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COMPLIANCE DETERMINATION STRATEGY
RRT 3.2.1.10 - POTENTIALLY ADVERSE CONDITION: EVIDENCE OF EXTREME EROSION

1.0 APPLICABLE REGULATORY REQUIREMENTS

10 CFR 60.21(c)(1)(ii)(A)
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.122(c)(16)

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 considered to be license application-related because, as specified in the license application (LA) content requirements of 10 CFR 60.21(c) and the 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 LA. Therefore, the staff will conduct an *Acceptance Review* of the LA for this regulatory requirement topic.

Safety Review (Type 3) Rationale

This regulatory requirement topic is considered to be 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 LA to determine compliance with this regulatory requirement topic.

This regulatory requirement topic, concerning a potentially adverse condition (PAC), evidence of extreme erosion, focuses on DOE demonstration, through appropriate investigations, of the evidence for (or against) extreme erosion within the controlled area during the Quaternary Period. In addition, such investigations shall extend beyond the controlled area if it is ascertained that extreme erosion might adversely impact isolation within the controlled area.

Evidence of extreme erosion during the Quaternary Period is to be characterized by DOE in order to understand the projected effect of such erosion, if present, on the waste isolation capability of the proposed geologic repository. DOE is expected to look in the geologic record for evidence of extreme erosion during the 2 million or so years before the present (Quaternary Period) by identifying the types and extent of erosion which might be classified as "extreme." The Nuclear Regulatory Commission (NRC) staff has defined "extreme erosion" as "the occurrence of substantial changes in landforms (as a result of erosion) over relatively short intervals of time" (Nuclear Regulatory Commission, 1983, p. 382).

Sufficient technical knowledge exists to allow for an adequate investigation and evaluation of the likelihood of this PAC. Based on information already known about the site and nearby environs related to this review plan topic, the analysts conclude that a safety determination can be made by evaluating the technical information submitted by DOE in its LA and that the review is expected to require no additional analyses or tests (Types 4 or 5 reviews).

Based on the above considerations, this regulatory requirement topic will be reviewed by the staff as a Type 3 (*Safety Review*). Should future analyses and/or data arise such that this initial assessment is questioned, the type of review this regulatory requirement topic should receive will be reassessed in light of the additional information.

To summarize, the following statements and assumptions have been made in developing this CDS:

(1) This regulatory requirement topic is limited to consideration of evidence for supporting or negating the existence of extreme erosion during the Quaternary Period at the site and nearby environs.

(2) If "extreme erosion" is determined to be present, or is believed to be present but undetected, then the effects of such "extreme erosion" on the performance objectives pertaining to the isolation of waste must be evaluated in the context of favorable conditions and the other potentially adverse conditions [e.g., 10 CFR 60.21(c)(1)(ii)(B)]. Evaluation of the performance of the repository will be achieved in those regulatory requirements dealing with overall system performance objective (e.g., 10 CFR 60.112).

2.0 REVIEW STRATEGY

2.1 Acceptance Review

To determine whether this section of the DOE LA is acceptable for docketing, the staff will determine whether the information submitted is consistent with that identified in the corresponding section of the FCRG.

Before the receipt of the LA, the staff will have conducted prelicensing reviews of the DOE's program, including technical reviews and quality assurance reviews and audits. The staff will have documented its concerns, resulting from these prelicense application reviews, as open items. Some of these open items, referred to as objections to LA submittal, may be critical to the staff LA review, because lack of acceptable DOE resolution would prevent NRC from conducting a meaningful review. Therefore, as part of its *Acceptance Review* for docketing, the staff will evaluate how significant any unresolved objection to LA submittal is, to the effective conduct of licensing activities, using the criteria given in Section 3.1 of this review plan.

2.2 Compliance Review

2.2.1 Safety Review

The regulatory requirement topic is limited to consideration of DOE demonstration, through appropriate investigations, of the evidence for (or against) extreme erosion during the Quaternary Period within the controlled area (and outside the controlled area, if considered necessary). For regulatory purposes, the

definition of the Quaternary Period is the last 2 million years (Nuclear Regulatory Commission, 1983, p. 373). The specific aspects of the LA on which the reviewer will focus are described below, and the Acceptance Criteria are identified in Section 3.0 of this review plan.

In conducting the *Safety Review*, the reviewer will, at a minimum, determine the adequacy of the data and analyses presented in the LA to support DOE demonstrations regarding 10 CFR 60.122(c)(16). Specifically, DOE will need to: (1) provide information to determine whether and to what degree evidence of extreme erosion during the Quaternary Period is present; (2) provide information to determine to what degree evidence of extreme erosion during the Quaternary Period is present, but undetected; (3) ensure the sufficiency of the areal extent of the data collection; and (4) evaluate the information presented in support of Items (1) and (2), with assumptions and analysis methods that adequately describe the presence (or absence) of evidence of extreme erosion during the Quaternary Period and ranges of relevant parameters.

DOE will also need to provide an explanation of the measures employed to support models used to assess the presence or absence of evidence of extreme erosion during the Quaternary Period.

The NRC reviewer should determine that DOE has characterized erosion thoroughly at the proposed Yucca Mountain (YM) repository and nearby by discussing, at a minimum, the following:

- Short-term (c. 10,000 years and less) and long-term erosion rates (up to length of Quaternary Period) on hillslopes and in valleys. The established longterm rates should be compared to possible short term catastrophic rates of erosion which have occurred within the geologic setting (not necessarily only at YM). The likelihood of such extreme erosion having occurred and remaining undetected or the inability of such erosion to have ever occurred at YM should be discussed. The NRC reviewer should determine that DOE has mapped the repository relative to the elevations of the surrounding topography in order to identify those aspects of the proposed repository which would be most vulnerable to extreme erosion. The reviewer should be especially interested in DOE evaluation of erosion in those areas where the depth to the horizontal projection of the repository horizon is less than 100 m (e.g., valleys in SE portion of the controlled area). In these areas, erosion less than that required to unearth the repository might act to "short circuit" the distance to the accessible environment if extreme erosion were to occur in the valleys.

- Aggradational and degradational history of Fortymile Wash and its tributaries. The interpretational history of Fortymile Wash drainage system and its sedimentation should be demonstrated to be internally consistent and in agreement with the paleoclimate and erosional history of the surrounding region and hillslopes. The reviewer should determine that DOE has investigated erosion in at least one tributary channel to Fortymile Wash by conducting a sediment balance in the tributary basin. Many erosive events and processes are recorded in the visible desert landscape; however, it is possible that erosive events and processes that are recorded in the various sediments of the interfluvial basins in the YM area cannot be directly evaluated. The amount of erosion during a bounded time period may be derivable from backcalculations from the volume of known, and dated sediment in a particular basin. The volume of sediment within the basin should approximate (balance with) the volume of material expected to be deposited if the degradation rate on the hillslopes is similar to that proposed by DOE in their calculations

of average regional denudation rates. A geologic map which indicates aggradational features relative to degradational erosional landscapes should be presented.

- Backwasting or scarp-retreat potential, particularly on west facing slopes on the Solitario Canyon side of YM. The reviewer should determine that DOE has investigated and documented any episodes of backwasting on the YM slopes adjacent to Solitario Canyon. Field measurements of slope conditions and talus accumulation leading to backcalculation of likely erosion rates should be a part of the DOE presentation.

- Evidence of surface stability including soil catenas, sediment properties, effect of paleoclimate, significance of appropriately age-dated boulder stripes, or other surface features should be presented. The location of relatively-age-dated, indurated soil surfaces on the Solitario Canyon side of YM, for example, should be shown on a geologic map of the vicinity and appropriate conclusions should be expressed regarding the significance of such relatively ancient and stable soil deposits. Similarly, concretionary features on the east-facing slopes evident in the form of calcified boulder stripes should be discussed for their relevance to the demonstration of slope and landform stability during the Quaternary in the YM vicinity.

- The effects of local and regional base level change on the nature of erosion in the YM vicinity should be investigated and reported in the LA. The regional base level represented by Fortymile Wash should be contrasted with the downcutting potential of tributaries of Fortymile Wash and the apparent aggrading nature of the Fortymile Wash during the recent Quaternary.

- The effects of climate change on the nature of erosion during the Quaternary Period in the YM vicinity should be discussed including a demonstration of the severity of Quaternary climate changes and the suspected impact on erosion rates in the YM vicinity. If the DOE believes that the YM vicinity evidences a different response to Pleistocene glaciation than is interpreted elsewhere in the Southwestern United States or the world, the LA should contain the corroborating data and appropriate discussions to defend such conclusions.

- The effects of erosional events and processes which have initiated significant erosion within the geologic setting during the Quaternary Period and which could occur in the repository's future in YM should be discussed. The DOE should demonstrate that an erosive event of such magnitude as the catastrophic draining and subsequent extreme erosion at Lake Tecopa could not occur at YM, for example. DOE should state why such extreme erosion could not have occurred at YM in the past.

- Complementary evidence for the extent and magnitude of erosion during the Quaternary Period within the geologic setting and at YM. The reviewer should determine that DOE has demonstrated that its investigations rely on multiple techniques which support and complement its evaluatory results. Reliance on and discussion of only one technique to demonstrate absence of extreme erosion in the YM area is not acceptable without significant support.

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses: (1) analyses that are sensitive to evidence of extreme erosion during the Quaternary Period; and (2) assumptions that are not likely to underestimate its effects. In general, the reviewer will assess the adequacy of DOE investigations for evidence of extreme erosion during the Quaternary Period, both within the controlled area and outside the controlled area, as necessary, in the manner outlined in 10 CFR 60.21(c)(1)(ii)(B).

To conduct an effective review, the reviewer will rely on staff expertise and independently acquired knowledge, information, and data such as the results of research activities being conducted by NRC Office of Nuclear Regulatory Research, in addition to that provided by DOE in its LA. The reviewer should focus on additional data that can refine knowledge of extreme erosion during the Quaternary Period, and should acquire, as necessary, additional information to confirm the resolution capabilities of the methodologies. The reviewer should have acquired a body of knowledge regarding these and other critical considerations, in anticipation of conducting the *Safety Review*, to ensure that DOE erosion program is sufficient in scope and depth to provide the information necessary for resolution of the concerns.

RATIONALE FOR REVIEW STRATEGY

Not Applicable.

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APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW

Type 1

10 CFR 60.21(c)(1)(ii)(A)
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.122(c)(16)

Type 3

10 CFR 60.21(c)(1)(ii)(A)
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.122(c)(16)

6.0 REFERENCES

References for Rationales

Nuclear Regulatory Commission. 1983. *Staff Analysis of Public Comments on Proposed Rule 10 CFR Part 60, Disposal of High-Level Radioactive Waste in Geologic Repositories*. NUREG-0804. Washington, DC: Office of Nuclear Regulatory Research.

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 Waste Management to identify the most current edition of the FCRG in effect.]

References for Review Strategies

Nuclear Regulatory Commission. 1983. *Staff Analysis of Public Comments on Proposed Rule 10 CFR Part 60, Disposal of High-Level Radioactive Waste in Geologic Repositories*. NUREG-0804. Washington, DC: Office of Nuclear Regulatory Research.

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 Waste Management to identify the most current edition of the FCRG in effect.]

U.S. Department of Energy. 1988. *Erosion, in Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada*. DOE/RW-0199. Washington, DC: U.S. Department of Energy: Chapter 8, Section 8.3.1.6. Vol. V, Part B.