer should also determine whether an appropriate range of alternative interpretations and models has been described.

Finally, the reviewer shall determine if the U.S. Department of Energy (DOE) has either resolved all the NRC staff objections that apply to LARP Section 3.2.4.1 or provided all the information requested in Section 1.6.2 of the FCRG, for unresolved objections. The reviewer will evaluate the effects of any unresolved objections, both individually and in combination with others, on: (1) the reviewer's ability to conduct a meaningful and timely review; and (2) the Commission's ability to make a decision regarding construction authorization within the three-year statutory period.

Safety Review:

In conducting the Safety Review, the reviewer will, at a minimum, determine the adequacy of the data and analyses presented in the license application to support DOE's demonstrations regarding 10 CFR 60.122(b)(8)(v). Specifically, DOE will need to: (1) provide information to determine whether and to what degree this favorable condition is present (i.e., that average annual historic precipitation is a small

percentage of the average annual potential evapotranspiration); (2) provide information to determine to what degree this favorable condition is present, but undetected; (3) assure the sufficiency of field data collection; and (4) evaluate the information presented under Items (1) and (2), using assumptions and analysis methods that adequately describe the presence or absence of the favorable condition. DOE will also need to explain the measures used to assess whether the favorable condition is present or absent (i.e., whether average annual historic precipitation is a small percentage of the average annual potential evapotranspiration).

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses: (1) analyses that are sensitive to evidence of whether the favorable condition is present or absent; and (2) assumptions which are not likely to overestimate effects of the favorable condition. In general, the reviewer will assess the adequacy of DOE's investigations for evidence of this favorable condition, both within the controlled area and outside the controlled area, as necessary, in the manner outlined in Section 60.21(c)(1)(ii)(B).

The reviewer will determine the adequacy of the data and analyses in the license application to assess DOE's evaluation regarding the presence or absence of this favorable condition. Any uncertainties in data availability, interpretation, and quality should be analyzed and presented. Specifically, DOE will need to: (1) document the average annual precipitation over the period of available historical records for the southern Great Basin, and (2) document methods and results for calculating potential evapotranspiration. This should include available historical records for temperature, wind velocities, humidity, relative amounts of snow as a percentage of total precipitation, and any other factors related to estimates of annual PE.

In order to conduct an effective review, reviewers will rely on staff expertise and independently acquired knowledge, and information such as the results of research activities being conducted by the NRC's Office of Nuclear Regulatory Research, in addition to that provided by the DOE in its license application. The reviewer should focus on additional data which can refine knowledge of the favorable condition, and should perform, as necessary, additional analyses to confirm the resolution capabilities of the methodologies. The reviewer must acquire a body of knowledge regarding these and other critical considerations in preparing to conduct the review.

Finally, work under the following DOE study plans is expected to provide data and analyses needed to determine whether this favorable condition is present or absent:

Study Plan No.	*Title*
8.3.1.2.1.1	*Characterization of the Meteorology for Regional Hydrology (DOE, 1991b)*
8.3.1.2.1.3	*Characterization of the Yucca Mountain Regional Ground-Water Flow System (DOE, 1991a)*
8.3.1.2.1.4	*Regional Hydrologic System Synthesis and Modeling (1992a)*
8.3.1.2.2.7	*Hydrochemical Characterization of the Unsaturated Zone (1990)*
8.3.1.5.1.4	*Analysis of the Paleoenvironmental History of the Yucca Mountain Region (1991c)*
8.3.1.5.1.5	*Paleoclimate-Paleoenvironmental Synthesis (in preparation by DOE)*
8.3.1.5.1.6	*Characterization of the Future Regional Climate and Environments (in preparation by DOE)*
8.3.1.5.2.2	*Characterization of Future Regional Hydrology Due to Climate Changes (1992b)*

Additional study plans related to this favorable condition, when available, will also be reviewed.

RATIONALE FOR REVIEW STRATEGY:

None.

Contributing Analysts:

NRC: Neil Coleman

CNWRA: Mike Miklas, Ross Bagtzoglou

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APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:

Type 1:
60.122(b)(8)(v)
60.21(c)(1)(i)(D)
60.21(c)(1)(ii)(A)
60.21(c)(1)(ii)(B)
60.21(c)(1)(ii)(F)
Type 3:
60.122(b)(8)(v)

REFERENCES:

Czarnecki, J. B., "Geohydrology and Evapotranspiration At Franklin Lake Playa, Inyo County, California," Open-File Report 90-356, U.S. Geological Survey, Denver, Colorado, 1990.

French, R. H., "Daily, Seasonal, and Annual Precipitation at the Nevada Test Site, Nevada, "Water Resources Center, Desert Research Institute, DOE/NV/10384-01, 1986.

Kohler, M. A., T. J. Nordenson, and D. R. Baker, "Evaporation Maps for the United States," U.S. Weather Bureau, Technical Paper 37, 1959.

Linsley, R. K., M. A. Kohler, and J. L. H. Paulhus, "Hydrology for Engineers, 3rd Edition," McGraw-Hill Book Company, 1982.

Nuclear Regulatory Commission, "Format and Content for the License Application for the High-Level Waste Repository," Office of Nuclear Regulatory Research [Refer to the "Products List" for the Division of High-Level Waste Management to identify the most current edition of the FCRG in effect].

Robinson, T. W., "The Phreatophyte Problem," in "Symposium on Phreatophytes," report presented at Pacific Southwest Regional Meeting, American Geophysical Union, Sacramento, California, February 14-15, 1957.

U.S. Department of Energy, "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Office of Civilian Radioactive Waste Management, Vol. 2, Part A, DOE/RW-0199, December 1988.

U.S. Department of Energy, "Hydrochemical Characterization of the Unsaturated Zone," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.2.2.7, September 1990. [Prepared by the U.S. Geological Survey].

U.S. Department of Energy, "Characterization of the Yucca Mountain Regional Ground-Water Flow System," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.2.1.3, January, 1991a. [Prepared by the U.S. Geological Survey].

U.S. Department of Energy, "Characterization of the Meteorology for Regional Hydrology," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.2.1.1, March 1991b. [Prepared by the U.S. Geological Survey].

U.S. Department of Energy, "Analysis of the Paleoenvironmental History of the Yucca Mountain Region," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.5.1.4, June 1991c. [Prepared by the U.S. Geological Survey].

U.S. Department of Energy, "Regional Hydrologic System Synthesis and Modeling," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.2.1.4, January 1992a. [Prepared by the U.S. Geological Survey].

U.S. Department of Energy, "Characterization of Future Regional Hydrology Due to Climate Changes," Office of Civilian Radioactive Waste Management, Study Plan No. 8.3.1.5.2.2, November 1992b. [Prepared by the U.S. Geological Survey].

Winograd, I. J. and W. Thordarson, "Hydrogeologic and Hydrochemical Framework, South-Central Great Basin, Nevada-California, with Special Reference to the Nevada Test Site," U. S. Geological Survey Professional Paper 712-C, 1975.