

**COMPLIANCE DETERMINATION STRATEGY
RRT 3.2.3.6 POTENTIALLY ADVERSE CONDITION: GROUNDWATER CONDITIONS
IN THE HOST ROCK THAT ARE NOT REDUCING**

APPLICABLE REGULATORY REQUIREMENTS:

10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.122(c)(9)

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 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 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, concerning a potentially adverse condition (PAC), oxidizing groundwater conditions, focuses on DOE's demonstration, through appropriate investigations, of oxidizing groundwater conditions in the controlled area. In addition, such investigations shall extend beyond the controlled area if it is ascertained that oxidizing groundwater conditions might adversely impact isolation within the controlled area.

Sufficient technical knowledge presently exists to allow for an adequate investigation and evaluation of the existence of this PAC. Based on information already known about the site and nearby environs, the analysts conclude that a safety determination can be made by evaluating the technical information

submitted by DOE in its license application 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) The methods for determination of oxidizing potential of groundwaters are generally accepted as standard procedures. However, the methods used for determining oxidation potential are sensitive to specific redox couples (e.g. Fe(II)-Fe(III)) which may not be in equilibrium. Although there will always be uncertainties associated with analytical measurements of any type, particularly for analysis of waters in the unsaturated zone, there will be sufficient evidence from other geochemical parameters (e.g. mineralogy of secondary phases and gaseous phase chemistry) to establish the presence/absence and extent of oxidizing groundwaters at Yucca Mountain.
- (2) The composition of gas flowing through Yucca Mountain has been reported to be that of air ($O_2 = 21\%$) with a slightly higher carbon dioxide content ($CO_2 = 0.125\%$ (Thorstenson et al., 1989)). The mineral composition of the tuffs at Yucca Mountain are silicic: alkali-feldspar, quartz and cristobalite, with minor occurrences of Fe-Ti oxides, hornblende, and mica (see Section 4.1.1.3, "Mineralogical...composition of the host rock," in DOE, 1988a). Diagenetic mineral assemblages in the Yucca Mountain tuffs include zeolites, clays, and calcite (Broxton et al., 1987). The air composition and the mineralogy strongly suggest that the waters in the unsaturated and saturated zone are oxidizing. The iron and manganese oxides are generally in oxidized form, associated with fractures and alteration of ferromagnesian minerals (e.g., Warren et al., 1984; Carlos et al., 1991). Therefore, unless demonstrated otherwise, it will be assumed that the groundwater conditions at Yucca Mountain are oxidizing.
- (3) This Compliance Determination Strategy is concerned only with the presence or absence of oxidizing groundwaters. It is not concerned with the effects of oxidizing conditions on the waste package, mineralogical assemblages of the host rock, or the release and transport of radionuclides. These issues will be covered in sections 3.2.3.4, 3.2.3.3, and 3.2.3.5, 3.2.3.7 and others of the license application.
- (4) After emplacement of the waste packages, reducing conditions may develop locally around the waste packages because of redox corrosion reactions with the waste packages. The effects of this condition on the host rock, engineered barrier system and solubility or sorption properties of the radionuclides will be discussed in sections 3.2.3.4 and 3.2.3.5, respectively, of the license application. This condition will also be considered under DOE's Performance Confirmation Program (10 CFR 60.141(c)-(d)) described in Section 8.1.3 of the license application.

REVIEW STRATEGY:

Acceptance Review:

In conducting the acceptance review of the existence of oxidizing groundwaters potentially adverse condition (PAC), the reviewer should determine if the information presented in the license application and its references for determining compliance with the regulatory requirements applicable to this PAC are complete in technical breadth and depth as identified in regulatory guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG). The reviewer should determine that all appropriate information necessary for the staff to review this PAC is presented such that the assessments required by the regulatory requirements associated with total system and subsystem performance objectives can be performed.

The information presented in the license application should be presented in such a manner that the assumptions, data and logic leading to a demonstration of compliance with the requirements are clear and do not require the reviewer to conduct extensive analyses or literature searches. The reviewer should also determine that controversial information and appropriate alternative interpretations and models have been adequately described and considered.

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

Safety Review:

This regulatory requirement topic is limited to consideration of DOE's demonstration, through appropriate investigations, of the evidence of oxidizing groundwater conditions within the controlled area (and outside the controlled area, if considered necessary). The specific aspects of the license application on which the reviewer will focus are described below and the Acceptance Criteria are identified in Section 3.0 of this review plan.

DOE has previously indicated that oxidizing groundwater conditions are present at Yucca Mountain (see Section 4.1.2.2, "Major Inorganic Content," DOE, 1988b).

Therefore, 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(c)(9). Specifically, DOE will need to: (1) provide information describing to what degree the groundwaters at Yucca Mountain are oxidizing; (2) assure the sufficiency of the lateral and vertical extent of the data collection; and (3) provide explanations of the methods used for evaluating the redox potential of the groundwaters.

DOE will also need to provide an explanation of the measures used to support models used to assess the presence or absence of oxidizing groundwater conditions. Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate

combination of such methods as field tests, *in-situ* tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies.

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses: (1) analyses and analytical techniques that are appropriate for determining groundwater oxidation potentials; (2) assumptions which are not likely to underestimate the effects of this potentially adverse condition. In general, the reviewer will assess the adequacy of DOE's investigations for evidence of oxidizing groundwater conditions both within the controlled area and outside the controlled area, as necessary, in the manner outlined in Section 60.21(c)(ii)(B).

In order to conduct an effective review, the reviewer will rely on staff expertise and independently acquired knowledge, information, and data in addition to that provided by DOE in its license application. The reviewer should be familiar with the techniques and limitations of the analyses used to establish the oxidation potential of groundwaters at Yucca Mountain. The reviewer must acquire knowledge regarding these and other critical considerations before conducting the review to assure that DOE's hydrochemistry program is sufficient in scope and depth to provide the information needed to resolve the concerns.

Finally, work under the following DOE studies is expected to provide data and analyses needed to determine whether this potentially adverse condition is present or absent:

<u>Study Plan No.</u>	<u>Title</u>
8.3.1.2.2.6	<i>Unsaturated Zone Gaseous Phase Movement (DOE, 1991)</i>
8.3.1.2.2.7	<i>Hydrochemical Characterization of the Unsaturated Zone (DOE, 1990)</i>
8.3.1.2.3.2	<i>Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry (DOE, 1992)</i>
8.3.1.3.2.1	<i>Mineralogy, Petrology, and Chemistry of Transport Pathways (DOE, 1989)</i>

Work from additional studies related to this potentially adverse condition will also be reviewed, as appropriate.

RATIONALE FOR REVIEW STRATEGY:

Not applicable

Contributing Analysts:

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APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:

Type 1:

10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.122(c)(9)

Type 3:

10 CFR 60.122(c)(9)

REFERENCES:

Broxton, D.E., D.L. Bish, and R.G. Warren, "Distribution and chemistry of diagenetic minerals at Yucca Mountain, Nye County, Nevada," *Clays and Clay Minerals*, 35: 89-110. [April 1987].

Carlos, B.A., Bish, D.L, and Chipera, S.J., "Fracture-Lining Minerals in the Lower Topopah Spring Tuff," *High-Level Radioactive Waste Management Proceedings of the 2nd International Conference*, 486-493 [1991].

Nuclear Regulatory Commission, "Format and Content for the License Application for the High-Level Waste Repository," Office of Nuclear Regulatory Research. [November 1990]. [Refer to the "Products List" for the Division of High-Level Waste Management to identify the most recent edition of the FCRG in effect].

Thorstenson, D.C., H. Haas, E.P. Weeks, and J.C. Woodward, "Physical and Chemical Characteristics of Topographically Affected Airflow in an Open Borehole at Yucca Mountain, Nevada," *American Nuclear Society, Proceedings of the Topical Meeting on Nuclear Waste Isolation in the Unsaturated Zone Focus '89*, Las Vegas Nevada September 1989, pp. 256-269.

U.S. Department of Energy, "Chapter 4, Section 4.1.1.3, 'Mineralogical, petrologic, and chemical composition of the host rock and surrounding units,' in "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Office of Civilian Radioactive Waste Management, DOE/RW-0199, December 1988a.

U.S. Department of Energy, "Chapter 4, Section 4.1.2.2, 'Major inorganic content,' in "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Office of Civilian Radioactive Waste Management, DOE/RW-0199, December, 1988b.

U.S. Department of Energy, "Mineralogy, Petrology, and Chemistry of Transport Pathways," Study Plan No. 8.3.1.3.2.1, Office of Civilian Radioactive Waste Management, June, 1989. [Prepared by Los Alamos National Laboratory].

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

U.S. Department of Energy, "Characterization of Yucca Mountain Unsaturated-Zone Gaseous Phase Movement," Study Plan No. 8.3.1.2.2.6, Office of Civilian Radioactive Waste Management, June, 1991. [Prepared by U.S. Geological Survey].

U.S. Department of Energy, "Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Study Plan No. 8.3.1.2.3.2, Office of Civilian Radioactive Waste Management, May, 1992. [Prepared by U.S. Geological Survey].

Warren, R.G., Byers, F.M. Jr., and Caporuscio, L.A., "Petrography and Mineral Chemistry of Units of the Topopah Spring, Calico Hills and Crater Flat Tuffs, and Older Volcanic Units, with Emphasis on Samples from Drill Hole USW G-1, Yucca Mountain, Nevada Test Site," LA-10003-MS, Los Alamos National Laboratory. [June 1984].