2

LETTER REPORT

IDENTIFICATION OF REGULATORY REQUIREMENTS PERTINENT FOR THE SYSTEMATIC REGULATORY ANALYSIS OF ISSUES RELATED TO VOLCANIC AND MAGMATIC HAZARDS IN 10 CFR PART 60

Prepared for

The U.S. Nuclear Regulatory Commission
Contract No. NRC-02-88-005

Prepared by

Gerry L. Stirewalt

Center for Nuclear Waste Regulatory Analyses
Arlington, Virginia

January 1992

3

IDENTIFICATION OF REGULATORY REQUIREMENTS PERTINENT FOR THE SYSTEMATIC REGULATORY ANALYSIS OF ISSUES RELATED TO VOLCANIC AND MAGMATIC HAZARDS IN 10 CFR PART 60

I. INTRODUCTION

The Center for Nuclear Waste Regulatory Analyses (CNWRA, or the Center) is charged with providing assistance to the Nuclear Regulatory Commission (NRC) for development of regulatory and technical guidance on issues related to volcanic and magmatic hazards. This effort is identified in the Geologic Setting Program Element section (Section 3.4) of the CNWRA FY92-93 Operations Plans for the NRC's Division of High-Level Waste Management (Revision 1, Change 2, dated December 1991) as Subtask 2.1.6 under Task 2 activities.

As delineated in the draft Volcanic/Magmatic Hazards Work Plan submitted to the NRC by the Center in October 1991, all Phase 1 activities of Subtask 2.1.6 (i.e., Activities 1.1 through 1.12) involve application of Systematic Regulatory Analysis (SRA) to analyze the sections of 10 CFR Part 60 (NRC, 1991) which pertain to volcanic and magmatic hazards. Identification of Regulatory Requirements (RRs) pertinent for applying SRA to issues related to volcanic and magmatic hazards in 10 CFR Part 60 is keyed specifically to Phase 1 Activity 1.1 of the draft work plan. To assist in identification of the pertinent RRs, technical staff at the Center reviewed appropriate parts of 10 CFR Part 60 and the CNWRA report by Mackin and Whiting (1991) entitled "Correlation of Regulatory Requirements and Regulatory Elements of Proof for 10 CFR Part 60."

This report on identification of RRs results from completion of Phase 1 Activity 1.1. under Subtask 2.1.6. It is the deliverable for Intermediate Milestone 3702-002-410-001 of the draft work plan. The report illustrates that the potential influence of volcanic and magmatic processes and events on repository performance must be taken into account for a spectrum of regulatory requirements related to containment and isolation of radioactive waste, and public health and safety.

II. BASIS FOR CONSIDERATION OF VOLCANIC/MAGMATIC HAZARDS

Although there is geological evidence which indicates that Quaternary (i.e., during the last 2 million years) basaltic volcanism has occurred in the vicinity of Yucca Mountain (Champion, 1991; Crowe, 1990), processes and events which controlled volcanism and magmatism in the Yucca Mountain region are not presently understood well enough to determine the potential effects of volcanism and magmatism on performance of the proposed repository. For regions where Quaternary volcanism and magmatism are known to have occurred, 10 CFR Part 60 clearly necessitates consideration of volcanic and magmatic processes and events through the two following potentially adverse conditions which directly address volcanic or igneous activity:

- 10 CFR 60.122(c)(3) - 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.

- 10 CFR 60.122(c)(15) - Evidence of igneous activity since the start of the Quaternary Period.

In addition to the NRC's recognition of concerns related to volcanic and magmatic hazards, the investigations related to volcanism planned by the Department of Energy (DOE), outlined in Volume V, Section 8.3.1.8.1, of the DOE Site Characterization Plan (SCP), also indicate DOE's concern about volcanic and magmatic processes and events in the vicinity of Yucca Mountain (DOE, 1988). Consequently, volcanic and magmatic processes and events are important in assessing the suitability of Yucca Mountain as a high-level radioactive waste repository site.

III. IDENTIFICATION OF REGULATORY REQUIREMENTS

10 CFR Part 60 was reviewed to delineate regulatory issues related to volcanic and magmatic hazards, and all citations where these hazards were interpreted by CNWRA technical staff to be either directly or indirectly involved were identified. The report by Mackin and Whiting (1991) and the CNWRA Program Architecture Relational Database (PADB) provided the bases for determining the specific RRs associated with these citations.

An initial list of candidate RRs interpreted to be related to issues concerning volcanic and magmatic hazards was prepared based on correlation of 10 CFR Part 60 citations with RRs currently defined in the Mackin and Whiting (1991) report. Seventeen (17) candidate RRs were identified in this manner. The candidate RRs were judiciously determined by CNWRA technical staff through consideration of the relative importance of volcanic and magmatic hazards to the intent of the RR. That is, the list of candidate RRs presents those for which volcanic and magmatic hazards are considered to be important concerns by CNWRA technical staff. The candidate RRs are listed below, with the following information included in the list: RR number - 10 CFR Part 60 citation - heading of regulatory citation - RR topic designation from Mackin and Whiting (1991):

- RR0074 - 60.21 - Content of application - License Application and Content

- RR0004 - 60.111(a) - Performance of the geologic repository operations area through permanent closure: Protection against radiation exposures and releases of radioactive material - Radiation Exposures and Releases

- RR0002 - 60.111(b)(1) - Performance of the geologic repository operations area through permanent closure: Retrievability of waste - Retrievability of Waste

5

- RR1001 - 60.112 - Overall system performance objective for the geologic repository after permanent closure - System Performance after Permanent Closure

- RR1002 - 60.113(a)(1)(i)(A) - Performance of particular barriers after permanent closure: Engineered barrier system - EBS Performance after Permanent Closure

- RR1003 - 60.113(a)(1)(i)(B) - Performance of particular barriers after permanent closure: Engineered barrier system - EBS Release of Radionuclides after Permanent Closure

- RR2001 - 60.113(a)(2) - Performance of particular barriers after permanent closure: Geologic setting - Favorable Conditions

- RR2004 - 60.122(c)(3) - Potentially adverse condition: Potential for natural phenomena (including volcanic activity) to produce surface water impoundments that change groundwater flow system - Adverse Condition: Change Surface Groundwater

- RR2006 - 60.122(c)(5) - Potentially adverse condition: Potential for changes in hydrologic conditions - Adverse Condition: Changes to Hydrology

- RR2008 - 60.122(c)(7) - Potentially adverse condition: Ground-water conditions in the host rock... that could increase solubility or chemical reactivity of the engineered barrier system - Adverse Condition: Groundwater Conditions Affecting the Engineered Barrier System

- RR2015 - 60.122(c)(14) - Potentially adverse condition: More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area in which the geologic setting is located - Adverse Condition: Higher Magnitude Earthquakes

- RR2016 - 60.122(c)(15) - Potentially adverse condition: Evidence of igneous activity since start of the Quaternary Period - Adverse Condition: Igneous Activity

- RR2021 - 60.122(c)(20) - Potentially adverse condition: Rock or groundwater conditions requiring complex engineering measures in the design and construction of underground facility or in sealing of boreholes and shafts - Adverse Condition: Complex Engineering Measures

- RR2023 - 60.122(c)(22) - Potentially adverse condition: Potential for water table to rise sufficiently to cause saturation of underground facility located in the unsaturated zone - Adverse Condition: Water Table Rise

- RR2024 - 60.122(c)(23) - Potentially adverse condition: Potential for existing or future perched water bodies that may saturate portions of underground facility or provide faster flow path from underground facility located in the unsaturated zone to the accessible environment - Adverse Condition: Perched Water

- RR2025 - 60.122(c)(24) - Potentially adverse condition: Potential for movement of radionuclides in a gaseous state through air-filled pore spaces of an unsaturated geologic medium to the accessible environment - Adverse Condition: Gaseous Radionuclides

- RR0001 - 60.131(b)(1) - General design criteria for the geologic repository operations area: Structures, systems, and components important to safety -- Protection against natural phenomena and environmental conditions - Important to Safety: Natural Phenomena & Environmental Conditions

To express the logic behind choice of the candidate RRs listed above, the rationale for their selection follows:

- RR0074 - 10 CFR 60.21(c)(1) requires the Safety Analysis Report to include a description and assessment of the site at which the geologic repository operations area is to be located, with appropriate attention to site features that might affect design and performance of the geologic repository operations area. This requirement encompasses description and analysis of volcanic and magmatic hazards.

- RR0004 and RR0002 - Since Quaternary volcanic activity has occurred in the Yucca Mountain area and recurrence interval is completely uncertain at this time, the possibility of volcanic or magmatic activity through the permanent closure time frame cannot be completely ruled out. Consequently, volcanic and magmatic hazards are a potential concern for the time frame through permanent closure, the time frame specified in 10 CFR 60.111.

- RR1001 - 10 CFR 60.112 requires that the geologic setting be selected and the engineered barrier system be designed to assure that releases of radioactive materials to the accessible environment after permanent closure conform to appropriate standards. This requirement encompasses consideration of volcanic and magmatic hazards after permanent closure.

- RR1002 and RR1003 - Since Quaternary volcanic activity has occurred in the Yucca Mountain area and recurrence interval is completely uncertain at this time, it is not possible to totally eliminate from consideration volcanic and magmatic hazards under anticipated processes and events. Consequently, volcanic and magmatic hazards are a potential concern under the wording of 10 CFR 60.113(1)(i) which relates to anticipated processes and events.

- RR2001 - Since Quaternary volcanic activity has occurred in the Yucca Mountain area and the recurrence interval is completely uncertain at this time, it is not possible to totally eliminate from consideration volcanic and magmatic hazards during pre-waste-emplacement time. Consequently, volcanic and magmatic hazards are a potential concern during the pre-waste-emplacement time frame specified in 10 CFR 60.113(a)(2).

- RR2004 - The potentially adverse condition under 10 CFR 60.122(c)(3) specifically mentions the potential for volcanic activity to produce surface water impoundments that could change the regional groundwater flow system. Consequently, volcanic and magmatic hazards are a direct concern for this adverse condition.

- RR2006 - The potentially adverse condition under 10 CFR 60.122(c)(5) is related to potential for changes in hydrologic conditions that would affect migration of radionuclides. Because volcanic and magmatic processes and events could affect groundwater hydrology, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR2008 - The potentially adverse condition under 10 CFR 60.122(c)(7) is related to groundwater conditions in the host rock that could increase solubility or chemical reactivity of the engineered barrier system. Because volcanic processes and events could affect groundwater conditions in the host rock, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR2015 - The potentially adverse condition under 10 CFR 60.122(c)(14) is related to more frequent occurrence of earthquakes or earthquakes of higher magnitude than typical of the area in which the geologic setting is located. Because the regulatory citation addresses magnitude and frequency of earthquakes without relating them to an origin or to historical events, this RR is the place in which to cover the concern involving earthquakes generated by volcanic and magmatic activity. Consequently, volcanic and magmatic hazards are a potential concern for this adverse condition. (Citation 60.122(c)(12) relates to historical earthquakes, and 60.122(c)(13) relates to earthquakes produced by tectonic activity. Therefore, these two potentially adverse conditions are not included under association of earthquakes and volcanism, even though the probable connection between tectonics and volcanism is recognized.)

- RR2016 - The potentially adverse condition under 10 CFR 60.122(c)(15) is related to evidence of Quaternary igneous activity. Consequently, volcanic and magmatic hazards are a direct concern for this adverse condition.

- RR2021 - The potentially adverse condition under 10 CFR 60.122(c)(20) is related to rock or groundwater conditions that would require complex engineering

measures in design and construction of the underground facility. Since Quaternary volcanic activity has occurred in the Yucca Mountain area and the recurrence interval is completely uncertain at this time, it is not possible to totally eliminate from consideration potential effects of volcanic and magmatic hazards on rock and groundwater conditions. Consequently, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR2023 - The potentially adverse condition under 10 CFR 60.122(c)(22) is related to the potential for the water table to rise enough to cause saturation of an underground facility located in the unsaturated zone. Because volcanic and magmatic processes could affect the groundwater hydrology and possible produce a rise in the water table level, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR2024 - The potentially adverse condition under 10 CFR 60.122(c)(23) is related to potential for future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from the facility to the accessible environment. Because volcanic and magmatic events could possible produce a perched water table, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR2025 - The potentially adverse condition under 10 CFR 60.122(c)(24) is related to the potential for radionuclides to move in a gaseous state through air-filled pore spaces of an unsaturated zone to the accessible environment. Because magmatic intrusion could result in hydrothermal effects and movement of steam and gaseous vapors into and through the repository horizon, volcanic and magmatic hazards are a potential concern for this adverse condition.

- RR0001 - 10 CFR 60.131(b)(1) requires the design of components of the repository important to safety to be constructed so that anticipated natural phenomena will not interfere with necessary safety functions at the geologic repository operations area. Since Quaternary volcanic activity has occurred in the Yucca Mountain area and recurrence interval is completely uncertain at this time, it is not possible to totally eliminate from consideration volcanic and magmatic hazards under design of components for anticipated processes and events. Consequently, volcanic and magmatic hazards are a potential concern for this adverse condition.

The list of seventeen (17) candidate RRs and the discussion of the rationale for their selection illustrates the encompassing influence of volcanic and magmatic processes and events on natural and engineered systems important for isolation and containment of radioactive waste and for public health and safety.

IV. REGULATORY REQUIREMENTS FOR SYSTEMATIC REGULATORY ANALYSIS

The specific RR which will be subjected to detailed SRA under Subtask 2.1.6 is RR 2016. This RR is keyed to the potentially adverse condition stated in 10 CFR 60.122(c)(15), which addresses evidence of igneous activity since the start of the Quaternary Period that may either occur in, or affect isolation in, the controlled area. This RR was chosen for initial application of SRA to issues related to volcanic and magmatic hazards because Quaternary igneous activity is the direct and explicit concern of the RR.

Application of SRA to the remaining sixteen (16) RRs in the list presented above, to which volcanic and magmatic hazards are interpreted to bear a relationship, will be undertaken either under other Task 2 activities of the Geologic Setting program element, or under other appropriate program elements. The options report to be prepared on RR2016 (Phase 1 Activity 1.9 of Subtask 2.1.6, as delineated in the draft Volcanic/Magmatic Hazards Work Plan submitted to the NRC by the Center in October 1991) will contain a discussion of volcanic and magmatic processes and events in relation to these remaining RRs in order to address the range of issues in 10 CFR Part 60 upon which these processes and events have a bearing.

V. REFERENCES

Champion, D. E. 1991. Volcanic episodes near Yucca Mountain as determined by paleomagnetic studies at Lathrop Wells, Crater Flat, and Sleeping Butte, Nevada. *Proceedings of Second International Conference on High-Level Radioactive Waste Management*. American Nuclear Society, Inc. and American Society of Civil Engineers: 61-67.

Crowe, B. M. 1990. Basaltic volcanic episodes of the Yucca Mountain Region. *Proceedings of First Annual International Conference on High-Level Radioactive Waste Management*. American Nuclear Society, Inc. and American Society of Civil Engineers: 65-73.

Mackin, P., and A. R. Whiting. 1991. Correlation of Regulatory Requirements and Regulatory Elements of Proof for 10 CFR Part 60. *Center for Nuclear Waste Regulatory Analyses (CNWRA) Systematic Regulatory Analysis Synopsis Report*. CNWRA Vol 1-5. San Antonio, Texas.

U.S. Department of Energy. 1988. *Site Characterization Plan - Yucca Mountain Site, Nevada Research and Development Area, Nevada*. Office of Civilian Radioactive Waste Management Report DOE/RW-0199, Vol I-IX. USDOE. Washington, DC.

10/10

10 CFR Part 60. 1991. *Disposal of High-Level Radioactive Waste in Geologic Repositories*. Title 10, Parts 51 to 199. Office of the Federal Register, National Archives and Records Administration. Washington, DC: NRC: 85-118.