DRAFT REVISION 1, NUREG–XXXX

YUCCA MOUNTAIN REVIEW PLAN

Draft Report for Comment

The Commission is releasing the July 2000 draft of its Yucca Mountain Review Plan (YMRP), which allegedly was released without authorization some time ago. To date, no version of the YMRP has been approved by the Commission. Thus, the Commission recommends that no one take any action based on the previously released version which is out-of-date, obsolete, and potentially misleading because it is not consistent with the U. S. Nuclear Regulatory Commission or U.S. Environmental Protection Agency final rules applicable to Yucca Mountain. The staff is working to conform the YMRP with those regulations. It is the Commission's intention to provide an opportunity for the public to comment on the YMRP when this revision is complete. We expect this will occur sometime after the first of the year.

Manuscript Completed: July 2000
Date Published: TBD

Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

ABSTRACT

The Yucca Mountain Review Plan (NUREG–XXXX) provides guidance to evaluate a license application for a geologic repository. The licensing criteria are contained in 10 CFR Part 63, Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada. The U.S. Department of Energy will submit the license application. The principle purpose of the Yucca Mountain Review Plan is to ensure the quality and uniformity of staff reviews. The has separate sections for reviews of repository safety prior to permanent closure, repository safety after permanent closure, the research and development program to resolve safety questions, the performance confirmation program, and administrative and programmatic requirements. Each of these sections supports determining compliance with specific regulatory requirements from 10 CFR Part 63. The regulations and the Yucca Mountain Review Plan are risk-informed and performance-based to the extent practical.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

TABLE OF CONTENTS (continued)

Page

FIGURES

ACRONYMS AND ABBREVIATIONS

AC	acceptance criteria
ALARA	as low as is reasonably achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
B&PVC	Boiler & Pressure Vessel Code
CFR	U.S. Code of Federal Regulations
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FEPs	features, events, and processes
GROA	geologic repository operations area
HLW	high-level radioactive waste
K_d	sorption coefficient
k_{eff}	waste forms effective neutron multiplication factor
NEPA	National Environmental Policy Act of 1969
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982
PCSA	preclosure safety analysis
RIPB	risk-informed, performance-based
RM	review method
SAR	Safety Analysis Report
SNF	spent nuclear fuel
SSCs	structures, systems, and components
TEDE	total effective dose equivalent
YM	Yucca Mountain
YMRP	Yucca Mountain Review Plan

1 INTRODUCTION

A U.S. Nuclear Regulatory Commission (NRC) license is required under the provisions of Title 10 of the U.S. Code of Federal Regulations, Part 63 (10 CFR Part 63), Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada disposal of high-level radioactive waste (HLW). NRC authority to regulate an HLW repository comes from the Atomic Energy Act of 1954, as amended, and the Nuclear Waste Policy Act of 1982 (NWPA), as amended.

The Energy Policy Act of 1992 directed the U.S. Environmental Protection Agency (EPA) to contract with the National Academy of Sciences to provide advice on the appropriate technical bases for public health and safety standards governing a Yucca Mountain (YM), Nevada, repository. In its report, Technical Bases for Yucca Mountain Standards (National Research Council, 1995), the National Academy of Sciences recommended that an individual protection standard, expressed as a limit on individual risk rather than on dose would provide a reasonable basis for protecting the health and safety of the general public. The Energy Policy Act of 1992 also directed the EPA to issue public health and safety standards for YM that “prescribe the maximum annual effective dose equivalent to individual members of the public” and that are “based upon and consistent with” the findings and recommendations made by the National Academy of Sciences in its 1995 report (National Research Council, 1995). This approach is different from that contained in EPA disposal standards at 40 CFR Part 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Wastes, that were applied at the Waste Isolation Pilot Plant in New Mexico. In addition, the Energy Policy Act of 1992 directs the NRC to modify the technical requirements and criteria contained in original NRC generic regulations for disposal of HLW in 10 CFR Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories to be consistent with the EPA standards applicable to YM. The NRC has decided to codify the regulatory criteria applicable to YM in 10 CFR Part 63.

Although the National Environmental Policy Act of 1969 (NEPA) requires an environmental evaluation for federal actions, the NWPA requires that NRC adopt, to the extent practical, the Final Environmental Impact Statement (EIS) prepared by the U.S. Department of Energy (DOE). Thus, NRC will not be conducting its own environmental evaluation work unless it cannot adopt DOE’s Final EIS. The 10 CFR 51.109 contains the criteria NRC will use to determine if the Final EIS published by DOE can be adopted.

DOE as the applicant for a construction authorization and a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area (GROA) at the YM site followed by permanent closure is required to provide detailed information on the facilities, equipment, and procedures to be used, and discuss the effect of proposed operations on public health and safety. This information is used by NRC staff to determine whether the proposed activities will meet the applicable regulatory requirements, and thus be protective of public health and safety. General licensing provisions are described in 10 CFR Part 2, Subpart A, Procedures for Issuance, Amendment, Transfer, or Renewal of a License.

Introduction

The purpose of this Yucca Mountain Review Plan (YMRP) is to provide the staff in the Office of Nuclear Material Safety and Safeguards with guidance on the review of the license application for a HLW disposal facility. Information in this YMRP will be used by the Nuclear Material Safety and Safeguards staff in the review of applications for new facilities, renewals, and amendments. Throughout the remainder of this YMRP, "application" is synonymous with license application or amendment to either the application itself, or an amendment to the construction authorization or license if either are issued. The principal purpose of any review plan is to ensure a consistent quality and uniformity in NRC staff reviews. Although there is only one application for a potential repository, use of this YMRP will begin now in the prelicensing consultative phase of the program. This will allow NRC staff to provide prelicensing consultation consistent with what is needed to make a determination in a licensing review. Also, the NRC will use this YMRP in informing the NRC's sufficiency comments on any Site Recommendation Consideration Report to the President for the same reason that is, ensure the NRC sufficiency comments are within the regulatory mission of NRC. Each YMRP section provides guidance on what is to be reviewed, the review basis, how the staff review is to be accomplished, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding the applicable sections in 10 CFR Part 63.

This YMRP is intended to cover only those aspects of the NRC regulatory mission that are related to the licensing of a HLW disposal facility. As such, the YMRP helps focus the staff review on determining if a facility can be constructed and operated in compliance with the applicable NRC regulations. The YMRP is also intended to make information about regulatory matters widely available and to improve communications and understanding of the staff review process by DOE, interested members of the public, the State of Nevada, affected units of local governments and Indian tribes, and other stakeholders. For amendments, the focus of the review should be on the changes proposed in the amendment. Reviewers should not review other previously accepted actions if they are not part of the amendment unless the review of the amendment package identifies problems with other aspects of facility operation.

It is important to note that the acceptance criteria laid out in this YMRP are for the guidance of Nuclear Material Safety and Safeguards staff responsible for the review of applications of a HLW repository at the YM. Review plans are not substitutes for the Commission's regulations, and compliance with the YMRP is not required. Methods and solutions different from those set out in the YMRP will be acceptable if DOE provides a basis for the findings requisite to the issuance or continuance of a license by NRC. However, to the extent practical, the staff has made the YMRP performance-based. This, coupled with the risk-informed regulations, helps ensure that the NRC review is focused on those aspects most important to the safety of any repository, which still affords DOE flexibility in how it chooses to meet the risk-informed regulation. It is important to note that although significant focus was placed on developing a performance-based YMRP, the staff also needed to balance that against having a review plan with sufficient detail to support the necessary conclusions. Acceptance criteria that are too general provide no guidance beyond what is specified in a risk-informed, performance-based (RIPB) rule, and thus, will make this review plan less useful, especially given the first-of-a-kind facility to be reviewed and the mandatory 3-year review schedule. The licensing review will use the YMRP in a flexible way. The scope of the review will be adjusted to the safety strategy adopted by the DOE. This approach is consistent with NRC policy regarding RIPB regulations (NRC, 1999a).

1.1 CONDUCT OF THE YUCCA MOUNTAIN LICENSING REVIEW

1.1.1 Licensing Review Philosophy

Since the Atomic Energy Act of 1954 was passed, the Commission has been engaged in a continuing process of interpreting and applying the agency's basic responsibilities to protect public health and safety, assure the common defense and security, minimize danger to life or property, and provide adequate protection. These terms are not defined in the Atomic Energy Act of 1954, nor are they self-explanatory. The underlying regulatory philosophy used by NRC in fulfilling its regulatory mission can be found in the NRC Strategic Plan[1] in the discussion of licensee responsibility, which states:

> "LICENSEE RESPONSIBILITY embodies the principle that, although the NRC is responsible for developing and enforcing the standards governing the use of nuclear installations and materials, *it is the licensee who bears the primary responsibility for conducting those activities safely. The NRC's role is not to monitor all licensee activities but to oversee and audit them* [emphasis added]. This allows the agency to focus its inspection, licensing, and other activities on those areas where the need, and the likely safety and safeguards benefit, is [sic] greatest."

Consequently, the safe operation of any nuclear facility is the responsibility of the licensee. This philosophy is an important foundation for how NRC staff conducts its reviews in general, and streamlined licensing reviews in particular. Streamlining begins with a recognition of NRC's regulatory role in relation to its licensees (i.e., that licensees have the primary responsibility for ensuring the safety of nuclear facilities).

The following three principles are important in implementing the NRC regulatory mission:

- NRC does not select sites or designs or participate with licensees or applicants in selecting proposed sites or designs. (However, the NWPA requires prelicensing consultation between NRC and DOE within specific constraints for the HLW program.)

- NRC's role is not to monitor all licensee activities but to oversee and audit them. The NRC should evaluate whether a license application meets the applicable regulations based on a review of what is in the application. Reviews using staff audit calculations should be performed in very limited situations, such as where there are unique proposals involving new methods or assumptions. Otherwise, the NRC staff should review the application to ensure that assumptions are justified, methods used are acceptable and applicable over the range presented, models are properly applied, and

[1] Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1614, "FY2000–2005 Strategic Plan: Draft for Comment." NRC: Washington, DC. August 2, 1999.

results are acceptable. Staff can and should do quick, bounding calculations and performance assessments, and confirmatory analyses using process-level models; however, in-depth, detailed analyses can be limited to a very few applications. Figure 1-1 shows the relationship of the level of detail to licensing reviews and inspections during the preclosure period.

- The three outcomes available to the NRC at the conclusion of a licensing review are: (i) grant the application, (ii) grant the application subject to conditions agreed upon by the licensee, or (iii) deny the application. Other than rejecting an applicant or licensee proposal, NRC has no power to compel a licensee to come forward or to require a licensee to prepare a different proposal.

The NRC regulatory role in any licensing action is to apply the applicable regulations and guidance, and to review applications for proposed actions to determine if compliance with regulations has been achieved. The burden of proof is on the applicant or licensee to show that the proposed action is safe, to demonstrate that regulations are met, and to ensure continued compliance with the regulations.

In conducting its reviews, the NRC is evaluating whether there is a demonstration that an applicant's proposed approach meets the codified requirements, not seeking scientific precision (i.e., having complete understanding and answers for all issues that could be raised concerning a proposal, including those not related to health and safety). The NRC staff should examine whether applicant and licensee proposals are acceptable. If a proposal meets the applicable regulations, the NRC staff has no basis for requiring something different or additional. To do so would be imposing a requirement on a licensee beyond what is required in the regulations. Imposing specific requirements on a licensee, consistent with the regulation, is done through the issuance of an order with hearing rights according to 10 CFR Part 2, subpart L.

In no instance should a reviewer determine that alternatives that are less protective than those proposed by the applicant are acceptable. NRC staff should submit requests for additional information when more information is needed to justify a proposal. In the HLW program, it is appropriate to inform DOE during prelicensing meetings when regulatory requirements are at risk of not being met. Also, as noted above, the NRC staff's job is to determine if DOE's proposal meets the applicable regulation.

1.1.2 Streamlining and Principles of Good Regulation

Streamlining the licensing process is consistent with the Commission's Principles of Good Regulation (NRC, 1999b). Streamlining is also necessary if the schedule and milestones

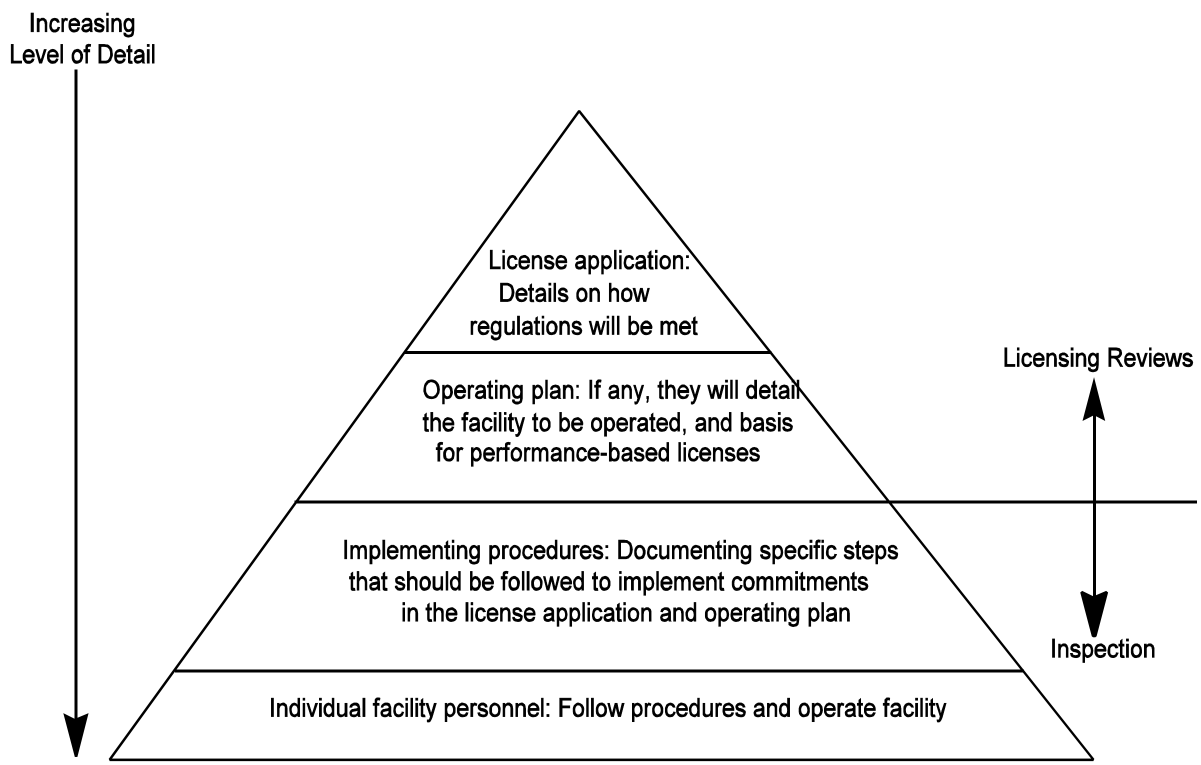

Figure 1-1. Schematic of Nuclear Regulatory Commission licensing and inspection process and applicability to licensing documents

are to be met. The following excerpts from these principles are relevant for improving the efficiency of licensing reviews:

- "EFFICIENT. The American taxpayer, the rate-paying consumer, and licensees are all entitled to the best possible management and administration of regulatory activities…

  Regulatory activities should be consistent with the degree of risk reduction they achieve. Where several effective alternatives are available, the option which minimizes the use of resources should be adopted. Regulatory decisions should be made without undue delay."

- "CLEAR…There should be a clear nexus between regulations and agency goals and objectives whether explicitly or implicitly stated. Agency positions (e.g., requests for additional information) should be readily understood and easily applied."

- "RELIABLE…Regulatory actions should always be fully consistent with written regulations and should be promptly, fairly, and decisively administered so as to lend stability to the nuclear operational and planning processes." (NRC, 1999b)

1.1.3 Approach to Reviews

A project manager will be assigned as the primary point-of-contact for all licensing-related communications with DOE. The project manager will arrange and chair pre-application meetings with the applicant. The project manager is responsible for written communications with DOE. The project manager, in conjunction with the associated technical reviewers, will prepare general correspondence, requests for additional information, the safety evaluation report, and any resulting license. The project manager will also ensure all correspondence is docketed.

The YMRP provides guidance to the Office of Nuclear Material Safety and Safeguards staff reviewers and indirectly provides guidance to DOE on the content of the license application. The YMRP objectives are to summarize the technical methods acceptable for meeting the regulatory requirements and to describe the procedures by which the Office of Nuclear Material Safety and Safeguards staff determines that these requirements have been satisfied. The YMRP assists in ensuring the quality and consistency of staff reviews. Deviations from use of the YMRP may be approved on a case-by-case basis by the respective Branch Chief.

Several key elements or characteristics are considered necessary for effective streamlining of the licensing review process from both time-efficiency and regulatory-acceptability perspectives, particularly considering that the general timing of the licensing action is defined in section 114(d) of the NWPA, as amended, which specifies that the Commission shall issue a final decision regarding issuance of a construction authorization within 3 years of DOE's application, with a provision for a 1-year extension if requested by NRC and approved.

These elements and characteristics include:

- Empowered reviewers

  Reviewers are given the freedom, within the NRC regulatory framework, to control the conduct of the review and to make licensing decisions without undue delay. Reviewers are able to exercise a high degree of independence to work toward timely resolution of technical issues and to complete licensing decisions in a period of time that meets the applicant's schedule constraints while ensuring that the licensing review is thorough.

- Defined goals

  Regulations define the goals for achieving safety. These goals are to ensure the safety, efficiency, and dependability of NRC licensing actions. Regulations form the basis for all aspects of the licensing review, including requests for additional information, safety evaluation reports, and environmental reviews. Licensing decisions are based on reasonable assurance of no undue risk to public health, safety, or the environment.

- Control over requests for additional information

  Agency positions should be readily understood by licensees, and should be consistent with written regulations. Preliminary safety evaluation reports should be developed early in the review process to focus any needs for additional information and to assure that all technical areas of concern are adequately addressed by the applicant. The goal of any licensing review is for no requests for additional information; however, if additional information is needed, the requests for additional information should be limited to one round. The requests should be concise, focused, and clear in defining the information that is required. If a second round or more of requests for additional information is needed, then division management approval should be obtained.

- Defined rules of engagement

  NRC review schedules and the expectations of timely and high quality DOE response should be defined and agreed upon by both parties. DOE will be informed regarding how its application will be treated and the streamlined licensing program will be explained prior to beginning the licensing review.

- Use of licensing review teams

  Multidisciplinary review teams will be formed to conduct simultaneous reviews of the various technical areas of DOE's license application using the YMRP.

- Discipline

  Procedures for streamlining provide discipline for an improved licensing process and for the prompt resolution of technical issues. Reviewers should not enter into interrogatories on obviously unacceptable proposals. If issues cannot be resolved in a timely manner, they must be elevated to higher management levels within the NRC and DOE.

- Early meetings

  Regulatory decisions should be made without undue delay and should be promptly announced. Early meetings contribute to an understanding of NRC positions, and help to clarify the information that is needed to resolve issues. Meetings with DOE should be held early in the review process to discuss preliminary findings and identified issues

Four primary milestones must be completed in conducting an effective review of DOE's license application. These milestones and their objectives are:

- Completion of the acceptance review

  The acceptance review determines the completeness of DOE's submitted materials, whether sufficient information is provided to support a detailed review, and the schedule for subsequent milestones. The procedures for conducting an acceptance review are presented in chapter 2 of the YMRP.

- Conduct of the detailed review

  The detailed review determines the safety of the proposed action, based on technical reviews of docketed DOE information and demonstrations of compliance with regulatory requirements.

- Preparation of requests for additional information

  Requests for additional information document insufficient or inadequate information submitted by DOE and communicate staff requests for additional information requirements for resolution of the identified deficiencies.

- Preparation of a safety evaluation report

  The safety evaluation report communicates the staff position on the safety acceptability of the DOE license application and documents the basis for the subsequent licensing action.

Completion of these milestones is generally sequential; however, the milestones are interdependent. For example, safety evaluation report preparation should be initiated in a preliminary form during the early stages of the detailed review. The preliminary safety evaluation report should follow the YMRP structure and be linked directly to applicable regulations. This allows the reviewers to focus on significant safety issues and reduces the potential for significant issues going unaddressed during subsequent milestones. Any deficiency identified during the detailed review can be documented and highlighted in the preliminary safety evaluation report, along with an identification of the information required to address the deficiency. Any deficiencies documented in the preliminary safety evaluation report constitute the foundation for the requests for additional information. The goal of conducting the detailed review in this manner is to limit the requests for additional information to one round.

Clear and early communication of potential problems or deficiencies is crucial for effective completion of the licensing review and is required by the NWPA. Consistent with requirements for public involvement, reviewers have been empowered to initiate early communication with DOE using teleconferences or videoconferences as means for verifying the staff's understanding of the information in the license application and determining which potential issues could be resolved by DOE supplying additional information. Meetings may be conducted, if appropriate, to facilitate understanding of issues. Meetings with DOE are open to the public and notice must be given in the Federal Register.

Early communication with DOE should also include discussion and agreement on a schedule for subsequent milestones in the review process. This discussion and agreement constitutes the official “rules of engagement” for the remaining phases of the licensing action and will be communicated in writing at the completion of the acceptance review. The consequences of not meeting the agreed upon schedule will be clearly communicated.

Empowerment of reviewers also requires that reviewers work with a high degree of independence and that issues be communicated to the appropriate DOE management level to assure timely resolution. Reviewers should be able to conduct an independent review that complies with programmatic needs and regulatory requirements with little management involvement.

If reviewers find that timely resolution is not being achieved even after contact with DOE management, NRC management should be informed. This helps ensure that NRC management is responsive to the issues and is focused on the status of the review. All requests for additional information, schedule agreements, and DOE responses must be communicated in writing to eliminate potential misunderstandings, provide an official record of staff/DOE interactions, and document DOE commitments. Written communications should be in a style and level of technical detail that can be understood by an informed member of the general public. A guideline for determining whether a document is targeted to an informed member of the public is to ask, “Could this document be read and understood by a high school graduate who has taken chemistry, mathematics, and physics”? Issuing documents that are difficult to read and understand does not promote effective and timely licensing decisions.

1.1.4 Format and Content of Documents

Correspondence and documents for each of the licensing review milestones should be logically organized and contain adequate information to convey NRC's position and requirements simply, clearly, and concisely. Procedures for conducting and documenting the acceptance review are presented in chapter 2 of the YMRP. Requests for additional information should be focused, brief, and clear. A request for additional information should include three parts:

- A statement of the issue

  This presents a summary of the identified deficiency and the regulatory requirement.

- A discussion of the basis for the information request

  This provides a summary of the additional information or response that is required and an explanation of why the existing information is inadequate.

- The action needed to resolve the issue

  This defines the information needed to address the deficiency without specifying how DOE is to obtain the information. The staff must be careful, when describing the action needed, not to assume DOE's responsibility to make and then defend its safety case.

Requests for additional information related to the technical adequacy of the license application should state all relevant problems and issues to be resolved prior to approval in a manner that is clear, concise, and consistent with the regulations and good engineering practice. A request for additional information is considered primarily an exchange through which the staff elicits the information necessary for it to determine if the applicant has demonstrated compliance with the regulations. The NRC staff may provide further supporting information depending on the complexity of the request.

During the technical review, some requests for additional information may be related to an apparent failure to meet regulatory requirements. In this case, the request for additional information should identify the specific section of the regulations, or other supporting documents [e.g., regulatory guides, standard review plans, NRC technical reports, American Society of Mechanical Engineers (ASME)/American Society for Testing and Materials (ASTM) codes, or techniques accepted by the scientific community] that relate to the issue. In this type of item, it is expected that supporting information will be provided both from a technical and a regulatory perspective.

Requests for additional information should be numbered sequentially, with the numbering for an individual request for additional information remaining constant through the course of the licensing review. The cover letter transmitting the requests for additional information will include a schedule for the applicant to provide responses and the dates of the remaining milestones. The letter will also reiterate the statement from the acceptance review that failure to respond within the specified time frame may be grounds for denial of the application, in accordance with 10 CFR 2.108(a).

The content of the safety evaluation report will be based on the guidance provided in the YMRP. If there are limits and restrictions imposed as a condition of approval and agreed to by DOE, they will be specified as conditions or technical specifications in the safety evaluation report and the license. The technical reviewer should notify the licensing project manager as soon as practical when potential license conditions are identified. The format for the safety evaluation report will follow the structure of the YMRP. The safety evaluation report will describe what information the staff reviewed, provide the technical basis for the staff conclusion regarding compliance, and state an evaluation finding. It is expected that substantial information from NRC issue resolution status reports will be incorporated in the safety evaluation report. The findings that have been made as a result of the detailed review will be stated in the safety evaluation report at the conclusion of each section. If there are limiting conditions that will be imposed, they will be highlighted for inclusion in the license. In all cases, the limiting conditions that are enumerated in the license will be identified in the safety evaluation report.

1.2 GENERAL REVIEW PROCEDURE

A licensing review is not intended to be a detailed evaluation of all aspects of facility operations. Specific information about implementation of the program outlined in an application is obtained through NRC review of procedures and operations done as part of the inspection function. A definition of the differences between licensing reviews and inspections is shown in figure 1-1. If a positive determination on a construction authorization or both construction authorization and License is made, changes to existing licensed activities and conditions require the issuance of an appropriate license amendment. An application for such an amendment should describe the proposed changes in detail, and should discuss the likely consequences of any environmental and health and safety impacts. Amendment requests should be reviewed using the appropriate sections of this document for guidance.

In conducting any review, the staff will rely upon the streamlined approach described in section 1.1 to ensure the efficient and effective use of resources. This streamlined approach will involve preparing a draft safety evaluation report with gaps where DOE has not provided sufficient information to make a regulatory conclusion. These gaps will then serve as the basis for the staff's requests for additional information. As needed, the NRC staff and DOE will interact on the response to the questions through either conference calls or public meetings. These interactions should help ensure that DOE responds to the requests for additional information in as complete as manner as possible, and that the responses do not result in additional requests for additional information. This process should allow the staff to conduct its review in a manner that should limit a majority of its review to one round of requests for additional information. While DOE is addressing the requests for additional information, the staff may publish the draft safety evaluation report as the safety evaluation report to allow for the hearing to begin on those issues where the staff has reached a regulatory conclusion. This should allow the Atomic Safety and Licensing Board to begin to address hearing issues as early in the process as possible.

The steps of the application review are described in the following sections.

1.2.1 Acceptance Review Objectives

The staff shall conduct an acceptance review of the application to determine the completeness of the information submitted. This review requires a comparison of the submitted information to the information specified in 10 CFR 63.21. The application will be considered complete for docketing if the information provided is complete, reflects an adequate reconnaissance and physical examination of the regional and site conditions, and provides appropriate analyses and design information to demonstrate that the applicable acceptance criteria will be met. The staff shall complete the acceptance review and transmit the results to the applicant within three months of the receipt of the application along with a projected schedule for the remainder of the review. In this transmittal, the staff shall identify any additional information needed to make the application complete. Detailed technical questions, although not required, can be included if they are identified during the acceptance review.

1.2.2 Detailed Review Objectives

Following completion of the acceptance review, the staff shall conduct a detailed technical review of the application. The results of this review and the basis for acceptance or denial of the requested licensing action are documented by the NRC staff in its safety evaluation report. Based on the mandatory time frame given in the NWPA, the NRC staff will conclude its review (including the acceptance review) in 18 months following receipt of the application. During the course of this 18-month review, the staff will publish its safety evaluation report, and possibly one or more supplements. As the NRC staff review is conducted, the safety evaluation report and supplements will provide the staff conclusions of its reviews along with open items, confirmatory items, and license conditions.

Open items are items that remain outstanding at the time of publication of the safety evaluation report. For these items, the staff has not completed its review and reached a final position. They, therefore, are considered open. The staff review of these items needs to be complete prior to a decision on issuance of a construction authorization or License.

In the staff review, those items that are essentially resolved to the staff’s satisfaction, but for which certain confirmatory information has not yet been received, are called confirmatory items. In these instances DOE may have committed to provide confirmatory information. The staff would need such information before it could close the open item. Unlike open items, not all confirmatory items will need to be resolved before licensing. Some may require information from construction activities before they can be closed. The staff will track these items through its inspection process.

Finally, the last category of items from the staff’s review will be called license conditions. These items will be incorporated into the construction authorization or License, if either are issued. These conditions are what the staff believes are needed to ensure the applicable requirements are met during facility operation. A license condition may be in the form of a condition in the body of the construction authorization or License, or an operating condition placed in the Technical Specifications, which outline the operational limits of the facility, appended to any License, if one is issued. It is important to note that any license condition must be based on a commitment made by DOE in its application. The NRC staff cannot unilaterally impose a condition on DOE without first getting a DOE commitment to such a condition. For the staff to impose any condition on DOE requires an order under 10 CFR Part 2, Subpart B, Procedures for Imposing Requirements by Order, or for Modification, Suspension, or Revocation of a License, or for Imposing Civil Penalties.

1.3 DEVELOPING A RISK-INFORMED, PERFORMANCE-BASED YUCCA MOUNTAIN REVIEW PLAN

The YMRP incorporates the following four principles:

- NRC defends its licensing decision, while DOE defends its safety case in the YM license application.

- 10 CFR Part 63, an RIPB and site-specific rule, will be implemented using an RIPB and site-specific review plan.

- The YMRP will be consistent with the applicable regulations and the review that the staff needs to complete to make the necessary findings on safety.

- The YMRP incorporates the more than 15 years of knowledge gained about the YM site and design during the prelicensing period and will avoid the imposition of unnecessarily prescriptive acceptance criteria.

To support review of the DOE safety analysis report (SAR), these principles are reflected in five major YMRP sections: (i) repository safety prior to permanent closure; (ii) repository safety after permanent closure; (iii) research and development program to resolve safety questions, (iv) performance confirmation plan, and (v) administrative and programmatic requirements. Subordinate chapters include this introduction, a chapter providing guidance for the conduct of the acceptance review, and a chapter that supports review of compliance with general information requirements in 10 CFR Part 63. The structure of the YMRP is presented in figure 1-2.

The preclosure and postclosure safety reviews will focus on whether the DOE SAR demonstrates, with reasonable assurance, that the corresponding performance objectives at 10 CFR Part 63 will be met. NRC staff is using a total system approach for both the preclosure and postclosure safety reviews that takes advantage of the knowledge of the site and design that has accumulated during the prelicensing period and the rapid growth in preclosure safety analysis (PCSA) and performance assessment capabilities. These improvements in capability include the results of performance assessment work by NRC and industry, and reviews of DOE

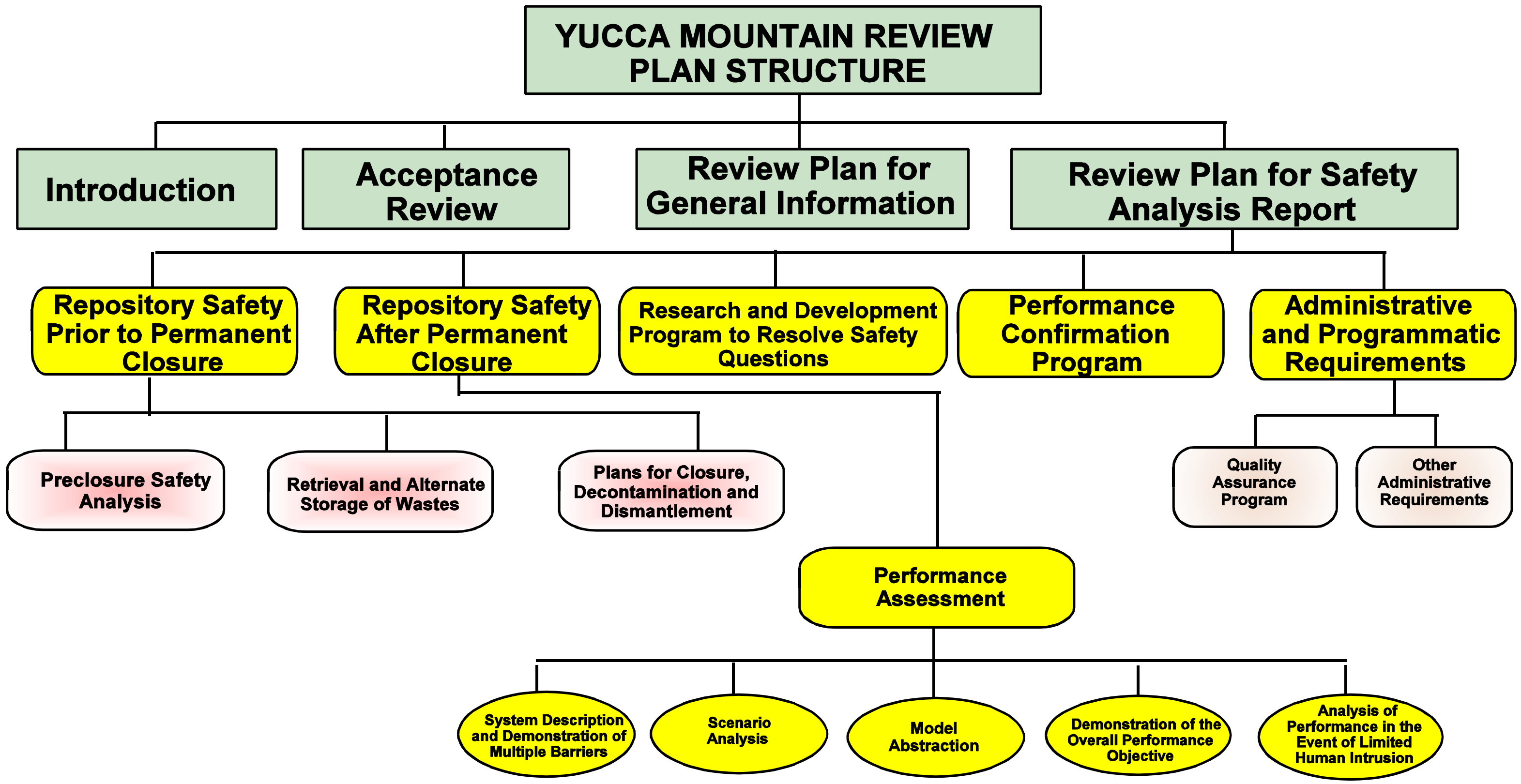

Figure 1-2. **Structure of the Yucca Mountain Review Plan**

performance assessments for YM. This total system approach facilitates integration of the technical disciplines required to review the YM license application. The YMRP uses existing NRC guidance from other regulatory programs that is applicable to the construction and operation of a geologic repository, modifying it as necessary for consistency with the RIPB philosophy. The approaches used to develop each of the three major YMRP sections are described in the following six subsections.

Chapter 2, Acceptance Review, provides the procedure for conducting the acceptance review of the license application. RIPB principles are not incorporated. The review verifies only that the information in the license application is complete, and therefore does not require an RIPB approach.

1.3.1 Developing a Risk-Informed, Performance-Based Review Plan for General Information

Any license application to construct a geologic repository at YM, submitted under 10 CFR Part 63, is to contain General Information, a SAR, and a final EIS.

Chapter 3, General Information, reviews the requirements specified in 10 CFR 63.21(b). The material to be reviewed is generally informational in nature, with the more detailed technical discussions and descriptions found elsewhere in the SAR section of the license application. There are five sections in chapter 3, and the extent to which each of these sections incorporates RIPB principles varies.

Section 3.1, General Description, provides for review of a general description of the GROA including its major structures, systems, and components (SSCs). The material in this section is generally informational in nature, comparable to that typically found in an executive summary, and no detailed technical analysis is required by the reviewer. The detailed review of information covered by these subjects will be conducted in other sections of the YMRP. Moreover, no performance objectives are addressed in this section of the license application. Consequently, it is neither appropriate nor meaningful to incorporate RIPB principles into this section of the YMRP.

Section 3.2, Proposed Schedules for Construction, Receipt, and Emplacement of Waste, provides for review of general schedules for various phases of repository construction and operation. Again, the material to be reviewed is informational in nature, and no detailed technical analysis is required by the reviewer. Moreover, no performance objectives are addressed in this section of the license application. Consequently, it is neither appropriate nor meaningful to incorporate RIPB principles into this section of the YMRP.

Section 3.3, Physical Protection Plan, provides for a review to determine with reasonable assurance that DOE has committed to having an adequate physical protection system. The system must provide assurance that activities involving HLW do not constitute an unreasonable risk to the public health and safety. General and specific performance objectives for the DOE to meet are listed in this section. The physical protection system should be designed to protect against a loss of control of the GROA that could be sufficient to cause radiation exposure exceeding the dose defined in 10 CFR 72.106. Physical protection requirements for HLW at a GROA are codified under 10 CFR 73.51.

Section 3.4 provides for a review of the Material Control and Accounting Program plan submitted by DOE. The plan describes how the system will be established, implemented, and maintained to ensure that it is adequate to protect against, detect, and respond to the loss of HLW. Material control and accounting requirements for HLW are required by 10 CFR 63.21(b)(4) and stipulated in 10 CFR 63.78. This section provides for a RIPB review of the DOE program and its capability to meet the requirement in 10 CFR 63.78. High priority will be given to the overall system detection and resolution capabilities at an implementation level.

Section 3.5, Description of Site Characterization Work, provides for review of an overview description of the site characterization work conducted up to the time of license application, and the results of that work, necessary to support the license application. The material to be reviewed is generally informational in nature and is intended to place the GROA in the context of the YM site and environs. Although there are no performance objectives addressed in this section of the license application, the information summaries provided in this section support the detailed safety reviews conducted in the preclosure and postclosure safety evaluation sections of the YMRP. Therefore, the adequacy and sufficiency of site characterization activities and the resulting information will be judged not in this section of the license application, but in the context of the compliance demonstrations and supporting technical bases provided in the SAR section of the license application. Consequently, it is neither appropriate nor meaningful to incorporate RIPB principles into this section of the YMRP.

1.3.2 Developing a Risk-Informed, Performance-Based Review Plan for Preclosure Safety Evaluation

Section 4.1.1, Preclosure Safety Analysis, provides for review of compliance with the performance objectives in 10 CFR Part 63 which are based on permissible levels of doses to workers and the public established on the basis of acceptable levels of risk.
10 CFR 63.21(c)(5) requires a PCSA of the GROA for the period before permanent closure to ensure compliance with the performance objectives. PCSA is a systematic examination of the site; the design; the potential hazards and initiating events and their consequences; and the potential dose consequences to workers and the public. PCSA considers the probability of potential hazards taking into account the range of uncertainty associated with the data that support the probability calculations. Design Basis Events are defined based on well-established (discipline-specific) methodologies which allow a combination of probabilistic and deterministic estimates. Sequences of human-induced and natural events are used as inputs to calculate consequences of potential failures of SSCs in terms of doses to workers and the public. These calculated doses are compared to allowable doses in establishing the importance of SSCs. The SSCs that must be functional to comply with the performance objective dose limits are identified as SSCs important to safety. PCSA also identifies and describes the controls that are relied on to prevent potential event sequences from occurring or to mitigate their consequences, and identifies measures taken to ensure the availability of the safety systems. The end products of the PCSA are a list of SSCs important to safety (also known as the Q-List) and the associated design criteria and technical specifications necessary to keep them

functional and to meet the performance objectives. The SSCs important to safety may also be further categorized based on relative safety significance using risk information from the PCSA. This distinction may be used to focus the requirement of design details and the application of quality assurance controls through a graded quality assurance program. DOE plans on categorizing SSCs into three bins based on safety/risk significance and implementing a graded quality assurance program commensurate with safety significance. Accordingly, the YMRP will develop appropriate criteria to evaluate DOE's technical basis for categorizing SSCs and grading quality assurance requirements.

The staff review is focused on items that are determined by PCSA to be important to safety. The rigor of review for the design items on the Q-List, and the level of attention to detail depend on relative safety significance. No prescriptive design criteria are imposed in the YMRP, because 10 CFR Part 63 allows DOE to develop the design criteria and demonstrate their appropriateness. Thus, DOE has flexibility to use any codes, standards, and methodologies it demonstrates to be applicable and appropriate. The performance-based review process in the YMRP focuses on determining compliance with performance objectives as demonstrated by DOE's PCSA. In summary, the review philosophy is based on the following premises: (i) DOE must demonstrate, through its PCSA that the repository will be designed, constructed, and operated to meet the specified exposure limits (performance objectives) throughout the preclosure period; (ii) the staff must focus the review on the design of the SSCs important to safety in the context of the design's ability to meet the performance objectives; and finally, (iii) the staff resources will be focused proportionately on the inspection and review of high risk significant SSCs important to safety.

Section 4.1.2, Plans for Retrieval and Alternate Storage of Radioactive Wastes, contains no performance objectives nor are any specified in 10 CFR Part 63. Review methods (RMs) and acceptance criteria (ACs) were developed from the associated regulatory requirements in 10 CFR Part 63, with a specific emphasis on allowing DOE flexibility in demonstrating compliance.

Section 4.1.3, Plans for Permanent Closure and Decontamination, or Decontamination and Dismantlement of Surface Facilities, identifies two areas of review: (i) the description of design considerations intended to facilitate closure and decontamination, and (ii) the plans for permanent closure and decontamination. The acceptance criteria do not prescribe additional requirements other than a description of the features incorporated into the design that may facilitate closure. The section makes reference to the Nuclear Material Safety and Safeguards decommissioning plans, which are being developed to be consistent with RIPB regulation only to the extent that DOE may have information related to closure and decontamination available at the time of license application submittal. The YMRP explicitly acknowledges that information submitted by DOE in the license application regarding closure and decontamination will be preliminary.

1.3.3 Developing a Risk-Informed, Performance-Based Review Plan for Postclosure Safety Evaluation

Section 4.2, Repository Safety After Permanent Closure, provides for an RIPB review of DOE's performance assessment. The performance assessment quantifies repository performance to demonstrate compliance with the postclosure performance objectives at 10 CFR 63.113. The DOE performance assessment is a systematic analysis that answers the risk triplet questions: what can happen?; how likely is it to happen?; and what are the consequences? The YM performance assessment is a sophisticated analysis that involves various complex considerations and evaluations. Examples include evolution of the natural environment, degradation of engineered barriers over a 10,000-year period, and disruptive events such as seismicity and igneous activity. The staff will also consider the technical support for models and parameters of the performance assessment based on detailed process models, laboratory and field experiments, and natural analogs. Because the performance assessment encompasses such a broad range of issues, the staff will use risk information throughout the review process. Using risk information will ensure the review focuses on those items most important to performance.

Section 4.2.1 requires the staff to apply risk information throughout the review of the performance assessment. First, the staff reviews the barriers important to waste isolation in section 4.2.1.1. The DOE must identify the important barriers (engineered and natural) for the performance assessment, describe each barrier's capability, provide the technical basis for that capability, and describe the extent of reliance on each barrier in meeting the overall performance objective. This risk information includes DOE's understanding of each barrier's importance. Staff review of the DOE barrier analysis considers risk insights from previous performance assessments conducted for the YM site, detailed process-level modeling efforts, laboratory and field experiments, and natural analog studies. The result of this review is a staff understanding of each barrier's importance to waste isolation, which focuses the reviews conducted in Sections 4.2.1.2 (Scenario Analysis) and 4.2.1.3 (Model Abstraction).

Scenario analysis and model abstraction are key aspects of the performance assessment. The risk information drawn from the review of the multiple barriers section will direct the staff review to those topics within scenario analysis and model abstraction that are important to waste isolation. Section 4.2.1.2 provides the review methods and acceptance criteria for scenarios for both nominal and disruptive events. An acceptable scenario selection method includes identification and classification, screening, and construction of scenarios from the features events and processes considered at the YM site. Then, abstracted models used in the performance assessment for the retained scenarios will be reviewed. The performance assessment review focuses on the fourteen model abstractions in section 4.2.1.3. These model abstractions derived from those aspects of the engineered, geosphere, and biosphere subsystems shown to be most important to performance based on prior performance assessments, knowledge of site characteristics, and repository design. Figure 1-3 presents these model abstractions and their relation to subsystem components. The staff developed each of the 14 sections in substantial detail, allowing for a detailed review. However, it is

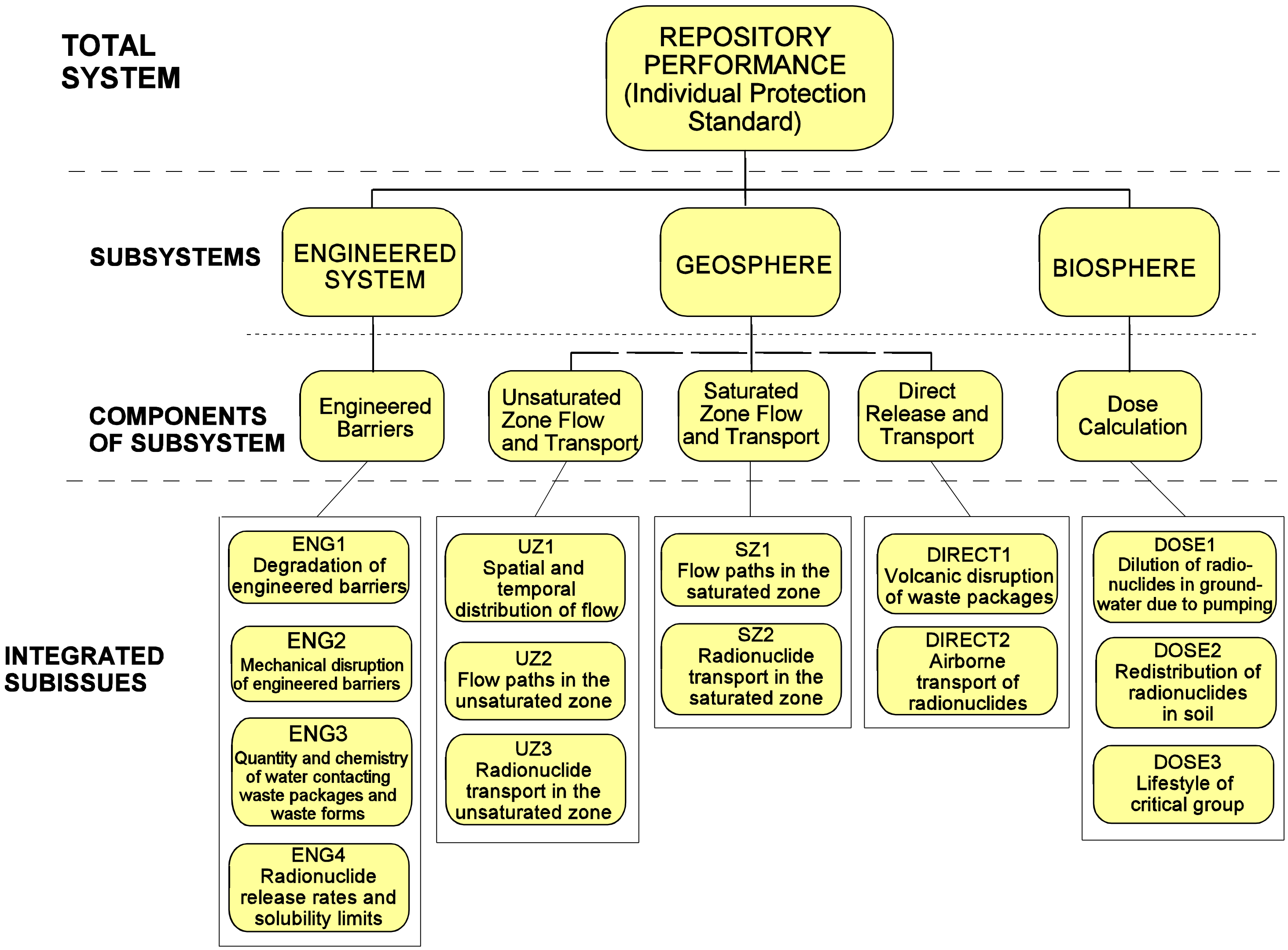

Figure 1-3. Components of Performance Assessment Review

unlikely that each of the abstractions will have the same risk significance. The staff will review the abstractions according to their risk significances determined in the multiple barrier review. Nevertheless, until DOE completes its safety case and the license application, the review plan sections dealing with model abstractions must remain flexible, and in substantial detail, so DOE will understand how NRC will review the abstractions. After the staff completes the review of scenarios and model abstractions, it will update, as necessary, its assessment of DOE's barrier analysis.

The staff will use 14 model abstraction sections (4.2.1.3) to determine compliance with 10 CFR Part 63.114(a). The abstractions consider the engineered, geosphere, and biosphere subsystems that may be important to performance. Important to performance means important to meeting the performance objective specified in 10 CFR Part 63.113, which is a radiation exposure limit. The risk of radiation health effects is the basis for the radiation exposure limit. The staff will focus its review to understand the importance to performance of the various assumptions, models, and data in the performance assessment. The staff will also focus it review to ensure the degree of technical support for models and data abstractions is appropriate for its contribution to risk. This means the staff will review each model abstraction to a detail level suitable to the degree the DOE relies on it to prove its safety case. The staff will be familiar with the DOE safety case because of the multiple barrier review (conducted using section 4.2.1.1). In the multiple barrier review, the staff will decide whether the supporting bases for the safety case adequately demonstrate the degree of reliance on various parts of the system. For example, if DOE relies on the unsaturated zone to provide significant delay (on the order of thousands of years) in the transport of radionuclides and/or radionuclide concentrations to the critical group, then the staff will perform a detailed review of this abstraction. However, if DOE shows that this abstraction has a minor impact on the delay (on the order of hundreds of years) of radionuclide transport to the critical group, then the staff will conduct a simplified review focusing on the bounding assumptions. The staff will use the review methods and acceptance criteria in these sections to decide whether the DOE properly characterized and factored the FEP's into the performance assessment. This is necessary to decide whether the DOE performance assessment is acceptable and complies with 10 CFR Part 63.114. The review methods and acceptance criteria the staff will use to evaluate compliance with the overall performance objective (a numerical standard) are in section 4.2.1.4.1 of the YMRP.

Section 4.2.1.4, Demonstration of the Overall Performance Objective, focuses on the role of the performance assessment to demonstrate that the overall performance objectives have been met with reasonable assurance. This is where the probability estimates from Scenario Analysis and consequence estimates from model abstraction are combined to form the risk estimate for the repository. It includes issues related to the calculation of the expected annual dose to the average member of the critical group and the consideration of parameter uncertainty, alternate conceptual models, and the results of a human-intrusion analysis.

1.3.4 Developing a Risk-Informed, Performance-Based Review Plan for the Research and Development Program to Resolve Safety Questions

Section 4.3 provides for a review of the research and development program for resolving safety questions. The program applies to SSCs important to safety and engineered or natural barriers important to waste isolation. The program identifies, describes, and discusses those safety features or components for which further technical information is required to confirm the adequacy of design. This section is performance-based because it focuses on those items which are most important to safety and waste isolation.

1.3.5 Developing a Risk-Informed, Performance-Based Review Plan for the Performance Confirmation Plan

Section 4.4 provides for a review of the performance confirmation program. The program is comprised of tests, experiments, and analyses conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives in subpart E (refer to 10 CFR 63.2). The need for a performance confirmation program is unique to the HLW program. This uniqueness reflects the uncertainties in estimating geologic repository performance over thousands of years. The bases for the acceptance criteria are the requirements for performance confirmation in 10 CFR Part 63, which are performance-based. Where suitable, the acceptance criteria are also risk-informed because performance confirmation focuses on those parameters and natural and engineered barriers already identified to be important to performance.

1.3.6 Development of the Administrative and Programmatic Requirements Section

This portion of the YMRP is the most difficult for which to implement an RIPB approach. No performance objectives are provided in 10 CFR Part 63 for this section. Existing NRC regulatory guidance and standard review plans were examined for examples of appropriate review methods and acceptance criteria that could be incorporated in the YMRP. However, some of these examples were greatly prescriptive, while others seemed inadequate based on our knowledge of expected repository operations and administrative programs. This situation is complicated by the unique nature of the HLW regulatory program and the lack of an operational history, or historical performance measure, such as are available for most other types of nuclear facilities. To the extent possible, acceptance criteria and review methods for this section of the YMRP are based on similar existing and successful NRC regulatory programs, considering expected operations and associated risks, while taking advantage of opportunities to omit prescriptive requirements, when appropriate.

The quality assurance section of the YMRP is risk-informed, explicitly as a result of allowing DOE to implement a graded quality assurance program. The review methods and acceptance criteria are written to either accommodate such a graded program or to support review of a nongraded program. The quality assurance section provides for quality assurance controls to be applied in a graded manner based on the safety/risk significance of the SSCs and the barriers important to safety or waste isolation. These quality assurance control provisions are intended to be applied to high safety/risk significant SSCs, and barriers and their related activities. DOE may propose reduced quality assurance requirements for low safety/risk significant SSCs, barriers, and their related activities. The quality assurance section also contains many review provisions for areas such as quality assurance for scientific investigations, software, and commercial-grade item dedication. The quality assurance section of the YMRP is performance based as a result of allowing DOE to concentrate its quality assurance activities on high safety/risk significant items and activities. 10 CFR Part 63 specifically requires that the quality assurance program be prescriptive by describing how the quality assurance requirement will be satisfied. The prescriptive requirements for the quality assurance program contained in this regulation are similar regulatory to requirements contained in 10 CFR Parts 50, 70, 71, and 72. Thus, the quality assurance section of the YMRP contains prescriptive review provisions that are intended to be applied to high safety/risk significant items and activities.

The other administrative and programmatic sections in the YMRP are nonprescriptive, providing flexible acceptance criteria and review methods and referring the reviewer to other NRC guidance documents, but not specifying the standards or practices DOE must use for compliance demonstration. Rather, these sections require DOE to: (i) identify any standards, programs, and procedures that will be used; (ii) demonstrate that those standards, programs, and procedures are appropriate; and (iii) commit to implement them properly. The acceptance criteria and review methods require the staff to evaluate the administrative and programmatic sections of DOE's license application based upon the validity and adequacy of the basis that DOE has presented in the application.

In developing this section of the YMRP, there has been a specific effort to implement an RIPB philosophy based on current NRC guidance. For example, Emergency Planning, Section 4.5.7 assesses several items which represent the frequency and consequence components of risk. Each acceptance criteria in Emergency Planning has measurable and inspectable performance requirements. Information provided in the administrative and programmatic sections is based, to the extent possible, on prelicensing interactions. This is especially true for quality assurance. In most cases; however, DOE has not committed to specific administrative and programmatic procedures, and the level of detail in the YMRP is minimal. NRC guidance is identified in the YMRP, but selection of the compliance demonstration approach is left to DOE.

1.4 COMPONENTS OF EACH REVIEW SECTION

Each YMRP section provides the complete procedures and acceptance criteria for all areas of review pertinent to that section. Because NRC is implementing an RIPB regulatory approach using risk insights, the staff reviewer may select and emphasize particular aspects from each YMRP section as appropriate. Consequently, in the review of the license application, the staff may not carry out in detail all of the review steps listed in each YMRP section. In some cases, the staff may rely upon a more detailed evaluation made in the prelicensing consultative phase of the program. Thus, the staff should be able to use the technical understanding and basis for issue resolution developed during prelicensing to help focus its review on areas where a more detailed, prelicensing consultative review was not done.

Each section of an NRC review plan typically contains areas of review, review methods, acceptance criteria, evaluation findings, and references.

Areas of Review Subsection

This subsection identifies the topical areas and defines the scope for the reviews. Having this scope in mind enables the reviewer to prepare for the review, including examining any technical or regulatory background material necessary to support the review.

Review Methods Subsection

The review methods provide the specific step-by-step procedures that the reviewer will use to assess compliance with regulatory requirements. The review methods are often technically specific, but their level of detail and complexity are determined by the particular regulatory requirements and, in the YMRP, by the significance of the topic to repository performance. Therefore, the individual review methods are RIPB.

Acceptance Criteria Subsection

This subsection delineates criteria that can be applied by the reviewer to determine the acceptability of the applicant compliance demonstration. The technical bases for these criteria have been derived from 10 CFR Part 63; NRC regulatory guides; general design criteria; codes and standards; branch technical positions; standard testing methods (e.g., ASTM standards); technical papers; and other similar sources. These sources typically include solutions and approaches previously determined to be acceptable by the staff for making compliance determinations for the specific area of review, or are based on the staff work from its first-of-a-kind reviews related to a HLW repository such as the postclosure performance assessment.

The acceptance criteria have been defined so that staff reviewers can use consistent and well-documented approaches from prelicensing consultation for review of the license application. Flexibility is provided to enable DOE to implement the type of operations appropriate for the GROA. DOE may take approaches to demonstrating compliance that are different from those presented in the YMRP as long as the staff can make the requisite decisions concerning compliance with the applicable regulations. However, DOE should recognize that, as is the case for all regulatory guidance, substantial staff time and effort have gone into the development of the review methods and acceptance criteria in the YMRP. Staff use of these criteria in its review is one of the important ways the NRC will use to meet the 3-year mandated deadline for completing the license review. Thus, if DOE proposes solutions and approaches to safety problems or safety-related design areas other than those described in the YMRP, it could result in longer review times and an increase in the number of NRC requests for additional information. The staff will consider proposals for other solutions and approaches on a generic basis, apart from a specific application, to avoid the impact of the additional review time for individual cases.

Evaluation Findings Subsection

This subsection presents general conclusions and findings of the staff that result from review of each area of the application as well as an identification of the applicable regulatory requirements. A conclusion is included in the safety evaluation report for each YMRP section. The safety evaluation report contains a description of the review; the basis for the staff findings, including aspects of the review selected or emphasized; where the facility design or the applicant programs deviate from the criteria stated in the YMRP; and the evaluation findings.

References Subsection

The references section of the review plan lists any references used in the development of the YMRP. Often, NRC review plans reference more detailed information to support review methods rather than reproducing detailed technical procedures or specifications within the review plan.

Yucca Mountain Review Plan Updates

The YMRP will be revised and updated periodically as the need arises to clarify the content or correct errors and to incorporate modifications approved by NRC management. A revision number and publication date are printed at a lower corner of each page of the YMRP. Since individual sections will be revised as needed, the revision numbers and dates may not be the same for all sections.

1.5 REFERENCES

National Research Council. *Technical Bases For Yucca Mountain Standards*. Washington DC: National Academy Press. 1995.

Nuclear Regulatory Commission (U.S.) (NRC). "Commission White Paper on Risk-Informed and Performance-Based Regulation." Washington, DC: NRC. March 11, 1999a.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1350, "Information Digest." 1999 Edition. Volume 10. NRC: Washington, DC. 1999b.

2 ACCEPTANCE REVIEW

2.1 DESCRIPTION AND PURPOSE OF ACCEPTANCE REVIEW

Our staff will do an acceptance review of the license application for construction authorization to check whether the information is complete. We will evaluate whether the information is sufficient to support a detailed review, and will assess the schedule for any later NRC milestones. The license application will be acceptable to docket if the information is complete in scope and detail about the site and engineering design. The acceptance review does not determine the technical adequacy of the submitted information.

We will send the results of the acceptance review, with a projected schedule for the rest of the review, to the DOE within 90 days of receiving the license application. This review period is consistent with streamlining plans for Division of Waste Management programs. We will document the acceptance review in a brief, one- to two-page letter recommending either acceptance to begin the detailed review or rejection. If the license application is acceptable for docketing, the letter will also set a schedule for the detailed technical review, including any intermediate milestones and the anticipated completion dates. The letter will contain a disclaimer stating that a request for additional information may result from the detailed technical review. The disclaimer will also note that the projected review schedule will depend on DOE supplying high-quality, timely responses to any request for additional information. The letter will inform DOE that failure to respond to a request for additional information in the specified period may be grounds to deny the application under 10 CFR 2.108(a) requirements. In this letter we will provide a request for additional information needed to make the application complete. Detailed technical questions are not required, but we may include them.

The acceptance review is the first screening of DOE's license application. The application must provide enough information, by inclusion or reference, to show that it meets the requirements of the regulations. If the license application does not meet this minimum standard, we will tell DOE that the application is not complete enough to conduct a detailed technical review. We would then give specific guidance on the corrective action. Accepting an incomplete license application for review will jeopardize the licensing review because of the potential for multiple requests for additional information and their attendant preparation and response time.

2.2 ACCEPTANCE REVIEW CHECKLIST

The staff will conduct the acceptance review using a checklist based on the structure of 10 CFR 63.21 (Content of Application). However, neither the DOE license application nor the YMRP will be organized strictly on this structure. Therefore, DOE will provide a table that relates the sections of the license application to the regulatory requirements in 10 CFR Part 63. The reviewer will also use this DOE table during the acceptance review.

To conduct the acceptance review, staff will use the extensive knowledge that we developed during prelicensing. The review will also evaluate whether DOE responded to NRC comments on the viability assessment, the site suitability report, and the draft EIS and its supplements. We will specifically compare the contents of the license application to the requirements in 10 CFR 63.21 (Content of Application). The acceptance review will include an assessment of the legibility of drawings, the general adequacy of information, any proprietary information, and obvious technical inadequacies. Most license application sections incorporate multidisciplinary input. Therefore, we will conduct acceptance reviews with teams of individuals from suitable disciplines. During the acceptance review, we will determine whether DOE has provided in sufficient scope and detail the following items which 10 CFR 63.21 describes. We provide a simple scale of acceptability to help the reviewers document their results.

- A general description of the proposed geologic repository at the YM site. This description will identify the GROA location, the general character of the proposed activities, and the basis for the Commission to exercise licensing authority.

  - ☐ Accept for Review
  - ☐ Accept, but Request for Additional Information Prepared
  - ☐ Reject, Inadequate to Support Detailed Review

- Proposed schedules to build, receive waste, and emplace wastes at the GROA.

  - ☐ Accept for Review
  - ☐ Accept, but Request for Additional Information Prepared
  - ☐ Reject, Inadequate to Support Detailed Review

- A description of the detailed security measures for the physical protection of HLW. This plan must include the design for physical protection, the licensee's safeguards contingency plan, and the training and qualification plan for the security organization. The plan must list tests, inspections, audits, and other means to show compliance.

  - ☐ Accept for Review
  - ☐ Accept, but Request for Additional Information Prepared
  - ☐ Reject, Inadequate to Support Detailed Review

- A description of the material control and accounting program.

  - ☐ Accept for Review
  - ☐ Accept, but Request for Additional Information Prepared
  - ☐ Reject, Inadequate to Support Detailed Review

- A description of work conducted to characterize the YM site.

  - ☐ Accept for Review

□ Accept, but Request for Additional Information Prepared

□ Reject, Inadequate to Support Detailed Review

- A description of the YM site, with appropriate attention to those FEPs of the site that might affect the design of the GROA and the performance of the geologic repository. The site description should include information about FEPs outside the site to the extent the information is relevant and material to safety or performance of the geologic repository. The site description should include:

  — Location of the GROA with respect to the site boundary;

  — Information about the geology, hydrology, and geochemistry of the site, including geomechanical properties and conditions of the host rock;

  — Information about the surface water hydrology, climatology, and meteorology of the site;

  — Information about the critical group's location and local human behaviors and characteristics as needed to select conceptual models and parameters used to define the reference biosphere and critical group.

  □ Accept for Review

  □ Accept, but Request for Additional Information Prepared

  □ Reject, Inadequate to Support Detailed Review

- Information relative to materials of construction of the GROA (including geologic media, general arrangement, and approximate dimensions), and codes and standards that DOE proposes to apply to the design and construction of the GROA.

  □ Accept for Review

  □ Accept, but Request for Additional Information Prepared

  □ Reject, Inadequate to Support Detailed Review

- A description and discussion of the various components of the GROA and the engineered barrier system including:

  — Dimensions, material properties, specifications, analytical and design methods used, and any applicable codes and standards;

  — Principal design criteria and their relationships to the postclosure performance objective; and

— Design bases and their relation to the principal design criteria.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of the kind, amount, and specifications of the radioactive material proposed for receipt and possession at the GROA.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A PCSA of the GROA for the period before permanent closure that assumes that operations will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the license application.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of the program for control and monitoring of radioactive effluents and occupational radiation exposures to maintain such effluents and exposures in accordance with the preclosure performance objectives.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of plans for retrieval and alternate storage of the radioactive wastes.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of design considerations that are intended to facilitate permanent closure and decontamination or decontamination and dismantlement of surface facilities.

□ Accept for Review

□ Accept, but Request for Additional Information Prepared

□ Reject, Inadequate to Support Detailed Review

- An assessment of the geologic repository's performance for the period after permanent closure including:

  — An assessment of the degree to which FEPs expected to materially affect compliance with postclosure performance objectives have been characterized and the extent to which they affect waste isolation. Investigations must extend from the surface to a depth sufficient to determine principal pathways for radionuclide migration. Specific FEPs must be investigated outside the site if they affect performance.

  — An assessment of the anticipated response of the geomechanical, hydrogeologic, and geochemical systems to the range of design thermal loadings, given the fracture patterns, other discontinuities, and heat transfer properties of the rock mass and groundwater.

  — A comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer containment and isolation of radioactive materials.

  — An analysis that demonstrates repository performance does not depend unduly on any single barrier.

  — An assessment of the ability of the proposed repository to limit radiological exposures in the event of limited human intrusion into the engineered barrier system.

  — An explanation of measures used to support models for performance assessments. These models should be supported using an appropriate combination of methods such as field tests, *in situ* tests, laboratory tests representative of field conditions, and natural analog studies.

□ Accept for Review

□ Accept, but Request for Additional Information Prepared

□ Reject, Inadequate to Support Detailed Review

- An identification of those SSCs of the geologic repository, both surface and subsurface, that require research and development to confirm the adequacy of design. For SSCs important to safety and for the engineered and natural barriers important to waste isolation, the license application should provide a detailed description of the programs designed to resolve safety questions. This should include a schedule showing when DOE would resolve these questions.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of the performance confirmation program.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- An identification and justification for selecting those variables, conditions, or other items that are determined to be probable subjects of license specifications.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- An explanation of how DOE used expert elicitation.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of the quality assurance program to be applied to the SSCs important to safety and to the engineered and natural barriers important to waste isolation, including a discussion of how the applicable requirements of 10 CFR 63.142 will be satisfied.

☐ Accept for Review

☐ Accept, but Request for Additional Information Prepared

☐ Reject, Inadequate to Support Detailed Review

- A description of the plan for responding to, and recovering from, radiological emergencies that may occur at any time before permanent closure and decontamination or decontamination and dismantlement of surface facilities.

- ☐ Accept for Review
- ☐ Accept, but Request for Additional Information Prepared
- ☐ Reject, Inadequate to Support Detailed Review

- Information concerning activities at the GROA including:

  — Organizational structure of DOE as it pertains to construction and operation of the GROA, including a description of any delegations of authority and assignments of responsibilities, whether in the form of regulations, administrative directives, contract provisions, or otherwise;

  — Identification of key positions that are assigned responsibility for safety at and operation of the GROA;

  — Personnel qualifications and training requirements;

  — Plans for startup activities and startup testing;

  — Plans for conduct of normal activities, including maintenance, surveillance, and periodic testing of SSCs of the GROA;

  — Plans for permanent closure and plans for the decontamination or decontamination and dismantlement of surface facilities; and

  — Plans to use the GROA for purposes other than disposal of radioactive wastes. The plans should include an analysis of the effects, if any, that such uses may have on the operation of SSCs important to safety and the engineered and natural barriers important to waste isolation.

- ☐ Accept for Review
- ☐ Accept, but Request for Additional Information Prepared
- ☐ Reject, Inadequate to Support Detailed Review

- A description of the program to be used to maintain records.

- ☐ Accept for Review
- ☐ Accept, but Request for Additional Information Prepared
- ☐ Reject, Inadequate to Support Detailed Review

Acceptance Review

- A description of the controls that DOE will apply to restrict access and to regulate land use at the YM site and adjacent areas. This should include a conceptual design of monuments that would be used to identify the site after permanent closure.

    - ☐ Accept for Review

    - ☐ Accept, but Request for Additional Information Prepared

    - ☐ Reject, Inadequate to Support Detailed Review

3 REVIEW PLAN FOR GENERAL INFORMATION

3.1 GENERAL DESCRIPTION

Review Responsibilities—High-Level Waste Branch

3.1.1 Areas of Review

This section reviews the General Information to be included in the license application to construct the proposed geologic repository at YM. Reviewers will evaluate the information required by10 CFR63.21(b)(1).

The General Information section of the license application is expected to contain a broad overview that describes the proposed geologic repository at YM, including its major SSCs, as well as a discussion of proposed GROA operations and activities. The level of detail presented should be similar to that in an "executive summary." The material to be reviewed is informational in nature, with the more detailed technical discussions and descriptions found elsewhere in the SAR section of the license application. Therefore, no detailed technical analysis of the information contained in this section of the YMRP is required. The detailed review of the information covered by these other technical subjects will be conducted under other sections of this review plan.

This review will address the following:

- A description of the location and facilities of SSCs of the GROA, both surface and subsurface;
- A discussion of the proposed GROA operations and activities; and ,
- The delineation of the statutory and regulatory basis for proposed geologic repository operations.

The General Information to be reviewed will be evaluated using the review methods and acceptance criteria found in sections 3.1.2 and 3.1.3, respectively, of the YMRP. In general, these review methods and acceptance criteria are based on well-established and accepted NRC regulatory activities. Because some of the information contained in this portion of the license application is informational in nature and may not concern performance-related issues, some of the review methods, used to evaluate this information may generally not be RIPB. In instances such as these, there will be no performance measures against which the review methods can be compared.

3.1.2 Review Methods

Performance Goal/Measure: There are none. The material to be reviewed in this section of the license application is informational in nature.

RM1 Location and Arrangement of SSCs of the GROA

Review Plan for General Information

Confirm that an accurate general description of the GROA has been provided by DOE. This general description, at a minimum, should include:

- A general discussion of the physical characteristics of the proposed repository site and environs critical to repository performance;
- Scaled drawings or maps showing the location of the GROA and its associated SSCs, including but not limited to, engineered barriers, roads and connecting transportation infrastructure, utility services, and natural and man-made boundaries;
- A summary of the major design features of the above- and below-ground SSCs, with a designation of whether they are temporary or permanent;
- Some GROA SSCs may be dismantled for the purposes of decommissioning and permanent closure;
- The identification and description of each major SSC of the GROA, including a definition of the purpose of each and a description of the interrelationships among these SSCs;
- A general discussion of the plans to restrict access to the GROA and to regulate land uses around the GROA (the detailed technical review of this information will take place in section 4.5.8 of the YMRP); and
- The identification and description of radiological and environmental monitoring instrumentation and activities, including DOE's plans for the mitigation of environmental impacts associated with the construction and operation of the proposed repository.
- This information should be consistent with DOE's Final Environmental Impact Statement for YM.

RM2 General Nature of the GROA Activities

The staff should confirm that a summary description of the proposed GROA operations has been provided by DOE. An acceptable summary description would include:

- Information on the types, kinds, and amounts of spent nuclear fuel (SNF) and other HLW to be disposed of at the proposed repository;
- Information on routine waste package receipt, handling, and emplacement operations (the detailed technical review of this information will take place in section 4.5.6 of the YMRP);
- Plans for the inspection and testing of waste forms and waste packages as they are received at the GROA (the detailed technical review of this information will take place in section 4.5.6 of the YMRP);

- In some instances, such as the case with Naval Reactor fuel, DOE will not be able to inspect the contents of the waste disposal canisters. Consequently, DOE will need to address this situation in the context of its nuclear material control and accounting procedures;

- Plans for the retrieval and the alternative storage of waste packages, from emplacement drifts (the detailed technical review of this information will take place in section 4.1.2 of the YMRP);

- This would include a summary of the criteria that DOE would use to decide when, and under what conditions, waste retrieval operations would be necessary;

- Plans for decommissioning and permanent closure of the GROA (the detailed technical review of this information will take place in section 4.1.3 of the YMRP);

  A general discussion of possible uses of the GROA for purposes other than the disposal of SNF and other types of HLW (the detailed technical review of this information will take place in section 4.5.9 of the YMRP.); and

- Plans for responses to emergencies. (The detailed technical review of this information will take place in section 4.5.7 of the YMRP.)

In general, the reviewer should verify that the aforementioned summaries include adequate plans and procedures for the movement of personnel, materiel, and equipment during construction and normal operations.

RM3 Basis for the Commission's Licensing Authority

The staff should verify that the license application contains a presentation of the appropriate provisions of the statutory authority and the citations from NRC regulations that apply to the proposed activities at the GROA. The reviewer should also verify inclusion of a confirmation that no applicable regulatory citations have been omitted.

3.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(b)(1) relating to the description of the general information.

AC1 The location and arrangement of the GROA are adequately defined.

- A general but accurate description of the GROA is provided. This description include:

  — A discussion of the physical characteristics of the site and the natural setting;

  — Scaled drawings or maps showing the location of the GROA and its associated SSCs;

— A summary of the design features of the above- and below-ground SSCs, with a designation of whether they are permanent or temporary;.

— A definition of the purpose of each GROA SSC and any interrelationships among them;

— Plans to restrict access to and to regulate land uses around the GROA; and

— A description of environmental monitoring instrumentation and activities, including DOE's plans for the mitigation of environmental impacts associated with the construction and operation of the proposed repository.

AC2 The general nature of the activities to be conducted at the geologic repository is adequately described.

- A summary description of the types, kinds, and amounts of SNF and other HLW to be disposed is provided;

- A summary description of the proposed operations is provided that includes receipt, handling, emplacement, retrieval, and testing and inspection of waste and waste packages;

- This description includes basic plans for the movement of personnel, materiel, and equipment during construction and normal operations;

- Plans for the retrieval and the alternative storage of waste packages, from emplacement drifts are included;

- Plans for decommissioning and permanent closure of the GROA are provided;

- A general discussion of possible uses of the GROA for purposes other than the disposal of SNF and other types of HLW is incorporated; and

- Plans for responses to emergencies are provided.

AC3 An adequate basis for the exercise of the Commission's licensing authority is provided.

- The license application contains a presentation of the appropriate provisions of the statutory authority and the citations from NRC regulations that apply to the proposed activities at the geologic repository. This verification includes a confirmation that no applicable regulatory citations have been omitted.

3.1.4 Evaluation Findings

The NRC staff has reviewed the General Information and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(b)(1).

An adequate general description of the geologic repository has been provided that identifies the location of the GROA, discusses the general character of the proposed activities at the GROA, and provides the basis for the exercise of the Commission's licensing authority.

3.1.5 References

None.

3.2 PROPOSED SCHEDULES FOR CONSTRUCTION, RECEIPT, AND EMPLACEMENT OF WASTE

Review Responsibilities—High-Level Waste and Performance Assessment Branch

3.2.1 Areas of Review

This reviews proposed schedules for construction, receipt, and emplacement of waste. Reviewers will evaluate the information required by10 CFR 63.21(b)(2).

The staff will evaluate the following parts of proposed schedules for construction, receipt, and emplacement of waste using the review methods and acceptance criteria in sections 3.2.2 and 3.3.3.

The material to be reviewed is informational in nature, and no detailed technical analysis is required. Because some of the information contained in this portion of the license application is informational in nature and may not concern performance-related issues, some of the review methods used to evaluate this information may generally not be risk-informed, performance-based. In instances such as these, there will be no performance measures against which the review methods can be compared.

- Schedules for construction of SSCs of the GROA (including development of requisite infrastructure both on- and off-site); and

- Proposed schedules for the receipt, handling, and emplacement of waste package canisters.

3.2.2 Review Methods

Performance Goal/Measure: There are none. The material to be reviewed in this section of the license application is informational in nature.

RM1 Major Steps for the Completion of Each Significant Work Element

Determine that the schedules for each significant work element necessary for both on- and off-site construction (including infrastructure development) and the receipt and emplacement of waste provide an adequate description of planned project activities. Traditional project management techniques (i.e., critical path method diagrams, Gantt charts, etc.) should be used to convey the necessary information. In evaluating the adequacy of project planning, recognize that scheduling will be a function of evolving circumstances and should expect out-year scheduling to be less detailed than near-term scheduling. This review of project planning schedules should include:

- Verifying that the schedules, time-scaled charts, or work progress flow charts are complete, consistent, and reflect a logical sequence of work.

- Ensuring that the scheduled time allocated for each work step and the identified interdependence of work steps are sufficient to provide an overall understanding of GROA and infrastructure construction and waste emplacement operations.

- Verifying that construction of GROA facilities will be substantially complete before the proposed scheduled receipt and emplacement of wastes.

3.2.3 Acceptance Criteria

The following acceptance criterion is based on meeting the requirements of 10 CFR 63.21(b)(2) relating to proposed schedules for construction, receipt, and emplacement of waste.

AC1 Major steps for the completion of each significant work element are adequately described.

- Major steps for the completion of each significant work element during construction of GROA facilities and the associated infrastructure are identified in the proposed schedule of activities.

- Major steps and activities associated with the receipt of and emplacement of wastes are identified in the proposed schedule of activities.

- For each of the activities described in the various phases of GROA operations and activities, an adequate description of planned overall project progress is provided. Specifically:

    — Schedules, work-flow diagrams, and other project-management planning tools are complete, consistent, and reflect a logical sequence of planned work and routine operational activities.

    — The scheduled time allocated for each major activity, and the identified interdependence of major activities are sufficient to provide an overall understanding of GROA and infrastructure construction and routine waste emplacement operations.

3.2.4 Evaluation Findings

NRC staff has reviewed the General Information and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(b)(2). DOE provides schedules for construction, receipt of waste, and waste emplacement at the GROA that are sufficiently detailed to allow staff to evaluate the overall construction program for the GROA and its infrastructure.

3.2.5 References

None.

3.3 PHYSICAL PROTECTION PLAN

This review determines with reasonable assurance whether DOE has committed to having a physical protection system that provides high assurance that activities involving HLW do not present an unreasonable risk to the public health and safety. The physical protection system should be designed to protect against a loss of control of the GROA that could be sufficient to cause radiation exposure exceeding the dose defined in 10 CFR 72.106. Physical protection requirements for HLW at a GROA are at 10 CFR 73.51. These regulations specify the physical protection measures a licensee must observe and to which a licensee must commit in an NRC-approved physical protection plan.

Review Responsibilities—High-Level Waste Branch; Division of Fuel Cycle Safety and Safeguards, Fuel Cycle Licensing Branch

3.3.1 Areas of Review

This section reviews the physical protection plan. Reviewers will evaluate the information required by 10 CFR 63.21(b)(3). Although the DOE is not expected to submit a physical protection plan with the application for construction approval, the DOE should commit to developing and implementing a physical protection system that meets or exceeds the acceptance criteria in section 3.3.3 prior to receipt of waste at the GROA.

The reviewer should evaluate DOE's submittal for an acceptable physical protection system that protects against a loss of control of the GROA that could be sufficient to cause radiation exposure exceeding the dose as defined in 10 CFR 72.106. The reviewer should ensure that DOE has described how the general performance requirements, the performance capabilities, and the specific measures included in 10 CFR 73.51 will be met through developing, implementing, and maintaining a physical protection system.

The staff will evaluate the following parts of the physical protection plan using the review methods and acceptance criteria in sections 3.3.2 and 3.3.3.

- Introduction and schedule for Implementation;
- General performance objectives;
- Protection goal;
- Security organization;

- Physical barrier subsystems;
- Access control subsystems and procedures;
- Detection, surveillance, and alarm subsystems and procedures;
- Communication subsystems;
- Equipment operability and compensatory measures;
- Contingency and response plans and procedures; and
- Reporting of safeguards events.

3.3.2 Review Methods

RM1 GROA Description and Schedule for Implementation

Verify that DOE specifies the GROA location. DOE should describe the GROA facilities, the nature of the wastes to be disposed, the GROA layout, the surrounding area, and the surrounding terrain. Ensure that DOE has included a map of the entire facility and other maps and illustrations to assess the physical protection plan. DOE should indicate on these maps the controlled area; the location of all buildings; the locations of physical protection systems, subsystems, and major components; the protected area; and all entry/exit points, entry/exit control points, alarm stations, and security posts.

Confirm that DOE has presented an adequate schedule for implementing the physical protection plan. HLW may not be stored or used at the GROA until the physical protection system is implemented and operational.

RM2 General Performance Objectives

Verify that DOE's commitments for the physical protection plan are consistent with 10 CFR 73.51. Items to be verified include:

- DOE has described, in general terms, how the physical protection system will have as its objective to provide high assurance that activities involving HLW do not present an unreasonable risk to the public health and safety.

- DOE has adequately described how, through establishing, maintaining, and arranging a physical protection system, the general performance objective and requirements in 10 CFR 73.51 will be met.

- DOE has identified and adequately described those portions of the physical protection system for which redundant and diverse components and redundant and diverse subsystems and components, are necessary to ensure adequate performance, as required by 10 CFR 73.51(b)(2). In general terms, DOE should describe in the subsystems and components to be used to provide this redundancy and diversity and the ways in which these subsystems and components are redundant and diverse.

- DOE has adequately described how the physical protection system is designed, tested, and maintained to ensure its continual effectiveness, reliability, and availability. This verification should be conducted onsite by the reviewer prior to plan approval.

RM3 Protection Goal

Verify that DOE has committed to protect against a loss of control of the GROA that could cause radiation exposure exceeding the dose defined in 10 CFR 72.106. DOE should have established a physical protection strategy which would deny unauthorized access to areas of the GROA which could result in a loss of control sufficient to cause radiation exposure exceeding the dose as described in 10 CFR 72.106. Ensure that DOE has committed to maintain and update the physical protection plan to reflect any changes that are necessary to ensure the continual ability to protect against situations leading to loss of control of the GROA.

RM4 Security Organization

Verify that DOE has described an adequate security organization to manage, control, and implement the physical protection system consistent with the physical protection plan and to maintain its effectiveness. The security organization will be acceptable if DOE's commitments are consistent with the requirements in 10 CFR 73.51(d); associated appendixes B, C, and G of 10 CFR Part 73; and the following criteria:

- DOE has stated whether the security organization is employed directly by DOE or is a contractor to DOE. Ensure, if the security organization is managed by a contractor, that DOE has described adequate written agreements between DOE and contract guard force management that will govern how the security force will meet requirements at 10 CFR 73.51(d) and in Appendix B, General Criteria for Security Personnel, to 10 CFR Part 73.

- DOE has committed to providing adequate structure and management for the security organization. This should include both uniformed security personnel and other persons responsible for security-related functions, consistent with 10 CFR 73.51(d). The structure description should include each supervisory and management position, with responsibilities and lines of authority to facility and corporate management. The security organization must provide for sufficient personnel each shift to monitor detection systems and to conduct surveillance, assessment, access control, and communications to assure adequate response time against a security threat.

- DOE has committed to review the physical protection program at least once every 24 months by individuals who are independent of physical protection management and who have no direct responsibility for implementation of the physical protection program. The physical protection program review shall evaluate the effectiveness of the physical protection system and of the liaison established with the designated response force or local law enforcement agency.

- DOE has committed that an approved Guard Force Training Plan, that meets 10 CFR Part 73, Appendix B, General Criteria for Security Personnel, will be in effect. The physical protection plan should commit to train, equip and qualify all members of the security organization to perform their security duties in accordance with

10 CFR Part 73, Appendix B, General Criteria for Security Personnel, consistent with 10 CFR 73.51(d)(5).

- DOE has committed that records required by 10 CFR 73.51(d)(13) will be maintained/retained and adequately describes how they will be maintained/retained.

RM5 Physical Barrier Subsystems

A performance objective of physical barriers is to define areas within which authorized activities and conditions are permitted. Other barrier performance objectives are to channel persons, vehicles, and material to or from entry/exit control points; to delay or deny unauthorized penetration attempts by persons, vehicles, or material; to delay attempts to cause loss of control of the GROA; to assist detection and assessment; and to permit a timely response by the security force or local law enforcement to prevent the intended act.

Ensure that DOE has adequately described the physical barrier subsystems for the GROA. This description will be acceptable if DOE's commitments to the physical protection plan are consistent with the following criteria:

- DOE has committed that HLW will be stored only within a protected area. Access to material in the protected area shall require passage or penetration through two physical barriers; one barrier at the perimeter of the protected area, and one barrier offering substantial penetration resistance. The physical barrier at the perimeter of the protected area must be as defined in 10 CFR 73.2. The barrier offering substantial resistance to penetration must be adequately defined and described. DOE should commit to installing the protected area barrier fence so that it cannot be lifted to allow an individual to crawl under it. DOE should describe any access points through the protected area barrier, the manner in which they are to be used, and the means to control and protect them to ensure the integrity of the barrier. Barriers designed to protect against the malevolent use of a vehicle are not required at the GROA.

- DOE has adequately described the location and size of any GROA isolation zones. DOE should commit that isolation zones alongside physical barriers at the perimeter of the protected area will be at least 20-feet wide and will be maintained clear of obstacles or structures on either side of the barriers to permit assessment consistent with 10 CFR 73.51(d)(1).

- DOE has described the lighting system sufficiently to demonstrate that it will be adequate to ensure Illumination for monitoring, observation, and assessment activities for exterior areas within the protected area. The illumination must be sufficient to assess unauthorized penetrations of or activities within the protected area consistent with 10 CFR 73.51(d)(2). DOE should demonstrate acceptable emergency backup power for protected area lighting and security assessment if normal power is lost. Illumination should be maintained during all periods of darkness (not just during periods of assessment). The level of illumination should be sufficient for the security assessment means proposed; however, 10 CFR 73.51 defines no specific required illumination level. The reviewer should consider that the physical layout of the GROA may complicate maintaining a consistent level of illumination throughout the protected area because of obstruction from such structures as storage casks.

RM6 Access Control Subsystems and Procedures

The performance objectives of access authorization controls and procedures are to verify the identity persons, vehicles, and materials, and to initiate timely response measures to deny unauthorized entries.

Ensure that DOE has committed to providing adequate access control subsystems for the GROA. These subsystems will be acceptable if DOE commitments are consistent with the requirements in 10 CFR 73.51(d)(9) and the following criteria:

- DOE will establish and maintain a personnel identification system to limit access only to authorized individuals. The personnel identification system should provide unique identification of individuals granted access to the protected area. A picture identification system using a drivers license photograph, a name badge system using a badge medium that is difficult to counterfeit, or facial recognition could be used. Use of facial recognition should be justified (e.g., long-term employment and small site population).

- DOE has described adequate procedures for control of points of personnel access into the protected area, consistent with 10 CFR 73.51(d)(9). These procedures should include a discussion of methods used to identify individuals and to verify individual authorization. Procedures should also describe techniques for conducting visual searches of individuals, vehicles, and hand carried packages for explosives before entry into the protected area. If an individual can be positively identified, is authorized access, and has been searched for explosives without positive findings, then no escort is required. If the individual cannot meet any one of these three criteria, access to the protected area should be denied.

- DOE has committed that a controlled lock system will be established and maintained to limit access to authorized individuals consistent with 10 CFR 73.51(d)(7). Regulatory Guide 5.12, General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials (NRC, 1973) should be used as guidance for developing a controlled lock system.

- DOE has committed to retain the following documentation for 3 years after the record is made or until termination of the license: (i) a log of individuals granted access to the protected area; (ii) screening records of members of the security organization; (iii) a log of all patrols; (iv) a record of each alarm received, identifying the type of alarm, location, date and time when received, and disposition of the alarm; and (v) the physical protection program review reports.

RM7 Detection, Surveillance, and Alarm Subsystems and Procedures

The performance objectives of detection, surveillance, and alarm subsystems and procedures are to detect, assess, and communicate any unauthorized access or penetrations or such attempts by persons, vehicles, or materials at the time of occurrence so the response will prevent the unauthorized access or penetration.

Ensure that DOE has adequate detection, surveillance, and alarm subsystems for the GROA. These subsystems will be acceptable if they are consistent with the requirements in 10 CFR 73.51(d) and the following criteria:

- An adequate intrusion detection system will be installed in the isolation zone between the two barriers at the protected area perimeter, consistent with 10 CFR 73.51(d)(3). DOE should commit to providing a volumetric intrusion detection system capable of detecting an individual weighing a minimum of 77 pounds, whether the individual is running, walking, crawling, jumping, or rolling through the isolation zone of the protected area. The capabilities, installation, and testing of the intrusion detection equipment should be consistent with Regulatory Guide 5.44, Perimeter Intrusion Alarm Systems, Revision 3 (NRC, 1997).

- The location, construction and characteristics of the central and secondary alarm stations are consistent with 10 CFR 73.51(d)(3). DOE should commit to having all required alarms annunciate in a continuously manned central alarm station located within the protected area and in at least one other continuously manned independent onsite station. Continuous manning of alarm stations and methods used for annunciation of required alarms should be described, along with protection afforded the stations (both procedural and physical), so that a single act cannot remove the capability of calling for assistance or responding to an alarm. The reviewer should confirm that access to the alarm stations will be controlled on a need-to-know basis, and that the central alarm station will not contain any activities that would interfere with the alarm response. The annunciation systems at the alarm stations should indicate the status of all alarms and alarm zones in both alarm stations. The secondary location need only provide a summary indication that an alarm has been generated. DOE should follow the guidelines of Regulatory Guide 5.44, Perimeter Intrusion Alarm Systems, Revision 3 (NRC, 1997), for alarm annunciation.

- Detection systems and supporting subsystems must be tamper indicating with line supervision. These systems and the surveillance/assessment and illumination systems must be maintained in operable condition.

- DOE has committed to monitor the protected area with daily random patrols consistent with 10 CFR 73.51(d)(4). To evaluate the proposed frequency of random patrols, the reviewer should consider the remoteness of the GROA, the nature of activities adjacent to the site, and the size of the GROA. A minimum of two patrols per security duty work shift should be conducted unless the facility is in a remote area where more patrols may be necessary.

RM8 Communication Subsystems

The performance objective of communication subsystems is to notify of an attempted unauthorized intrusion so response can prevent loss of control of the GROA.

Ensure that DOE will have adequate communications subsystems for the GROA. The communications subsystems will be acceptable if they are consistent with the requirements in 10 CFR 73.51(d) and the following criteria:

- The individual in each continuously manned alarm station should be able to call for assistance from other guards and watchmen and from local law enforcement.

- Redundant and diverse systems should be used to ensure communications with the local law enforcement authority, consistent with 10 CFR 73.51(d)(8).

- The methods used to maintain communications systems in operable condition should be consistent with 10 CFR 73.51(d)(11).

RM9 Equipment Operability and Compensatory Measures

The performance objective of test and maintenance procedures is to provide confidence that security equipment will be available and reliable to perform when needed.

Ensure that DOE will have adequate test and maintenance programs for the GROA. The test and maintenance programs will be acceptable if they are consistent with the requirements in 10 CFR 73.51(d) and DOE commits to a testing program for the perimeter intrusion detection system consistent with Regulatory Guide 5.44, Revision 3 (NRC, 1997).

RM10 Contingency and Response Plans and Procedures

The performance objective for contingency response plans and procedures is to provide predetermined response to safeguards contingency events so the adversary will be engaged and impeded until off-site assistance arrives.

Ensure that DOE has adequate contingency and response plans for the GROA. The contingency and response plans will be acceptable if DOE plans are consistent with the requirements in 10 CFR 73.51(d)(10), appendix C to 10 CFR Part 73, and the following criteria:

- DOE has provided a commitment to develop a safeguards contingency plan for unauthorized penetrations of or activities within the protected area that includes the Category 5, Procedures, of Appendix C to 10 CFR Part 73, consistent with 10 CFR 73.51(d)(10).

- DOE will have adequate documented response arrangements with designated response force or local law enforcement agencies, consistent with the requirements of 10 CFR 73.51(d)(6). The designated response force could be a privately contracted security force that meets the requirements of appendix B to 10 CFR Part 73. If the designated response force cannot respond quickly enough, additional protective measures may be required, including the use of armed guards.

RM11 Reporting of Safeguards Events

Verify that DOE has committed to reporting safeguards events to the NRC consistent with the criteria in 10 CFR Part 73, Appendix G, Reportable Safeguards.

3.3.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(b)(3) relating to the physical protection plan.

AC1 The physical protection plan contains an adequate GROA description and provides an acceptable schedule for implementation.

- The physical protection plan adequately specifies the location of the GROA, the GROA facilities, the nature of the wastes to be disposed, the GROA layout, the surrounding area, and the surrounding terrain. Adequate maps are provided to support the physical protection plan.

  An acceptable schedule is provided for implementing the physical protection plan. HLW will not be stored or used at the GROA facility until the physical protection system is implemented and operational.

AC2 General performance objectives will be met.

- The physical protection system will provide high assurance that activities involving HLW do not present an unreasonable risk to the public health and safety.

- Through establishing, maintaining, and arranging a physical protection system, the general performance objective and requirements prescribed in 10 CFR 73.51 will be met.

- Those portions of the physical protection system for which redundant and diverse components, and redundant and diverse subsystems and components, are necessary to ensure adequate performance will meet the requirements of 10 CFR 73.51(b)(2).

- The physical protection system will be designed, tested, and maintained to ensure its continual effectiveness, reliability, and availability.

AC3 The protection goal will be met.

The physical protection system will be designed to protect against a loss of control of the GROA that could cause radiation exposure exceeding the dose defined in 10 CFR 72.106. DOE will have a physical protection strategy that will deny unauthorized access to areas of the GROA which could result in a loss of control sufficient to cause radiation exposure exceeding the dose as described in 10 CFR 72.106. DOE will maintain and update the physical protection plan to reflect any changes that are necessary to ensure the continual ability to protect against situations leading to loss of control of the GROA.

AC4 The security organization will be adequate.

DOE has an adequate security organization to manage, control, and implement the physical protection system consistent with the physical protection plan and will continually maintain its effectiveness.

- DOE has stated whether the security organization is employed directly by DOE or is a contractor to DOE. DOE has, or has committed to, adequate written agreements between DOE and the contract guard force.

- DOE has an adequate structure and management for the security organization, including both uniformed security personnel and other persons responsible for security-related functions. The security organization provides for sufficient personnel each shift to monitor detection systems and to conduct surveillance, assessment, access control, and communications to assure adequate response time against security threats.

- DOE will review the physical protection program at least once every 24 months using individuals who are independent of physical protection management and who have no direct responsibility for implementation of the physical protection program. The physical protection program review will evaluate the effectiveness of the physical protection system and of the liaison established with the designated response force or local law enforcement agency.

- DOE will establish an adequate Guard Force Training Plan. The physical protection plan will commit to properly train, equip and qualify members of the security organization to perform their security duties.

- DOE will adequately maintain the records required by 10 CFR 73.51(d)(13).

AC5 Physical barrier subsystems will be adequate.

The physical barriers will control areas within which authorized activities and conditions are permitted. The barriers will channel persons, vehicles, and material to or from entry/exit control points; will delay or deny unauthorized penetration attempts by persons, vehicles, or material; will delay any attempts to cause loss of control of the GROA; will assist detection and assessment; and will permit a timely response by the security force or local law enforcement to prevent the intended act.

DOE has adequate physical barrier subsystems at the GROA.

- HLW will be stored only within a protected area. Access to material in the protected area will require passage or penetration through two physical barriers; one barrier at the perimeter of the protected area, and one barrier offering substantial penetration resistance. The physical barrier at the perimeter of the protected area will be as defined in 10 CFR 73.2. The barrier offering substantial resistance to penetration is adequately defined and described. DOE will install the protected area barrier fence so that it cannot be lifted to allow an individual to crawl under it. Access points through the protected area barrier, the manner in which they are to be used, and the means to control and protect them to ensure the integrity of the barrier are adequately described.

- The location and size of any GROA isolation zones are adequately defined. The isolation zones adjacent to the physical barriers at the perimeter of the protected area will be at least 20-feet wide, and will be maintained clear of obstacles or structures on either side of the barriers to permit assessment consistent with 10 CFR 73.51(d)(1).

- DOE has described the lighting system sufficiently to demonstrate that it will be adequate to ensure Illumination for monitoring, observation, and assessment activities for exterior areas within the protected area. The illumination will be sufficient to permit assessment of unauthorized penetrations of or activities within the protected area consistent with 10 CFR 73.51(d)(2). DOE demonstrates that there will be acceptable emergency backup power for protected area lighting and security assessment capability if normal power is lost. Illumination will be maintained during all periods of darkness. The level of illumination will be sufficient for the security assessment means proposed.

AC6 Access control subsystems and procedures will be adequate.

Controls and procedures are adequate to verify the identity of persons, vehicles, and materials, and to initiate timely response measures to deny unauthorized entries.

DOE will provide adequate access control subsystems for the GROA.

- DOE will establish and maintain an adequate personnel identification system to limit access only to authorized individuals. The personnel identification system will provide unique identification of individuals granted access to the protected area.

- DOE will provide adequate procedures for control of points of personnel access into the protected area. These procedures will include appropriate methods to identify individuals and to verify individual authorization and techniques for conducting visual searches of individuals, vehicles, and hand-carried packages for explosives before entry into the protected area.

- DOE will employ an adequate controlled lock system to limit access to authorized individuals consistent with 10 CFR 73.51(d)(7).

- DOE will maintain adequate records of access control.

AC7 Detection, surveillance, and alarm subsystems and procedures will be adequate.

Detection, surveillance, and alarm subsystems and procedures will be adequate to detect, assess, and communicate any unauthorized access or penetrations or such attempts by persons, vehicles, or materials at the time of the act or the attempt so the response can prevent the unauthorized access or penetration.

DOE has adequate detection, surveillance, and alarm subsystems for the GROA.

- An adequate intrusion detection system will be installed in the isolation zone between the two barriers at the protected area perimeter

- The location, construction and characteristics of the central and secondary alarm stations are consistent with 10 CFR 73.51(d)(3). DOE will have all required alarms annunciate in a continuously manned central alarm station located within the protected area and in at least one other continuously manned independent onsite station. DOE will provide continuous manning of alarm stations, and methods used for annunciation of required alarms are adequate, so that a single act cannot remove the capability of calling for assistance or responding to an alarm. Access to the alarm stations will be controlled on a need-to-know basis, and the central alarm station will not contain any operational activities that would interfere with the execution of alarm response functions. The annunciation systems at the alarm stations will indicate the status of all alarms and alarm zones in both alarm stations.

- Detection systems and supporting subsystems will be tamper indicating with line supervision. These systems and the surveillance/assessment and illumination systems will be maintained in operable condition.

- The protected area will be monitored with adequate daily random patrols.

AC8 Communication subsystems will be adequate.

The communication subsystems will provide adequate notification of an attempted unauthorized intrusion so that response can prevent loss of control of the GROA.

DOE will have adequate communications subsystems for the GROA.

- The individual in each continuously manned alarm station will be capable of calling for assistance from other guards and watchmen and from local law enforcement authorities.

- Redundant and diverse systems will be used to ensure the capability of communications with the local law enforcement authority.

- The methods used to maintain communications systems in operable condition are adequate.

AC9 Equipment operability and compensatory measures are adequate.

Test and maintenance procedures provide adequate confidence that security equipment will be available and reliable to perform when needed.

DOE will have adequate test and maintenance programs for the GROA physical protection systems.

AC10 Contingency and response plans and procedures will be adequate.

Contingency response plans and procedures will provide adequate predetermined response to safeguards contingency events so that the adversary will be engaged and impeded until off-site assistance arrives.

DOE has adequate contingency and response plans for the GROA.

- DOE will provide an adequate safeguards contingency plan for dealing with unauthorized penetrations of or activities within the protected area.

- DOE will have adequate documented response arrangements with designated response force or local law enforcement agencies.

AC11 Reporting of safeguards events will be adequate.

DOE will provide adequate reporting of safeguards events to the NRC.

3.3.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(b)(3). DOE will implement an adequate physical protection program for HLW that includes physical protection, a safeguards contingency plan, and a security organization personnel training and qualification plan that complies with 10 CFR 73.51 of this chapter.

3.3.5 References

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 5.44, “Perimeter Intrusion Alarm Systems,” Revision 3. NRC: Washington, DC. October 1997.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 5.12, “General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials. NRC: Washington, DC. November 1973.

3.4 MATERIAL CONTROL AND ACCOUNTING PROGRAM

This review is to ensure DOE’s material control and accounting plan describes, establishes, implements, and maintains a program adequate to protect against, detect, and respond to loss of HLW. Material control and accounting requirements for HLW are required by 10 CFR 63.21(b)(4) and stipulated in 10 CFR 63.78.

Review Responsibilities—High-Level Waste Branch

In conducting this review, the reviewer should consider that emplaced waste is stored until the repository is closed.

3.4.1 Areas of Review

This section reviews the material control and accounting program. Reviewers will evaluate the information required by 10 CFR 63.21(b)(4).

The staff will evaluate the following parts of the material control and accounting program using the review methods and acceptance criteria in sections 3.4.2 and 3.4.3. The program may not be in place when DOE submits a license application for construction authorization. Therefore, commitments by DOE to implement the material control and accounting program requirements are sufficient for construction authorization.

- Material balance, inventory, and records and procedures for stored HLW;
- HLW inventory procedures;
- Procedures for preparing accidental criticality or loss of special nuclear material reports;
- Procedures for preparing material status reports; and
- Procedures for preparing nuclear material transfer reports.

3.4.2 Review Methods

RM1 Material Balance, Inventory, and Records Keeping Procedures

Verify the material control and accounting plan establishes the bases for identifying, controlling, and accounting for the nuclear materials DOE will be authorized to possess at the GROA.

Verify records will adequately document the receipt, inventory (including location), disposal, acquisition, and transfer of SNF and HLW, including provision to maintain inventory during any retrieval operations. Information on the waste form, proposed waste package, characteristics of any encapsulation material, radionuclide characteristics, heat generation rate, and history should be provided in these records. Ensure procedures require that records be maintained for as long as the material is stored and for 5 years after the repository is closed. Verify that the following minimum information will be included in the retained records:

- Name of shipper,
- Estimated quantity of radioactive material per item including HLW,
- Item identification and seal number,
- Storage or emplacement location,
- Onsite movement of each fuel assembly or storage canister, and
- Ultimate disposal.

Determine that a physical inventory of SNF and HLW in storage will be made at intervals not to exceed 12 months (unless directed otherwise by the Commission). The license application should include a commitment to retain a copy of the current inventory until the Commission terminates the license.

Verify that policies, practices, and procedures are designed and implemented to ensure the quality of physical inventories and the control and maintenance of records and documentation associated with the physical inventories. A copy of the current inventory should be maintained until the Commission terminates the license.

Confirm that written material control and accounting procedures sufficient for DOE to account for the material in storage will be established, maintained, and followed. The license application should include a commitment to retain a copy of the current material control and accounting procedures until the Commission terminates the license.

Verify that checks and balances in the material control and accounting system ensure falsification of data and reports that could conceal a diversion of HLW by employees acting individually or in collusion will be readily detected.

Determine that records of SNF or HLW in storage will be in duplicate. Duplicate sets of records should be at separate locations so a single event will not destroy both sets. The license application should include a commitment to preserve records of SNF or HLW transferred out of the GROA for a minimum of 5 years after transfer.

RM2 Reports of Accidental Criticality or Loss of Special Nuclear Material

Verify that any loss is considered and incorporated in a collusion protection program designed to thwart attempts from an insider to divert special nuclear material.

Verify that procedures ensure that anomalies (off-normal or abnormal situations) suggesting a likelihood that a significant quantity of special nuclear material may be missing (whether or not the cause is assumed deliberate) are promptly and accurately reported to the NRC.

Ensure the anomaly reporting system is able to respond promptly to alarms indicating potential loss of special nuclear material and discrimination of actual loss or system error is readily determined. Verify appropriate remedial action is planned, verified, and reported after alarms are tripped.

Confirm adequate procedures for reporting accidental criticality or loss of special nuclear material to the NRC Operations Center using the Emergency Notification System. If this system is inoperable, commercial telephone, other dedicated telephonic service, or any means which assures NRC receipt of the report may be utilized. Reports should be made within one hour of the discovery of accidental criticality or any loss of special nuclear material.

RM3 Procedures for Preparation of Material Status Reports

Determine procedures require a material status report will be completed, in computer readable format, and submitted to the Commission in accordance with instructions in NUREG/BR–0007 (NRC, 2000a) and Nuclear Materials Management and Safeguards Report D–24, Personal Computer Data Input for NRC Licensees (NRC, 1994). Information on special nuclear material contained in the SNF possessed, received, transferred, disposed, or lost by the licensee should be reported. Confirm procedures require material status reports as of March 31 and September 30 of each year, to be filed within 30 days after the end of the period covered by the report, unless otherwise specified by the Commission or by 10 CFR 75.35 pertaining to implementation of the United States/International Atomic Energy Agency Safeguards Agreement.

RM4 Procedures for Preparation of Nuclear Material Transfer Reports

Determine that DOE establishes auditable records sufficient to demonstrate reporting requirements have been met. Verify procedures specify forms of records and adequate safeguards to insure the integrity of records. Verify procedures require that whenever SNF is transferred or received, a Nuclear Material Transaction Report will be completed, in computer readable format, in accordance with instructions in NUREG/BR–0006 (NRC, 2000b) and Nuclear Materials Management and Safeguards System Report D–24, Personal Computer Data Input for NRC Licensees (NRC, 1994), as required by 10 CFR 72.78.

3.4.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.78 relating to the material control and accounting program achieving the system capabilities stipulated by 10 CFR 72.72, 72.74, 72.76, and 72.78.

AC1 Material balance, inventory, and records keeping procedures for SNF and HLW are adequate.

- The material control and accounting plan establishes the basis for identifying, controlling, and accounting for the nuclear materials that DOE will be authorized to possess
- Records adequately document the receipt, inventory (including location), disposal, acquisition, and transfer of SNF and HLW, including provision to maintain inventory during any retrieval operations. Adequate information on the waste form, proposed waste package, characteristics of any encapsulation material, radionuclide characteristics, heat generation rate, and history is provided. The procedures require that records be maintained for as long as the material is stored and for 5 years after the repository is closed. The information in the retained records will include:

  — Name of shipper,
  — Estimated quantity of radioactive material per item including HLW,
  — Item identification and seal number,
  — Storage or emplacement location,
  — Onsite movement of each fuel assembly or storage canister, and

    — Ultimate disposal.

- A physical inventory of SNF and HLW in storage will be made at intervals not to exceed 12 months (unless directed otherwise by the Commission).

- Adequate policies, practices, and procedures are designed and implemented to ensure the quality of physical inventories, and the control and maintenance of records and documentation associated with the physical inventories. A copy of the current inventory will be retained until the Commission terminates the license.

- Written material control and accounting procedures sufficient for DOE to account for the material in storage are established, maintained, and followed. A copy of the current material control and accounting procedures will be retained until the Commission terminates the license.

- The material control and accounting system incorporates checks and balances sufficient to detect falsification of data and reports that could conceal a possible diversion of HLW by employees acting individually or in collusion.

- Records of SNF or HLW in storage are in duplicate. Duplicate sets of records are kept at separate locations so a single event will not destroy both sets. Records of SNF or HLW transferred out of the facility will be preserved for a minimum of 5 years after transfer.

AC2 Procedures are adequate to ensure timely reports of accidental criticality or loss of special nuclear material.

- DOE will have an adequate collusion protection program to thwart attempts from an insider to divert special nuclear material.

- DOE will report to NRC any anomalies (off-normal or abnormal conditions or situations) suggesting a likelihood that a significant quantity of special nuclear material may be missing (whether or not the cause is deliberate).

- DOE’s anomaly reporting system is able to respond promptly to alarms indicating a potential loss of special nuclear material and allows determination whether the unusual observable condition is caused by an actual loss or by a system error. The reporting procedure and resolution program will identify the type of system error or innocent cause so remedial action can be taken. The response will be timely to ensure that indicators that might result from diversion, loss or other misuse, are investigated and resolved promptly.

- Procedures for reporting accidental criticality or loss of special nuclear material to the NRC Operations Center using the Emergency Notification System are adequate. If this system is inoperable, commercial telephone, other dedicated telephonic service or any means which assures NRC receipt of the report may be utilized. Reports should be made within 1 hour of the discovery of accidental criticality or any loss of special nuclear material.

AC3 Procedures for preparation of material status reports are adequate.

- Procedures require that a material status report be completed, in computer readable format, and submitted to the Commission in accordance with instructions in NUREG/BR–0007 (NRC, 2000a) and Nuclear Materials Management and Safeguards System Report D–24, Personal Computer Data Input for NRC Licensees (NRC, 1994). Information on the special nuclear material contained in the SNF possessed, received, transferred, disposed, or lost by the licensee will be reported. Procedures require material status reports as of March 31 and September 30 of each year, to be filed within 30 days after the end of the period covered by the report unless otherwise specified by the Commission or by 10 CFR 75.35 pertaining to implementation of the United States/International Atomic Energy Agency Safeguards Agreement.

AC4 Procedures for preparation of nuclear material transfer reports are adequate.

- DOE will establish auditable records sufficient to demonstrate that reporting requirements have been met. In addition, each record pertaining to receipt and disposal of SNF will be retained until the Commission terminates the license.
- The procedures specify in what form those records will be kept.
- The procedures provide adequate safeguards against tampering with and loss of records.
- Procedures require that whenever SNF is transferred or received a Nuclear Material Transaction Report is completed, in computer readable format, in accordance with instructions in NUREG/BR–0006 (NRC, 2000b) and Nuclear Materials Management and Safeguards System Report D–24, Personal Computer Data Input for NRC Licensees (NRC, 1994), as required by 10 CFR 72.78.

3.4.4 Evaluation Findings

NRC staff has reviewed the safety analysis report and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.78. DOE has established a material control and accounting program that meets the requirements of 10 CFR 72.72, 72.74, 72.76, and 72.78.

3.4.5 References

Nuclear Regulatory Commission (U.S.) (NRC). *Personal Computer Data Input for NRC Licensees*. Nuclear Materials Management and Safeguards System Report D–24. NRC: Washington, DC. May 1994.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG/BR–0006, "Instructions for Completing Nuclear Material Transfer Reports." Revision 4. NRC: Washington, DC. February 2000a.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG/BR–0007, "Instructions for the Preparation and Distribution of Material Status Reports." Revision 3. NRC: Washington, DC. February 2000b.

3.5 DESCRIPTION OF SITE CHARACTERIZATION WORK

Review Responsibilities—High-Level Waste Branch

3.5.1 Areas of Review

This section reviews the description of site characterization work performed at YM, and its results, that supports the technical discussions and descriptions found elsewhere in the SAR. The reviewers will evaluate the information required by 10 CFR 63.21(b)(5).

The level of detail presented in this section of the license application should be similar to that in an executive summary. The material to be reviewed is informational in nature, with the more detailed technical discussions and descriptions found elsewhere in the SAR section of the license application. Therefore, no detailed technical analysis of the information contained in this section of the YMRP is required. The detailed review of the information covered by these other technical subjects will be conducted using other sections of the YMRP.

The staff will review the following parts of the description of site characterization work using the review methods and acceptance criteria in sections 3.5.2 and 3.5.3.

- Geology;
- Hydrology;
- Geochemistry;
- Geotechnical properties and conditions of the host rock;
- Climatology, meteorology, and other environmental sciences;
- Reference biosphere definition; and
- Rationale/strategy for site characterization activities.

Because the information contained in this section of the YMRP is generally informational in nature and may not concern performance-related issues, some of the review methods may generally not be RIPB. In instances such as these, there are no performance measures against which the review methods can be compared.

3.5.2 Review Methods

Performance Goal/Measure: There are none. The material to be reviewed in this section of the license application is informational in nature.

RM1 Description of Site Characterization Activities

Confirm that site characterization has been described in the General Information section of the license application. This general description, at a minimum, should include site-specific information in the following areas:

- Geology;
- Hydrology;
- Geochemistry;
- Geotechnical properties and conditions of the host rock;
- Climatology, meteorology; and
- Reference biosphere definition.

For each of the aforementioned areas, DOE should identify how the information was provided (i.e., whether it was obtained from the published technical literature, derived from site characterization investigations specific to the YM site, or formally/informally elicited from knowledgeable subject matter experts. Place particular emphasis on information elicited to condition the PCSA and the Total System Performance Assessment.

Verify that DOE has provided an adequate rationale/strategy that explains how its site characterization activities met specific information needs in the requisite technical evaluations found elsewhere in the SAR.

RM2 Summary of Site Characterization Results

Confirm that the results of site characterization activities have been described in the General Information section of the license application. An acceptable summary description should include areas such as:

- An overview of geology consistent with other site characterization summaries that includes:

  — A description of the physical setting of the site, including the major physiographic and geographic features;

  — A description of the principal rock units, at the surface and in the subsurface, and their stratigraphic relationships;

  — A description, and location of potentially important stratigraphic and structural features (such as faults, fractures, and joint sets and systems);

  — A description of geotechnical properties of stratigraphic units involved in the operation and performance of the proposed repository;

  — The delineation of the proposed geologic system to be used in estimating the performance of the proposed repository;

  — A summary of regional geomorphic, tectonic, seismic, and volcanic models (i.e., conceptual, technical basis, interpretation of data), with particular emphasis on those FEPs that may have an affect of repository operations and performance;

- — The identification of potential geologic hazards requiring complex engineering measures;
- — A summary evaluation of seismic probability;
- — A summary evaluation of volcanic probability;
- — The extent to which there are alternative, credible conceptual models or system state descriptions; and
- — The extent to which uncertainty in geologic data, models, or system states affects the compliance with performance objectives.

• An overview of hydrology consistent with other site characterization summaries that includes:

- — A description of hydrogeologic (aquifers and confining units) features, including those occurring at the critical group location, with emphasis on known or inferred hydrologic significance: this description should include information on hydraulic conductivity, transmissivity, porosities, permeability, and other important hydrogeologic parameters of the major hydrostratigraphic units, as appropriate;
- — An interpretation of the regional groundwater flow system, including a discussion of the major features and controls that effect local and regional groundwater supply: this information should identify modes of flow with respect to dominance by matrix flow, fracture flow, or an appropriate combination of the two modes, within the respective aquifers;
- — The delineation of the proposed hydrogeologic system (saturated and unsaturated) to be used in estimating the performance of the proposed repository;
- — A description and discussion of local climate, including precipitation, temperature, and surface runoff;
- — A discussion of groundwater quality;
- — A discussion of current water-use patterns, including groundwater withdrawals by aquifer source;
- — An estimated water budget for the respective aquifer systems;

- The identification of surface hydrologic features, including impoundments and stream channels (either continuous or intermittent), or other geomorphic features, that could potentially affect GROA operations and/or performance;

- A description of the Quaternary-age paleohydrologic conditions in the YM region;

- The identification and discussion of possible measures necessary to prevent future development of groundwater resources;

- The extent to which there are alternative, credible conceptual models or system state descriptions; and

- The extent to which uncertainty in geohydrologic data, models, or system states affects compliance with performance objectives.

• An overview of geochemistry consistent with other site characterization summaries that includes:

  - A delineation of the proposed geochemical environment (system) to be used in estimating the performance of the proposed repository;

  - Evaluation of groundwater to determine characteristics such as water chemistry, radionuclide solubility, and radionuclide sorption capability, and other factors;

  - An evaluation of the host rock and other hydrogeologic units to determine such characteristics radionuclide solubilities, radionuclide sorption capabilities, and other parameters significant to performance;

  - The results of other geochemical analyses (of rock matrix, fracture fillings, etc.) necessary to define the proposed geochemical environment;

  - A discussion of the results of thermal-mechanical-hydrologic-chemical modeling of the host rock and its immediate environs, to predict the evolution of the proposed geochemical environment;

  - A model of the anticipated geochemical environment under both ambient and proposed thermally perturbed conditions in the vicinity of emplaced waste packages, to predict the evolution of the proposed geochemical environment;

  - The extent to which there are alternative, credible conceptual models or system state descriptions; and

  - The extent to which uncertainty in geochemical data, models, or system states affects compliance with performance objectives.

• An overview of geotechnical properties and conditions consistent with other site characterization summaries that includes:

- A discussion of the results of site investigations necessary to characterize the engineering properties of the soils present at the site;

- A discussion of the results of site investigations necessary to characterize the engineering properties of the rock types present at the site, with particular emphasis on the host rock and its immediate environs necessary for the underground excavation of the geologic repository;

- A description of the types and kinds of geotechnical investigations conducted and the basis for the selection of the various design parameters, based on the investigations described;

- The statistical representativeness of the geotechnical data collected for parameters characterizing design conditions;

- A discussion and description of other site characterization work conducted necessary to define the relevant geotechnical properties and anticipated response/performance of both surface and subsurface facilities;

- A discussion of the results of predictive thermal-mechanical-hydrologic-chemical modeling, of the host rock and its immediate environs, to describe the short-term and long-term thermal-mechanical-hydrologic-chemical response of the host rock and its immediate environs, due to thermal loading by the emplacement of waste; and

- The extent to which uncertainty in geologic data, models, or system states affects decisions regarding the selection of key geotechnical design parameters, and investigations to characterize those parameters.

• An overview of climatological, meteorological, and other environmental information and data found in DOE’s final EIS (to be adopted by NRC to the extent practicable). This overview should also include a description of paleoclimate FEPs as well as future changes likely to occur during the timeframe of regulatory interest.

• An overview of the reference biosphere. The biosphere pathways selected for dose assessments should be consistent with arid or semi-arid conditions found in a mid-latitude desert. In addition, inasmuch as the location and characteristics of the critical group are already specified in the regulation at 10 CFR 63.115(b), DOE need not repeat that information in this section of the license application. The detailed review of information on the characteristics of the critical group is conducted using Section 4 (Review Plan for Safety Analysis Report) of the YMRP. The overview of the reference biosphere should be consistent with:

  - Present knowledge or theories of natural processes in and around the YM site, and

— Present knowledge regarding the future geologic and climatic evolution in the YM region based on interpretation of the geologic/paleoclimatological record.

3.5.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(b)(5) and 10 CFR 63.115(a) relating to the description of site characterization work provided in the General Information section of the license application. (In general, the detailed technical review of this information will take place in section 4 of the YMRP.)

AC1 The General Information contains an adequate description of the YM site and its environs. This description includes:

- An overview of the geology; hydrology; geochemistry; geotechnical properties and conditions of the host rock; climatology, meteorology, and other environmental sciences; and a reference biosphere definition.

- An understanding of current features and processes present in the YM region.

- An understanding of future FEPs likely to be present in the YM region that could effect future repository performance.

- A rationale/strategy that explains how site characterization activities support specific information needs in the technical evaluations found elsewhere in the SAR.

AC2 The General Information contains an adequate summary of the scientific activities and investigations conducted at YM.

- The description permits the reviewer to trace the information and data presented to original/authoritative sources to confirm the accuracy, applicability, or appropriateness of the information and data. Sources such as the following were used:

  — Existing technical literature;

  — Previous and current site characterization investigations specific to YM, the Nevada Test Site, or its environs; and

  — Formally/informally elicited information from knowledgeable subject matter experts.

AC3 In describing the YM site and its environs, the General Information addresses limitations that would qualify the descriptions including:

- Uncertainty in the data and/or models supporting the description;

- The potential for alternative, credible conceptual models or system states to be used and the rationale for selection of the preferred model or system description;

- Features and processes that may exist but not be detected;

- Additional site characterization work necessary to increase basic scientific understanding of any significant FEP; and

- Areas for which performance confirmation work may be necessary to confirm technical assumptions related to siting, design, and performance.

- The descriptions found in the General Information address the statistical representativeness of the data collected for parameters characterizing FEPs.

AC4 The General Information contains an adequate description of the reference biosphere and critical group that is:

- Consistent with present knowledge of natural processes in and around the YM site, including the critical group location; and

- Consistent with present knowledge regarding the future geologic and climatic evolution in the YM region, including the critical group location, based on interpretation of the geologic/paleoclimatological record.

3.5.4 Evaluation Findings

NRC staff has reviewed the General Information and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(b)(5). An adequate summary description of the work done to characterize the YM site and a summary of the results from that work, to allow staff to evaluate the overall sufficiency of that program have been provided.

3.5.5 References

None.

4 REVIEW PLAN FOR SAFETY ANALYSIS REPORT

4.1 REPOSITORY SAFETY PRIOR TO PERMANENT CLOSURE

4.1.1 Preclosure Safety Analysis

Risk-Informed Review Process for Preclosure Safety Analysis—This section provides for review of compliance with the performance objectives in 10 CFR Part 63, which are based on permissible levels of doses to workers and the public established on the basis of acceptable levels of risk. 10 CFR 63.21(c)(5) requires a PCSA of the GROA for the period before permanent closure to ensure compliance with the performance objectives. PCSA is a systematic examination of the site; the design; the potential hazards and initiating events and their consequences; and the potential dose consequences to workers and the public. PCSA considers the probability of potential hazards taking into account the range of uncertainty associated with the data that support the probability calculations. Event sequences are defined, and these sequences of human-induced and natural events are used as inputs to calculate consequences of potential failures of SSCs in terms of doses to workers and the public. These calculated doses are compared to allowable doses in establishing the importance of SSCs. The SSCs that must be functional to comply with the performance objective dose limits are identified as SSCs important to safety. PCSA also identifies and describes the controls that are relied on to prevent potential event sequences from occurring or to mitigate their consequences, and identifies measures taken to ensure the availability of the safety systems. The end products of the PCSA are a list of SSCs important to safety (also known as the Q-List) and the associated design criteria and technical specifications necessary to keep them functional and to meet the performance objectives. The SSCs important to safety may also be further categorized based on relative safety significance using risk information from the PCSA. This distinction may be used to focus the requirement of design details and the application of quality assurance controls through a graded quality assurance program. DOE plans on categorizing SSCs into three bins based on safety/risk significance and implementing a graded quality assurance program commensurate with safety significance. Accordingly, the YMRP will develop appropriate criteria to evaluate DOE’s technical basis for categorizing SSCs and grading quality assurance requirements.

The staff review is focused on items that are determined by PCSA to be important to safety. The rigor of review for the design items on the Q-List, and the level of attention to detail depend on relative safety significance. No prescriptive design criteria are imposed in the YMRP, because 10 CFR Part 63 allows DOE to develop the design criteria and demonstrate their appropriateness. Thus, DOE has flexibility to use any codes, standards, and methodologies it demonstrates to be applicable and appropriate. The performance-based review process in the YMRP focuses on determining compliance with performance objectives as demonstrated by DOE’s PCSA. In summary, the review philosophy is based on the following premises: (i) DOE must demonstrate, through its PCSA, that the repository will be designed, constructed, and operated to meet the specified exposure limits (performance objectives) throughout the preclosure period; (ii) the staff must focus the review on the design of the SSCs important to safety in the context of the design’s ability to meet the performance objectives; and finally, (iii) the staff resources will be focused proportionately on the inspection and review of high risk significant SSCs important to safety.

4.1.1.1 Site Description as it Pertains to Preclosure Safety Analysis

Review Responsibilities—High-Level Waste Branch

4.1.1.1.1 Areas of Review

This section reviews the site description as it pertains to PCSA and GROA design. The reviewers will also evaluate the information required by 10 CFR 63.21(c)(1).

The adequacy of the site description should be assessed in the context of the information required to conduct the PCSA and GROA design. The reviewers of this section should coordinate their reviews with the reviewers of Section 4.1.1.3 (Identification of Hazards and Initiating Events) of the YMRP.

The staff will evaluate the following parts of the site description as it pertains to PCSA and GROA design using the review methods and acceptance criteria in sections 4.1.1.1.2 and 4.1.1.1.3.

- Site geography,
- Regional demography,
- Local meteorology and regional climatology,
- Regional and local surface and groundwater hydrology,
- Site geology and seismology including geoengineering properties that are relevant to design of surface and subsurface facilities,
- Igneous activity,
- Site geomorphology, and
- Site geochemistry.

4.1.1.1.2 Review Methods

RM1 Description of Site Geography

Verify that the site location is adequately defined and is specified relative to prominent natural and man-made features such as mountains, streams, military bases, civilian and military airports, population centers, and potentially hazardous commercial operations and manufacturing centers that may be significant for the review of the PCSA and GROA design.

Confirm that the characteristics of natural and man-made features within the restricted area of the site that may be significant for evaluation of the PCSA and GROA design have been acceptably defined.

Ascertain that maps of the site and nearby facilities are included and are of sufficient detail and of appropriate scale to provide information needed to review the PCSA and GROA design. A site map should clearly indicate the site boundary and the restricted area, restricted area access points, and distances from the boundary to significant features of the installation. Maps should describe the site topography and surface drainage patterns, as well as roads, railroads, transmission lines, wetlands, and surface water bodies.

RM2 Description of Regional Demography

Verify that regional demographic information is based on current census data and presents the population distribution as a function of distance from the GROA. The demographic information should be in sufficient detail to determine the location of real members of the public.

RM3 Description of Local Meteorology and Regional Climatology

Evaluate the adequacy of the license application data on local meteorology and regional climatology that may be significant for the review of the PCSA and GROA design, including items such as:

- Temperature extremes,
- Atmospheric stability,
- Average wind speeds and prevailing wind direction,
- Extreme winds, and
- Tornadoes.

Confirm that data collection techniques are based on accepted methods [e.g., those described in NUREG–0800 (NRC, 1987)] and that technical bases for data summaries are provided.

Assess the information provided on the annual amount and forms of precipitation and the probable maximum precipitation at the site. Confirm that acceptable methods were used to develop this information.

Confirm the license application adequately defines the type, frequency, magnitude, and duration of severe weather such as tornados, lightning, and storms; and assess the validity of the design bases/criteria provided for the severe weather assessment.

Determine whether DOE conducted appropriate trending analyses supported by sufficient historical data.

RM4 Description of Regional and Local Surface and Groundwater Hydrology

Evaluate the description of the YM surface and groundwater hydrology to ensure that hydrologic features relevant to the PCSA and GROA design are adequately identified, such as:

- Stream locations,
- Natural drainage features,
- Flooding potential,
- Perched water,

- River or stream control structures, and
- Depth of aquifers beneath the site and their recharge and discharge features.

Verify that the analyses of the effects of any proposed changes to natural drainage features on GROA design are acceptable. To make this determination, coordinate with the reviewer of Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP.

Ensure the calculation of probable maximum flood is supported by sufficient data, including actual storm data in the region of the drainage basin. Section 2.4.3 of NUREG–0800 (NRC, 1987) may be used to conduct this review.

RM5 Descriptions of Site Geology and Seismology

Verify that DOE has provided sufficient data on the geology of the site to support the PCSA and GROA design, including the stratigraphy and lithology over the entire surface and subsurface construction area. To make this determination, coordinate with the reviewers of Section 4.2.1.3 (Model Abstraction) of the YMRP.

Confirm that site characterization data include geomechanical properties and conditions of host rock based on *in situ* and laboratory test results for the rock formations where major construction activities will take place. Collection and processing of these data should be based on accepted industry techniques and standards. These rock properties data should include parameters such as:

- Elastic properties and uniaxial compressive and tensile strength of intact rock;
- Triaxial compressive strength and triaxial test data of intact rock;
- Thermal conductivity, thermal expansion coefficient, and specific heat;
- Strata porosity, and permeability;
- Lithophysae characteristics and distribution;
- Jointing characteristics including joint mechanical properties;
- Rock-mass classification;
- Rock-mass properties relevant to the design of GROA facilities;
- *In situ* stresses; and
- Backfill characteristics.

Verify that rock mechanics testing data support the license application analyses of the stability of subsurface materials. Note that evaluation of the sufficiency of data and appropriateness of design parameters will be conducted using the appropriate subsection of Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP.

Confirm that the engineering properties provided for soils in the areas where surface facilities will be constructed are based on laboratory and *in situ* test results. Verify that DOE collected and processed these data using accepted industry techniques. The soil properties should include parameters such as:

- Soil classification;
- Particle size distribution, Atterberg limits, and water content;
- Drained and undrained shear strength (cohesion);
- Soil friction angles;
- Allowable bearing capacities;
- Blow counts for standard penetration tests; and
- Shear wave velocity.

Confirm that detailed soil testing data support the license application analyses of the stability of surface materials, considering surface subsidence, previous loading histories, and liquefaction potential.

Consult with the reviewers of Section 4.2.1.3.2.3 (Acceptance Criteria—Mechanical Disruption of Engineered Barriers) of the YMRP to ensure the vibratory ground motion and surface and subsurface fault displacements of the site have been adequately characterized. This assessment should include a list of capable faults, areal seismic source zones, earthquake parameters such as maximum magnitude and recurrence for each source, historical earthquake data, paleoseismic data, and ground motion attenuation models.

Determine that conversion of the characterized vibratory ground motion and surface and subsurface fault displacements of the site to engineering design parameters uses acceptable methods.

Evaluate the analyses of the static and dynamic stability of facility foundations, subsurface emplacement drifts, and natural and manmade slopes (both cut and fill), the failure of which could lead to radiological release. Ensure that appropriate methods are used for the analyses, data used are appropriate for the methods, and results are properly interpreted.

RM6 Igneous Activity Information

Consult with the reviewer of Section 4.2.1.2 (Scenario Analysis) of the YMRP to ensure the license application adequately considers igneous activity at the site including volcanic eruption, subsurface magmatic activity/flow, and volcanic ash flow/ash fall.

RM7 Site Geomorphology Information

Evaluate the analysis of site geomorphology [using guidance such as NUREG/CR–3276 (Schumm and Chorley, 1983) and Standard Format and Content for Documentation of Remedial Action Selection at Title I Uranium Mill Tailings Sites (NRC, 1989), as appropriate]. Assess the extent of erosion of the land surface and the likelihood that extreme erosion such as landslides, rock avalanches, other mass wasting, and rapid fluvial degradation in channels or interfluves might affect site structures or operations.

RM8 Geochemical Information

Evaluate the description of the geochemical information at YM that is relevant to the PCSA and GROA design to ensure that it is adequate, including items such as:

- Geochemical composition of any subsurface water held within the rock matrix or perched water zones, or episodically flowing through fractures to determine corrosivity;
- Geochemical composition of rock strata within and above the repository horizon to identify minerals that might leach and increase the corrosivity of water flowing through the strata; and
- Any geochemical alterations to the rock fractures and rock matrix through heating or other processes that might significantly alter geomechanical rock mass properties.

4.1.1.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.112(c) relating to the site description as it pertains to the PCSA.

AC1 The license application contains a description of the site geography adequate to permit evaluation of the PCSA and the GROA design.

- The site location is adequately defined. The site location is specified relative to prominent natural and man-made features such as mountains, streams, military bases, civilian and military airports, population centers, and potentially hazardous commercial operations and manufacturing centers that may be significant for the review of the PCSA and GROA design.
- The characteristics of natural and man-made features within the restricted area of the site that may be significant for evaluation of the PCSA and GROA design are adequately defined.
- Maps of the site and nearby facilities are included and are of sufficient detail and of appropriate scale to provide information needed to review the PCSA and GROA design. A site map clearly indicates the site boundary and the restricted area, restricted area access points, and distances from the boundary to significant features of the installation. Maps describe the site topography and surface drainage patterns, as well as roads, railroads, transmission lines, wetlands, and surface water bodies.

AC2 The license application contains a description of the regional demography adequate to permit evaluation of the PCSA and the GROA design.

- Regional demographic information is based on current census data and presents the population distribution as a function of distance from the GROA.

AC3 The license application contains a description of the local meteorology and regional climatology adequate to permit evaluation of the PCSA and the GROA design.

- The license application data on local meteorology and regional climatology, that may be significant for the review of the PCSA and GROA design, is adequate.

- The data collection techniques are based on accepted methods, and the technical bases for data summaries are provided.

- Adequate information is provided on the annual amount and forms of precipitation, and the probable maximum precipitation at the site. Acceptable methods are used to develop this information.

- The license application adequately defines the type, frequency, magnitude, and duration of severe weather. Valid design bases/criteria are provided for the severe weather assessment.

- Trending analyses are appropriately conducted and supported by sufficient historical data presented in the license application.

AC4 The license application contains sufficient local and regional hydrological information to support evaluation of the PCSA and the GROA design.

- The description of the YM surface and groundwater hydrology adequately identifies hydrologic features relevant to the PCSA and GROA design.

- The analyses of the effects of any proposed changes to natural drainage features on GROA design are acceptable.

- The calculation of probable maximum flood is supported by sufficient data, including actual storm data in the region of the drainage basin.

AC5 The license application contains descriptions of the site geology and seismology adequate to permit evaluation of the PCSA and the GROA design.

- The license application provides sufficient data on the geology of the site to support the PCSA and GROA design, including the stratigraphy and lithology over the entire surface and subsurface construction area.

- Site characterization data adequately include rock mechanics properties based on *in situ* and laboratory test results for the rock formations where major construction activities will take place. Collection and processing of these data are based on accepted industry techniques.

- Rock mechanics testing data adequately support the license application analyses of the stability of subsurface materials.

- The engineering properties provided for soils in the areas where surface facilities will be constructed are based on laboratory and *in situ* test results. These data are collected and processed using accepted industry techniques.

- Detailed soil testing data support the license application analyses of the stability of surface materials, considering surface subsidence, previous loading histories, and liquefaction potential.

- The vibratory ground motion and surface and subsurface fault displacements of the site are adequately characterized, taking into account the assessment in Section 4.2.1.3.2.3 (Mechanical Disruption of Engineered Barriers) of the YMRP and considering a list of capable faults, areal seismic source zones, earthquake parameters such as maximum magnitude and recurrence for each source, historical earthquake data, paleoseismic data, and ground motion attenuation models.

- Acceptable methods are used to develop seismic design data using the characterized vibratory ground motion and surface and subsurface fault displacement.

- The license application provides adequate analyses of the stability of the facility foundations, subsurface emplacement drifts, and natural and manmade slopes (both cut and fill), the failure of which could result in radiological release. Appropriate methods are used for the analyses, data used are appropriate for the methods, and results are properly interpreted.

AC6 The license application contains descriptions of the historical regional igneous activity adequate to permit evaluation of the PCSA and the GROA design.

- The license application adequately considers igneous activity at the site including volcanic eruption, subsurface magmatic activity/flow, and volcanic ash flow/ash fall.

AC7 The license application provides analysis of site geomorphology adequate to permit evaluation of the PCSA and GROA design.

- The license application adequately considers the extent of erosion of the land surface and the likelihood that extreme erosion such as landslides, rock avalanches, other mass wasting and rapid fluvial degradation in channels or interfluves might affect site structures or operations.

AC8 The license application contains sufficient geochemical information to support evaluation of the PCSA and the GROA design.

- Information on the geochemical composition of subsurface water held within the rock matrix or perched water zone, or from episodic flows through fractures is sufficient to determine corrosivity.

- The geochemical composition of the rock strata within and above the repository horizon is adequately defined to identify minerals that might leach and add to the corrosivity of water flowing through the strata.

- Potential geochemical alterations to the rock fractures and the rock matrix through heating or other processes that might significantly alter geomechanical rock mass properties are adequately characterized.

4.1.1.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.112(c). Requirements for conducting an adequate PCSA and evaluation of GROA design have been met in that adequate data from the YM site and the surrounding region have been provided to identify naturally occurring and human-induced hazards.

4.1.1.1.5 References

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.” LWR edition. NRC: Washington, DC. 1987.

Nuclear Regulatory Commission (U.S.) (NRC). *Standard Format and Content for Documentation of Remedial Action Selection at Title I Uranium Mill Tailings Sites*. NRC: Washington, DC. 1989.

Schumm, S.A., and R.J. Chorley. NUREG/CR–3276, “Geomorphic Controls on the Management of Nuclear Waste.” NRC: Washington, DC. 1983.

4.1.1.2 Description of Structures, Systems, Components, Equipment, and Operational Process Activities

Review Responsibilities—High-Level Waste Branch

4.1.1.2.1 Areas of Review

This section reviews the description of SSCs, equipment, and operational process activities. The reviewers will also evaluate the information required by 10 CFR 63.21(c)(2), (c)(3)(i), and (c)(4).

The description of SSCs, equipment, and operational process activities should be sufficient for the reviewer to understand the design of GROA facilities and to identify hazards and event sequences. The reviewers of this section should coordinate their reviews with the reviews under Sections 4.1.1.3 (Identification of Hazards and Initiating Events) and 4.1.1.4 (Identification of Event Sequences) of the YMRP.

The staff will evaluate the following parts of the description of SSCs, equipment, and operational process activities using the review methods and acceptance criteria in sections 4.1.1.2.2 and 4.1.1.2.3.

- Descriptions of location of surface facilities and their functions, including SSCs and equipment;
- Descriptions of and design details for SSCs and equipment of surface facilities;
- Descriptions of and design details for SSCs and equipment of the subsurface facility;
- Characterization of HLW;
- Descriptions of engineered barrier system components (e.g., waste package, drip shield, and backfill); and
- Description of GROA operational process activities and procedures including interfaces and relationships between SSCs.

4.1.1.2.2 Review Methods

RM1 Description of Location of Surface Facilities and their Functions

Determine that the license application describes all surface facilities, including their location and arrangement at the site and their distance from the site boundary. This description should include drawings of sufficient detail and appropriate scale.

Verify that the discussion of the design of the surface facilities is adequate to permit an evaluation of the PCSA.

Verify that descriptions of the functional requirements for all the facilities are sufficient to provide an understanding of GROA operational activities, sequences, and locations sufficient for evaluation of the PCSA and GROA design.

Verify that the license application has descriptions of the capabilities of the equipment, training of the operators, and testing/maintenance plans sufficient for evaluation of the PCSA. Make this verification in collaboration with the reviewers for Sections 4.5.3 (Training and Certification of Personnel) and 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

RM2 Descriptions of and Design Details for SSCs and Equipment of Surface Facilities

Confirm the license application has provided adequate descriptions and design information for the SSCs and equipment of the surface facilities, such as:

- Design codes and standards employed;
- Building and facility structure floor plans and drawings;
- Materials of construction;
- Equipment layout;
- Process flow diagrams;
- Piping and instrumentation diagrams;
- Electrical systems;
- Pressure relief systems;
- Crane systems;
- Welding systems;
- Heating, ventilation, air conditioning, and filtration systems;
- Transportation systems;
- Confinement system;
- Decontamination system;
- Safety systems (e.g., interlocks, radiation detection, and fire suppression systems);
- Waste package and cask receipt, transfer, and handling systems;
- Loading and unloading systems (including remote operations);
- Emergency and radiological safety systems;
- Criticality and radiological monitoring systems;
- Communication and control systems;
- Power distribution systems including any backup power supplies;
- Shielding and criticality control systems; and
- Water supply systems.

Focus on systems used for radiological waste handling, packaging, transfer, containment, or storage and on any other SSCs important to safety. Identification of SSCs important to safety is reviewed using Section 4.1.1.6 (Identification of Structures, Systems, and Components Important to Safety; Safety Controls; and Measures to Ensure Availability of the Safety Systems) of the YMRP.

Verify the license application has provided adequate descriptions of the location and functional arrangement of the SSCs within each facility.

Confirm the license application has provided adequate discussion of design information about the capability of the surface facilities to withstand natural phenomena (e.g., seismic ground motions). The appropriateness and adequacy of the design will be reviewed using

Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP.

RM3 Descriptions of and Design Details for SSCs and Equipment of the Subsurface Facility

Confirm the license application has provided adequate descriptions and design information for the SSCs and equipment of the subsurface facility, such as:

- The layout of the subsurface facility in relation to any constraints imposed by natural conditions (geologic and hydrologic) and generic design goals (e.g., maximum rock temperature allowable);
- Ground control/support systems;
- Power distribution systems;
- Subsurface ventilation systems;
- Communication and monitoring systems;
- Transportation systems;
- Safety, detection, and suppression systems for fire and radiological emergencies;
- Waste package emplacement system;
- Emergency and radiological safety systems;
- Air seal systems to separate the waste emplacement area from the emplacement drift construction area;
- Waste package support/invert systems;
- Drip shield and drip shield placement systems;
- Backfill emplacement systems;
- Instrumentation and control systems; and
- Limits and interlocks.

RM4 Characterization of HLW

Verify the license application has adequately characterized the ranges of parameters that describe the HLW, such as:

- Reactor type (e.g., boiling water, pressurized water);
- Cask type;
- Fuel assembly manufacturer, model designation, and number;
- Fuel assembly physical characteristics and dimensions;
- Fuel cladding material (including crud deposits, oxide layer, hydride content, and extent of failure and damage);
- Thermal characteristics;
- Heat generation rate and dose rate;
- Radionuclide inventory;
- Radiochemical characteristics; and
- History (enrichment, burnup, and postirradiation storage).

Confirm the license application has adequately characterized properties of the HLW, such as:

- Waste form composition and amount,
- Waste form characteristics (phase stability and product consistency),
- Canister and characteristics of any waste encapsulation,
- Radionuclide inventory,
- Radiochemistry,
- Heat generation rate and dose rate,
- Proposed storage unit of material, and
- History.

RM5 Description of Engineered Barrier System and its Components

Confirm that the principal characteristics of the waste package, including dimensions, weights, materials, fabrications, weldings, and results of nondestructive examination and inspection have been provided.

Ensure that adequate discussion on analyses and characterization of functional features of the waste package, such as containment, criticality control, shielding, and confinement, has been provided.

Verify that the discussion of analyses and characterization of engineered barrier system components, such as drip shields, backfill (if used in the license application design), support/inverts, and sorption barrier, is sufficient for evaluation in the PCSA and GROA design review.

RM6 Description of GROA Operational Processes and Procedures

Evaluate the descriptions of GROA operational processes and procedures to ensure that they provide an adequate understanding of the component and facility functions and sequences of activities. Verify that information provided on operational process design, equipment design and specifications, and instrumentation and control systems is sufficient to assess the PCSA. This information should include:

- The purpose of each operational process and its relationship to overall GROA operations;

- Basic operational process function and theory, including a discussion of the basic theory of operational processes and an adequate discussion of ranges and limits for measured variables used to ensure safe operation of processes;

- Diagrams or flow charts that demonstrate the safety interrelationships of parts of the operational processes, such as schematics or descriptions showing the inventory, location, and geometry of nuclear materials, moderators, and other materials associated with processes;

- Hazardous material locations and quantities;

- Locations and types of interlocks and controls;

- Process block diagrams including decontamination and monitoring;

- Safety equipment; control systems; and instrumentation locations, characteristics, and functions; and

- Maximum intended inventories of radioactive materials.

4.1.1.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(2), 63.21(c)(3)(i), 63.21(c)(4), and 63.112(a) relating to the description of SSCs, equipment, and operational process activities.

AC1 The license application contains a description of the location of the surface facilities and their designated functions sufficient to permit evaluation of the PCSA and the GROA design.

- The license application has a description of surface facilities that includes their location and arrangement at the site and their distance from the site boundary. This description includes drawings of sufficient detail and appropriate scale.

- The discussion of the design of the surface facilities is adequate to permit an evaluation of the PCSA.

- The descriptions of the functional requirements for the facilities are adequate to provide an understanding of GROA operational activities, sequences, and locations sufficient for evaluation of the PCSA and GROA design.

- The descriptions of the capabilities of the equipment, training, level of the operators, and testing/maintenance plan are sufficient for evaluation of the PCSA.

AC2 The license application contains descriptions and design details for SSCs and equipment of the surface facilities sufficient to permit evaluation of the PCSA and the GROA design.

- The license application provides adequate descriptions and design information for the SSCs and equipment of the surface facilities.

- The license application provides adequate descriptions of the location and functional arrangement of the SSCs within each facility.

- The license application provides adequate discussion of design information regarding the capability of the surface facilities to withstand the effects of natural phenomena.

AC3 The license application contains descriptions and design details for SSCs and equipment of the subsurface facility sufficient to permit evaluation of the PCSA and the GROA design.

- The license application provides adequate descriptions and design information for the SSCs and equipment of the subsurface facility.

AC4 The license application characterizes the HLW sufficiently to permit evaluation of the PCSA and the waste package design.

- The license application adequately characterizes the ranges of parameters that characterize the HLW.

- The license application adequately characterizes the properties of the HLW.

AC5 The license application provides a general description of the engineered barrier system and its components sufficient to support evaluation of the PCSA and the engineered barrier system design.

- The principal characteristics of the waste package, including dimensions, weights, materials, fabrications, and weldings, are defined.

- Adequate characterization of functional features of the waste package, such as criticality control, shielding, and confinement, is provided.

- The discussion of analyses and characterization of engineered barrier system components, such as drip shields, backfill, support/inverts, and sorption barrier, is sufficient to support evaluations in the PCSA and GROA design reviews.

AC6 The description of the operational processes to be used at the GROA is sufficient for review of the PCSA.

- Descriptions of GROA operational processes provide an adequate understanding of the component and facility functions and sequences of activities.

- Information provided on operational process design, equipment design and specifications, and instrumentation and control systems is sufficient to assess the PCSA.

4.1.1.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance that they satisfy the requirements of 10 CFR 63.112(a) in that an adequate general description of the SSCs, equipment, and process activities of the GROA has been provided.

4.1.1.2.5 References

None.

4.1.1.3 Identification of Hazards and Initiating Events

Review Responsibilities—High-Level Waste Branch

4.1.1.3.1 Areas of Review

This section reviews the identification of hazards and initiating events. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(5).

The staff will evaluate the following parts of the identification of hazards and initiating events using the review methods and acceptance criteria in sections 4.1.1.3.2 and 4.1.1.3.3. The reviewers of this section should coordinate their reviews with the reviewers of Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis) and 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

- Technical basis and assumptions for methods used for identification of hazards and initiating events,

- Use of site data for identification of hazards and initiating events,

- Determination of frequency or probability of occurrence of hazards and initiating events,

- Technical basis for inclusion or exclusion of specific hazards and initiating events, and

- List of hazards and initiating events to be considered in the PCSA.

4.1.1.3.2 Review Methods

RM1 Technical Basis and Assumptions for Methods Used for Identification of Hazards and Initiating Events

Confirm that methods used to identify hazards and initiating events are consistent with standard industry practices [e.g., NUREG/CR–2300 (NRC, 1983), NUREG–1513[1], NUREG–1520[2], the American Institute of Chemical Engineers (1992) appendixes A and B]. If expert elicitation was used, review the expert elicitation process using Section 4.5.4 (Expert Elicitation) of the YMRP.

If standard industry practices are not used by DOE, evaluate whether the DOE basis and justification for choosing a particular hazard and initiating event identification method are defensible.

Ensure that methods selected for hazard and initiating event identification are appropriate for the available data on the site and GROA. Review descriptions of the site and its SSCs using Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety) and 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

Confirm that assumptions used to identify naturally occurring and human-induced hazards and initiating events are well-defined and have adequate technical basis, and are supported by information in Section 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis) and Section 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

RM2 Use of Site Data for Identification of Hazards and Initiating Events

Verify that appropriate site-specific data (including frequency of occurrence, where relevant) have been used to identify naturally occurring and human-induced hazards and initiating events such as:

- Seismicity and faulting,
- Winds and tornadoes,
- Volcanic activity,
- Slope instability,
- Other extreme meteorological or geological conditions, and
- Human-induced events (e.g., aircraft crash at the site).

[1]Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1520, “Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility.” Draft Report. NRC: Washington, DC. 2000.

[2]Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1513, “Integrated Safety Analysis Guidance Document.” Draft Report. NRC: Washington, DC. 2000.

Coordinate with the reviewer for Section 4.2 (Repository Safety After Permanent Closure) of the YMRP to ensure that naturally occurring hazards (e.g., seismicity, faulting, and igneous activity) identified in this section are consistent with the list of FEPs.

Verify that the appropriate properties and factors are considered in determining the adequacy of the hazard and initiating event identification, such as:

- Heat generation from the HLW;
- Flammable, corrosive, pressurized, and toxic materials;
- Conditions under which available fissionable material could pose a criticality hazard; and
- Potential interactions among hazardous materials and conditions.

Confirm the identification of human-induced hazards encompasses relevant aspects of the GROA radiological systems. In particular, consider the list of such systems evaluated using Section 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP. Confirm that the identification of hazards encompasses all GROA modes of operation. Modes of GROA operation include normal process operations, maintenance (e.g., shutting down critical equipment), removal of damaged nuclear waste disposal containers from subsurface to surface facilities, and backfilling operations (if included in the license application design) within waste emplacement drifts.

Consult with reviewers of Section 4.1.1.2.3 (Acceptance Criteria—Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP to ensure that system descriptions used to support hazard and initiating event identification are adequate.

RM3 Determination of Frequency or Probability of Occurrence of Hazards and Initiating Events

Ensure that methods selected for determining probability or frequency of occurrence for hazards and initiating events are appropriate. Also ensure that uncertainties associated with the frequency or probability estimates are quantified.

If standard industry practices are not used by DOE, evaluate whether the DOE basis and justification for choosing the method(s) used to determine the frequency or probability of occurrence of hazards and initiating events are defensible.

If relevant frequency or probability data are insufficient or not available, verify that appropriate bounding values are used and defensible technical bases are provided. Also evaluate the adequacy of the associated bounding calculations. If expert elicitation was used, review the expert elicitation process using Section 4.5.4 (Expert Elicitation) of the YMRP.

Consult with the reviewers of Section 4.2.1.2.1 (Identification of Features, Events, and Processes Affecting Compliance With the Overall Performance Objectives) of the YMRP to ensure the validity of the frequencies and/or probabilities established for naturally occurring events. Also assess the validity of the frequencies and/or probabilities established for human-induced hazards and initiating events.

Ensure that human errors that may lead to radiological consequences are adequately identified and that adequate human reliability analyses are performed. Ensure that DOE provides an adequate technical basis for any human reliability method used, its range of applicability, and its assumptions and uncertainties. Guidance from documents such as NUREG–1278 (NRC, 1983), NUREG–1624 (NRC, 2000), and NUREG–2300 (NRC, 1983) can assist the review.

RM4 Technical Basis for Inclusion or Exclusion of Specific Hazards and Initiating Events

Verify that adequate technical bases for the inclusion and exclusion of hazards and initiating events are provided.

Determine if technical bases are defensible and consistent with site and system information reviewed in Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis) and 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

Ensure that technical bases include consideration of uncertainties.

RM5 List of Hazards and Initiating Events to Be Considered in the PCSA

Verify that the DOE list of hazards and initiating events contains the credible natural and human-induced events.

Perform limited independent assessment to confirm that the list of hazards and initiating events that may result in radiological releases is acceptable.

4.1.1.3.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.112(b) and (d) relating to the identification of hazards and initiating events.

AC1 Technical basis and assumptions for methods used for identification of hazards and initiating events are adequate.

- Methods used for hazard and initiating event identification are consistent with standard industry practices.

- If standard industry practices are not used, the DOE basis and justification for choosing particular hazard and initiating event identification method(s) are defensible.

- Methods selected for hazard and initiating event identification are appropriate for the available data on the site and GROA.

- Assumptions used to identify naturally occurring and human-induced hazards and initiating events are well-defined, have adequate technical basis, and are supported by information on the site and its SSCs and operational processes.

AC2 Site data and system information are appropriately used in identification of hazards and initiating events.

- Appropriate site-specific data are used to identify naturally occurring hazards and initiating events.

- In determining the adequacy of the hazard and initiating event identification, the appropriate properties and factors are considered.

- The identification of human-induced hazards encompasses relevant aspects of the GROA radiological systems. The identification of hazards encompasses all GROA modes of operation.

AC3 Determination of frequency or probability of occurrence of hazards and initiating events is acceptable.

- Methods selected for determining probability or frequency of occurrence for hazards and initiating events are appropriate, and uncertainties are adequately quantified.

- An appropriate basis and justification is provided for any use of nonstandard practices for determining frequency or probability estimates.

- The frequencies and/or probabilities established for naturally occurring events and human-induced hazards and initiating events are valid.

- Human errors that may lead to radiological consequences are adequately identified, and adequate human reliability analyses are performed.

AC4 Adequate technical bases for the inclusion and exclusion of hazards and initiating events are provided.

- The technical bases are defensible and consistent with site and system information.

- The technical bases include adequate consideration of uncertainties associated with frequency or probability of the hazards and initiating events.

AC5 The list of hazards and initiating events that may result in radiological releases is acceptable.

- The DOE list of hazards and initiating events contains the credible natural and human-induced events.

- Independent assessment confirms that the list of hazards and initiating events that may result in radiological releases is acceptable.

4.1.1.3.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.112(b) related to identification of hazards and initiating events. The naturally occurring and human-induced hazards and potential initiating events have been adequately identified. The identification of the initiating events and the associated probabilities of occurrence are acceptable.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.112(d). An adequate technical basis for either inclusion or exclusion of specific naturally occurring or human-induced hazards and initiating events has been provided.

4.1.1.3.5 References

American Institute of Chemical Engineers. “Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples.” New York: American Institute of Chemical Engineers, Center for Chemical Process Safety. 1992.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG/CR–2300, “PRA Procedures Guide–A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants.” NRC: Washington, DC. 1983.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1278, “Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Application.” NRC: Washington, DC. 2000.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1624, “Technical Basis and Implementation Guidelines for A Technique for Human Event Analysis (ATHEANA).” Revision 1 NRC: Washington, DC. 2000.

4.1.1.4 Identification of Event Sequences

Review Responsibilities—High-Level Waste Branch

4.1.1.4.1 Areas of Review

This section reviews the identification of event sequences considered in the PCSA. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(5).

The staff will evaluate the following parts of the identification of event sequences using the review methods and acceptance criteria in sections 4.1.1.4.2 and 4.1.1.4.3.

- Technical bases for methods used and assumptions made for identification of event sequences, and

- Category 1 and 2 event sequences.

4.1.1.4.2 Review Methods

RM1 Technical Basis and Assumptions for Methodology

Ensure that methods selected for event sequence identification are appropriate and are consistent with standard practices [e.g., NUREG/CR–2300 (NRC, 1983) and American Institute of Chemical Engineers (1992) appendixes A and B].

Confirm that methods selected are consistent with and supported by site-specific data.

Verify that assumptions made in determining the event sequences are justified and valid.

RM2 Category 1 and 2 Event Sequences

Verify that DOE has properly considered the hazards and initiating events reviewed in section 4.1.1.3 (Identification of Hazards and Initiating Events) of the YMRP. Confirm that DOE has applied appropriate methods for identification of event sequences and has provided adequate technical bases for assumptions used in identification of event sequences.

Ensure that the potentially relevant human factors reviewed using Section 4.1.1.3 (Identification of Hazards and Initiating Events) of the YMRP have been appropriately considered in event sequence identification. To the extent practical, NUREG–1624 [Technical Basis and Implementation Guidelines for A Technique for Human Event Analysis (ATHEANA)] (NRC, 2000) can be used to assist the review.

Verify that DOE has considered reasonable combinations of initiating events and the associated event sequences that could lead to exposure of individuals to radiation.

Verify that Category 1 event sequences are identified on the basis that they will occur one or more times during the preclosure period. Confirm that the methods and/or technical bases for determining those event sequences are acceptable.

Verify that Category 2 event sequences include those event sequences with probabilities less than 1 and greater than one chance in 10,000 of occurring during the preclosure period. Confirm that the methods and/or technical bases for determining those event sequence probabilities are acceptable.

Perform limited independent assessments to confirm that possible event sequences that may lead to radiological releases have been adequately identified and to verify that DOE analyses and calculations were performed properly.

4.1.1.4.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.112(b) relating to the identification of event sequences.

AC1 Adequate technical basis and justification are provided for the methodology used and assumptions made to identify PCSA event sequences.

- Methods selected for event sequence identification are appropriate and are consistent with standard industry practices.

- The methods selected are consistent with and supported by site-specific data.

- Assumptions made in identifying event sequences are valid.

AC2 Category 1 and 2 event sequences are adequately identified.

- DOE has adequately considered the relevant hazards and initiating events. Appropriate methods have been applied to identify event sequences and adequate technical bases for assumptions have been provided.

- The potentially relevant human factors are appropriately considered in the event sequence identification.

- DOE considers reasonable combinations of initiating events and the associated event sequences that could lead to exposure of individuals to radiation.

- Category 1 event sequences are identified on the basis that they will occur one or more times during the preclosure period, and the technical methods or approaches used to determine the event sequences are acceptable.

- Category 2 event sequences include all those event sequences with probabilities less than 1 and greater than one chance in 10,000 of occurring during the preclosure period, and the technical methods or approaches used to determine the probabilities of occurrence are acceptable.

- Limited independent assessments confirm that possible event sequences that may cause radiological releases are adequately identified, and related DOE analyses and calculations are performed properly.

4.1.1.4.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy, in part, the requirements of 10 CFR 63.112(b). A reasonably comprehensive identification and analysis of potential event sequences has been provided.

4.1.1.4.5 References

American Institute of Chemical Engineers. “Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples.” New York: American Institute of Chemical Engineers, Center for Chemical Process Safety. 1992.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–2300, “PRA Procedures Guide–A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants.” NRC: Washington, DC. 1983.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1624, “Technical Basis and Implementation Guidelines for A Technique for Human Event Analysis (ATHEANA).” Revision 1 NRC: Washington, DC. 2000.

4.1.1.5 Consequence Analyses

4.1.1.5.1 Consequence Analysis Methodology and Demonstration that the Design Meets 10 CFR Part 20 and 10 CFR Part 63 Numerical Radiation Protection Requirements for Normal Operations and Category 1 Event Sequences

Review Responsibilities—High-Level Waste Branch

4.1.1.5.1.1 Areas of Review

This section reviews the consequence analysis methodology and demonstration that the design meets 10 CFR Part 20 and 10 CFR Part 63 numerical radiation protection requirements for normal operations and Category 1 event sequences. The reviewers will also evaluate the information required by 10 CFR 63.21(c)(5).

The staff will evaluate the following parts of consequence analysis methodology and demonstration that the design meets 10 CFR Part 20 and 10 CFR Part 63 numerical radiation protection requirements for normal operations and Category 1 event sequences using the review methods and acceptance criteria in sections 4.1.1.5.1.2 and 4.1.1.5.1.3.

- Consequence evaluations for normal operations and Category 1 event sequences,
- Onsite and offsite doses during normal operations and Category 1 event sequences, and
- Compliance with performance objectives.

4.1.1.5.1.2 Review Methods

RM1 Consequence Analyses of Normal Operations, Category 1 Event Sequences, and Factors that Allow an Event Sequence to Propagate within the GROA

Ensure that DOE has conducted consequence analyses for normal operations and Category 1 event sequences that were reviewed using Section 4.1.1.4 (Identification of Event Sequences) of the YMRP. Verify that consequence analyses consider the following:

- Hazard event sequences that could lead to radiological consequences (including the controls used to prevent or mitigate the event sequences);

- Interactions of identified hazards and proposed controls;

- Modes of GROA operation including normal process operations, maintenance (e.g, shutting down critical equipment), removal of damaged nuclear waste disposal containers from subsurface to surface facilities, and backfilling operations (if included in the license application design) within waste emplacement drifts. Analyses should assume that operations will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the license application; and

- Descriptions of event sequences for which consequences (radiation dose) will be determined including information on the hazard, SSCs that take part in the event sequences, and controls relied on to prevent or mitigate the event sequences.

RM2 Assessment of Calculations of Consequences to Workers and Members of the Public from Normal Operations and Category 1 Event Sequences

Evaluate methods used to perform the consequence (radiation dose) calculations. Verify that adequate technical bases for selecting these methods have been provided. Ensure that adequate technical bases have been provided for assumptions used for the calculations and methods. Confirm methods are consistent with site-specific data and system design and process information that were evaluated using Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis) and 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

Evaluate the identification of the member of the public likely to receive the highest dose from GROA normal operations or Category 1 event sequences and the rationale for this identification. Confirm that the dose to this individual bounds the annual dose to any real member of the public located beyond the site boundary.

Ensure that input data and information used for the consequence analyses are identified and are consistent with site-specific data and system design and process information. Verify that adequate technical bases are provided for selection of this input data and information.

Evaluate the calculation of the source term and confirm the following:

- Characteristics of the HLW used in the source term calculation (e.g., enrichment, burnup, and decay time) reasonably represent or bound the range of characteristics of waste that will be handled at the GROA, as reviewed using Section 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP; and

- The type, quantity, and concentration of airborne radionuclides released during normal operations and Category 1 event sequences are supported by appropriate data or are in accordance with appropriate NRC guidance documents, such as NUREG–1567 (NRC, 2000).

Evaluate the calculations of onsite and offsite direct exposures during normal operations and Category 1 event sequences and ensure the following:

- The analyses are consistent with commonly acceptable shielding calculations such as the guidance in NUREG–1567 (NRC, 2000) and are provided in sufficient detail to allow independent confirmatory calculations,

- Credit taken for shielding materials that reduce direct exposure dose rates is appropriate and accounts for any degradation that may occur as a result of the event sequences,

- Methodologies used in shielding analyses are appropriate for the radiation types and geometries and materials modeled and have been validated using dose rate measurements from similar facilities, and

- Flux-to-dose conversion factors, atmospheric dispersion data, and cross-section data used in the analyses are consistent with accepted practice such as is documented in American National Standards Institute (ANSI)/American Nuclear Society (ANS) 6.1.1 and ANSI/ANS 6.1.2 (ANS Standards Committee Working Group, 1977, 1989).

Evaluate the calculations of dose to workers and members of the public from airborne radionuclides during normal operations and following Category 1 event sequences and ensure the following:

- Credit taken for the use of ventilation and filtration systems in mitigating the release of airborne radioactive materials is appropriate.

- For the calculation of dose to the public from airborne radionuclides:

  — Airborne transport modeling uses acceptable methods, such as those outlined in Regulatory Guide 1.109 (NRC, 1977) for routine releases; and

  — DOE has considered appropriate exposure pathways such as direct exposure to airborne radionuclides, inhalation of airborne radionuclides, and pathways associated with radionuclides deposited on the ground in the receptor location for potential long-term exposure of the receptor.

- For the calculation of dose to workers from airborne radionuclides:

  — The calculation of airborne radioactivity concentrations within the GROA utilizes times and levels of elevated airborne radioactivity concentrations that are reasonable or conservative based on technically defensible data, and

— The times that workers are assumed to be exposed to elevated radiation fields and airborne concentrations of radioactivity are reasonable or conservative based on technically defensible data.

- The inhalation dose conversion factors used in the analyses are standard for dose assessments such as those in Federal Guidance Report # 11 (Eckerman, et al., 1992).

RM3 Limitation of Dose to Workers and Members of the Public from Normal Operations and Category 1 Event Sequences to Within Limits Specified in 10 CFR 63.111(a)

Confirm that normal operations and Category 1 event sequences that could adversely affect radiological exposures have been considered.

Verify that an appropriate method has been used to aggregate the doses from normal operations and Category 1 event sequences.

Confirm that the doses to workers and members of the public will be as low as is reasonably achievable (ALARA) as evaluated using Section 4.1.1.8 (Meeting the 10 CFR Part 20 As Low As Is Reasonably Achievable Requirements for Normal Operations and Category 1 Event Sequences) of the YMRP.

4.1.1.5.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.111(a)(1), (a)(2), (b)(1), (c)(1), and (c)(2) relating to consequence analysis methodology and demonstration that the design meets 10 CFR Part 20 and 10 CFR Part 63 numerical radiation protection requirements for normal operations and Category 1 event sequences.

AC1 Consequence analyses adequately assess normal operations and Category 1 event sequences as well as factors that allow an event sequence to propagate within the GROA.

- DOE conducts consequence analyses for normal operations and Category 1 event sequences that adequately consider hazard event sequences that could lead to radiological consequences, interactions of identified hazards and proposed controls, and all modes of GROA operation. Analyses assume that operations are carried out at the maximum capacity and rate of receipt of radioactive waste stated in the license application. The consequence analyses provide details on the related hazard and the SSCs and controls that are relied on to prevent or mitigate event sequences.

AC2 Consequence calculations adequately assess the consequences to workers and members of the public from normal operations and Category 1 event sequences.

- Adequate methods are used to perform the consequence calculations, and adequate technical bases are provided for selecting these methods. Adequate technical bases are also provided for assumptions used for the calculations and methods. The selected methods are consistent with site-specific data and system design and process information.

- The identification of the member of the public likely to receive the highest dose from GROA normal operations or Category 1 event sequences is adequate, and the rationale for this identification is adequate. The dose to this individual bounds the annual dose to any real member of the public located beyond the site boundary.

- Input data and information used for the consequence analysis are identified and are consistent with site-specific data and system design and process information. Adequate technical bases are provided for selection of this data and information.

- The calculation of the source term is acceptable and is based on the following:

  — Characteristics of the HLW used in the source term calculation reasonably represent or bound the range of characteristics of waste that will be handled at the GROA; and

  — The type, quantity, and concentration of airborne radionuclides released during normal operations and Category 1 event sequences are supported by appropriate data or are in accordance with NRC guidance documents.

- The calculations of onsite and offsite direct exposures during normal operations and Category 1 event sequences are based on the following:

  — The analyses are consistent with commonly acceptable shielding calculations and are provided in sufficient detail to allow independent confirmatory calculations,

  — Credit taken for shielding materials that reduce direct exposure dose rates is appropriate and accounts for any degradation that may occur as a result of the event sequences,

  — Methodologies used in any shielding analyses are appropriate for the radiation types and geometries and materials modeled and are validated using dose rate measurements from similar facilities, and

  — Flux-to-dose conversion factors, atmospheric dispersion data, and cross-section data used in the analyses are consistent with accepted practice.

- The calculations of dose to workers and members of the public from airborne radionuclides during normal operations and following Category 1 event sequences are adequate and are based on the following:

  — Credit taken for the use of ventilation and filtration systems in mitigating the release of airborne radioactive materials is appropriate;

— For the calculation of dose to the public from airborne radionuclides, airborne transport modeling is conducted using acceptable methods, and DOE considers appropriate exposure pathways;

— For the calculation of dose to workers from airborne radionuclides, the calculation of airborne radioactivity concentrations within the GROA utilizes times and levels of elevated airborne radioactivity concentrations that are reasonable or conservative based on technically defensible data. The times that workers are assumed to be exposed to elevated radiation fields and airborne concentrations of radioactivity are reasonable or conservative based on technically defensible data; and

— The inhalation dose conversion factors used in the analyses are appropriate for dose assessments.

AC3 The dose to workers and members of the public from normal operations and Category 1 event sequences is within the limits specified in 10 CFR 63.111(a).

- Normal operations and Category 1 event sequences that could adversely affect radiological exposures are adequately considered.

- An appropriate method is used to aggregate the doses from normal operations and Category 1 event sequences.

- Doses to workers and members of the public will be ALARA.

4.1.1.5.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(a)(1). Performance objectives for the GROA up to the time of permanent closure have been met in that the radiation exposure limits in 10 CFR Part 20 will not be exceeded.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(a)(2). Performance objectives for the GROA up to the time of permanent closure have been met in that, during normal operations and for Category 1 event sequences, the annual dose to any real member of the public, located beyond the boundary of the site, will not exceed a total effective dose equivalent (TEDE) of 0.25 mSv (25 mrem).

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance that they satisfy the requirements of 10 CFR 63.111(b)(1). The GROA has been designed such that, taking into consideration normal operation and Category 1 event sequences, radiation exposures, radiation levels, and releases of radioactive materials will be maintained within the limits of 10 CFR 63.111(a).

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(c)(1). The PCSA meets the requirements specified at 10 CFR 63.112 and demonstrates that the radiation protection limits of 10 CFR Part 20 will be met. During normal operations and Category 1 event sequences, the annual dose to any real member of the public, located beyond the boundary of the site, will not exceed a TEDE of 0.25 mSv (25 mrem).

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance that they satisfy the requirements of 10 CFR 63.111(c)(2). The PCSA meets the requirements specified at 10 CFR 63.112 and demonstrates that the preclosure numerical radiation protection requirements will be met for GROA normal operations and Category 1 event sequences.

4.1.1.5.1.5 References

American Nuclear Society (ANS) Standards Committee Working Group. “Neutron and Gamma Ray Flux-to-Dose-Rate Factors.” ANSI/ANS 6.1.1-1977. American National Standards Institute: Washington, DC. 1977. [or latest version]

American Nuclear Society (ANS) Standards Committee Working Group. “Neutron and Gamma-Ray Cross Sections for Nuclear Radiation Protection Calculations for Nuclear Power Plants.” ANS 6.1.2–1989. American National Standards Institute: Washington, DC. 1989. [or latest version]

Eckerman, K.F., A.B. Wolbarst, and A. Richardson. Federal Guidance Report #11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.” U.S. Department of Commerce: Springfield, VA. 1992.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.109, “Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I. NRC: Washington, DC. 1977. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1567, “Standard Review Plan for Spent Fuel Storage Facilities.” Final Report. NRC: Washington, DC. 2000.

4.1.1.5.2 Design Meeting 10 CFR Part 63 Numerical Radiation Protection Requirements for Category 2 Event Sequences

Review Responsibilities—High-Level Waste Branch

4.1.1.5.2.1 Areas of Review

This section reviews the design meeting 10 CFR Part 63 numerical radiation protection requirements for Category 2 event sequences. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(5).

The staff will evaluate the following parts of the design meeting 10 CFR Part 63 numerical radiation protection requirements for Category 2 event sequences using the review methods and acceptance criteria in sections 4.1.1.5.2.2 and 4.1.1.5.2.3.

- Consequence evaluations for Category 2 event sequences,
- Offsite doses for Category 2 event sequences, and
- Compliance with performance objectives.

4.1.1.5.2.2 Review Methods

RM1 Consequence Analyses of Category 2 Event Sequences and Factors that Allow an Event Sequence to Propagate within the GROA

Ensure that DOE has conducted consequence analyses for Category 2 event sequences that were reviewed using Section 4.1.1.4 (Identification of Event Sequences) of the YMRP. Verify that consequence analyses consider the following:

- Hazard event sequences that could result in radiological consequences (including the controls used to prevent or mitigate the event sequences);

- Interactions of identified hazards and proposed controls;

- Whether DOE analyses assume that operations will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the license application, and

- Descriptions of event sequences for which consequences (radiation dose) will be determined including information on the hazard, SSCs that take part in the event sequences, and controls relied on to prevent or mitigate the event sequences.

RM2 Assessment of Calculations of Consequences to Members of the Public from Category 2 Event Sequences

Evaluate the methods used to perform consequence calculations and verify that adequate technical bases for selecting these methods have been provided. Ensure that adequate technical bases have also been provided for assumptions used for the calculations and methods. Confirm that methods are consistent with site-specific data and system design and process information that was evaluated using Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis) and 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP.

Evaluate the identification of the hypothetical member of the public, located on or beyond the site boundary, likely to receive the highest dose from the GROA during a Category 2 event sequence and the rationale for this identification.

Ensure that input data and information used for the consequence analyses are identified and are consistent with site-specific data and system design and process information. Verify that adequate technical bases are provided for selection of this input data and information.

Evaluate the calculation of the source term and confirm the following:

- Characteristics of the HLW used in the source term calculation (e.g., enrichment, burnup, and decay time) reasonably represent or bound the range of characteristics of waste that will be handled at the GROA as reviewed using Section 4.1.1.2 (Description of Structures, Systems, Components, Equipment, and Operational Process Activities) of the YMRP; and

- The type, quantity, and concentration of airborne radionuclides that could be released during Category 2 event sequences are supported by appropriate data and analyses or are estimated in accordance with NRC guidance documents, such as NUREG–1567 (NRC, 2000).

Evaluate the calculations of offsite dose from direct exposure following Category 2 event sequences and ensure the following:

- The analyses are consistent with commonly acceptable shielding calculations such as the guidance in NUREG–1567 (NRC, 2000). The analyses are provided in sufficient detail to allow independent confirmatory calculations;

- Credit taken for shielding materials that reduce direct exposure dose rates is appropriate and accounts for any degradation that may occur as a result of the event sequences;

- Methodologies used in shielding analyses are appropriate for the radiation types and geometries and materials modeled and have been validated using dose rate measurements from similar facilities;

- The time a member of the public is assumed to be exposed to elevated levels of radiation from Category 2 event sequences is reasonable. This time is based on the amount of time required for the facility to recover from the event sequence; and

- Flux-to-dose conversion factors and cross-section data used in the analyses are consistent with accepted practice such as is documented in ANSI/ANS 6.1.1 and ANSI/ANS 6.1.2 (ANS Standards Committee Working Group, 1977, 1989).

Evaluate the calculation of dose to members of the public from airborne radionuclides following Category 2 event sequences and ensure that:

- Credit taken for the use of ventilation and filtration systems in mitigating the release of airborne radioactive materials is appropriate. The analyses consider credible damage to the ventilation system that may result from event sequences such as ventilation duct collapse, fan failure, or filter blowout;

- Airborne transport modeling uses an acceptable method, such as that outlined in Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants (NRC, 1983);

- DOE has considered appropriate exposure pathways such as:
  - Direct exposure to airborne radionuclides;
  - Inhalation of airborne radionuclides;
  - Pathways associated with radionuclides deposited on the ground in the receptor location for potential long-term exposure of the receptor. This pathway may be omitted if the site emergency plan [reviewed using Section 4.5.7 (Emergency Plan) of the YMRP] has provisions to mitigate doses to members of the public following any accident that releases significant quantities of radioactive material;
- The time that a member of the public is assumed to be exposed to airborne radioactive materials from Category 2 event sequences is reasonable and is based on the time that radioactive effluents are released from the GROA, and
- The inhalation dose conversion factors used in the analyses are standard for dose assessments, such as those in Federal Guidance Report # 11 (Eckerman, et al., 1992).

RM3 Limitation of Dose to Hypothetical Members of the Public from Category 2 Event Sequences to Limits Specified in 10 CFR 63.111(b)(2)

Confirm that Category 2 event sequences that could adversely affect radiological exposures have been considered. Also verify that no identified Category 2 event sequence will lead to a dose to a member of the public that exceeds the dose limit in 10 CFR 63.111(b)(2).

4.1.1.5.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.111(a)(1), (b)(2), and (c) relating to the design meeting 10 CFR Part 63 numerical radiation protection requirements for Category 2 event sequences.

AC1 Consequence analyses include Category 2 event sequences as well as factors that allow an event sequence to propagate within the GROA.

- DOE conducts consequence analyses for Category 2 event sequences that adequately consider hazard event sequences that could lead to radiological consequences, interactions of identified hazards and proposed controls, and the maximum capacity and rate of receipt of radioactive waste. The consequence analyses provides details on the SSCs and controls that are relied on to prevent or mitigate event sequences.

AC2 Consequence calculations adequately assess the consequences to members of the public from Category 2 event sequences.

- Adequate methods are used to perform the consequence calculations, and adequate technical bases are provided for selecting these methods. Adequate technical bases are also provided for assumptions used for the calculations and methods. The selected methods are consistent with site-specific data and system design and process information.

- The identification of the hypothetical member of the public, located on or beyond the site boundary, likely to receive the highest dose from the GROA during a Category 2 event sequence is adequate, and the rationale for this identification is adequate.

- Input data and information used for the consequence analysis are identified and are consistent with site-specific data and system design and process information. Adequate technical bases are provided for their selection.

- The calculation of the source term is based on the following:

  — Characteristics of the HLW used in the source term calculation reasonably represent or bound the range of characteristics of waste that will be handled at the GROA; and

  — The type, quantity, and concentration of airborne radionuclides that could be released during Category 2 event sequences are supported by appropriate data and analyses or are estimated in accordance with NRC guidance documents.

- The calculations of offsite dose from direct exposure following Category 2 event sequences are adequate and are based on the following:

  — The analyses are consistent with commonly acceptable shielding calculations and are provided in sufficient detail to allow independent confirmatory calculations;

  — Credit taken for shielding materials that reduce direct exposure dose rates is appropriate and accounts for any degradation that may occur as a result of the event sequence;

  — Methodologies used in any shielding analyses are appropriate for the radiation types and geometries and materials modeled and are validated using dose rate measurements from similar facilities;

  — The time that a member of the public is assumed to be exposed to elevated levels of radiation from Category 2 event sequences is reasonable. The time is based on the amount of time required for the facility to recover from the event sequence; and

  — Flux-to-dose conversion factors and cross-section data used in the analyses are consistent with accepted practice.

- The calculation of dose to members of the public from airborne radionuclides following Category 2 event sequences is adequate and is based on the following:

  - Credit taken for the use of ventilation and filtration systems in mitigating the release of airborne radioactive materials is appropriate. The analyses consider credible damage to the ventilation system that may result from event sequences,

  - Airborne transport modeling uses an acceptable method,

  - DOE considers appropriate exposure pathways,

  - The time that a member of the public is assumed to be exposed to airborne radioactive materials from Category 2 event sequences is reasonable and is based on the time that radioactive effluents are released from the facility, and

  - The inhalation dose conversion factors used in the analyses are standard for dose assessments.

AC3 The dose to hypothetical members of the public from Category 2 event sequences is within the limits specified in 10 CFR 63.111(b)(2).

- Category 2 event sequences that could adversely affect radiological exposures are adequately considered.

- No identified Category 2 event sequence will lead to a dose to a member of the public that exceeds the dose limit in 10 CFR 63.111(b)(2).

4.1.1.5.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(a)(1). The GROA will meet the radiation protection limits of 10 CFR Part 20 for Category 2 event sequences.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(b)(2). The design of the GROA is such that, taking into consideration Category 2 event sequences, no individual located on, or beyond, any point on the boundary of the site will receive, as a result of the single Category 2 event sequence, the more limiting of a TEDE of 0.05 Sv (5 rem), or the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) or 0.5 Sv (50 rem). The lens dose equivalent will not exceed 0.15 Sv (15 rem), and the shallow dose equivalent to skin will not exceed 0.5 Sv (50 rem).

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance that they satisfy the requirements of 10 CFR 63.111(c). The PCSA meets the requirements specified at 10 CFR 63.112 including a demonstration that the radiation protection limits of 10 CFR Part 20 and the numerical guides for design objectives for Category 2 events in 10 CFR 63.111(b)(2) are met.

4.1.1.5.2.5 References

American Nuclear Society (ANS) Standards Committee Working Group. “Neutron and Gamma Ray Flux-to-Dose-Rate Factors.” ANSI/ANS 6.1.1-1977. American National Standards Institute: Washington, DC. 1977. [or latest version]

American Nuclear Society (ANS) Standards Committee Working Group. “Neutron and Gamma-Ray Cross Sections for Nuclear Radiation Protection Calculations for Nuclear Power Plants.” ANS–6.1.2–1989. American National Standards Institute: Washington, DC. 1989. [or latest version]

Eckerman, K.F., A.B. Wolbarst, and A. Richardson. Federal Guidance Report # 11., “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.” U.S. Department of Commerce: Springfield, VA. 1992.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.” NRC: Washington, DC. 1983. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1536, “Standard Review Plan for Dry Cask Storage Systems.” NRC: Washington, DC. 1997.

4.1.1.6 Identification of Structures, Systems, and Components Important to Safety; Safety Controls; and Measures to Ensure Availability of the Safety Systems

Review Responsibilities—High-Level Waste Branch

4.1.1.6.1 Areas of Review

This section reviews the identification of SSCs important to safety, safety controls, and measures to ensure availability of the safety systems. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(5).

The staff will evaluate the following parts of the identification of SSCs important to safety, safety controls, and measures to ensure availability of the safety systems using the review methods and acceptance criteria in sections 4.1.1.6.2 and 4.1.1.6.3.

- SSCs important to safety and measures to ensure availability of safety systems,
- Administrative or engineered safety controls for SSCs important to safety, and
- Risk significance categorization of SSCs Important to Safety (to be developed).

4.1.1.6.2 Review Methods

RM1 List of SSCs Important to Safety, Technical Bases for Performance-Based Identification of SSCs and Safety Controls, and List and Analysis of Measures to Ensure Availability of Safety Systems

Verify that analysis and classification of SSCs for the GROA used results of the consequence analyses reviewed using Section 4.1.1.5 (Consequence Analyses) of the YMRP. This consequence analysis should be the basis to identify SSCs that are important to safety that should be functional to meet the performance objectives. All SSCs and controls assumed to be functional in the consequence analyses should be considered in the list. Confirm that SSCs are classified as important to safety according to the definition specified in 10 CFR 63.2.

Compare the DOE classification of SSCs important to safety with similar SSCs listed in NUREG/CR–6407 (NRC, 1996) for other types of nuclear storage and transportation systems.

Confirm that analyses used to identify SSCs important to safety, safety controls, and measures to ensure the availability of the safety systems include adequate consideration of:

- Means to limit concentration of radioactive material in air, such as:
  - Ventilation systems designed in accordance with Regulatory Guide 3.32, General Design Guide for Ventilation Systems for Fuel Reprocessing Plants (NRC, 1975);
  - Use of seals and/or air locks as part of GROA design; and
  - Installation of radiation monitoring systems that provide information on the dose rate and concentration of airborne radioactive material in selected areas.
- Means to limit time required to perform work in the vicinity of radioactive materials, such as:
  - Features that minimize the time that maintenance, health physics, or inspection personnel must remain in restricted areas; and
  - Use of remotely operated or robotic equipment such as welders, wrenches, cutting tools, and radiation monitors, and means to remotely place temporary shielding.
- Suitable shielding, such as:
  - Shielding provided by the radioactive material being stored;
  - Neutron capture provided by borated water in casks and waste transfer pools, and by borated materials incorporated into casks;

- Gamma and neutron shielding provided by the structural and nonstructural materials in the walls and ends of storage/transfer casks; and

- Temporarily positioned shielding used during operations for preparing the storage cask for storage or retrieval, and/or during transfer into the storage position at the storage location, and shielding provided by any pool facility interior and exterior walls.

Verify that the shielding design includes selection of appropriate shielding materials and that the design analysis of the shielding performance for normal and Category 1 and 2 event sequence loadings is acceptable. Coordinate with the reviewer of the repository design for Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP.

- Means to monitor and control dispersal of radioactive contamination.

- Means to control access to high radiation areas, very high radiation areas, or airborne radioactivity areas to ensure compliance with the requirements of subparts G and H of 10 CFR Part 20, such as:

  - Analyses that identify airborne radioactivity areas. These analyses should provide a technical basis for any inability to practically apply process or other engineering controls to restrict the concentrations of radioactive material in air to values below those that define an airborne radioactivity area;

  - A plan for monitoring and limiting intakes of radiation (e.g., controlling access, limiting individual exposure times, using individual respiratory protection equipment); and

  - Application of design guidance in Regulatory Guide 8.38, Control of Access to High and Very High Radiation Areas of Nuclear Power Plants (NRC, 1993).

- Means to prevent or control criticality, such as complying with ANSI/ANS–8 nuclear criticality safety standard documents listed in Regulatory Guide 3.71 (NRC, 1998).

- A radiation alarm system designed to warn of significant increases in radiation levels, concentrations of radionuclides in air, and increased radioactivity in effluents. This system should be designed to provide prompt notification to personnel both in the work area where an increase in radiation is detected and in control centers. Features of control centers should include:

  - Appropriate installation of radiation alarms in areas where waste is being stored, transferred, or processed/repackaged;

- — Availability of backup power systems for radiation alarm systems; and
- — Design and operation of interior evacuation signals and signs consistent with Regulatory Guide 8.5, Criticality and Other Interior Evacuation Signals (NRC, 1981).

- The ability of SSCs to perform their intended safety functions, assuming the occurrence of event sequences, considering results from the review of consequence analyses using Section 4.1.1.5 (Consequence Analyses) of the YMRP.

- Explosion and fire detection systems and appropriate suppression systems, features of which may include:

  - — Installation of detection and suppression systems near probable sources of fire or explosion, and
  - — Designs to accommodate the interactions of ventilation systems with potential fires or explosions.

- Means to control radioactive waste and radioactive effluents and to permit prompt termination of operations and evacuation of personnel during an emergency, such as:

  - — Design and operation of the GROA to reduce the quantity of radioactive waste generated;
  - — Off-gas treatment, filtration, and ventilation systems for control of airborne radioactive effluents;
  - — Liquid waste management systems to handle the expected volume of potentially radioactive liquid waste generated during normal operations and Category 1 and 2 event sequences. Design features and procedures for these systems should minimize generation of liquid waste and the possibility of spills and should provide for control of spills, overflows, or leakage during packaging and transfer of site-generated radioactive liquid waste; and
  - — Solid waste management systems to handle the expected volume of potentially radioactive solid waste (e.g., contaminated equipment and personnel clothing) generated during normal operations and Category 1 and 2 event sequences.

- Means to provide reliable and timely emergency power to instruments, utility service systems, and operating systems important to safety, such as:

  - — Instrumentation and/or monitoring systems with battery power, for which the duration of backup battery life should be consistent with reasonable time periods of primary power loss;
  - — Uninterruptible power supplies on process control computers; and

— Standby diesel generators that should start on demand if primary power is lost and should continue to operate for the required period of time.

- Means to provide redundant systems necessary to maintain, with adequate capacity, the capability of utility services important to safety, such as electrical systems, ventilation systems, air supply systems, water supply systems for fire suppression, and communication systems. Examples of design features for consideration in these systems may include electrical systems, ventilation systems, water supply systems, and communication systems.

- Means to inspect, test, and maintain SSCs important to safety, as necessary, to ensure their continued function and readiness. This assessment should take into account the review of plans for conduct of normal activities including maintenance, surveillance, and periodic testing conducted using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

RM2 Administrative or Procedural Safety Controls to Prevent Event Sequences or Mitigate Their Effects

Confirm that management systems and procedures are sufficient to ensure that administrative or procedural safety controls will function properly. Coordinate with the reviewer for Sections 4.5.5 (Plans for Startup Activities and Testing) and 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP. Examples of such management systems are:

- Procedures;
- Training;
- Maintenance, calibration, and surveillance plans and schedules;
- Configuration controls for SSCs;
- Human factor evaluations;
- Audits and self-assessments;
- Emergency planning; and
- Accident/incident investigation requirements.

Confirm that administrative or procedural safety controls required for the SSCs to be functional and to meet the dose requirements are included in the list of SSCs important to safety.

RM3 Risk Significance Categorization of SSCs Important to Safety

(To be developed.)

4.1.1.6.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.112(e) relating to the identification of SSCs important to safety, safety controls, and measures to ensure availability of the safety systems.

AC1 An adequate list of SSCs identified as being important to preclosure radiological safety, the technical bases for the approaches used to identify SSCs important to safety and safety controls based on analysis of their performance, and a list and analysis of the measures to be taken to ensure the availability of the safety systems are provided.

- The analysis and classification of SSCs for the GROA uses results of the consequence analyses as a basis to identify those SSCs that are important to safety.

- The DOE classification of SSCs important to safety compares appropriately with similar classifications for other types of nuclear storage and transportation systems.

- The analyses used to identify SSCs important to safety, safety controls, and measures to ensure the availability of the safety systems include adequate consideration of:

  — Means to limit concentration of radioactive material in air;

  — Means to limit time required to perform work in the vicinity of radioactive materials;

  — Suitable shielding;

  — Means to monitor and control dispersal of radioactive contamination;

  — Means to control access to high radiation areas, very high radiation areas, or airborne radioactivity areas;

  — Means to prevent or control criticality;

  — A radiation alarm system designed to warn of significant increases in radiation levels, concentrations of radionuclides in air, and increased radioactivity in effluents;

  — Ability of SSCs to perform their intended safety functions, assuming the occurrence of event sequences;

  — Explosion and fire detection systems and appropriate suppression systems;

  — Means to control radioactive waste and radioactive effluents and to permit prompt termination of operations and evacuation of personnel during an emergency;

  — Means to provide reliable and timely emergency power to instruments, utility service systems, and operating systems important to safety;

  — Means to provide redundant systems necessary to maintain, with adequate capacity, the capability of utility services important to safety; and

— Means to inspect, test, and maintain SSCs important to safety, as necessary, to ensure their continued function and readiness.

AC2 Administrative or procedural safety controls needed to prevent event sequences or mitigate their effects are adequate and are included in the list of SSCs important to safety.

- Management systems and procedures are sufficient to ensure that administrative or procedural safety controls will function properly.

- Administrative or procedural safety controls required for SSCs to be functional and to meet dose requirements are included in the list of SSCs important to safety.

AC3 Risk significance categorization of SSCs important to safety is technically defensible.

(To be developed.)

4.1.1.6.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.112(e). An adequate analysis of the performance of the SSCs important to safety has been provided. In particular, this analysis demonstrates that:

- SSCs important to safety are identified,

- Risk criteria for categorization of SSCs important to safety are adequately developed,

- Controls that will be relied upon to limit or prevent potential event sequences or mitigate their consequences are acceptable, and

- Measures are adequate to ensure the availability of SSCs important to safety.

4.1.1.6.5 References

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 3.32, “General Design Guide for Ventilation Systems for Fuel Reprocessing Plants.” NRC: Washington, DC. 1975. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.5, “Criticality and Other Interior Evacuation Signals.” NRC: Washington, DC. 1981. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.38, “Control of Access to High and Very High Radiation Areas in Nuclear Power Plants.” NRC: Washington, DC. 1993. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). NUREG/CR–6407, “Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Important to Safety.” NRC: Washington, DC. 1996.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 3.71, “Nuclear Criticality Safety Standards for Fuels and Material Facilities.” NRC: Washington, DC. 1998. [or latest version]

4.1.1.7 Design of Structures, Systems, and Components Important to Safety and Safety Controls

Review Responsibilities—High-Level Waste Branch

4.1.1.7.1 Areas of Review

This section reviews the design of SSCs important to safety and safety controls. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(2) and (c)(3). Coordinate review of information such as the geologic media, general arrangement, and dimensions, as specified in 10 CFR 63.21(c)(2), with the review of sections 4.1.1.1 and 4.1.1.2 of the YMRP.

The staff will evaluate the following parts of the design of SSCs important to safety and safety controls using the review methods and acceptance criteria in sections 4.1.1.7.2 and 4.1.1.7.3.

- Design criteria and design bases,
- Design methodologies, and
- Repository design and design analyses.

The GROA SSCs important to safety have not been identified at the time of YMRP preparation. Their determination will depend largely on the final design and PCSA results. The review methods and acceptance criteria provided in the following sections are examples. These SSCs may or may not be important to safety. If some SSCs listed below are determined not to be important to safety based on the review conducted using section 4.1.1.6 of the YMRP, the reviewer may not have to review these SSCs. Similarly, for SSCs that are identified to be important to safety but are not included in the YMRP, the general aspects of the review methods and acceptance criteria provided below may still be applicable. However, for the remaining aspects not addressed in the following sections, the reviewer should exercise professional judgment to conduct the review.

4.1.1.7.2 Review Methods

4.1.1.7.2.1 Design Criteria and Design Bases

RM1 Definitions of Relationship between Principal Design Criteria and 10 CFR 63.111(a) and (b) Requirements, Relationship between Design Bases and Principal Design Criteria, and Design Criteria and Design Bases for SSCs Important to Safety

Verify that principal design criteria and bases for SSCs important to safety and for those SSCs that affect the proper functioning of the SSCs important to safety have been identified. Confirm these design criteria and bases are derived from the site characteristics and consequence analyses reviewed using Sections 4.1.1.1 (Site Description as it Pertains to Preclosure Safety Analysis), and 4.1.1.5 (Consequence Analyses) of the YMRP. Ensure these design criteria and bases are consistent with analyses used to identify SSCs as reviewed using Section 4.1.1.6 (Identification of Structures, Systems, and Components Important to Safety; Safety Controls; and Measures to Ensure Availability of the Safety Systems) of the YMRP.

Determine whether the design criteria for normal operating conditions are adequately developed so that designs do not result in any degradation of the capabilities of the GROA to protect radiological health and safety. Verify that design criteria do not permit degradation of the GROA SSCs important to safety which will reduce:

- Radioactive material-handling and waste-processing capability,
- Capability to withstand further occurrence of Category 1 and 2 event sequences without remedial action, or
- Capability to perform design functions for the full system lifetime without remedial action.

Ensure that design criteria adequately consider PCSA results. Verify that SSCs important to safety will continue to prevent consequences such as unacceptable releases of radioactive material, unacceptable radiation doses for workers or the public, and loss of removal capability.

Confirm that structural design criteria and bases for SSCs important to safety meet relevant guidance such as that provided in:

- Regulatory Guides 1.76 (U.S. Atomic Energy Commission, 1974) and 1.117 (NRC, 1978a) for tornado protection;
- Regulatory Guides 1.29 (NRC, 1978b), 1.60 (U.S. Atomic Energy Commission, 1973a), 1.61 (U.S. Atomic Energy Commission, 1973b), 1.92 (NRC, 1976a), and 1.122 (NRC, 1978c) for protection against seismic events;
- Regulatory Guide 1.91 (NRC, 1978d) for explosion protection;
- Regulatory Guides 1.59 (NRC, 1977a) and 1.102 (NRC, 1976b) as well as ANSI/ANS–2.8 (ANSI/ANS, 1992a) for flood protection; and
- NUREG–0800 (NRC, 1987) and other accepted NRC guidelines such as “Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects,” (Kennedy, 1975) for tornado missile protection.

Verify that the thermal design criteria and bases are consistent with guidance such as that provided in Regulatory Guide 1.120 (NRC, 1976c) and ANSI/ANS–15.17 (ANSI/ANS, 1981), for fire protection.

Verify that the design criteria and bases for shielding and confinement systems use, where appropriate, guidance provided in:

- ANSI/ANS–6.4 (ANSI/ANS, 1997a),
- Regulatory Guide 1.143 (NRC, 1979a),
- Regulatory Guide 8.5 (NRC,1981),
- Regulatory Guide 8.25 (NRC, 1992a), and
- Regulatory Guide 8.34 (NRC, 1992b).

Confirm that designs for fixed-area radiation monitors and continuous airborne monitoring instrumentation for radiological protection are consistent with references such as:

- ANSI N13.1–1993, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities (ANS Standards Committee Working Group, 1993);

- ANSI–HPSSC–6.8.1–1981, Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Reactors (ANSI, 1981);

- NUREG–0800, section 11.5, Process and Effluent Radiological Monitoring Instrumentation and Sampling Systems (NRC, 1996);

- Regulatory Guide 8.25, Air Sampling in the Workplace (NRC, 1992a); and

- Regulatory Guide 4.1, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants (NRC, 1975a).

Verify that criticality design criteria are developed based on the consequence analysis results from the PCSA. Confirm that criticality design criteria are factored into models and assumptions used for criticality analysis. These criteria should be consistent with those given in NUREG–1567 (NRC, 2000) and those ANSI/ANS–8 nuclear criticality standards adopted by the NRC as listed in Regulatory Guide 3.71 (NRC, 1998). For example:

- ANSI/ANS–8.10, Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement (ANSI/ANS, 1983);

- ANSI/ANS–8.1, Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors (ANSI/ANS, 1988);

- ANSI/ANS–8.3, Criticality Accident Alarm System (ANSI/ANS, 1997b);

- ANSI/ANS–8.7, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials (ANSI/ANS, 1998);

- ANSI/ANS–8.20, Nuclear Criticality Safety Training (ANSI/ANS, 1991b);

- ANSI/ANS–8.22, Nuclear Criticality Safety Based on Limiting and Controlling Moderators (ANSI/ANS, 1997c); and

- ANSI/ANS–8.23, Nuclear Criticality Accident Emergency Planning and Response (ANSI/ANS, 1997d).

Verify that design bases and design criteria are based on the above listed or other guidance documents and standards, considering the normal GROA operating conditions and Category 1 and 2 event sequences. For example, these design bases should include:

- Thermal design bases and criteria that include temperatures for those temperature sensitive SSCs important to safety that consequence analyses (reviewed using section 4.1.1.5 of the YMRP) show pose a potential radiological hazard if the design temperatures are not met. In reviewing adequacy of the structural design bases and criteria, the staff should:

  — Verify that thermal design criteria for the surface and subsurface facilities have been adequately developed based on the maximum design waste inventory,

  — Verify that design criteria for fire protection (e.g., fire ratings, fire barriers) are adequate based on the maximum credible GROA fire (duration and temperature) if determined to be of design importance from the consequence analyses (reviewed using section 4.1.1.5 of the YMRP), and

  — Verify that design criteria for the surface and subsurface ventilation systems have been adequately developed based on thermal and fire protection design criteria in addition to airborne radiological dose limits.

- Structural design bases and criteria including maximum loads, stress/pressure loadings (static and/or dynamic), and displacements for SSCs important to GROA safety which consequence analyses (reviewed using section 4.1.1.5 of the YMRP) show pose a potential radiological hazard if the design loads and displacements are violated. In reviewing adequacy of the structural design bases and criteria:

  — Verify that event sequences are properly converted into structural loads, pressures, and/or displacements based on accepted methods; and

  — Verify that the use of factored loads and load combinations is based on accepted methods.

- Shielding design bases and criteria, including maximum dose rates and annual dose rates to workers and the public from the exterior of shielding surfaces, for SSCs important to safety.

- Criticality design bases and criteria including fuel geometry configurations, moderators, and k_{eff} limits to ensure that nuclear fuel remains subcritical during handling, transfer, repackaging, storage, and retrieval.

- Operating design bases and criteria, including the maximum limits of travel, vertical lift, and/or velocity, for SSCs important to safety for handling and transfer of HLW or containers which consequence analyses (reviewed using section 4.1.1.5 of the YMRP) show present a potential radiological hazard if operating limits are violated.

4.1.1.7.2.2 Design Methodologies

RM1 GROA Design Methodologies

Confirm that proposed design methodologies are supported by adequate technical bases and are consistent with established industry practice. Verify that uncertainties associated with the proposed methodologies have been adequately addressed.

If the design methodologies depend on site-specific test data, confirm that such data are available. Also ensure that any analytical or numerical models used to support the design methodologies have been verified, calibrated, and validated. Verify that any assumptions or limitations relating to the proposed methodologies are identified and that their implications for the design have been adequately analyzed and documented.

If the design methodologies depend on data from expert elicitations, coordinate with the reviewer of Section 4.5.4 (Expert Elicitation) of the YMRP to ensure that these elicitations are conducted and documented in accordance with NUREG–1563 (Kotra, et al., 1996).

Confirm that seismic design methodologies use ground motion information that is consistent with proposed DOE methodologies for hazard assessment and that, taken together, they provide adequate input for seismic design and for performance assessments.

4.1.1.7.2.3 Repository Design and Design Analyses

I. Designs and Design Analyses for SSCs, Equipment, and Safety Controls That are Safety Related for Surface Facilities

RM1 Design Codes and Standards

Ensure that applicable design codes and standards are specified for the structural, thermal, shielding and confinement, criticality, and decommissioning designs. This review should include:

- Confirmation that structural design, fabrication, and testing of emplacement casks for storage of SNF is in accordance with the Boiler and Pressure Vessel Code (B&PVC), section III, subsections NB or NC. Welds on these casks should be in accordance with Section IX (ASME, 1993);

- Verification that prestressed and reinforced concrete structures within the GROA that are used for containment of radioactive material are designed in accordance with ACI 359 (American Concrete Institute and ASME, 1992).

- Confirmation that design, construction, material selection, and specifications for reinforced concrete structures that are not within the scope of ACI 359 (American

Concrete Institute and ASME, 1992), but are considered important to safety, are in accordance with ACI 349 (American Concrete Institute, 1997) and ANSI/ANS–57.9 (ANSI/ANS, 1984).

- Determination that steel structures and components are designed and constructed in accordance with applicable steel design codes and standards [i.e., Specification for Structural Steel Buildings—Allowable Stress Design and Plastic Design, American Institute of Steel Construction (1989); Load and Resistance Factor Design Specification for Structural Steel Buildings, American Institute of Steel Construction (1993), and Code of Standard Practice for Steel Buildings and Bridges, American Institute of Steel Construction (1992)].

- Determination that foundations supporting SSCs important to safety are constructed in accordance with the applicable American Construction Institute code standards, and that site-related geotechnical parameters are obtained based on guidelines such as those provided in ANSI/ANS–2.11 (ANSI/ANS, 1978a).

- Verification that applicable standard codes have been used for design and construction of processing equipment and facility power systems, instrumentation, control, and other operations systems including, for example:

  — Crane systems [Nuclear Standard NOG–1–1995 (ASME, 1995); NUREG–0554 (NRC, 1979b); and appropriate Crane Manufacturer's Association of America standards],

  — Electrical/power systems [appropriate National Electrical Manufacturers Association codes and Institute of Electrical and Electronics Engineers, Inc. nuclear standards, Regulatory Guide 1.118 (NRC, 1995), Regulatory Guide 1.32 (NRC, 1977b), Regulatory Guide 1.75 (NRC, 1978e), and Regulatory Guide 1.120 for designing electrical systems for protection from fires (NRC, 1976c)],

  — Air control systems powering nuclear safety-related components and other equipment important to safety [ANSI/ANS–59.3 (ANSI/ANS, 1992a)],

  — Instrumentation and control systems (appropriate International Society for Measurement and Control and Institute of Electrical and Electronics Engineers codes),

  — Fire detection and suppression systems [NFPA22 (National Fire Protection Association, 1987); NFPA801 (National Fire Protection Association, 1998); and other appropriate National Fire Protection Association codes], and

  — Ventilation systems [Regulatory Guide 3.32 (NRC, 1975), Regulatory Guide 1.120 related to fire protection and removal of fire combustion products (NRC, 1976c)], ANSI/ANS–56.7 (ANSI/ANS, 1978b), and applicable standards or guides published by the American Society of Heating, Refrigeration, and Air

Conditioning Engineers [e.g., ASHRAE Handbook, Chapter 23—Nuclear Facilities; (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1995)].

If other methods, standards, or guides are used for design, verify that the license application has provided adequate technical bases for their usage.

RM2 Consistency of Materials with Design Methodologies

Verify that materials used for SSCs important to safety in surface facility design are consistent either with the accepted design criteria, codes, standards, and specifications or with those specifically developed by DOE. For example, if ASME B&PVC, section III, subsection NB or NC (ASME, 1993), is used for waste package design criteria, the materials should be consistent with those prescribed by the particular section III paragraphs of the ASME B&PVC code, or their equivalent. Other examples include:

- For concrete and steel design, applicable ASTM standard specifications as listed in section 5.4.3.3 of NUREG–1567 (NRC, 2000); and

- For shielding materials, ANSI/ANS 6.4.2, Specification for Radiation Shielding Materials, (ANSI/ANS, 1985) may be used, and the geometric arrangement and the potential for shielding material to experience changes in material properties and geometry at high temperatures should be assessed. Confirm, based on review of the license application shielding analyses/design, that any temperature-sensitive shielding materials will not be subject to temperatures at or above their design limitations during normal operations and Category 1 and 2 event sequences.

Evaluate the material properties and allowable stresses and strains for the design to verify the adequacy of the materials.

Confirm that the materials and their properties are appropriate for the expected design loading conditions. Also confirm that anticipated stress limits for each material are based on maximum temperatures established in the thermal analysis evaluation in the license application.

Verify DOE has considered the potential for creep or brittle fracture of materials to ensure that SSCs important to safety are adequate to perform their safety functions.

RM3 Load Combinations Used for Normal and Category 1 and 2 Event Sequence Conditions

Verify that loads used in the design analyses are consistent with those normal and Category 1 and 2 event sequence loadings for SSCs important to safety.

Evaluate load combinations used in the design analyses for consistency with those accepted by the NRC for the design of similar types of nuclear facilities and for steel and reinforced concrete structures designed in accordance with ANSI/ANS 57.9 (ANSI/ANS, 1984) and ACI 359 (American Concrete Institute/ASME, 1992).

Verify that design analyses use appropriate techniques that were correctly applied to provide design temperatures, mechanical loads, and pressures for the SSCs important to safety.

RM4 Performance and Documentation of Design Analyses

Verify that design analyses include the relevant structural, thermal, shielding, criticality, confinement, and decommissioning factors, such as:

- For all analyses:
  - Computational models, data, assumptions, and results are adequately documented;
  - Computational models are validated;
  - Data are derived from relevant site and system information;
  - Assumptions are conservative, and adequate technical justifications or bases are provided;
  - Normal operations and Category 1 and 2 event sequences are considered in developing system loadings and environments;
  - Analyses are based on the maximum capacity and rate of receipt of radioactive waste; and
  - Limited confirmatory calculations are performed.
- For shielding design and design analyses:
  - Dose rate estimates are presented for representative areas, and
  - Bases for flux-to-dose conversions are adequately documented [conversion factors acceptable to the NRC are contained in ANSI/ANS 6.1.1 (ANSI/ANS, 1991a)].
- For criticality design and design analyses:
  - Calculations determine the highest K_{eff} that is likely to occur under the examined loading conditions,
  - Calculations are appropriate for the material properties, and
  - Analyses are consistent with those for similar facilities.
- For thermal design and design analyses:

— Analyses are consistent with limiting fuel burnup and cooling times, and

— Analyses specify the maximum and minimum temperatures for all components.

- For structural design and design analyses, loadings are correctly translated into either static or time-varying nodal forces or element face pressures.

Confirm that values of material properties used for the design analyses have adequate technical bases and are consistent with site-specific data.

Ensure that loads and load combinations used in the design analyses are consistent with defined normal operations and Category 1 and 2 event sequences.

Verify that analytical methods, models, and codes used for the design analyses are appropriate for the conditions analyzed and are properly benchmarked.

Confirm that technical bases for the assumptions used in the design analyses are conservatively defined and based on accepted engineering practice.

Ensure that designs and design analyses for SSCs important to safety are performed correctly. Also verify that these SSCs have sufficient capability to withstand normal and Category 1 and 2 event sequence loadings.

Conduct limited confirmatory checks or analyses using appropriate analytical methods, models, or codes.

II. Designs and Design Analyses for SSCs, Equipment, and Safety Controls That are Safety Related for Subsurface Facility

RM1 Design Assumptions, Codes, and Standards

Ensure the applicable design codes, standards, or other detailed criteria used for the design of the subsurface facility are specified. Codes and standards should be equivalent to and consistent with those accepted by the NRC for design of nuclear facilities with similar hazards and functions. If nonstandard approaches are used, confirm that the license application has provided adequate technical bases to justify why they are used.

Verify that the assumptions made for the design of the subsurface facility are technically defensible.

Confirm that GROA subsurface facility designs for steel and concrete structures and components, air controlled systems, electrical power systems, and ventilation systems for the subsurface facility use applicable standards such as those listed in Section 4.1.1.7.2.3 (Repository Design and Design Analyses) of the YMRP.

RM2 Design of Subsurface Operating Systems

Verify that the methods, assumptions, and input data used in the ventilation design are consistent with proposed thermal loading performance goals in the emplacement drifts. Conduct limited confirmatory analyses to verify the results presented in the license application. Also confirm that the analyses adequately address the thermal load in the ventilation tunnel and shafts and raises.

Evaluate design analyses of control system functions, equipment, instrumentation, control links, and communication systems to ensure that the subsurface monitoring and control systems are appropriate for the SSCs important to safety during waste transportation, emplacement, and monitoring.

Assess the design of the waste transport and emplacement system for compatibility with proposed waste transport and emplacement procedures. Also verify that interfaces with other systems are identified and assessed and that continuity of operations and safety can be achieved.

Evaluate the layout of the subsurface facilities. Ensure that emplacement drifts are located away from major faults, consistent with the seismic design, and that the subsurface layout is appropriate for the quantity of waste to be emplaced and the design thermal load.

Verify that standards and codes used for design of subsurface operating systems were properly applied.

RM3 Materials and Material Properties Used for Subsurface Facility Design

Confirm that the selection of materials and the properties of these materials are appropriate for the anticipated subsurface environment.

Verify that materials and material properties are consistent with applicable design criteria, codes, standards, and specifications. If no standards are used, evaluate the technical bases provided to ensure that they are acceptable. Confirm that applicable ASTM standard specifications such as ASTM B575–99a (ASTM, 2000a) and ASTM A666–00 (ASTM, 2000b) are used.

Evaluate whether the selection of ground support materials accounts for degradation of such materials under elevated temperature and thermal loading. Also ensure that plausible mechanisms for material degradation are identified and properly incorporated in assessments of subsystem SSC performance.

Verify that subsurface ventilation systems are constructed of fire resistant materials (e.g., fire resistant filters) to protect against fires occurring inside or outside the systems. Verify that ventilation equipment/components and materials, particularly those within or near waste emplacement drifts, are designed to withstand prolonged high temperature conditions, effects of sudden blast cooling, and wet and corrosive environments, to minimize maintenance/ replacement of potentially contaminated ventilation components.

RM4 Load Combinations Used for Normal and Category 1 and 2 Event Sequences

Confirm that the arrangement of waste packages within the subsurface facility satisfies the thermal load design criteria.

Ensure that the magnitude and time history of the applied thermal loading are consistent with the anticipated characteristics of the proposed nuclear waste, repository design configurations, and design areal mass loading.

Verify that thermal analyses have an appropriate technical basis, use site-specific thermal property data, consider temperature dependency and uncertainties of thermal property data, and use thermal models and analyses that are properly documented. If credit is taken for use of ventilation, confirm that assessments of the effects of ventilation are adequate.

Ensure that design analyses consider appropriate *in situ* stresses, potential running ground conditions, and hydrologic changes to the rock mass during the heating period which might effect mechanical properties.

Confirm that dynamic loads used in design analyses are consistent with the seismic design ground motion parameters including any repeated seismic effects, consider faulting effects, and are consistent with accepted methodologies for assessing faulting hazards.

RM5 Models and Site-Specific Properties of Host Rock Used in Design Analyses and Consideration of Spatial and Temporal Variation and Uncertainties in Such Properties

Ensure that appropriate combinations of continuum and discontinuum modeling, as well as two- and three-dimensional modeling, have been used for assessing the behavior of a fractured rock mass under prolonged heated conditions and Category 1 and 2 event sequences. Confirm that the bases for the choice of specific models and model combinations are adequate and that appropriate bases for the assumptions and limitations of the modeling approach are provided.

Confirm that principles for the design analyses, the underlying assumptions, and the anticipated limitations are documented, are consistent with modeling objectives, and are technically sound.

Verify that values for the rock-mass thermal expansion coefficient are consistent with properly interpreted site-specific data and that such interpretation accounts for likely scale effects and temperature dependency. Ensure that uncertainty in the thermal expansion coefficient has been adequately assessed and considered in the thermal stress calculation.

For continuum rock-mass modeling, confirm that values for rock-mass elastic parameters (Young’s modulus and Poisson’s ratio) and strength parameters (friction angle and cohesion) are consistent with properly interpreted site-specific data. If the parameter values are obtained through empirical correlations with a rock quality index, verify that the empirical equations used are appropriate for the site and are applied correctly. Confirm that the values of the index are consistent with site-specific data. If intact-rock-scale values are used, ensure that the bases for application of the values to the rock-mass scale are adequate.

For discontinuum rock-mass modeling, verify that the selection of fracture patterns for numerical modeling is appropriate for the objectives of the design and analyses. Confirm that the interpretation of modeling results adequately considers effects of simplification of the characteristics of the modeled fracture network compared to those of the *in situ* fracture network.

Confirm that the selection of stiffness and strength parameters for rock blocks between any fractures that are explicitly represented in the model are appropriate and account for fractures that are not explicitly represented.

Verify that the values for fracture stiffness and strength parameters are consistent with properly interpreted site-specific data.

For both continuum and discontinuum modeling, confirm that time-dependent mechanical degradation of the rock mass, fractures, and ground support that may occur following the emplacement of nuclear waste is adequately accounted for in thermal-mechanical analyses. This may be based on extrapolations from DOE's long-term exploratory studies facility heated drift and single heater test studies, the cross drift thermal test study, or other methods. Verify that the bases for the magnitude and rate of mechanical degradation applied in the analyses are appropriately established and are technically defensible.

Ensure that uncertainties in rock mass and fracture mechanical properties are adequately estimated and considered in both continuum and discontinuum modeling.

Verify that the models adequately address the stability of openings around drift intersections considering the rock mass and its degraded properties and thermal loading. This information should be used in the design of ground support.

Conduct limited confirmatory continuum and discontinuum analyses to verify the rock mass behavior results presented in the license application under design (normal) operating conditions and Category 1 and 2 event sequences.

RM6 Design Methodologies and Interpretations of Modeling Results for Ground Support Systems

Confirm that design methodologies or combinations of design methodologies are properly applied to the design of ground support systems. Ensure that, when used, the empirical design approach is consistent with accepted technology in the underground tunneling and mining industry. Also verify that the evaluation and selection of ground support systems are supported by analyses that satisfy acceptance criteria 4 and 5 under subsection II in Section 4.1.1.7.3.3 (Repository Design and Design Analyses) of the YMRP. These analyses should provide mechanical evaluation of ground support systems under thermal and dynamic loads.

Confirm that the ground support system responses are adequately evaluated based on the results of model analyses. If the ground support system is explicitly modeled, verify that the ground support responses include an adequate assessment of deformation and potential failure of the ground support systems. Ensure that the interaction between the ground support system and the host rock units (e.g., interactions of rock bolts with lithophysae) is considered in the analysis. Review method 5 under this subsection and acceptance criterion 5 under subsection II in Section 4.1.1.7.2.3 (Repository Design and Design Analyses) of the YMRP should be used in assessing ground support system responses, where applicable. If the ground support system is not explicitly modeled, confirm that the anticipated ground support system responses from the modeling results are reasonably estimated and that technical bases for these estimations are adequate.

Verify that geometrical, thermal, and mechanical characteristics of the ground support system used in the thermal-mechanical analyses are consistent with the design and construction specifications. Also confirm that the time-dependent mechanical degradation of the ground support system under heated conditions is adequately accounted for in the analyses.

Verify that stability of emplacement drifts, ventilation tunnels, and shafts is adequately assessed both with and without ground support. The assessment should identify rock blocks with potential to fall in the drifts; the potential for cave-in, collapse, or closure of the excavations; and the extent and severity of rock-mass disturbance near excavations. Ensure that selection of a ground support system is consistent with the anticipated rock-mass responses and potential failure mechanisms of the rock mass near the excavations.

RM7 Design of Ventilation Systems

Confirm that the design of subsurface ventilation systems is consistent with the design criteria, codes, standards, and specifications normally used by the underground mining industry or with those specifically developed by DOE.

Confirm that subsurface ventilation systems (including their power sources) important to safety (reviewed using section 4.1.1.6 of the YMRP) are designed to function under normal subsurface operating conditions (e.g., high temperature, potentially wet environments) and under Category 1 and 2 event sequences. Coordinate with the reviewer of sections 4.1.1.3, 4.1.1.4, and 4.1.1.5 to ensure subsurface ventilation design has adequately considered event sequences which have radiological safety consequences.

Confirm that, to the extent applicable, ventilation design guidance such as that provided in Regulatory Guide 3.32, General Design Guide for Ventilation Systems for Fuel Reprocessing Plants (NRC, 1975b) for surface nuclear facilities is met for the subsurface ventilation design. Specifically consider (i) general radiological safety, (ii) occupied area ventilation systems, (iii) process area ventilation systems, (iv) exhaust ventilation and filtration systems, (v) fans, (vi) ventilation system construction and layout, (vii) ventilation system testing and monitoring, and (viii) quality assurance. Regulatory Guide 1.120 (NRC, 1976c) contains guidance for protection from fires.

Confirm that subsurface ventilation equipment important to safety has backup or standby equivalents. This equipment should also have fail-safe mechanisms (e.g., backflow prevention) for the primary ventilation equipment (i.e., in a high radiation area). Alternatively, DOE's ventilation design and analysis can demonstrate that such equipment could be repaired/replaced without causing a subsurface radiation safety hazard.

Confirm that subsurface ventilation equipment important to safety has recording devices to give continuous readouts of important parameters to control centers (e.g., operating temperature, pressures, vibration levels).

Verify that subsurface ventilation systems important to safety are designed to continue operating in the event of a main subsurface power outage (e.g., ventilation fans operated from an independent power circuit or other emergency backup power source is readily available), if determined to be necessary.

Confirm that DOE has an adequate periodic inspection, testing, and maintenance program to assure that ventilation requirements can be maintained and that concentrations of radioactive materials within the subsurface worker operations areas, escape routes, and exhaust air are ALARA. Verify that this program includes among others:

- Periodic replacement of high-efficiency particulate air filters in the GROA exhaust shafts, ramps, or other high radiation areas;

- Periodic testing/calibration of radiological monitoring devices that activate or deactivate high-efficiency particulate air filter systems;

- Routine testing of any standby/backup ventilation equipment and emergency power to assure readiness to maintain ventilation functions and radiation safety; and

- Routine testing and calibration of airborne radiological monitoring devices, smoke detectors, and temperature sensors.

Verify that DOE's subsurface ventilation design is adequate to seal off or isolate potential airborne radiological release areas (e.g., waste haulage routes, emplacement drifts) to limit the extent of radiological contamination and worker exposure.

Ensure that DOE's ventilation design analysis is based on accepted industry codes or methods, incorporates site specific data (i.e., resistance factors, humidity levels, time-varying waste package heat fluxes), and is based on an accurate representation of the subsurface drift structure (i.e., varying drift shapes and dimensions, varying flow rates between emplacement drifts and main drifts). Verify that subsurface ventilation flows from the least likely contaminated areas to the most contaminated areas and meets design criteria (e.g., worker radiation exposure limits or other contaminant limits, air temperature limits, pressure differentials between high radiation/nonradiation areas).

Conduct limited confirmatory analyses as an independent verification of DOE's ventilation design analyses results.

RM8 Design of Subsurface Power and Power Distribution Systems

Verify that the design of subsurface electric power supplies (e.g., electric transformers, electric substations) and power distribution systems, for SSCs important to safety, is consistent with accepted design criteria, codes, standards, and specifications for underground usage. Confirm these systems are suitable for the normal GROA operating environment and those Category 1 and 2 event sequences of radiological consequence reviewed using section 4.1.1.5 of the YMRP.

Confirm that the design incorporates proper grounding of electrical power sources/equipment to protect workers.

Ensure that the design has sufficient emergency backup power capability to support equipment that is important to safety.

Verify that DOE's design of electric power systems important to safety permits appropriate periodic inspection and testing.

RM9 Maintenance Plan for Subsurface Facility SSCs, Equipment, and Controls Important to Safety

Evaluate the adequacy of the maintenance plan developed to maintain drift stability prior to permanent closure of the repository. Ensure that the maintenance plan considers the likely effects of uncertainties due to high temperature and high radiation levels and is based on an appropriate interpretation of modeling results that assess the possibility of degradation of both the rock mass and the ground support system under sustained thermal load.

Verify that adequate maintenance plans for other subsurface facility SSCs, equipment, and controls important to safety are in place and that they account for drift stability and accessibility during the period prior to permanent closure. Also ensure that the consideration of drift stability effects in the maintenance plan is based on an appropriate interpretation of modeling results. Plans for conduct of normal activities including maintenance, surveillance, and periodic testing are reviewed using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

III. Designs for SSCs and Safety Controls That are Safety Related for Waste Package/Engineered Barrier System

RM1 Design of Waste Package and Engineered Barrier System SSCs and Their Controls

Confirm that the waste package/engineered barrier system design adequately incorporates containment (considering corrosion resistance), criticality control, shielding, structural strength of waste packages, thermal control, waste form degradation, drip shield, waste package support/invert, backfill, and sorption barrier, as appropriate.

Verify that the description and assessment of components for the waste packages include containers and internal structures such as structural guides, baskets, fuel baskets, fuel basket plates with neutron absorbers, neutron absorber rods, canisters, fillers, and fill gas. The description and assessment should also consider specific components of the engineered barrier system such as drip shield, backfill, and sorption barrier. Confirm that the design analyses for these components are adequate.

Verify that the materials, methods, and processes used in the fabrication of containers, internal waste package components, and engineered barrier system components are consistent with accepted design criteria, codes, standards, and specifications such as ASME B&PVC, section III (ASME, 1993). Confirm that processes specified for fabrication, assembly, closure, and inspection are based on accepted industry technology. Confirm that the license application documents significant discrepancies or uncertainties related to the corrosion and mechanical resistance of container materials and relevant engineered barrier system components such as the drip shield. If DOE uses design criteria, codes, standards, specifications, and industry technology other than those mentioned above, evaluate the adequacy of the technical bases provided.

Confirm that specifications for the container and internal waste package materials are in agreement with those established in the final design. Verify that the specifications for closure welding, preparation for welding, materials to be used in welds, and inspection of welding comply with appropriate ASME codes such as ASME B&PVC code, section IX (ASME, 1993). Assess the acceptability of any documented deficiencies or variations with respect to the specifications of the code.

Verify that appropriate methods for nondestructive examination of fabricated containers and other structural components of waste packages have been identified to detect and evaluate fabrication defects and any other defects that may lead to premature failure.

Confirm that criticality design criteria are consistent with those used in model calculations that support the design and that isotopic enrichment of waste is properly characterized for these models. Verify the model configurations are appropriate for the postulated repository environments, and that appropriate computer models are used in design calculations.

Verify that the assessment of shielding provided by the containers is adequate. This assessment should include estimates of dose rates, a description of the source of data for the evaluation, and the methods for estimating dose rate, including the use of computational codes.

Ensure that the components of the waste package and internals have been designed to sustain loads from normal operation and Category 1 and 2 event sequences.

Confirm that thermal control is such that the fuel cladding temperature is sufficiently low to prevent cladding failure. Verify that appropriate models have been used for calculating decay heat, considering fuel age and fuel blending inside waste packages.

Verify that the materials used in construction of the internal components of the waste package are compatible with the waste form and that interactions among these materials will not be detrimental to the stability of the waste form. This verification should confirm that no pyrophoric, explosive, or chemically reactive materials are introduced in the waste package.

Confirm that the design of any drip shield, including materials of construction, configuration, and method of emplacement, is adequate to prevent water from contacting the waste packages. Confirm that the safety aspects of the engineered barrier system design and waste package handling are not impaired by the drip shield.

Verify that the design of backfill (if used in the license application design), including materials and physical characteristics, configuration, and methods of emplacement and compaction, is adequate to reduce the relative humidity near the waste packages. The design should also divert the flow of water away from the drip shield and waste packages and prevent direct impact of rockfall on the drip shield. These design features should retain the safety aspects of the engineered barrier system design and waste package handling.

Confirm that the design of any sorption barrier is adequate to control the migration of radionuclides and that materials and sorption properties, depth of placement, mixing with other materials, and degree of compaction provide adequate sorption barrier performance.

4.1.1.7.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.112(f) relating to the design of SSCs important to safety and safety controls.

4.1.1.7.3.1 Design Criteria and Design Bases

AC1 The relationship between the principal design criteria and the requirements specified in 10 CFR 63.111(a) and (b), the relationship between the design bases and the principal design criteria, and the design criteria and design bases for SSCs important to safety are adequately defined.

- Principal design criteria and bases for SSCs important to safety and for those SSCs that affect the proper functioning of SSCs important to safety are identified, and these criteria and bases are derived from the specific site characteristics and consequence analyses. The design criteria and bases are consistent with the analyses used in the identification of the SSCs.

- Design criteria for normal operating conditions are adequately developed so that designs do not result in any degradation of the capabilities of the GROA to protect radiological health and safety. Design criteria do not permit degradation of the performance of GROA SSCs important to safety.

- Design criteria adequately consider PCSA results to ensure that SSCs important to safety will continue to prevent unacceptable consequences.

- Structural design criteria and bases for SSCs important to safety meet relevant guidance.

- Thermal design criteria and bases are consistent with relevant regulatory guidance.

- Design criteria and bases for shielding and confinement systems utilize appropriate guidance.

- Designs for fixed-area radiation monitors and continuous airborne monitoring instrumentation are consistent with relevant regulatory guidance.

- Criticality design criteria are developed based on consequence analysis results from the PCSA and are consistent with relevant regulatory guidance. Design criteria are adequately factored into the models and assumptions used for criticality analysis.

- Design bases and criteria are clearly identified for thermal, structural, shielding, criticality, and other operating limits for the GROA facilities.

4.1.1.7.3.2 Design Methodologies

AC1 GROA design methodologies are adequate.

- Proposed design methodologies are supported by adequate technical bases, are consistent with established industry practice, and address uncertainties. If the design methodologies depend on site-specific test data, such data are available; analytical or numerical models used to support the design methodologies are verified, calibrated, and validated; and assumptions or limitations relating to the proposed methodologies are identified and their implications for the design are adequately analyzed and documented.

- Expert elicitations are properly conducted.

- Seismic design methodologies use ground motion information that is consistent with proposed DOE methodologies for hazard assessment and, taken together, they provide adequate input for seismic design and for performance assessments.

4.1.1.7.3.3 Repository Design and Design Analyses

I. Designs and Design Analyses for SSCs, Equipment, and Safety Controls That are Safety Related for Surface Facilities

AC1 Design codes and standards used for the design of surface facility SSCs important to safety are identified and are appropriate for the design methodologies selected.

- Applicable design codes and standards are specified for structural, thermal, shielding and confinement, criticality, and decommissioning designs.

- If other methods are used for design, the license application provides adequate technical bases for those methods.

AC2 The materials to be used for SSCs important to safety related to surface facility design are consistent with the design methodologies.

- Materials used for SSCs important to safety related to surface facility design are consistent either with the accepted design criteria, codes, standards, and specifications or with those specifically developed by DOE.

- Materials are adequate, considering the material properties and allowable stresses and strains associated with the design.

- Materials and their properties are appropriate for the expected design loading conditions. In addition, anticipated stress limits for each material are based on maximum temperatures as established in the thermal analysis evaluation presented in the license application.

- The potential for creep or brittle fracture of materials is adequately assessed to ensure that SSCs important to safety will perform their safety functions.

AC3 Design analyses use appropriate load combinations for normal and Category 1 and 2 event sequence conditions.

- The loads used in the DOE design analyses are consistent with those normal and Category 1 and 2 event sequence loadings of radiological importance.

- The load combinations used in the design analyses are consistent with those used and accepted by the NRC for the design of similar types of nuclear facilities and for steel and reinforced concrete structures.

- The design analyses use appropriate techniques that are correctly applied to provide established design temperatures, mechanical loads, and pressures for the SSCs important to safety.

AC4 Design analyses are properly performed and documented.

- The design analyses include relevant structural, thermal, shielding, criticality, confinement, and decommissioning factors.

- Values of material properties used for the design analyses have adequate technical bases and are consistent with site-specific data.

- Loads and load combinations used in the design analyses are consistent with defined normal operations and Category 1 and 2 event sequences.

- Analytical methods, models, and codes used for the design analyses are appropriate for the conditions analyzed and are properly benchmarked.

- Technical bases for the assumptions used in the design analyses are conservatively defined and are based on accepted engineering practice.

- The designs and design analyses for SSCs important to safety are performed correctly. These SSCs have sufficient capability to withstand normal and Category 1 and 2 event sequence loadings.

- Confirmatory checks indicated that the design analyses are adequate.

II. Designs and Design Analyses for SSCs, Equipment, and Safety Controls That are Safety Related for Subsurface Facility

AC1 Design assumptions, codes, and standards used for the design of subsurface facility SSCs important to safety are acceptable.

- Applicable design codes, standards, or other detailed criteria used for the design of the subsurface facility are specified. Codes and standards are equivalent to and consistent with those accepted by the NRC for design of nuclear facilities with similar hazards and functions. If nonstandard approaches are used, the license application provides adequate technical bases to justify why they are used.

- Assumptions made for the design of the subsurface facility are technically defensible.

- Designs for steel and concrete structures and components, air controlled systems, electrical power systems, and ventilation systems use applicable standards.

AC2 The design of subsurface operating systems is adequate.

- Methods, assumptions, and input data used in the ventilation design are consistent with proposed thermal loading performance goals. Confirmatory analyses verify the results in the license application. Analyses adequately address the thermal loads.

- Considering the design analyses of control system functions, equipment, instrumentation, control links, and communication systems, the subsurface monitoring and control systems are appropriate for the safety functions of the SSCs during waste transportation, emplacement, and monitoring.

- The design of the waste transport and emplacement system is compatible with proposed waste transport and emplacement procedures. Interfaces with other systems are identified and assessed, and continuity of operations and safety can be achieved.

- Considering the layout of the subsurface portion of the repository, emplacement drifts are located away from major faults, consistent with the seismic design, and the subsurface layout is appropriate for the quantity of waste to be emplaced and the design thermal load.

- Standards and codes used for design of subsurface operating systems are properly applied.

AC3 Materials and material properties used for the subsurface facility design are appropriate.

- The selection of materials and the properties of these materials are appropriate for the anticipated subsurface environment.

- Materials and material properties are consistent with applicable design criteria, codes, standards, and specifications. If no standards are used, the technical bases provided are acceptable.

- Applicable ASTM standard specifications are used.

- The selection of ground support materials accounts for degradation of such materials under elevated temperature and thermal loading. Plausible mechanisms for material degradation are identified and properly incorporated in assessments of subsystem SSC performance.

- Fire resistant materials are incorporated into the design of the subsurface ventilation systems. Ventilation equipment/components are designed to withstand prolonged high temperature conditions, effects of sudden blast cooling, and wet and corrosive environments.

AC4 Design analyses use appropriate load combinations for normal and Category 1 and 2 event sequence conditions.

- The arrangement of waste packages within the subsurface facility satisfies the thermal load design criteria.

- The magnitude and time history of the applied thermal loading are consistent with the anticipated characteristics of the proposed nuclear waste, repository design configurations, and design areal mass loading.

- Thermal analyses have an appropriate technical basis, use site-specific thermal property data, consider temperature dependency and uncertainties of thermal property data, and use thermal models and analyses that are properly documented. If credit is taken for use of ventilation, assessments of the effects of ventilation are adequate.

- Design analyses consider appropriate *in situ* stresses, potential running ground conditions, and hydrologic changes to the rock mass during the heating period.

- The dynamic loads used in design analyses are consistent with seismic design ground motion parameters including any repeated seismic effects, consider faulting effects, and are consistent with accepted methodologies for assessing faulting hazards.

AC5 Design analyses use appropriate models and site-specific properties of the host rock and consider spatial and temporal variation and uncertainties in such properties.

- Appropriate combinations of continuum and discontinuum modeling as well as two- and three-dimensional modeling are conducted to assess the behavior of a fractured rock mass under prolonged heated conditions and identified Category 1 and 2 event sequences. The bases for the choice of specific models and model combinations are adequate. Appropriate bases for the assumptions and limitations of the modeling approach are provided.

- Principles for the design analyses, the underlying assumptions, and the anticipated limitations are documented, are consistent with modeling objectives, and are technically sound.

- Values for the rock mass thermal expansion coefficient are consistent with properly interpreted site-specific data, and such interpretation accounts for likely scale effects and temperature dependency. The uncertainty in the thermal expansion coefficient is adequately assessed and considered in the thermal stress calculation.

- For continuum rock-mass modeling, the values for rock-mass elastic parameters (Young's modulus and Poisson's ratio) and strength parameters (friction angle and cohesion) are consistent with properly interpreted site-specific data. If the parameter values are obtained through empirical correlations with a rock quality index, the empirical equations used are appropriate for the site and are applied correctly and the values of the index are consistent with site-specific data. If intact-rock-scale values are used, the bases for application of the values to the rock-mass scale are adequate.

- For discontinuum rock mass modeling, the selection of fracture patterns for numerical modeling is appropriate for the objectives of the design and analyses. The interpretation of modeling results adequately considers effects of simplification of the characteristics of the modeled fracture network compared to those of the *in situ* fracture network.

- For discontinuum modeling, the selection of stiffness and strength parameters for rock blocks between any fractures that are explicitly represented in the model are appropriate and account for fractures that are not explicitly represented.

- For discontinuum modeling, the values for fracture stiffness and strength parameters are consistent with properly interpreted site-specific data.

- For both continuum and discontinuum modeling, time-dependent mechanical degradation of the rock mass, fractures, and ground support that may occur following the emplacement of nuclear waste is adequately accounted for in thermal-mechanical analyses. The bases for the magnitude and rate of mechanical degradation applied in the analyses are appropriately established and are technically defensible.

- Uncertainties in rock mass and fracture mechanical properties are adequately estimated and considered in both continuum and discontinuum modeling.

- Models adequately address the stability of openings around drift intersections considering the rock mass and its degraded properties and thermal loading.

- Confirmatory checks indicate that the design analyses are adequate.

AC6 The design of ground support systems is based on appropriate design methodologies and interpretations of modeling results.

- Design methodologies or combinations of design methodologies are properly applied to the design of ground support systems. When used, the empirical design approach is consistent with accepted technology in the underground tunneling and mining industry. The evaluation and selection of ground support systems are supported by analyses that satisfy the previous two acceptance criteria and that provide mechanical evaluation of ground support systems under thermal and dynamic loads.

- The ground support system responses are adequately evaluated, based on the results of model analyses. If the ground support system is explicitly modeled, the ground support responses include an adequate assessment of deformation and potential failure of the ground support systems. The interaction between the ground support system and the host rock units is adequately considered in the analysis. If the ground support system is not explicitly modeled, the anticipated ground support system responses from the modeling results are reasonably estimated and the technical bases for these estimates are adequate.

- The geometrical, thermal, and mechanical characteristics of the support system used in the thermal-mechanical analyses are consistent with design and construction specifications. The time-dependent mechanical degradation of the support system under heated conditions is adequately accounted for in the analyses.

- Stability of drifts, shafts, and ventilation tunnels is adequately assessed both with and without ground support. Such assessment includes identification of rock blocks that have potential to fall in the drifts; the potential for cave-in, collapse, or closure of the emplacement drifts; and the extent and severity of rock-mass disturbance near the excavations. The selection of a ground support system is consistent with the anticipated rock-mass responses and potential failure mechanisms of the rock mass near the excavations.

AC7 The subsurface ventilation systems are adequately designed.

- The design of subsurface ventilation systems is consistent with the design criteria, codes, standards, and specifications or with those specifically developed by DOE.

- The subsurface ventilation systems (including their power sources) important to safety (reviewed using section 4.1.1.6 of the YMRP) are designed to continue functioning under normal subsurface operating conditions, and under Category 1 and 2 event sequences.

- Applicable ventilation design guidance is met for the subsurface ventilation design.

- Subsurface ventilation equipment important to safety has backup or standby equivalents and fail safe mechanisms, where required, or DOE's ventilation design and analysis adequately shows that such equipment is not required.

- Subsurface ventilation equipment important to safety has adequate recording devices for important parameters.

- Subsurface ventilation systems important to safety are designed to continue operating in the event of a main subsurface power outage, if necessary.

- There is an adequate periodic inspection, testing, and maintenance program to assure that concentrations of radioactive materials meet the limits specified in 10 CFR Part 20 and 10 CFR Part 63 as practicable.

- The subsurface ventilation design is adequate to seal off or isolate airborne radiation within areas that could have a potential release.

- The ventilation design analysis is based on accepted industry codes or methods, incorporates site specific data, and is based on an accurate representation of the subsurface drift structure. The ventilation design analysis shows that subsurface ventilation flows from the least likely contaminated areas to the most likely contaminated areas and meets all other specified design criteria.

- Confirmatory checks indicate that the design analyses are adequate.

AC8 The design of subsurface power and power distribution systems for SSCs and operations important to safety is adequate.

- The design of subsurface electric power supplies and power distribution systems for SSCs important to safety is consistent with accepted design criteria, codes, standards, and specifications for underground usage and is suitable for the normal operating environment and Category 1 and 2 event sequences.

- The design incorporates proper grounding of electrical power sources/equipment.

- The design has sufficient emergency backup power capability for SSCs important to safety.

- The design of electric power systems important to safety permits appropriate periodic inspection and testing.

AC9 An adequate maintenance plan exists for subsurface facility SSCs, equipment, and controls important to safety.

- The maintenance plan developed to maintain drift stability prior to permanent closure of the repository is adequate. This maintenance plan considers the likely effects of uncertainties due to high temperature and high radiation levels and is based on an appropriate interpretation of modeling results that assess the possibility of degradation of both the rock mass and the ground support system under sustained thermal load.

- Adequate maintenance plans for other subsurface facility SSCs, equipment, and controls important to safety are in place, and they account for drift stability and accessibility during the period prior to permanent closure. The consideration of drift stability effects in the maintenance plan is based on an appropriate interpretation of modeling results.

III. Designs for SSCs and Safety Controls That are Safety Related for Waste Package/Engineered Barrier System

AC1 Waste package and engineered barrier system SSCs and their controls are adequately designed.

- The waste package/engineered barrier system design adequately incorporates containment, criticality control, shielding, structural strength of waste packages, thermal control, waste form degradation, drip shield, waste package support/invert, backfill, and sorption barrier, as appropriate.

- The description and assessment of the components for the various types of waste packages include containers and internal structures such as structural guides, baskets, fuel baskets, fuel basket plates with neutron absorbers, neutron absorber rods, canisters, fillers, and fill gas, in addition to specific components of the engineered barrier system such as drip shield, backfill, and sorption barrier. The design analyses for these components are adequate.

- The materials, methods, and processes used in the fabrication of containers, internal waste package components, and engineered barrier system components are consistent with accepted design criteria, codes, standards, and specifications. Processes specified for fabrication, assembly, closure, and inspection are based on accepted industry technology. The license application documents any significant discrepancies or uncertainties related to the corrosion and mechanical resistance of container materials and relevant engineered barrier system components such as the drip shield. If DOE chooses to use design criteria, codes, standards, specifications, and industry technology different from those normally used, the technical bases provided are adequate.

- The specifications for container and internal waste package materials are in agreement with those established in the final design. The specifications for closure welding, preparation for welding, materials to be used in welds, and inspection of welding comply with applicable ASME codes. Any documented deficiencies or variations with respect to the specifications of the code are adequately supported.

- Appropriate methods for nondestructive examination of fabricated containers and other structural components of waste packages are identified to detect and evaluate fabrication defects and any other defects that may lead to premature failure.

- Criticality design criteria are consistent with those used in model calculations that support the design. Isotopic enrichment of waste is properly characterized for these models. Model configurations are appropriate for the various postulated repository environments, and appropriate computer models are used in design calculations.

- The assessment of shielding provided by the containers is sufficient. The assessment includes estimates of dose rates, a description of the source of data for the evaluation, and the methods for estimating dose rate, including the use of computational codes.

- The components of the waste package and internals are designed to sustain loads from normal operation and Category 1 and 2 event sequences.

- Thermal control is such that the fuel cladding temperature will be sufficiently low to prevent cladding failure. Appropriate models are used for the calculation of decay heat, taking into consideration fuel age and fuel blending inside waste packages.

- The materials used in construction of the internal components of the waste package are compatible with the waste form, and interactions among these materials will not be detrimental to the stability of the waste form. No pyrophoric, explosive, or chemically reactive materials will be introduced in the waste package.

- The design of any drip shield, including materials of construction, configuration, and method of emplacement, is sufficient to prevent water from contacting the waste packages. The safety aspects of the engineered barrier system design and waste package handling are not impaired by the drip shield.

- The design of any backfill, including materials and physical characteristics, configuration, and methods of emplacement and compaction, is adequate to reduce the relative humidity near the waste packages. The design will divert the flow of water away from the drip shield and waste packages, and prevent direct impact of rockfall on the drip shield without impairing the safety aspects of the engineered barrier system design and waste package handling.

- The design of any sorption barrier is adequate to control the migration of radionuclides and materials. Sorption properties, depth of placement, mixing with other materials, and degree of compaction provide adequate sorption barrier performance.

4.1.1.7.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.112(f). An adequate description of the GROA design that adequately defines the relationship between principal design criteria and the performance objectives and that identifies the relationship between the design bases and the principal design criteria has been provided.

4.1.1.7.5 References

American Concrete Institute. "Code Requirements for Nuclear Safety Related Concrete Structures." ACI 349. American Concrete Institute: Detroit, MI. 1997. [or latest version]

American Concrete Institute/American Society of Mechanical Engineers (ASME) (Joint Committee). "Code for Concrete Reactor Vessels and Containments." ACI 359. Also designated as ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, Division 2. American Concrete Institute: Detroit, MI. 1992. [or latest version]

American Institute of Steel Construction. *Specification for Structural Steel Buildings—Allowable Stress Design and Plastic Design*. Chicago, IL: American Institute of Steel Construction. 1989.

American Institute of Steel Construction. *Load and Resistance Factor Design Specification for Structural Steel Buildings*. Chicago, IL: American Institute of Steel Construction. 1993.
American National Standards Institute (ANSI). "Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Reactors." ANSI/ANS–HPSSC–6.8.1. ANSI: Washington, DC. 1981. [or latest version]

American Institute of Steel Construction *Code of Standard Practice for Steel Buildings and Bridges*. Chicago, IL: American Institute of Steel Construction. 1992.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Guidelines for Evaluating Site-Related Geotechnical Parameters at Nuclear Power Plants." ANSI/ANS–2.11. ANSI/ANS: La Grange Park. 1978a. [or latest version].

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Boiling Water Reactor Containment Ventilation Systems." ANSI/ANS–56.7. ANSI/ANS: La Grange Park, IL. 1978b.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Fire Protection Program Criteria for Research Reactors." ANSI/ANS–15.17. ANSI/ANS: La Grange Park, IL. 1981.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement." ANSI/ANS–8.10. ANSI/ANS: La Grange Park, IL. 1983.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)." ANSI/ANS–57.9. ANSI/ANS: La Grange Park, IL. 1984. [or latest version]

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Specification for Radiation Shielding Materials." ANSI/ANS 6.4.2. ANSI/ANS: La Grange Park, IL. 1985. [or latest version]

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Criticality Safety in Operations with fissionable Material Outside Reactors." ANSI/ANS–8.1. ANSI/ANS: La Grange Park, IL. 1988.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "American National Standard for Neutron and Gamma-Ray Flux to Dose Factors." ANSI/ANS 6.1.1. ANSI/ANS: La Grange Park, IL. 1991a. [or latest version]

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Criticality Safety Training." ANSI/ANS–8.20. ANSI/ANS: La Grange Park, IL. 1991b.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Safety Criteria for Control Air Systems." ANSI/ANS–59.3. ANSI/ANS: La Grange Park, IL. 1992a.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Determining Design Basis Flooding at Power Reactor Sites." ANSI/ANS–2.8. ANSI/ANS: La Grange Park, IL. 1992b.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants." ANSI/ANS–6.4. ANSI/ANS: La Grange Park, IL. 1997a.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Criticality Accident Alarm System." ANSI/ANS–8.3. ANSI/ANS: La Grange Park, IL. 1997b.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Criticality Accident Emergency Planning and Response." ANSI/ANS–8.23. ANSI/ANS: La Grange Park, IL. 1997c.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Nuclear Criticality Safety Based on Limiting and Controlling Moderators." ANSI/ANS–8.22. ANSI/ANS: La Grange Park, IL. 1997d.

American National Standards Institute/American Nuclear Society (ANSI/ANS). "Guide for Nuclear Criticality Safety in the Storage of Fissile Materials." ANSI/ANS–8.7. ANSI/ANS: La Grange Park, IL. 1998.

American Nuclear Society Standards Committee Working Group. "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities." ANSI N13.1–1993. American National Standards Institute: Washington, DC. 1993. [or latest version]

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). *ASHRAE Handbook—HVAC Applications.* Atlanta, GA: ASHRAE. 1995.

American Society of Mechanical Engineers (ASME). "ASME Boiler and Pressure Vessel Code." Section III. Subsections NB and NC. ASME: New York. 1993. [or latest version]

American Society of Mechanical Engineers (ASME). "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)." ASME NOG–1–1995. ASME: New York. 1995. [or latest version]

American Society for Testing and Materials (ASTM). "Specifications for Low-Carbon Nickel-Molydbdenum-Chromium, Low-Carbon Nickel-Chromium-Molydbdenum, Low-Carbon Nickel-Chromium-Molydbdenum-Copper, Low-Carbon Nickel-Chromium-Molydbdenum-Tantalum, Low-Carbon Nickel-Chromium-Molydbdenum-Tungsten Alloy Plate, Sheet and Strip." ASTM B575–99a. ASTM: West Conshohocken, PA. 2000a.

American Society for Testing and Materials (ASTM). "Standard Specifications for Annealed or Cold-Worked Austenitic Steel Sheet, Strip, Plate, and Flat Bar." ASTM A666–00. ASTM: West Conshohocken, PA. 2000b.

Kennedy, R.P. *Review of Procedures for the Analysis and Design of Concrete Structures to Resist Missile Impact Effects*. Holmes and Narver Inc. 1975.

Kotra, J.P., et al. NUREG–1563, "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program." Washington, DC: Nuclear Regulatory Commission (NRC). 1996.

National Fire Protection Association. "Standard for Water Tanks for Private Fire Protection." NFPA22. National Fire Protection Association: Quincy, MA. 1987.

National Fire Protection Association. "Standard for Fire Protection for Facilities Handling Radioactive Materials." NFPA801. National Fire Protection Association: Quincy, MA. 1998.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants." NRC: Washington, DC. 1975a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 3.32: "General Design Guide for Ventilation Systems for Fuel Reprocessing Plants." NRC: Washington, DC. 1975b.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis." Revision 1. NRC: Washington, DC. 1976a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants." Revision 1. NRC: Washington, DC. 1976b. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.120, "Fire Protection Guidelines for Nuclear Power Plants." NRC: Washington, DC. 1976c. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.59, “Design Basis Floods for Nuclear Power Plants.” Revision 2. NRC: Washington, DC. 1977a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.32, “Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants.” Revision 2. NRC: Washington, DC. 1977b. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.117, “Tornado Design Classification.” NRC: Washington, DC. 1978a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.29, “Seismic Design Classification.” Revision 3. NRC: Washington, DC. 1978b. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.122, “Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components.” NRC: Washington, DC. 1978c. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.91, “Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants.” Revision 1. NRC: Washington, DC. 1978d. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.75, “Physical Independence of Electric Systems.” Revision 2. NRC: Washington, DC. 1978e. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.” NRC: Washington, DC. 1979a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–0554, “Single-Failure-Proof Canes for Nuclear Power Plants.” NRC: Washington, DC. 1979b.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.5, “Criticality and Other Interior Evacuation Signals.” NRC: Washington, DC. 1981. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants.” LWR edition. NRC: Washington, DC. 1987.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.25, “Air Sampling in the Workplace.” Revision 1. NRC: Washington, DC. 1992a. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.34, “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.” NRC: Washington, DC. 1992b. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.118, “Periodic Testing of Electric Power and Protection Systems.” Revision 3. NRC: Washington, DC. 1995.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–0800, “Process and Effluent Radiological Monitoring Instrumentation and Sampling Systems.” NRC: Washington, DC. 1996.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 3.71, “Nuclear Criticality Safety Standards for Fuels and Material Facilities.” NRC: Washington, DC. 1998.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1567, “Standard Review Plan for Spent Fuel Storage Facilities.” Final Report. NRC: Washington, DC. 2000.

U.S. Atomic Energy Commission. Regulatory Guide 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants. U.S. Atomic Energy Commission: Washington, DC. 1973a. [or latest version]

U.S. Atomic Energy Commission. Regulatory Guide 1.61, “Damping Values for Seismic Design of Nuclear Power Plants.” U.S. Atomic Energy Commission: Washington, DC. 1973b. [or latest version]

U.S. Atomic Energy Commission. Regulatory Guide 1.76, “Design Basis Tornado for Nuclear Power Plants.” U.S. Atomic Energy Commission: Washington, DC. 1974. [or latest version]

4.1.1.8 Meeting the 10 CFR Part 20 As Low As Is Reasonably Achievable Requirements for Normal Operations and Category 1 Event Sequences

Review Responsibilities—High-Level Waste Branch

4.1.1.8.1 Areas of Review

This section reviews meeting the 10 CFR Part 20 ALARA requirements for normal operations and Category 1 event sequences. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(5) and (c)(6).

The staff will evaluate the following parts of meeting the 10 CFR Part 20 ALARA requirements for normal operations and Category 1 event sequences using the review methods and acceptance criteria in sections 4.1.1.8.2 and 4.1.1.8.3.

- Policy Considerations,
- Design Considerations, and
- Operational Considerations.

4.1.1.8.2 Review Methods

RM1 Management Commitment to Maintain Exposures ALARA

Confirm that the management commitment includes provisions for ensuring that:

- No practice involving radiation exposure will be undertaken unless its use produces a net benefit;

- Supervisors will integrate appropriate radiation protection controls into work activities;

- Personnel are aware of the management commitment to ALARA principles;

- Workers will receive sufficient and appropriate initial and periodic training related to ALARA principles, considering the review of training and certification of personnel conducted using Section 4.5.3 (Training Certification of Personnel) of the YMRP; and

- An operations program to control radiation exposure will be implemented. This program will ensure that individual and collective doses are ALARA, considering the review of plans for conduct of normal operations conducted using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

RM2 Consideration of ALARA Principles in GROA Design

Verify the design of the GROA has considered the ALARA philosophy as stated in Regulatory Guide 8.8, Information Relevant to Ensuring that Occupational Radiation Exposure at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable (NRC, 1978). Note that Regulatory Guide 8.8 is for nuclear power plants, where radiation hazards are more severe than the radiation hazards at the GROA; consider this aspect when using this guidance.

Confirm that ALARA principles are adopted in the design considerations, to the extent possible, to ensure the following:

- Engineered design features minimize the time workers must stay in radiation areas.

- Remotely operated or robotic equipment such as welders, wrenches, or radiation monitors are used to minimize worker dose.

- Suitable methods are used to monitor for possible blockage of air cooling passages or to perform inspection of materials.

- Design permits placement of equipment and temporary shielding by remote control to reduce doses where possible.

- Materials and design features minimize the potential for accumulation of radioactive materials or surface contamination to facilitate decontamination or decontamination and dismantlement of surface facilities.

- Offices, security areas, and laboratory facilities are located away from radiation sources.

- Radioactive material handling and storage facilities are located sufficiently far from the site boundary and from other onsite work stations. The controlled area of the facility is sufficient to maintain doses at locations accessible to members of the public at acceptable levels.

- Transfer routes for HLW will maintain the desired distance from the site perimeter.

- Multiple restricted areas within the controlled area provide control of access to areas with radiation levels that would pose unacceptable risk to workers within those areas, if appropriate.

Confirm that modifications to the design of the GROA to maintain doses ALARA have been incorporated in the PCSA to ensure they do not adversely influence other components of the design.

RM3 Incorporation of ALARA Principles into Proposed Operations at the GROA

Verify that operational procedures follow the ALARA philosophy in Regulatory Guides 8.8 and 8.10 (NRC, 1978, 1977). Plans for conduct of normal activities including maintenance, surveillance, and testing should be reviewed using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

Confirm that GROA operational procedures will ensure that the doses to workers and members of the public will be ALARA, including the consideration of items such as:

- An operations program designed to control radiation exposure will be implemented to ensure both individual and collective doses are ALARA plans for conduct of normal operations are reviewed using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP).

  Tradeoffs between requirements for increased monitoring or maintenance activities (and the increased exposures that would result) and the potential hazards associated with reduced frequency of these activities;

- Placement sequence of HLW in a manner that maximizes shielding by casks or structures;

- Dry runs to develop proficiency in procedures involving radiation exposures, to determine exposures likely to be associated with specific procedures, and to consider alternative procedures to minimize exposures;

- Development of tested contingency procedures for potential off-normal occurrences; and

- ALARA operational alternatives based on experience with independent SNF storage installations, pool facilities, and waste management facilities.

Confirm that modifications to proposed operations of the GROA to maintain doses ALARA have been incorporated in the PCSA to ensure that they do not adversely influence other aspects of GROA operations.

4.1.1.8.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.111(a)(1) and (c)(1) relating to meeting the 10 CFR Part 20 ALARA requirements for normal operations and Category 1 event sequences.

AC1 An adequate statement of management commitment to maintain exposures to workers and the public ALARA is provided.

- The management commitment includes provisions for ensuring that::
  - No practice involving radiation exposure will be undertaken unless its use produces a net benefit;
  - Supervisors will integrate appropriate radiation protection controls into work activities;
  - Personnel are aware of the management commitment to ALARA principles;
  - Workers will receive sufficient and appropriate initial and periodic training related to ALARA principles; and
  - An operations program to control radiation exposure will be implemented. This program will ensure that individual and collective doses are ALARA.

AC2 ALARA principles are adequately considered in GROA design.

- The design of the GROA adequately considers the ALARA philosophy.
- ALARA principles are adopted in the design considerations, to the extent possible, to ensure the following:
  - Engineered design features minimize the time workers must stay in radiation areas;
  - Remotely operated or robotic equipment such as welders, wrenches, or radiation monitors are used to minimize worker dose;
  - Suitable methods are used to monitor for possible blockage of air cooling passages or to perform inspection of materials;

— Design permits placement of equipment and temporary shielding by remote control to reduce doses where possible;

— Materials and design features minimize the potential for accumulation of radioactive materials or surface contamination to facilitate decontamination or decontamination and dismantlement of surface facilities;

— Offices, security areas, and laboratory facilities are located away from radiation sources;

— Radioactive material handling and storage facilities are located sufficiently far from the site boundary and from other onsite work stations. The controlled area of the facility is sufficient to maintain doses at locations accessible to members of the public at acceptable levels;

— Transfer routes for HLW will maintain the desired distance from the site perimeter; and

— Multiple restricted areas within the controlled area provide control of access to areas with radiation levels that would pose unacceptable risk to workers within those areas;

- Modifications to the design of the GROA to maintain doses ALARA have been incorporated in the PCSA to ensure they do not adversely influence other components of the design.

AC3 Proposed operations at the GROA adequately incorporate ALARA principles.

- Operational procedures follow the ALARA philosophy.

- GROA operational procedures will ensure that the doses to workers and members of the public will be ALARA, including the consideration of items such as:

— An operations program designed to control radiation exposure will be implemented to ensure both individual and collective doses are ALARA;

Tradeoffs between requirements for increased monitoring or maintenance activities (and the increased exposures that would result) and the potential hazards associated with reduced frequency of these activities;

— Placement sequence of HLW in a manner that maximizes shielding by casks or structures;

— Dry runs to develop proficiency in procedures involving radiation exposures, to determine exposures likely to be associated with specific procedures, and to consider alternative procedures to minimize exposures;

- — Development of tested contingency procedures for potential off-normal occurrences; and

- — ALARA operational alternatives based on experience with independent SNF storage installations, pool facilities, and waste management facilities.

- Modifications to proposed operations of the GROA to maintain doses ALARA have been incorporated in the PCSA to ensure that they do not adversely influence other aspects of GROA operations.

- Verify that operational procedures are follow the ALARA philosophy in Regulatory Guides 8.8 and 8.10 (NRC, 1978, 1977). Plans for conduct of normal activities including maintenance, surveillance, and testing should be reviewed using Section 4.5.6 (Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing) of the YMRP.

- Confirm that GROA operational procedures will ensure that the doses to workers and members of the public will be ALARA, including the consideration of items such as:

  - — An operations program designed to control radiation exposure will be implemented to ensure both individual and collective doses are ALARA (plans for conduct of normal operations are reviewed using section 4.5.6 of the YMRP);

    Tradeoffs between requirements for increased monitoring or maintenance activities (and the increased exposures that would result) and the potential hazards associated with reduced frequency of these activities;

  - — Placement sequence of SNF in a manner that maximizes shielding by casks or structures;

  - — Dry runs to develop proficiency in procedures involving radiation exposures, to determine exposures likely to be associated with specific procedures, and to consider alternative procedures to minimize exposures;

  - — Development of tested contingency procedures for potential off-normal occurrences; and

  - — ALARA operational alternatives based on experience with independent SNF storage installations, pool facilities, and waste management facilities.

- Confirm that modifications to proposed operations of the GROA to maintain doses ALARA have been incorporated in the PCSA to ensure that they do not adversely influence other aspects of GROA operations.

4.1.1.8.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(a)(1). The operations at the GROA through permanent closure will comply with the ALARA requirements in 10 CFR Part 20.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they meet the performance objective at 10 CFR 63.111(c)(1). The requirements of 10 CFR 63.111(a) for ALARA will be met.

4.1.1.8.5 References

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable." Revision 1. NRC: Washington, DC. 1977. [or latest version]

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable." Revision 3. NRC: Washington, DC. 1978. [or latest version]

4.1.2 Plans for Retrieval and Alternate Storage of Radioactive Wastes

Review Responsibilities—High-Level Waste Branch

4.1.2.1 Areas of Review

This section reviews plans for retrieval and alternate storage of radioactive wastes. Reviewers will also evaluate the information specified in 10 CFR 63.21(c)(7).

The staff will evaluate the following parts of plans for retrieval and alternate storage of radioactive wastes using the review methods and acceptance criteria in sections 4.1.2.2 and 4.1.2.3.

- Plans meeting performance objectives in 10 CFR 63.111(a) and (b),
- Adequate alternate storage for retrieved wastes, and
- Reasonable retrieval schedule.

4.1.2.2 Review Methods

RM1 Waste Retrieval Plans

Confirm that waste retrieval plans include a discussion of (i) retrieval operations processes, (ii) equipment to be used, and (iii) compliance with 10 CFR 63.111(a) and (b) preclosure performance objectives during retrieval of waste.

Verify that DOE has developed scenarios under which retrieval operations will take place. Confirm that development of the scenarios has considered the 50-year requirement for the retrievability option and the projected duration of retrieval operations. Assess the reasonableness of the scenarios developed.

Confirm that adequate methodologies have been established for identifying and analyzing potential problems for the various retrieval operations scenarios. Evaluate whether the solutions proposed for the problems identified are feasible and are based on sound engineering principles. Ensure that the extent of degradation of the emplacement drifts during the period of retrieval operations has been appropriately considered in the retrieval plans. Verify that retrieval plans contain acceptable maintenance plans to support the completion of retrieval within the projected duration.

If the backfilling option is used in emplacement drifts before the end of the period of design for retrievability, determine whether the retrieval plans adequately address the requirements of 10 CFR 63.111(e).

Verify that DOE has provided a discussion of the potential effect of the duration of the planned performance confirmation program on the time frame required to maintain the option of waste retrieval. Assess whether there is a need for a different time frame for the period of design for retrievability so it will be consistent with the duration proposed by DOE for conducting the performance confirmation program.

RM2 Compliance with Preclosure Performance Objectives

Verify DOE has demonstrated that preclosure performance objectives in 10 CFR 63.111(a) and (b) can be met during waste retrieval. Use the review methods and acceptance criteria in Section 4.1.1.8 (Meeting the 10 CFR Part 20 As Low As Is Reasonably Achievable Requirements for Normal Operations and Category 1 Event Sequences) of the YMRP for this assessment.

RM3 Proposed Alternate Storage

Determine whether the physical location and boundary of the proposed alternate storage area are adequately defined.

Determine if the proposed alternate storage area is sufficient to hold the waste to be retrieved.

Assess whether the plans are adequate for protection of workers and the public while transporting the retrieved wastes to the alternate storage area.

RM4 Retrieval Operations Schedule

Verify that plans for retrieval meet the 10 CFR 63.111(e)(3) requirement that retrieval can be completed within a time frame consistent with that required to construct the GROA and emplace waste.

4.1.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.111(e) relating to plans for retrieval and alternate storage of radioactive wastes.

AC1 Plans for retrieval of waste packages, based on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, are provided and can be implemented, if necessary.

- Waste retrieval plans include a discussion of (i) retrieval operations processes, (ii) equipment to be used, and (iii) compliance with 10 CFR 63.111(a) and (b) preclosure performance objectives during retrieval of waste.

- DOE has prepared reasonable scenarios under which retrieval operations will take place. The scenarios consider the 50-year requirement for retrievability option and the projected duration required to complete retrieval operations.

- Adequate methodologies are established for identifying and analyzing potential problems for the various retrieval operations scenarios. The solutions proposed for the problems identified are feasible and are based on sound engineering principles. The extent of degradation of emplacement drifts during the period of retrieval operations is appropriately considered in the retrieval plans. The retrieval plans contain acceptable maintenance plans to support the completion of retrieval within the projected duration.

- Should the backfilling option be used in emplacement drifts before the end of the period of design for retrievability, the retrieval plans adequately address the requirements of 10 CFR 63.111(e).

- DOE provides a discussion of the potential effect of the duration of the planned performance confirmation program on the time frame required to maintain the option of waste retrieval. If there is a need for a different time frame for the period of design for retrievability, the time frame is consistent with the duration proposed by DOE for conducting the performance confirmation program.

AC2 The proposed retrieval operations comply with the requirements of the preclosure performance objectives.

AC3 The proposed alternate storage of retrieved radioactive wastes is reasonable.

- The physical location and boundary of the proposed alternate storage area are adequately defined.

- The proposed alternate storage area is sufficient to hold the waste to be retrieved.

- Plans are adequate for protection of workers and the public while transporting the retrieved wastes to the alternate storage area.

AC4 A reasonable schedule for potential retrieval operations is provided.

- Plans for retrieval meet the 10 CFR 63.111(e)(3) requirement that retrieval can be completed within a time frame consistent with that required to construct the GROA and emplace waste.

4.1.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.111(e). The GROA has been designed to allow for retrievability of wastes. The option of waste retrieval has been preserved until completion of a performance confirmation program and Commission review of that program. The design allows for retrieval on a reasonable schedule.

4.1.2.5 References

None.

4.1.3 Plans for Permanent Closure and Decontamination, or Decontamination and Dismantlement of Surface Facilities

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.1.3.1 Areas of Review

This section reviews plans for permanent closure and decontamination, or decontamination and dismantlement of surface facilities. Reviewers will evaluate the information required by 10 CFR 63.21(c)(8) and (c)(16)(vi).

In determining the acceptability of these plans, the reviewer should consider that plans submitted at the time of initial licensing will be prospective in nature and will not reflect knowledge gained over the course of facility operation (e.g., detailed knowledge of the types, extent, and precise locations of contamination). Therefore, it is not reasonable to expect plans submitted with the initial license application to have the same level of detail as final plans, especially with respect to elements such as planned decontamination activities and the final radiation survey. DOE will be required to submit final plans; these will be reviewed and approved before license termination.

In preparing for the review of the proposed plans for permanent closure, decontamination, and dismantlement, the reviewer should consult the general review procedures contained in any Nuclear Materials Safety and Safeguards decommissioning standard review plan.[3] However,

[3] Nuclear Regulatory Commission (U.S.) (NRC). *NMSS Decommissioning Standard Review Plan.* Draft. NRC: Washington, DC. 2000. [or latest version]

the reviewer should keep in mind that these documents are for use with final plans that are prepared at the time of license termination.

The staff will review the following parts of plans for permanent closure and decontamination, or decontamination and dismantlement of surface facilities using the review methods and acceptance criteria in sections 4.1.3.2 and 4.1.3.3.

- The description of design considerations that are intended to facilitate permanent closure and decontamination, or decontamination and dismantlement of surface facilities; and

- Plans for permanent closure and decontamination, or decontamination and dismantlement.

4.1.3.2 Review Methods

RM1 Design Considerations That Will Facilitate Permanent Closure and Decontamination, or Decontamination and Dismantlement

Ensure that the license application describes the functions of design features as they relate to permanent closure and decontamination, or decontamination and dismantlement.

Determine whether the repository design is compatible with the objectives of permanent closure and decontamination, or decontamination and dismantlement. Note that the design could be considered to meet this requirement if design provisions included, where feasible and economical, design choices that support closure and decontamination, or decontamination and dismantlement over competing alternatives. If such features were not chosen, an acceptable rationale for not adopting the more favorable alternatives should be provided. Examples of favorable design features include:

- Selection of materials and processes to minimize waste production;

- Minimization of the mass of shielding materials subject to neutron activation;

- Use of modular design and inclusion of lifting points to facilitate removal and dismantlement;

- Selection of materials for compatibility with projected closure and decontamination, or decontamination and dismantlement, or waste processing procedures;

- Use of minimum surface roughness finishes on SSCs that have potential for contamination;

- Use of coatings that preclude penetration into porous materials by radioactive gas, condensate, deposited aerosols, or spills to permit decontamination by surface treatment;

- Incorporation of features to contain leaks and spills;
- Incorporation of waste minimization techniques; and
- Incorporation of features that would maintain occupational and public radiation exposures ALARA during decommissioning.

Coordinate with reviewers of the design of waste management systems for Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP to ensure that these designs will facilitate closure and decontamination or decontamination and dismantlement.

RM2 Plans for Permanent Closure and Decontamination, or Decontamination and Dismantlement

Confirm that the license application presents adequate preliminary plans for permanent closure and decontamination, or decontamination and dismantlement of the surface facilities, as appropriate. Use any Nuclear Material Safety and Safeguards decommissioning standard review plan as guidance for evaluating the adequacy of the preliminary plans. In conducting the review, consider that permanent closure and decommissioning and dismantlement would not begin for many years after the submittal of the license application. Therefore, do not expect DOE to submit detailed plans for permanent closure and decommissioning and dismantlement with the license application. However, the preliminary plans that DOE does submit with the license application should have detail sufficient to indicate that DOE has considered what the requirements, process, and impact of permanent closure and decommissioning and dismantlement may be in the future.

Evaluate whether DOE, in its preliminary plans for permanent closure and decommissioning and dismantlement, has addressed the content areas in any decommissioning standard review plan. For each section of such standard review plan, evaluate whether the preliminary plans provided by DOE indicate that DOE has evaluated the requirements, process and impacts of permanent closure and decommissioning and dismantlement. Specifically, evaluate the following.

Facility history: DOE should describe the type of information that will be required to facilitate decommissioning with respect to the facility's operating history. This will include information such as records documenting the radionuclides received and processed at the facility and the locations of the processing activities. DOE should also indicate how it would document the routine and nonroutine contamination of areas within the facility to facilitate future decommissioning activities. The reviewer should refer to any decommissioning standard review plan for a description of the types of information related to the facility's operating history that DOE will be required to provide at permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at the time of permanent closure and decommissioning.

Facility description: DOE should describe the type of information related to the facility and its environs that will be required to evaluate estimation of doses to onsite and offsite populations during, and at the completion of, permanent closure and decommissioning. Refer to any decommissioning standard review plan for a description of the types of information related to the facility and its environs that DOE will be required to provide at the time of permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Radiological status of the facility: DOE should describe the type of information that will be required to facilitate decommissioning with respect to the facility's radiological status at permanent closure and decommissioning. This will include information such as the types and extent of radionuclide contamination in media at the facility including buildings, systems and equipment, surface and subsurface soil, and surface and groundwater. DOE should provide a preliminary description of the anticipated magnitude of decommissioning activities with respect to these and any other media. Refer to any decommissioning standard review plan for a description of the types of information related to the facility's radiological status that DOE will be required to provide at permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Dose modeling evaluations: DOE should describe the general type of information that will be required to facilitate decommissioning with respect to the dose modeling at the time of permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Alternatives for decommissioning: DOE should describe the general type of information that will be required to facilitate decommissioning with respect to evaluating alternative decommissioning strategies. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

ALARA analysis: DOE should describe the general type of information that will be required to facilitate decommissioning with respect to ALARA analyses. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Planned decommissioning activities: DOE should describe the type of information that will be required to facilitate decommissioning with respect to the planned closure and decommissioning activities. DOE should provide preliminary information to allow the reviewer to understand the general approach to decommissioning activities. DOE should also provide a preliminary schedule for completing the activities. Refer to any decommissioning standard review plan for a description of the types of information related to planned decommissioning activities that DOE will be required to provide at permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Project management and organization: DOE should describe the type of information that will be required to facilitate decommissioning with respect to project management and organization. DOE should provide preliminary information to allow the reviewer to understand the general approach to managing closure and decommissioning activities. Refer to any decommissioning standard review plan for a description of the types of information related to the management of closure and decommissioning activities that DOE will be required to provide at permanent closure and decommissioning.

Health and safety program during decommissioning: DOE should describe the type of information that will be required to facilitate decommissioning with respect to health and safety program. DOE should indicate how the program would be developed and integrated with the preclosure health and safety program.

Environmental monitoring and control program: DOE should describe the type of information that will be required to facilitate decommissioning with respect to environmental monitoring and control. DOE should indicate how the program would be developed and integrated with the preclosure environmental and control program.

Radioactive waste management program: DOE should describe the type of information that will be required to facilitate decommissioning with respect to the management of radioactive waste generated through planned closure and decommissioning activities. DOE should provide preliminary estimates of the types and quantities of radioactive waste that may be generated through closure and decommissioning activities. DOE should provide preliminary plans for minimizing the quantities of radioactive waste, and discuss preliminary plans for disposing of the radioactive waste. Refer to any decommissioning standard review plan for a description of the types of information related to radioactive waste management that DOE will be required to provide at permanent closure and decommissioning. DOE should indicate how it will ensure the necessary information will be available and defensible at permanent closure and decommissioning.

Quality assurance program: DOE should describe the type of information that will be required to facilitate decommissioning with respect to quality assurance. DOE should indicate how the program would be developed and integrated with the preclosure quality assurance program. The DOE quality assurance program is reviewed using section 4.5.1 of the YMRP.

Facility radiation surveys: DOE should describe the general type of information that will be required to facilitate decommissioning with respect to radiation surveys to support closure and decommissioning activities.

Financial assurance: DOE is not required to provide a financial assurance plan in support of closure or decommissioning.

4.1.3.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(8) and (c)(16)(vi) relating to plans for permanent closure and decontamination, or decontamination and dismantlement of surface facilities.

AC1 The license application describes and provides bases for features of the GROA design that will facilitate permanent closure and decontamination, or decontamination and dismantlement of surface facilities.

- The license application describes the functions of design features as they relate to permanent closure and decontamination, or decontamination and dismantlement.

- The repository design is compatible with the objectives of permanent closure and decontamination, or decontamination and dismantlement. Design provisions are included where feasible and economical and those design choices that support closure and decontamination, or decontamination and dismantlement are selected over competing alternatives. An acceptable rationale for not adopting the more favorable alternatives is provided.

- Designs will facilitate closure and decontamination or decontamination and dismantlement.

AC2 The license application includes adequate preliminary plans for permanent closure and decontamination, or decontamination and dismantlement of surface facilities.

- The license application demonstrates that DOE is cognizant of the information, analyses and programs that will be required at permanent closure, decommissioning, and dismantlement.

- The license application demonstrates that DOE will ensure the necessary information to support closure and decommissioning, related to operating history, facility description and radiological status, dose evaluations, alternatives for decommissioning, and ALARA requirements will be available at the time of permanent closure and decommissioning.

- The license application demonstrates that DOE has an estimate of the scope of closure and decommissioning activities, has preliminary plans for conducting and managing the activities, and has preliminary estimates and plans for managing radioactive waste generated through closure and decommissioning activities.

- The license application demonstrates that DOE has considered the requirements of the health and safety, environmental monitoring, and quality assurance programs required during closure and decommissioning and has considered how these programs will be developed and integrated with the comparable preclosure programs.

4.1.3.4 Evaluation Findings

The staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(8). Requirements for the content of the license application have been met in that DOE has provided an adequate description of design considerations that are intended to facilitate permanent closure and decontamination, or decontamination and dismantlement of surface facilities.

The staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(16)(vi). DOE has provided adequate plans for permanent closure and decontamination, or decontamination and dismantlement of surface facilities.

4.1.3.5 References

None.

4.2 REPOSITORY SAFETY AFTER PERMANENT CLOSURE

4.2.1 Performance Assessment

Risk-Informed Review Process for Performance Assessment—The performance assessment quantifies repository performance as a means of demonstrating compliance with the postclosure performance objectives at 10 CFR 63.113. The DOE's performance assessment is a systematic analysis that answers the risk triplet questions: what can happen; how likely is it to happen; and what are the consequences. The YM performance assessment is a sophisticated analysis that involves various complex considerations and evaluations. Examples include evolution of the natural environment, degradation of engineered barriers over a 10,000-year period, and disruptive events such as seismicity and igneous activity. The staff also needs to consider the technical support for models and parameters of the performance assessment based on detailed process models, laboratory and field experiments, and natural analogs. Because the performance assessment encompasses such a broad range of issues, the staff needs to use risk information throughout the review process. Using risk information will ensure the review focuses on those items most important to performance.

Section 4.2.1 requires the staff to apply risk information throughout the review of the performance assessment. First, the staff reviews the barriers important to waste isolation in section 4.2.1.1. The DOE must identify the important barriers (engineered and natural) of the performance assessment, describe each barrier's capability, provide the technical basis for that capability, and describe the reliance on each barrier in meeting the overall performance objective. This risk information describes DOE's understanding of each barrier's importance. Staff review of the DOE's barrier analysis considers risk insights from previous performance assessments conducted for the YM site, detailed process modeling efforts, laboratory and field experiments, and natural analog studies. The result of this review is a staff understanding of each barrier's importance to waste isolation, which directs the reviews conducted in Sections 4.2.1.2 (Scenario Analysis) and 4.2.1.3 (Model Abstraction).

Scenario analysis and model abstraction are the key attributes of the performance assessment. The risk information, drawn from the review of the multiple barriers section, will direct the staff review to those topics within scenario analysis and model abstraction that are important to waste isolation. Section 4.2.1.2 provides the review methods and acceptance criteria for scenarios for both nominal and disruptive events. An acceptable scenario selection method includes identification and classification, screening, and construction of scenarios from the features, events and processes considered at the YM site. Then, it is necessary to review abstracted models used in the performance assessment for the retained scenarios. The performance assessment review focuses on the fourteen model abstractions in section 4.2.1.3. These model abstractions stemmed from those aspects of the engineered, geosphere, and biosphere subsystems shown to be most important to performance based on prior performance assessments and knowledge of site characteristics and repository design. The staff developed each of the fourteen sections in substantial detail to allow for a detailed review. However, it is unlikely that each of the abstractions will have the same risk significance. The staff will review the abstractions according to the risk significance determined in the multiple barrier review using section 4.2.1.1. Nevertheless, until the DOE completes its safety case and the license application, the review plan sections dealing with model abstractions must remain flexible, and in enough detail, so the DOE will understand how the NRC will review the abstractions. After the staff completes the review of scenarios and model abstractions, the staff will update, as necessary, its assessment of DOE's barrier analysis.

4.2.1.1 System Description and Demonstration of Multiple Barriers

Review Responsibilities—High-Level Waste Branch and Environmental Performance Assessment Branch

4.2.1.1.1 Areas of Review

This section addresses review of the system description and demonstration of multiple barriers. Reviewers will evaluate the information required by 10 CFR 63.21(c)(1), (9)(i)–(iv) and (vi).

The staff will evaluate the following parts of the system description and demonstration of multiple barriers using the review methods and acceptance criteria in sections 4.2.1.1.2 and 4.2.1.1.3.

- Identification of barriers relied on for postclosure performance;

- Demonstration of reliance on at least one barrier from the engineered system and one from the natural system;

- Description of the capability of identified barriers to contribute to isolation of radioactive waste, including the uncertainty associated with this capability and the consistency of the capability with approaches used in the total system performance assessment;

- Identification of the degree of reliance placed on each barrier, and the demonstration that this reliance corresponds to the barrier performance in the total system performance assessment;

- Technical bases for assertions that barrier capability is commensurate with the degree of reliance placed on a particular barrier in the performance assessment and with the associated uncertainties; and

- Demonstration of the capability of the remaining barriers of the repository system to (at least partially) compensate for a barrier that performs less well than estimated in the Total System Performance Assessment.

4.2.1.1.2 Review Methods

RM1 Identification of Barriers

Verify DOE has described the repository system in terms of the engineered components and FEPs of the geologic setting that are barriers contributing to the postclosure performance of the repository. Confirm that DOE has clearly linked identified barriers to a contribution to postclosure performance (i.e., leads to smaller dose). Verify that, among the materials, structures and FEPs identified as barriers, at least one is engineered and one is part of the geologic setting and that each identified barrier contributes significantly to the isolation of radioactive waste.

RM2 Description of Barrier Capability

Verify that DOE's description of barrier capability is explained in terms of limiting dose to the average member of the critical group and includes a characterization of the related uncertainty. Confirm that DOE has identified the degree of reliance placed on each barrier. Confirm that the description of barrier capability and identification of the degree of reliance is as quantitative as practical, or that, DOE can use semiquantitative methods (e.g., ranking reliance of barriers as high, medium, or low).

Examine the description of the uncertainty associated with barrier capabilities. Confirm the description is sufficient to evaluate propagation of the uncertainty through the barrier performance calculation.

Evaluate quantitative analyses in the DOE total system performance assessment (e.g., sensitivity and uncertainty analyses, and intermediate results for individual barriers) to verify the capabilities described are consistent with the corresponding total system performance assessment calculations.

Confirm DOE has adequately demonstrated that the stated degree of reliance on each barrier (e.g., as articulated in the repository safety strategy) corresponds to the barrier performance in the Total System Performance Assessment. This demonstration may be made using intermediate outputs, sensitivity analyses, importance analyses, or other analytical methods. Use information gained from Total-system Performance Assessment code (Mohanty and McCartin, 1998) audit calculations and/or other appropriate quantitative analyses to confirm the barrier capabilities and the appropriateness of DOE's reliance on each of the barriers.

RM3 Technical Basis for Barrier Capability

Use information gained from the review conducted using RM2 about the degree of reliance on each barrier to focus the review and to assess the adequacy of the technical bases. Verify DOE has provided technical bases to support the descriptions of barrier capability commensurate with the reliance placed on each barrier and the associated uncertainties. Based on the reviews conducted using Section 4.2.1.2 (Scenario Analysis), confirm the quality and completeness of the technical bases for the barrier capabilities. Evaluate the degree to which the technical bases are appropriate for the barrier performance demonstrations they support.

RM4 Demonstration of System Resilience

Evaluate the degree of diminished capability DOE considered for each barrier and the justification for this diminished capability. Consider the evidence available to characterize the performance of the barrier (e.g., laboratory tests, field tests, natural and archaeological analogs, and theoretical calculations) and the technical bases reviewed using RM3, with appropriate consideration given to the uncertainty and limitations of knowledge associated with the estimation of barrier capability, to determine whether the degree of diminished capability is acceptable. Evaluate DOE analyses for underperforming barriers to determine whether the remaining barriers of the repository system can (at least partially) compensate for a barrier that performs less well than expected. Use the Total-system Performance Assessment code (Mohanty and McCartin, 1998), as appropriate, to assess the degree to which the repository system, with one underperforming barrier, continues to limit the dose.

4.2.1.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements at 10 CFR 63.113(a) and (d), and 10 CFR 63.114(b)(1)–(4).

AC1 Identification of barriers is adequate.

Barriers relied on to achieve compliance with 10 CFR 63.113(b), as demonstrated in the Total System Performance Assessment, are adequately identified and are clearly linked to their contribution to postclosure performance. The barriers identified include at least one from the engineered system and one from the natural system.

AC2 Description of barrier capability to isolate waste is acceptable.

The capability of the identified barriers to contribute to the isolation of radioactive waste is adequately identified and described:

- The uncertainty associated with barrier capabilities is adequately described.
- The described capabilities are consistent with the results from the total system performance assessment.
- The degree of reliance placed on each barrier is adequately identified and demonstrated and corresponds to the barrier performance in the Total System Performance Assessment. This demonstration is made by using intermediate outputs, sensitivity analyses, importance analyses, or other analytical methods.

AC3 Technical basis for barrier capability is adequately presented.

A sufficient technical basis for assertions of barrier capability that is commensurate with the degree of reliance placed on a particular barrier and the associated uncertainties is provided.

AC4 Demonstration of system resilience is acceptable.

The capability of the balance of the repository system to compensate, at least in part, for the hypothetical underperformance (i.e., less than the capability demonstrated in the Total System Performance Assessment) of each barrier is adequately demonstrated.

4.2.1.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.113(a) and (d). An engineered barrier system has been designed that, working in combination with natural barriers, satisfies the requirement for a system of multiple barriers in compliance with the postclosure performance objectives.

The NRC staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.114(b)(1)–(4). Those design features of the engineered barrier system and natural features of the geologic setting that are considered barriers important to waste isolation have been identified. A description has been provided of the capability of barriers identified as important to waste isolation to isolate waste, taking into account uncertainties in characterizing and modeling the barriers, and the technical basis for this description has been provided. An analysis has been provided to demonstrate that the repository system does not depend unduly on any single barrier and, as a result, is more tolerant of failures and external challenges.

4.2.1.1.5 References

Mohanty, S., and T.J. McCartin, coords. *Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User's Guide (Draft)*. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1998.

4.2.1.2 Scenario Analysis

4.2.1.2.1 Identification of Features, Events, and Processes Affecting Compliance With the Overall Performance Objective

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.2.1.1 Areas of Review

This section reviews identification of FEPs affecting compliance with the overall performance objective. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(1) and (9)(i).

Review DOE's methodology for inclusion or exclusion of FEPs in the Total System Performance Assessment. DOE is not required to use steps provided here that involve categorization and screening of the initial comprehensive FEPs list for an acceptable license application. However, many steps can be used in accordance with the requirements in 10 CFR Part 63 to reduce the burden of the analysis and to focus the representation of the system on those FEPs that most affect compliance with the overall performance objective. All included FEPs must be appropriately incorporated into the Total System Performance Assessment and will be reviewed as part of the model abstraction review conducted using section 4.2.1.3 of the YMRP.

To evaluate repository postclosure safety, ensure that DOE has conducted analyses that consider potential future conditions a repository may be subjected to during the period of regulatory concern. These analyses should address those FEPs necessary to describe the future evolution of the repository system.

The staff will review the following parts of the identification of FEPs affecting compliance with the overall performance objective using the review methods and acceptance criteria in sections 4.2.1.2.1.2 and 4.2.1.2.1.3.

- Identification of an initial list of FEPs,
- Screening of the initial list of FEPs,
- Formation of scenario classes using the reduced set of FEPs, and
- Screening of scenario classes.

4.2.1.2.1.2 Review Methods

RM1 Identification of an Initial List of FEPs

Verify that DOE's list of FEPs includes all FEPs having a potential to influence repository performance. Use knowledge gained reviewing the YM site and regional characterization data and the description of the modes of degradation, deterioration, and alteration of the engineered barriers (using section 4.2.1.3 of the YMRP) to assess the completeness of the FEP list. The staff should use, as appropriate, available generic lists of FEPs (e.g., Nuclear Energy Agency, 1997) as a reference to determine the completeness of DOE's list of FEPs.

RM2 Screening of the Initial List of FEPs

Examine the excluded features and processes. Evaluate the adequacy of the rationale for excluding each feature and process based on the description of the site, the design specifications, and the waste characteristics. Consider information from site and regional characterization, natural analog studies, the repository design, and the results of the review conducted using Section 4.2.1.3 (Model Abstraction) during this evaluation.

Examine DOE's event screening rationale to determine whether an event is appropriately defined. Use the results of the review conducted using section 4.2.1.2.2 of the YMRP for this purpose. Assess DOE's justification (i.e., whether the probability of occurrence can be technically supported) for those events that fall below the regulatory probability criterion to evaluate whether these events were too narrowly defined by DOE and were inappropriately excluded.

Review the criteria used to screen FEPs related to the geologic setting, and the degradation, deterioration, or alteration of engineered barriers from the performance assessment based on their limited effect on the magnitude and time of the average annual dose. Evaluate DOE's analyses or calculations supporting this screening and the use of bounding or representative estimates for the consequences. Independently assess, using tools such as the Total-system Performance Assessment code (Mohanty and McCartin, 1998), the potential consequences to confirm DOE's screening of FEPs.

RM3 Formation of Scenario Classes Using the Reduced Set of Events

Evaluate DOE's description of the approach and technical bases to determine whether the resulting scenario classes are mutually exclusive and include all events that have not been screened from the performance assessment.

RM4 Screening of Scenario Classes

Review the criteria used by DOE to screen scenario classes from the performance assessment on the basis that their omission would not significantly change the magnitude or time of the average annual dose. Examine DOE analyses or calculations supporting this screening and the use of bounding or representative estimates for the consequences. Independently assess, using tools such as the Total-system Performance Assessment code (Mohanty and McCartin, 1998) as needed, the potential consequences to confirm DOE's screening of scenario classes.

Evaluate whether DOE has adequately considered coupling of processes in estimates of consequences used to screen scenario classes. For each screened scenario class, assess related scenario classes to evaluate whether a narrow definition resulted in the premature exclusion of the scenario class.

Examine those scenario classes excluded for the YM repository and the supporting technical bases. Consider the site description, design specifications, and waste characteristics in this examination. Also consider information from site and regional characterization, natural analog studies, and repository design, and the results of the review conducted under Section 4.2.1.3 (Model Abstraction) in this evaluation.

Use the results of the review conducted using section 4.2.1.2.2 of the YMRP to examine DOE's technical justification for screening scenario classes from the performance assessment based on their probability being below the regulatory criterion.

4.2.1.2.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements at 10 CFR 63.114(a)(5) and (6).

AC1 The identification of an initial list of FEPs is adequate.

- The license application contains a comprehensive list of FEPs that are present or might occur in the YM region that is consistent with the site characterization data and includes those FEPs that have the potential to influence repository performance. Moreover, the comprehensive FEP list includes, but is not limited to, potentially disruptive events related to igneous activity (extrusive and intrusive), seismic shaking (high frequency- low magnitude, and rare large magnitude events), tectonic evolution (slip on existing faults and formation of new faults), climatic change (change to pluvial conditions), and criticality.

AC2 Screening of the initial list of FEPs is appropriate.

- FEPs that are excluded from the performance assessment for the YM repository are identified and sufficient technical basis is provided for the exclusion.

- Events that are screened from the performance assessment on the basis that their probability falls below the regulatory criterion are identified and sufficient justification is provided.

- FEPs related to the geologic setting or the degradation, deterioration, or alteration of engineered barriers (including those processes that would affect the performance of natural barriers) that are screened from the performance assessment on the basis that their omission would not significantly change the magnitude or time of the average annual dose, are identified and sufficient justification is provided.

AC3 Formation of scenario classes using the reduced set of events is adequate.

- Scenario classes are mutually exclusive and complete, clearly documented, and technically acceptable.

AC4 Screening of scenario classes is appropriate.

- Screening of scenario classes is comprehensive, clearly documented, and technically acceptable.

- DOE has adequately considered coupling of processes in estimates of consequences used to screen scenario classes. Scenario classes were not prematurely excluded by a narrow definition.

- Scenario classes that are screened from the performance assessment on the basis that their probability falls below the regulatory criterion are identified and sufficient justification is provided.

- Scenario classes that are screened from the performance assessment on the basis that their omission would not significantly change the magnitude and time of the average annual dose are identified and sufficient justification is provided.

4.2.1.2.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114(a)(5). An adequate technical basis has been provided for the inclusion or exclusion of FEPs in the performance assessment. Specific FEPs have been evaluated in detail if the magnitude and time of the average annual dose would be significantly changed by their omission.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114(a)(6). An adequate technical basis has been provided for the inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. These processes were evaluated in detail if the magnitude and time of the average annual dose would be significantly changed by their omission.

4.2.1.2.1.5 References

Mohanty, S., and T.J. McCartin, coords. *Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User's Guide (Draft)*. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1998.

Nuclear Energy Agency. *An International Database of Features, Events, and Processes [Draft]*. NEA Working Group on the Development of a Database of Features, Events, and Processes Relevant to the Assessment of Post-Closure Safety of Radioactive Waste Repositories, Safety Assessment of Radioactive Waste Repositories Series. United Kingdom: Safety Assessment Management Limited. June 24, 1997.

4.2.1.2.2 Identification of Events With Probabilities Greater Than 10^{-8} Per Year

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.2.2.1 Areas of Review

This section reviews identification of events with probabilities greater than 10^{-8} per year. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), and (5).

The staff will evaluate the following parts of the identification of events with probabilities greater than 10^{-8} per year using the review methods and acceptance criteria in sections 4.2.1.2.2.2 and 4.2.1.2.2.3.

- Definitions of events such as faulting, seismicity, igneous activity, and criticality;

- The probability assigned to each event and the technical bases used to support this assignment;

- Conceptual models evaluated or considered in determining the probabilities of events;
- Parameters used to calculate the probabilities of events; and
- Uncertainty in models and parameters used to calculate the probabilities of events.

4.2.1.2.2.2 Review Methods

RM1 Event Definition

Evaluate whether the definitions for events (potentially beneficial or disruptive) applicable to the YM repository are unambiguous, probabilities are estimated for the specific event, and event definitions are used consistently and appropriately in probability models.

Confirm that probabilities of intrusive and extrusive igneous events are calculated separately. Verify that definitions of faulting and earthquakes are derived from the historical record, paleoseismic studies, or geological analyses. Confirm that criticality events, for the purpose of initial screening of the FEPs list, are calculated separately only by location of the criticality event (e.g., in-package, near-field, and far-field).

RM2 Probability Estimates

Evaluate whether the probability estimates for events applicable to YM are based on past patterns of natural events in the YM region, or are consistent with the design of the proposed repository system. Evaluate whether DOE interpretations of the likelihood of future occurrence of the events are compatible with current understandings of present and likely future conditions of the natural and engineered repository systems.

Verify that probability estimates for future igneous events are based on past patterns of igneous events in the YM region. Evaluate the adequacy and sufficiency of DOE characterization and documentation of past igneous activity. This should include uncertainties about the distribution, timing, and characteristics of past igneous activity. Confirm that, at a minimum, documentation of past igneous activity since about 12 million years ago encompasses the area within about 50 kilometers of the proposed repository site. Give particular attention to the documentation of the locations, ages, volumes, geochemistry, and geologic settings of less than 6-million-year old basaltic igneous features, such as cinder cones, lava flows, igneous dikes, and sills. Verify that DOE used geological and geophysical information relevant to past igneous activity contained in the literature.

Verify that probability estimates for future faulting and seismic events are based on past patterns of these events in the YM region. Examine the adequacy and sufficiency of characterization and documentation of past faulting and seismicity in the YM region since 2 million years ago. This should include characterization of uncertainties in the age, timing, magnitude (i.e., displacements), distribution, size, location, and style of faulting and seismicity. Evaluate whether interpretations of faulting and seismicity from surficial and underground mapping, interpretations of geophysical data, or analog investigations are internally consistent and geologically feasible, so reasonable projections can be made about the probability of future faulting and earthquake-induced ground vibrations at the site.

Evaluate whether probability estimates for future criticality events are based on design characteristics and natural features of the proposed YM repository system. Ensure that DOE has included all fuel types to be disposed at the proposed YM repository in calculating probability of future criticality events. Confirm that the estimate of probability of criticality is determined using methodology outlined in the DOE Topical Report on Disposal Criticality (DOE, 1998), as amended by responses to the NRC request for additional information (DOE, 1999), and subject to conditions and limitations in the NRC safety evaluation report (NRC, 2000).

RM3 Probability Model Support

Confirm that a technical justification is provided for models used to estimate the probability for events applicable to the YM repository. Determine whether justifications include comparison with results from detailed process models, or comparison with empirical observations such as reasonably analogous natural systems, or appropriate laboratory tests. Ensure that alternative modeling approaches consistent with available data and current scientific understanding are investigated and results and limitations are appropriately factored into the probability models.

Examine whether DOE probability models are consistent with known less than 12-million-year old basaltic igneous events in the YM-Death Valley magmatic system. Determine whether the DOE probability models are consistent with patterns of igneous activity in other, comparable volcanic fields outside the YM region. Use independent models to estimate the probabilities of igneous activity based on geologic information from the YM region. Verify that DOE considered alternative interpretations of probability for igneous events. Assess whether igneous activity probability models are consistent with the range of tectonic models used to assess other geological processes such as seismic source characterization, site geological models, and patterns of groundwater flow.

Determine whether results of the DOE probabilistic and Total System Performance Assessment models compare reasonably to results from seismotectonic process models, and/or empirical observations from appropriate analogs. Verify that DOE appropriately adopted acceptable and documented procedures to construct and test empirical and physical models used to estimate the seismic and fault-displacement hazards. For faulting, ascertain whether the DOE models used to describe primary and secondary (or distributed) faulting are justified technically and are adequate to predict the effects of faulting on repository performance. For seismicity, determine whether the DOE considered credible alternative modeling approaches for determining tectonic ground motions that relate to repository performance. Assess whether faulting models are consistent with fault-slip rates, fault displacements, or earthquake data used in the seismic hazard analysis and evaluate whether the timing and magnitude of future seismic events are consistent with the results of the fault-hazard analysis.

Confirm that models used to estimate the probability of future criticality events are validated using methodology outlined in the DOE Topical Report on Disposal Criticality (DOE, 1998), as amended by responses to the NRC request for additional information (DOE, 1999), and subject to conditions and limitations contained in the NRC safety evaluation report (NRC, 2000).

Probability model support for infrequent events should include data from analog systems that contain significantly more events than the YM system. This support should also include justification that the models reproduce the timing and characteristics of post events in the YM system. Confirm that probability models for a natural events use geologic bases that are consistent with other relevant FEPs.

RM4 Probability Model Parameters

Determine whether the parameters used to calculate the probability of events applicable to the YM repository are reasonable based on data from the YM region or analogous natural systems, and/or design and engineering characteristics of the proposed YM repository system.

Assess whether the parameters used in probabilistic volcanic hazard assessments are reasonable based on data from the YM region, and confirm that comparable volcanic systems outside the YM region were considered in developing such parameters.

Verify whether parameter values used in probabilistic seismic and fault-displacement hazard assessments are adequately supported by YM region faulting and earthquake data or appropriate analogs, so the effects of faulting and seismicity are appropriately factored into repository performance. Ensure that parameters are consistent with the range of faulting characteristics and seismicity observed in the YM region, or with parameters derived from representative analogs, and ascertain that the parameters account for variability in data precision and accuracy. For example, determine whether the DOE adequately evaluated uncertainties in faulting or earthquake activity (i.e., recurrence). Confirm that DOE has established reasonable and consistent correlations between parameters, where appropriate.

Where sufficient data do not exist, confirm that parameter values and conceptual models are based on appropriate use of other sources, such as expert elicitation using NUREG–1563 (Kotra, et al., 1996).

RM5 Uncertainty in Event Probability

For events applicable to the YM repository, determine whether DOE has adequately identified and propagated uncertainties in estimating probabilities. Ensure that an adequate technical basis that includes treatment of uncertainty is provided for the probability value. For probability distributions or ranges, confirm that a technical basis for the analysis is provided and that the distribution or range accounts for the uncertainty in the probability estimates.

Assess the probability values used for igneous events by considering the range of values available in the literature for the YM region and comparable volcanic fields outside the YM region. To confirm that probability models are sufficiently robust to reasonably approximate the distribution of YM region igneous features, evaluate probability models by testing their sensitivity to uncertainties about the past distribution of volcanic vents, recurrence rates of volcanism, and relationships between igneous activity and tectonism.

Verify that probabilities used in the evaluation of faulting and seismicity effects on repository performance includes both infrequent seismic and faulting events with relatively large-magnitude ground motions and fault displacements, and the cumulative effects of repeated ground motions or fault displacements due to more frequent and lower-magnitude seismic or faulting events.

4.2.1.2.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements at 10 CFR 63.114(a)(4).

AC1 Events are adequately defined.

- Events or event classes are defined without ambiguity and used consistently in probability models, such that probabilities for each event or event class are estimated separately.

- Probabilities of intrusive and extrusive igneous events are calculated separately. Definitions of faulting and earthquakes are derived from the historical record, paleoseismic studies, or geological analyses. Criticality events are calculated separately by location.

AC2 Probability estimates for future events are supported by appropriate technical bases.

- Probabilities for future natural events are based on past patterns of the natural events in the YM region, considering the likely future conditions and interactions of the natural and engineered repository system. These probability estimates have specifically included igneous events, faulting and seismic events, and criticality events.

AC3 Probability model support is adequate.

- Probability models are justified through comparison with output from detailed process-level models and/or empirical observations (e.g., laboratory testing, field measurements, or natural analogs including YM site data). Specifically:

    — For infrequent events, DOE justifies, to the extent possible, proposed probability models with data from reasonably analogous systems. Analog systems should contain significantly more events than the YM system in order to provide reasonable evaluations of probability model performance.

    — DOE justifies, to the extent possible, the ability of probability models to reproduce the timing and characteristics (e.g., location and magnitude) of successive past events in the YM system.

— The DOE probability models for natural events use underlying geologic bases (e.g., tectonic models) that are consistent with other relevant FEPs evaluated using section 4.2.1.2.1.

AC4 Probability model parameters have been adequately established.

- Parameters used in probability models are technically justified and documented by DOE. Specifically:

  — Parameters for probability models are constrained by data from the YM region and engineered repository system to the extent practical.

  — DOE appropriately establishes reasonable and consistent correlations between parameters.

  — Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of other sources, such as expert elicitation conducted in accordance with appropriate guidance.

AC5 Uncertainty in event probability is adequately evaluated.

- Probability values appropriately reflect uncertainties. Specifically:

  — DOE provides a technical basis for probability values used and the values account for the uncertainty in the probability estimates.

  — The uncertainty for reported probability values adequately reflects the influence of parameter uncertainty on the range of model results (i.e., precision) and the model uncertainty as it affects the timing and magnitude of past events (i.e., accuracy).

4.2.1.2.2.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114(a)(4). The license application considers those events that have at least one chance in 10,000 of occurring over 10,000 years.

4.2.1.2.2.5 References

Kotra, et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

Nuclear Regulatory Commission (U.S.) (NRC). *Draft Safety Evaluation Report on Disposal Criticality Analysis Methodology Topical Report.* Revision 0. Washington, DC: NRC. 2000.

U.S. Department of Energy (DOE). *Disposal Criticality Analysis Methodology Topical Report.* Revision 0. YMP/TR–004Q. Las Vegas, NV: DOE, Office of Civilian Radioactive Waste Management. November 1998.

U.S. Department of Energy (DOE). *U.S. Department of Energy (DOE) Response to U.S. Nuclear Regulatory Commission Request for Additional Information on the DOE Topical Report on Disposal Criticality Analysis Methodology*. Letter from S. Brocoum (November 19) to C.W. Reamer, Nuclear Regulatory Commission. Washington, DC: DOE. 1999.

4.2.1.3 Model Abstraction

There are 14 model abstraction sections the staff will use to determine compliance with 10 CFR 63.114(a). The abstractions consider the engineered, geosphere, and biosphere subsystems that may be important to performance. Important to performance means important to meeting the performance objective specified in 10 CFR 63.113, which is a radiation exposure limit. The risk of radiation health effects is the basis for the radiation exposure limit. The staff will decide which abstractions are important to performance by using current and prior performance assessments, knowledge of site characteristics and repository design, and review of the DOE's safety case. Each section provides enough review methods and acceptance criteria to allow for a detailed review. However, it is unlikely that each of the 14 abstraction topics will have the same risk significance and need the same review level. Nevertheless, until the DOE completes its safety case and the license application, the sections about model abstractions need to be flexible, and in enough detail, that the staff clearly understands how to conduct the review of abstraction information provided by the licensee. The staff will focus its review to understand the importance to performance of the various assumptions, models, and data in the performance assessment. The staff will also focus it review to ensure the degree of technical support for models and data abstractions is equal to its contribution to risk. This means the staff will review each model abstraction to a detail level suitable to the degree the DOE relies on it to prove its safety case. The staff will be familiar with the DOE safety case because of the multiple barrier review (refer to section 4.2.1.1). In the multiple barrier review, the staff will decide whether the supporting bases for the safety case clearly show the degree of reliance on various parts of the system. For example, if DOE relies on the unsaturated zone to provide significant delay (on the order of thousands of years) in the transport of radionuclides to the critical group, then the staff will perform a detailed review of this abstraction. However, if DOE shows that this abstraction has a minor impact on the delay (on the order of hundreds of years) of radionuclides to the critical group, then the staff will conduct a simplified review focusing on the bounding assumptions. The staff will use the review methods and acceptance criteria in these sections to decide whether the DOE properly characterized and factored the FEPs into the performance assessment. This is necessary to decide whether the DOE performance assessment is acceptable and complies with 10 CFR 63.114. The review methods and acceptance criteria the staff will use to evaluate compliance with the overall performance objective (numerical standard) are in section 4.2.1.4.1 of the YMRP.

4.2.1.3.1 Degradation of Engineered Barriers

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which degradation of engineered barriers affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon the engineered barriers to provide significant delay (on the order of thousands of years) in the transport of radionuclides to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.1.1 Areas of Review

This section reviews degradation of engineered barriers within the emplacement drift. Reviewers will also evaluate information required by 10 CFR 63.21(c)(3), (9)(i)–(iii) and (v), and (13) that is relevant to the abstraction of degradation of engineered barriers. It is important to note that the scope of this review includes various parts of the engineered barrier system as specified in 10 CFR 63.2.

The staff will evaluate the following parts of the abstraction of degradation of engineered barriers using review methods and acceptance criteria in sections 4.2.1.3.1.2 and 4.2.1.3.1.3.

- Description of the engineered barrier system, hydrology, geochemistry, and thermal effects related to the degradation of engineered barrier system and the technical basis DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare the output from the Total System Performance assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.1.2 Review Methods

To review the abstraction of degradation of engineered barriers, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the DOE license application description of design features, physical phenomena, and couplings, as well as the description of the waste package, and features of the engineered barrier system that contribute to HLW isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction for the degradation of engineered barriers.

Examine assumptions, technical bases, data, and models used by DOE in the Total System Performance Assessment abstraction degradation process models in the Total System Performance Assessment abstraction of the degradation of engineered barriers for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for the abstraction of the degradation of the engineered barriers.

Evaluate whether the DOE description aspects of environmental conditions within the waste package emplacement drifts, design features, physical phenomena, and couplings that may affect the degradation of the engineered barriers is adequate. Verify that conditions and assumptions used in the Total System Performance Assessment abstraction of the degradation of the engineered barriers are consistent with the body of data presented in the abstraction.

Confirm that DOE has propagated boundary and initial conditions used in the Total System Performance Assessment abstraction of the degradation of engineered barriers throughout its abstraction approaches.

Examine the FEPs related to the degradation of the engineered barriers that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion.

Evaluate the technical bases used by DOE for selecting the design criteria that mitigates any potential impact of in-package criticality on repository performance including all FEPs that may increase the reactivity of the system inside the waste package; all the configuration classes and configurations that have potential for nuclear criticality; changes in radionuclide inventory and thermal conditions in the abstraction of the degradation of engineered barriers.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al. 1988a,b), or other acceptable approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the experimental and site characterization data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of degradation of engineered barriers.

Verify whether sufficient data have been collected to adequately model degradation processes, as well as characteristics of the geochemistry, hydrology, design features, and thermal effects to establish initial and boundary conditions for the Total System Performance Assessment abstraction of degradation of engineered barriers. For example, mechanical property data should cover the range of anticipated temperatures and microstructural conditions. The corrosion data should consider the appropriate range of environmental conditions such as chloride concentration.

Evaluate and confirm that data used to support the DOE Total System Performance Assessment abstraction of the degradation of engineered barriers are based on appropriate techniques and are adequate for the accompanying sensitivity/uncertainty analyses. Evaluate the need for additional data based on the sensitivity analyses.

Verify that DOE demonstrates the adequacy of the degradation of engineered barriers models used to assess the range of possible degradation processes.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process models, and alternative conceptual model considered in the Total System Performance Assessment abstraction of degradation of engineered barriers. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for the uncertainties and variabilities in the data.

Examine the abstraction for those degradation processes that DOE assumes are not important to performance and confirm that the parameters used in these abstractions are assigned values consistent with the abstractions of other degradation processes determined to be significant to performance of the engineered barriers, as well as the initial and boundary conditions used in other abstractions for the Total System Performance Assessment.

Determine whether DOE has used parameters in the abstraction of the degradation of engineered barriers that are based on laboratory experiments, field measurements, natural analog or industrial analog research, and process-level modeling studies conducted under conditions relevant to the range of environmental conditions in the emplacement drifts located in the unsaturated zone at YM. Examine the results of DOE engineered barrier degradation tests and confirm that DOE has provided adequate models.

Evaluate the methods used by DOE for nondestructive examination of fabricated engineered barriers, including the type, size, and location of fabrication defects that may lead to premature failure as a result of rapidly initiated engineered barrier degradation. Examine the justification for the allowable distribution of fabrication defects in the engineered barriers, and evaluate how DOE assesses the effect on engineered barrier performance of defects that cannot be detected.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for degradation of engineered barriers. Examine the model parameters in the context of available site characterization data, laboratory corrosion tests, field measurements, and process-level modeling studies.

Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of the degradation of engineered barriers including waste package corrosion. Examine the effects of the alternative conceptual models on repository performance and evaluate how model uncertainties are defined, documented and assessed.

Examine the mathematical models used in the analyses of degradation of engineered barriers. Examine and evaluate the bases for excluding alternative conceptual models and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of the degradation of engineered barriers and compare the results with a combination of data from laboratory corrosion testing and field measurements, as well as results obtained through process-level modeling. Evaluate the sensitivity analyses used to support the abstraction of the degradation of engineered barriers in the Total System Performance Assessment.

Use detailed models of degradation processes to evaluate the Total System Performance Assessment abstractions of the degradation of engineered barriers. If practical, use an alternative to the Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of the degradation of the engineered barriers and assess the effects on repository performance. Compare results of the DOE abstraction to approximations shown to be appropriate for closely analogous systems, industrial experience, and experimental results.

Evaluate evidence to show that models used to evaluate performance are not likely to underestimate the actual degradation and failure of engineered barriers as a result of corrosion or other degradation processes.

In developing supporting evidence for the models, verify that mathematical models for the degradation of engineered barriers are based on the same environmental parameters, material factors, assumptions, and approximations shown to be appropriate for closely analogous engineering or industrial applications and experimental investigations.

Examine the procedures used by DOE to construct and test its mathematical and numerical models.

As appropriate, use an alternative Total System Performance Assessment model to evaluate the DOE sensitivity or bounding analyses and confirm that DOE has used ranges consistent with available site characterization data, field and laboratory tests, industrial and natural analog research.

4.2.1.3.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the degradation of engineered barriers model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the degradation of engineered barriers abstraction process.

- The Total System Performance Assessment abstraction of the degradation of engineered barriers uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for degradation of engineered barriers should be consistent with the Total System Performance Assessment abstractions of the quantity and chemistry of water contacting the waste packages and waste forms (section 4.2.1.3.3) spatial and temporal distributions on flow in the unsaturated zone (section 4.2.1.3.5) and mechanical disruption of waste packages (section 4.2.1.3.2). The descriptions and technical bases provide transparent and traceable support for the abstraction of the degradation of engineered barriers.

- The description of engineered barriers, design features, degradation processes, physical phenomena, and couplings that may affect the degradation of the engineered barriers is adequate. For example, include materials and methods used to construct the engineered barriers and considers degradation processes such as uniform corrosion, pitting corrosion, crevice corrosion, stress corrosion cracking, intergranular corrosion, microbially influenced corrosion, dry-air oxidation, hydrogen embrittlement, as well as the effects of wet and dry cycles, material aging and phase stability, welding, and initial defects on the degradation modes for the engineered barriers.

- Boundary and initial conditions used in the Total System Performance Assessment abstractions are propagated consistently throughout its abstraction approaches. For example, the conditions and assumptions used in the degradation of engineered barriers are consistent with those used to model the quantity and chemistry of water contacting the waste packages and waste forms (section 4.2.1.3.3) spatial and temporal distributions on flow in the unsaturated zone (section 4.2.1.3.5) and mechanical disruption of waste packages (section 4.2.1.3.2)

- Sufficient technical bases for the inclusion of FEPs related to degradation of engineered barriers in the Total System Performance Assessment abstractions are provided.

- Adequate technical bases are provided for selecting the design criteria that mitigates any potential impact of in-package criticality on repository performance including considering all FEPs that may increase the reactivity of the system inside the waste package. For example, the technical bases for the abstraction of the degradation of engineered barriers include configuration classes and configurations that have potential for nuclear criticality, changes in radionuclide inventory, and changes in thermal conditions.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Parameters used to evaluate the degradation of engineered barriers in the safety case are adequately justified (e.g., laboratory corrosion tests, site-specific data such as data from drift scale tests, in-service experience in pertinent industrial applications, and test results not specifically performed for the YM site, etc.). DOE describes how the data were used, interpreted, and appropriately synthesized into the parameters.

- Sufficient data have been collected on the characteristics of the engineered components, design features, and the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of degradation of engineered barriers.

- Data on the degradation of the engineered barriers, (e.g., general and localized corrosion, microbial influenced corrosion, galvanic interactions, hydrogen embrittlement, and phase stability) used in the Total System Performance Assessment abstraction are based on laboratory measurements, site specific field measurements, industrial analog and/or natural analog research, and tests designed to replicate the range of conditions that may occur at the YM site. As appropriate, sensitivity or uncertainty analyses used to support the DOE Total System Performance Assessment abstraction are adequate to determine the possible need for additional data.

- Degradation models for the processes that may be significant to the performance of the engineered barriers are adequate. For example, DOE models consider the possible degradation of the engineered barriers as a result of uniform and localized corrosion processes, stress corrosion cracking, microbial influenced corrosion, hydrogen embrittlement, and incorporate the effects of fabrication processes, thermal aging, and phase stability.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- For those degradation processes that the Total System Performance Assessment abstraction indicates are significant to the performance of the engineered barriers, DOE provides appropriate parameters based on techniques that may include laboratory experiments, field measurements, industrial analogs, and process-level modeling studies conducted under conditions relevant to the range of environmental conditions within the waste package emplacement drifts. DOE also demonstrates the capability to predict the degradation of the engineered barriers in laboratory and field tests.

- For the selection of parameters used in conceptual and process-level models of engineered barrier degradation that can be expected under repository conditions, assumed range of values and probability distributions are not likely to underestimate the actual degradation and failure of engineered barriers as a result of corrosion.

- DOE uses appropriate methods for nondestructive examination of fabricated engineered barriers, the type, size, and location of fabrication defects that may lead to premature failure as a result of rapidly initiated engineered barrier degradation. DOE specifies and justifies the allowable distribution of fabrication defects in the engineered barriers and assesses the effects of defects that cannot be detected on the performance of the engineered barriers.

- Where sufficient data do not exist, the definition of parameter values and conceptual models used by DOE is based on appropriate use of other sources such as expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model Uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Conceptual model uncertainties are defined and documented and conclusions regarding performance of the engineered barriers are properly assessed.

- DOE uses alternative modeling approaches consistent with available data and current scientific understanding, and evaluates their model results and limitations using tests and analyses that are sensitive to the processes modeled. For example, for processes such as uniform corrosion, localized corrosion, and stress corrosion cracking of the engineered barriers, DOE considers alternative modeling approaches to develop its understanding of environmental conditions and material factors are significant to these degradation processes.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Numerical corrosion models used to calculate the lifetimes of the engineered barriers are adequate representations, considering the associated uncertainties in the expected long-term behaviors, the range of conditions (including residual stresses) and the variability in engineered barrier fabrication processes (including welding).

- Evidence is sufficient to show that models used to evaluate performance are not likely to underestimate the actual degradation and failure of engineered barriers as a result of corrosion or other degradation processes.

- Mathematical models for the degradation of engineered barriers are based on the same environmental parameters, material factors, assumptions, and approximations shown to be appropriate for closely analogous engineering or industrial applications and experimental investigations.

- Accepted and well-documented procedures are used to construct and test the numerical models to simulate the engineered barrier chemical environment and degradation of engineered barriers.

- Sensitivity analyses or bounding analyses are provided to support the Total System Performance Assessment abstraction of degradation of engineered barriers that cover ranges consistent with the site data, field or laboratory experiments and tests, and industrial analogs.

4.2.1.3.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 regarding abstraction of degradation of engineered barriers in the performance assessment. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.1.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.2 Mechanical Disruption of Engineered Barriers

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which mechanical disruption of engineered barriers affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon the engineered barriers to provide significant delay (on the order of thousands of years) in the transport of radionuclides to the critical group, then perform a more detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the delay (on the order of hundreds of years) of radionuclides to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.2.1 Areas of Review

This section reviews mechanical disruption of engineered barriers. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (2), (3), (9)(i)–(iii) and (vi), and (13) that is relevant to the abstraction of mechanical disruption of engineered barriers.

The staff will evaluate the following parts of the abstraction of degradation of engineered barriers using the review methods and acceptance criteria in sections 4.2.1.3.2.2 and 4.2.1.3.2.3.

- Description of the geological and engineering aspects of mechanical disruption of engineered barriers and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.2.2 Review Methods

To review the abstraction of mechanical disruption of engineered barriers, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings included in the mechanical disruption of engineered barriers abstraction. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers.

Evaluate whether the description of design features, physical phenomena, and couplings that may affect mechanical disruption of engineered barriers is adequate. Verify that conditions and assumptions used in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers are consistent with the body of data presented in the description.

Examine assumptions, technical bases, data, and models used by DOE in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for the abstraction of mechanical disruption of engineered barriers.

Confirm that DOE has propagated boundary and initial conditions used in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers throughout its abstraction approaches.

Examine the FEPs related to mechanical disruption of engineered barriers that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion.

Evaluate the DOE conclusion with respect to the impact of transient criticality on the integrity of the engineered barriers.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological and engineering data used to support parameters for conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers. Evaluate the basis for the data on physical phenomena, couplings, geology, and engineering used in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers. This basis may include a combination of techniques such as laboratory experiments, site-specific field measurements, natural analog research, process-level modeling studies, and expert elicitation.

Verify that sufficient data have been collected to adequately characterize the geology of the natural system, engineering materials, and initial manufacturing defects to establish initial and boundary conditions for the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers.

Evaluate and confirm that data used to support the DOE Total System Performance Assessment abstraction of mechanical disruption of engineered barriers are based on appropriate techniques and are adequate for the accompanying sensitivity/uncertainty analyses. Evaluate the need for additional data based on sensitivity analyses.

Verify that DOE demonstrates the adequacy of engineered barrier mechanical failure models for disruption events.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Evaluate the DOE justification of process-level models used to represent mechanically disruptive events within the emplacement drifts at the proposed YM repository. Verify that DOE parameter values are adequately constrained by YM site data such that the effects of mechanically disruptive events on engineered barrier integrity are not underestimated. Confirm that DOE identifies parameters within conceptual models for mechanically disruptive events that are consistent with the range of characteristics observed at YM.

Assess how uncertainty is represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for mechanical disruption of engineered barriers. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency.

Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of mechanical disruption of engineered barriers.

Examine the effects of the alternative conceptual model(s) on repository performance and evaluate how model uncertainties are defined, documented, and assessed.

Examine the mathematical models included in the analyses of mechanical disruption of engineered barriers. Also examine and evaluate the bases for excluding alternative conceptual models, and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of mechanical disruption of engineered barriers and compare the results with an appropriate combination of site characterization data, process-level modeling, laboratory testing, field measurements, and natural analog research.

Use detailed models of geological and engineering processes to evaluate the Total System Performance Assessment abstractions of mechanical disruption of engineered barriers. If practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of mechanical disruption of engineered barriers and evaluate the effects on repository performance. Compare results of the DOE abstraction to approximations shown to be appropriate for closely analogous natural systems or experimental systems.

Examine the procedures used by DOE to develop and test its mathematical and numerical models.

As appropriate, use an alternative Total System Performance Assessment model to evaluate the DOE sensitivity or bounding analyses and confirm that DOE has used ranges consistent with available site characterization data, field and laboratory tests, and natural analog research.

4.2.1.3.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the mechanical disruption of engineered barriers model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the mechanical disruption of engineered barriers abstraction process.

- The description of geological and engineering aspects of design features, physical phenomena, and couplings that may affect mechanical disruption of engineered barriers is adequate. For example, the description may include materials used in the construction of engineered barrier components, environmental effects (e.g., temperature, water chemistry, humidity, radiation, etc.) on these materials, and mechanical failure processes and concomitant failure criteria used to assess the performance capabilities of these materials. Conditions and assumptions in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of mechanical disruption of engineered barriers uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, assumptions used for mechanical disruption of engineered barriers are consistent with the Total System Performance Assessment abstraction of degradation of engineered barriers (section 4.2.1.3.1 of the YMRP). The descriptions and technical bases provide transparent and traceable support for the abstraction of mechanical disruption of engineered barriers.

- Boundary and initial conditions used in the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers are propagated throughout its abstraction approaches.

- Sufficient data and technical bases to assess the degree to which FEPs have been included in this abstraction are provided.

- The conclusion with respect to the impact of transient criticality on the integrity of the engineered barriers is defensible.

- Follow the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches.

AC2 Data are sufficient for model justification.

- Geological and engineering values used in the safety case to evaluate mechanical disruption of engineered barriers are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data have been collected on the geology of the natural system, engineering materials, and initial manufacturing defects to establish initial and boundary conditions for the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers.

- Data on geology of the natural system, engineering materials, and initial manufacturing defects used in the Total System Performance Assessment abstraction are based on appropriate techniques. These techniques may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies. As appropriate, sensitivity or uncertainty analyses used to support the DOE Total System Performance Assessment abstraction are adequate to determine the possible need for additional data.

- Engineered barrier mechanical failure models for disruption events are adequate. For example, these models may consider effects of prolonged exposure to the expected emplacement drift environment, material test results not specifically designed or performed for the YM site, and engineered barrier component fabrication flaws.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- Process-level models used to represent mechanically disruptive events within the emplacement drifts at the proposed YM repository are adequate. Parameter values are adequately constrained by YM site data such that the effects of mechanically disruptive events on engineered barrier integrity are not underestimated. Parameters within conceptual models for mechanically disruptive events are consistent with the range of characteristics observed at YM.

- Uncertainty is adequately represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers. This may be done either through sensitivity analyses or use of conservative limits.

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed.

- Appropriate alternative modeling approaches are investigated that are consistent with available data and current scientific knowledge, and appropriately consider their results and limitations using tests and analyses that are sensitive to the processes modeled.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Outputs of mechanical disruption of engineered barriers abstractions reasonably produce or bound the results of corresponding process-level models, empirical observations, or both.

- Well-documented procedures that have been accepted by the scientific community to construct and test the mathematical and numerical models are used to simulate mechanical disruption of engineered barriers.

- Sensitivity analyses or bounding analyses are provided to support the Total System Performance Assessment abstraction of mechanical disruption of engineered barriers that cover ranges consistent with site data, field or laboratory experiments and tests, and natural analog research.

4.2.1.3.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 regarding abstraction of mechanical disruption of engineered barriers in the performance assessment. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.2.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1247, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.3 Quantity and Chemistry of Water Contacting Waste Packages and Waste Forms

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which quantity and chemistry of water contacting waste packages and waste forms affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon the processes effecting quantity and chemistry of waste contacting water packages and waste forms to significantly reduce dose to the critical group, then a detailed review of this abstraction will be performed. If, on the other hand, this abstraction is demonstrated by the DOE to have a minor impact on the dose to the critical group, then a simplified review will be conducted focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of the overall performance objective is evaluated in section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.3.1 Areas of Review

This section reviews quantity and chemistry of water contacting waste packages and waste forms. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (2), (3), (4), (9)(i)–(iii) and (vi), and (13) that is relevant to the abstraction of quantity and chemistry of water contacting waste packages and waste forms.

The staff will evaluate the following parts of the abstraction of quantity and chemistry of water contacting waste packages and waste forms using the review methods and acceptance criteria in sections 4.2.1.3.3.2 and 4.2.1.3.3.3.

- Description of the geological, hydrological, and geochemical aspects of quantity and chemistry of water contacting waste packages and waste forms and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.3.2 Review Methods

To review the abstraction of quantity and chemistry of water contacting waste packages and waste forms, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the descriptions of design features (including drip shield, backfill, waste packages, drift design and support, thermal loading, and other engineered barrier components), relevant physical features, physical phenomena, and couplings, as well as the description of the geological, hydrological, geochemical, and geomechanical aspects of the unsaturated zone included in the abstraction of quantity and chemistry of water contacting the waste packages and waste forms. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of quantity and chemistry of water contacting waste packages and waste forms.

Evaluate whether the description of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect the quantity and chemistry of water contacting waste packages and waste forms is adequate. Verify that conditions, assumptions, and the technical bases used in the Total System Performance Assessment abstraction of quantity and chemistry of water contacting waste packages and waste forms are consistent with other related DOE abstractions.

Verify that important design features such as waste package design and material selection, backfill, drip shield, ground support, thermal loading strategy, and degradation processes, are included in determining the initial and boundary conditions for calculations of the quantity and chemistry of water contacting waste packages and waste forms.

Examine the spatial and temporal abstractions to determine whether they appropriately address the physical couplings (thermal-hydrologic-mechanical-chemical).

Assess the technical bases for the geological hydrological, geochemical, and geomechanical descriptions and for incorporating them in the Total System Performance Assessment abstraction for coupled thermal-hydrologic-mechanical-chemical effects. Determine whether the technical bases used for modeling assumptions and approximations have been documented and are adequate. Evaluate whether the descriptions provide transparent and traceable support to the abstraction and are consistent with other Total system Performance Assessment model abstractions.

Evaluate the Total System Performance Assessment model abstraction for quantity and chemistry of water contacting waste packages and waste forms to ensure that it reasonably bounds the expected range of environmental conditions within the waste package emplacement drifts, inside of breached waste packages, and contacting the waste forms.

Evaluate the consistency of the Total System Performance Assessment model abstraction for quantity and chemistry of water contacting waste packages and waste forms with detailed information on waste package design and other engineered features.

Examine the FEPs related to the quantity and chemistry of water contacting waste packages and waste forms that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion.

Determine whether processes that have been observed in thermohydrologic tests and experiments and that are significant to performance are included in the Total System Performance Assessment model abstraction.

Ensure that DOE includes likely modes for container corrosion (section 4.2.1.3.1 of the YMRP) in determining the quantity and chemistry of water entering the waste packages and contacting waste forms. Evaluate the treatment of parameters such as pH and carbonate concentration, and the effect of waste package corrosion on the quantity and chemistry of water contacting waste packages and waste forms.

Evaluate the Total System Performance Assessment abstraction of in-package criticality or external-to-package criticality within the emplacement drift and the associated technical basis for screening these events. Ensure that if either event is included in the Total System Performance Assessment, DOE uses acceptable technical bases for selecting the design criteria that mitigate the potential impact of in-package criticality on repository performance, identifies the FEPs that may increase the reactivity of the system inside the waste package, identifies the configuration classes and configurations that have potential for nuclear criticality, and includes changes in thermal conditions and degradation of engineered barriers in the abstraction of the quantity and chemistry of water contacting the waste packages and waste forms.

Verify that DOE reviews follow the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, hydrological, and geochemical data used to support parameters used in conceptual models, process-level models, and alternative conceptual models (if any) considered in the Total System Performance Assessment abstraction of quantity and chemistry of water contacting waste packages and waste forms. Evaluate whether the basis includes a combination of techniques such as laboratory experiments, site-specific field measurements, natural analog research, process-level modeling studies, and expert elicitation. Assess how the data were used, interpreted, and synthesized into the parameters. Examine and confirm the sufficiency, transparency, and traceability of the data that support the technical bases for FEPs related to the quantity and chemistry of water contacting waste packages and waste forms that have been included in the Total System Performance Assessment abstraction.
Verify that sufficient data were collected on the characteristics of the natural system and engineered materials to establish initial and boundary conditions for conceptual models of thermal-hydrologic-mechanical-chemical coupled processes that affect seepage and flow and the waste package chemical environment, and the chemical environment for radionuclide release.

Ensure that DOE has used results from thermohydrologic tests to identify important processes and establish temperature ranges for repository conditions in developing its mathematical models. Verify that the data are sufficient to support thermohydrologic conceptual models.

Evaluate the sufficiency of data used to support the conceptual approaches for water contact with the drip shield, waste package, and waste forms.

Examine the sufficiency of data used to support the analysis of the potential for microbial activity affecting the waste package chemical environment and the chemical environment for radionuclide release. Ensure that the data are sufficient to constrain the probability for microbially influenced corrosion and microbially enhanced dissolution of the HLW glass form.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the sufficiency of the technical bases for parameter values and ranges used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction. Determine whether the DOE has reasonably accounted for uncertainties and variabilities in developing parameter values and ranges.

Determine whether the parameter values are based on site-specific data obtained from techniques such as laboratory and field experiments. As necessary, evaluate whether the parameter values and ranges derived from natural analog research or process-level models are correctly incorporated in the Total System Performance Assessment model abstraction of quantity and chemistry of water contacting waste packages and waste forms.

Examine the initial and boundary conditions used to evaluate coupled thermal-hydrologic-chemical effects on the quantity and chemistry of water contacting waste packages and waste forms for consistency with available data.

Evaluate the initial and boundary conditions used to evaluate coupled thermal-hydrologic-chemical effects on the quantity and chemistry of water contacting waste packages and waste forms for consistency with available data. As necessary, confirm that correlations between input values have been appropriately established in the DOE Total System Performance Assessment.

Evaluate the DOE assessment of uncertainty and variability in parameters. Determine whether DOE incorporates data uncertainty and temporal and spatial variability in conditions affecting coupled thermal-hydrologic-mechanical-chemical effects into parameter ranges.

If in-package criticality or external-to-package criticality is included in the Total System Performance Assessment, examine the methods and parameters used by DOE to calculate the effective neutron multiplication factor (k_{eff}).

If expert elicitations were used as a basis for data uncertainty for this abstraction, confirm they were conducted in accordance with appropriate guidance (Kotra, et al., 1996).

RM4 Model Uncertainty

Determine whether DOE has considered appropriate alternative conceptual models. Examine the bases for alternative conceptual models considered in the Total System Performance Assessment model abstraction of quantity and chemistry of water contacting waste packages and waste forms and the limitations and uncertainties of the chosen model. Evaluate the discussion of alternative modeling approaches not considered in the final analysis and the limitations and uncertainties of the chosen model. Evaluate the selected model for consistency with available data.

Evaluate DOE's assessment of the effects of model uncertainty on conclusions regarding performance.

Review the methods used by DOE in considering the effects of thermal-hydrologic-mechanical-chemical coupled processes in different alternative conceptual models.

Determine whether DOE has provided an adequate demonstration of the effects on dose to the critical group in its assessment of alternative conceptual models of coupled thermal-hydrologic-mechanical-chemical coupled processes.

RM5 Model Support

Evaluate the output from the abstraction of the quantity and chemistry of water contacting waste packages and waste forms and compare the results with an appropriate combination of site characterization and design data, process-level modeling, laboratory testing, field measurements, and natural analog data.

Examine the analytical and numerical models used in the thermal-mechanical analyses for consistency with site-specific or natural analog data. Evaluate predicted changes in hydrologic properties and the magnitudes and distributions of changes resulting from effects of thermal-mechanical processes for consistency with results of thermal-mechanical analyses of the underground facility.

Examine the output from the mathematical models for abstractions of coupled processes effects on the quantity and chemistry of water contacting waste packages and waste forms for consistency with conceptual models based on inferences about the near-field environment, field data, and natural alteration observed at the site, and expected engineered materials properties. Examine the use of abstracted model results and compare mathematical models to judge the robustness of results. Evaluate the acceptability of the sensitivity analyses used to support the abstraction of the quantity and chemistry of water contacting waste packages and waste forms in the Total System Performance Assessment. To the extent practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction and to evaluate the effects of the quantity and chemistry of water contacting the waste packages and waste forms on repository performance.

4.2.1.3.3.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3), (5)–(7) relating to the quantity and chemistry of water contacting waste packages and waste forms model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System Description and Model Integration are Adequate

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the quantity and chemistry of water contacting waste packages and waste forms abstraction process.

- The Total System Performance Assessment abstraction of the quantity and chemistry of water contacting waste packages and waste forms uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for quantity and chemistry of water contacting waste packages and waste forms are consistent with the Total System Performance Assessment abstractions of degradation of engineered barriers (section 4.2.1.3.1), mechanical disruption of waste packages (section 4.2.1.3.2), radionuclide release rates and solubility limits (section 4.2.1.3.4), climate and infiltration (section 4.2.1.3.5), and flow paths in the unsaturated zone (section 4.2.1.3.6). The descriptions and technical bases provide transparent and traceable support for the abstraction of quantity and chemistry of water contacting waste packages and waste forms.

- Important design features such as waste package design and material selection, backfill, drip shield, ground support, thermal loading strategy, and degradation processes, are adequate to determine the initial and boundary conditions for calculations of the quantity and chemistry of water contacting waste packages and waste forms.

- Spatial and temporal abstractions appropriately address physical couplings (thermal-hydrologic-mechanical-chemical). For example, DOE evaluates the potential for focusing of water flow into drifts caused by coupled thermal-hydrologic-mechanical-chemical processes.

- Sufficient technical bases and justification are provided for Total System Performance Assessment assumptions and approximations for modeling coupled thermal-hydrologic-mechanical-chemical effects on seepage and flow, the waste package chemical environment, and the chemical environment for radionuclide release. The effects of distribution of flow on the amount of water contacting the waste packages and waste forms are consistently addressed in all relevant abstractions.

- The expected range of environmental conditions within the waste package emplacement drifts, inside of breached waste packages, and contacting the waste forms and their evolution with time are identified. These ranges may be developed to include: (i) the effects of the drip shield and backfill on the quantity and chemistry of water (e.g., the potential for condensate formation and dripping from the underside of the shield), (ii) conditions that promote corrosion of engineered barriers and degradation of waste forms, (iii) irregular wet and dry cycles, (iv) gamma-radiolysis, and (v) size and distribution of penetrations of waste packages.

- The Total System Performance Assessment model abstraction for quantity and chemistry of water contacting waste packages and waste forms is consistent with the detailed information on waste package design and other engineered features. For example, consistency is demonstrated for: (i) dimensionality of the abstractions, (ii) various design features and site characteristics, and (iii) alternative conceptual approaches are applied consistently. Analyses are adequate to demonstrate that no deleterious effects are caused by design or site features that DOE does not take into account in this abstraction.

- Adequate technical bases are provided, including activities such as independent modeling, laboratory or field data, or sensitivity studies, for inclusion of any thermal-hydrologic-mechanical-chemical couplings and FEPs.

- Performance-affecting processes that have been observed in thermohydrologic tests and experiments are included into the performance assessment. For example, DOE either demonstrates that liquid water will not reflux into the underground facility or incorporates refluxing water into the performance assessment calculation and bounds the potential adverse effects of alteration of the hydraulic pathway that result from refluxing water.

- Likely modes for container corrosion (section 4.2.1.3.1 of the YMRP) are identified and considered in determining the quantity and chemistry of water entering the waste packages and contacting waste forms. For example, the Total System Performance Assessment model abstractions consistently address the role of parameters such as pH, carbonate concentration, and the effect of waste package corrosion on the quantity and chemistry of water contacting waste packages and waste forms.

- The abstraction of in-package criticality or external-to-package criticality within the emplacement drift provides an adequate technical basis for screening these events. If either event is included in the Total System Performance Assessment then DOE uses acceptable technical bases for selecting the design criteria that mitigate the potential impact of in-package criticality on repository performance, identifies the FEPs that may increase the reactivity of the system inside the waste package, identifies the configuration classes and configurations that have potential for nuclear criticality, and includes changes in thermal conditions and degradation of engineered barriers in the abstraction of the quantity and chemistry of water contacting the waste packages and waste forms.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are Sufficient for Model Justification

- Geological, hydrological, and geochemical values used in the safety case are adequately justified. Adequate description of how the data were used, interpreted, and appropriately synthesized into the parameters is provided.

- Sufficient data were collected on the characteristics of the natural system and engineered materials to establish initial and boundary conditions for conceptual models of thermal-hydrologic-mechanical-chemical coupled processes that affect seepage and flow and the waste package chemical environment.

- Thermohydrologic tests were designed and conducted with the explicit objectives of observing thermohydrologic processes for the temperature ranges expected for repository conditions and make measurements for mathematical models. Data are sufficient to verify that thermohydrologic conceptual models address important thermohydrologic phenomena.

- Sufficient information to formulate the conceptual approach(es) for analyzing water contact with the drip shield, waste package, and waste forms is provided.

- Sufficient data is provided to complete a nutrient and energy inventory calculation, if it has been used to justify the inclusion of the potential for microbial activity affecting the waste package chemical environment and the chemical environment for radionuclide release. As necessary, data are adequate to constrain the probability for microbially influenced corrosion and microbial effects such as production of organic by-products and microbially enhanced dissolution of the HLW glass form.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans are identified for further testing to acquire the necessary information as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data Uncertainty is Characterized and Propagated Through the Model Abstraction

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- Parameter values, assumed ranges, probability distributions, and bounding assumptions used in the quantity and chemistry of water contacting waste packages and waste forms calculations in Total System Performance Assessment are technically defensible and reasonable, based on data from the YM region (e.g., results from large block and drift-scale heater and niche tests) and a combination of techniques that may include laboratory experiments, field measurements, natural analog research, and process-level modeling studies.

- Input values used in the quantity and chemistry of water contacting engineered barriers (e.g., drip shield and waste package) calculations in Total System Performance Assessment are consistent with the initial and boundary conditions and the assumptions of the conceptual models and design concepts for the YM site. Correlations between input values are appropriately established in the DOE Total System Performance Assessment.

- Parameters used to define initial conditions, boundary conditions, and computational domain in sensitivity analyses involving coupled thermal-hydrologic-mechanical-chemical effects on seepage and flow, the waste package chemical environment, and on the chemical environment for radionuclide release are consistent with available data.

Reasonable or conservative ranges of parameters or functional relations are established.

- Adequate representation of uncertainties in the characteristics of the natural system and engineered materials is provided in parameter development for conceptual models, process-level models, and alternative conceptual models. DOE may constrain these uncertainties using sensitivity analyses or conservative limits. For example, DOE demonstrates how parameters used to describe flow through the engineered barrier system bound the effects of backfill and excavation-induced changes.

- If criticality is included in the Total System Performance Assessment, then DOE uses an appropriate range of input parameters for calculating the effective neutron multiplication factor (k_{eff}).

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate other sources such as expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996).

AC4 Model Uncertainty is Characterized and Propagated Through the Model Abstraction

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Alternative modeling approaches are considered and the selected modeling approach is consistent with available data and current scientific understanding. A description that includes a discussion of alternative modeling approaches not considered in the final analysis and the limitations and uncertainties of the chosen model is provided.

- Adequate consideration is given to effects of thermal-hydrologic-mechanical-chemical coupled processes in the assessment of alternative conceptual models. These effects may include: (i) thermohydrologic effects on gas, water, and mineral chemistry; (ii) effects of microbial processes on the waste package chemical environment and the chemical environment for radionuclide release; (iii) changes in water chemistry that may result from the release of corrosion products from the waste package and interactions between engineered materials and groundwater; and (iv) changes in boundary conditions (e.g., drift shape and size) and hydrologic properties relating to the response of the geomechanical system to thermal loading.

- If DOE uses an equivalent continuum model for the Total System Performance Assessment abstraction, the models produce conservative estimates of the effects of coupled thermal-hydrologic-mechanical-chemical processes on calculated overall performance.

AC5 Model Abstraction Output is Supported by Objective Comparisons

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Abstracted models for coupled thermal-hydrologic-mechanical-chemical effects on seepage and flow and the waste package chemical environment, as well as on the chemical environment for radionuclide release, are based on the same assumptions and approximations demonstrated to be appropriate for process-level models or closely analogous natural or experimental systems. For example, abstractions of processes such as thermally-induced changes in hydrological properties or estimated diversion of percolation away from the drifts are adequately justified by comparison to results of process-level modeling that are consistent with direct observations and field studies.

- Accepted and well-documented procedures are used to construct and test the numerical models to simulate coupled thermal-hydrologic-mechanical-chemical effects on seepage and flow, waste package chemical environment, and the chemical environment for radionuclide release. Analytical and numerical models are appropriately supported. Abstracted model results are compared with different mathematical models to judge robustness of results.

4.2.1.3.3.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to quantity and chemistry of water contacting waste packages and waste forms and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for this abstraction. Technical requirements for conducting a performance assessment in the area of quantity and chemistry of water contacting waste packages and waste forms have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their effect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.3.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.4 Radionuclide Release Rates and Solubility Limits

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on radionuclide release rates and solubility limits to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if the DOE safety case relies upon the release rates and solubility limits to significantly reduce dose to the critical group, then perform a detailed review of this abstraction. If, on the other hand, this abstraction is demonstrated by the DOE to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of the overall performance objective is evaluated in section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.4.1 Areas of Review

This section reviews radionuclide release rates and solubility limits. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (2), (3), (4), (9)(i)–(iii) and (vi), and (13) that is relevant to the abstraction of radionuclide release rates and solubility limits.

The staff will evaluate the following parts of the abstraction of radionuclide release rates and solubility limits using the review methods and acceptance criteria in sections 4.2.1.3.4.2 and 4.2.1.3.4.3.

- Description of the geological, hydrological, and geochemical aspects of radionuclide release rates and solubility limits and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and
- Use of expert elicitation.

4.2.1.3.4.2 Review Methods

To review the abstraction of radionuclide release rates and solubility limits, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the descriptions of design features (including drip shield, backfill, waste packages, waste forms, thermal loading, and other engineered barrier components), relevant physical features, physical phenomena, and couplings, as well as the description of the geological, hydrological, and geochemical aspects of the unsaturated zone included in the abstraction of radionuclide release rates and solubility limits. Verify that the description is adequate and that the conditions and assumptions in the Total System Performance Assessment abstraction are consistent with the information presented in the description of barriers important to waste isolation as reviewed using section 4.2.1.1 of the YMRP.

Assess the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction. Where simplifications for modeling coupled thermal-hydrologic-chemical effects on the chemical environment for radionuclide release rates and solubility limits were used in the Total System Performance Assessment abstraction, determine whether the technical bases used for modeling assumptions and approximations have been documented and are adequate. Evaluate whether the descriptions provide transparent and traceable support to the abstraction and are consistent with other Total System Performance Assessment model abstractions.

Evaluate the design information on waste packages and engineered barrier systems provided in the Total System Performance Assessment abstraction on radionuclide release rates and solubility limits. Verify that the information is sufficient and consistent with design information in other model abstractions.

Examine the DOE description of environmental conditions expected inside breached waste packages and in the engineered barrier environment surrounding the waste package. Ensure that the ranges in conditions are described in sufficient detail.

Verify that the DOE description of process-level conceptual and mathematical models is sufficiently complete with respect to thermal-hydrologic processes affecting radionuclide release from the emplacement drifts.

Examine the FEPs related to radionuclide release rates and solubility limits that have been included in the Total System Performance Assessment abstraction, and evaluate the sufficiency of the technical bases for their inclusion.

Evaluate the Total System Performance Assessment abstraction of in-package criticality or external-to-package criticality within the emplacement drift and the associated technical basis for screening these events. Ensure that if either event is included in the Total System Performance Assessment DOE uses acceptable technical bases for selecting the design criteria that mitigate the potential impact of in-package criticality on the repository performance, identifies the FEPs that may increase the reactivity of the system inside the waste package, identifies the configuration classes and configurations that have potential for nuclear criticality, and includes changes in thermal conditions and degradation of engineered barriers in the abstraction of radionuclide release rates and solubility limits.

Verify that DOE reviews follow the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, hydrological, and geochemical data used to support conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of radionuclide release rates and solubility limits. Evaluate the basis for the data on design features (including drip shield, backfill, waste packages, waste forms, and other engineered barrier components) used in the Total System Performance Assessment abstraction of radionuclide release rates and solubility limits.

Examine and confirm that DOE has provided sufficient data on the characteristics of the natural system and engineered materials to establish initial and boundary conditions for conceptual models and simulations of thermal-hydrologic-chemical coupled processes.

Examine and evaluate the models used to support abstraction of solubility limits, and ensure that they are consistent with guidance in (NRC, 1984).

Evaluate the DOE corrosion and radionuclide release testing program for HLW waste forms intended for disposal. Verify that it provides consistent, sufficient, and suitable data for the in-package and in-drift chemistry used in the abstraction of radionuclide release rates and solubility limits. Evaluate the justification for the use of test results not specifically collected from the YM site.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate whether DOE has developed parameter ranges, probability distributions, and bounding values that adequately account for data uncertainty and variability.

Evaluate the technical bases for parameter ranges, probability distributions, or bounding values. The reviewer should determine whether the parameter values are derived from site-specific data or an analysis is included to show that the assumed parameter values lead to a conservative assessment of performance. Examine the technical bases for parameter values and ranges in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction.

Examine the initial conditions, boundary conditions, and computational domain used in sensitivity analyses involving coupled thermal-hydrologic-chemical effects on radionuclide release for consistency with available data.

Evaluate DOE's assessment of uncertainty and variability in parameters used in model abstractions. Determine whether uncertainty in data due to both temporal and spatial variations in conditions affecting radionuclide release was incorporated into the parameter ranges.

Evaluate the parameters used to describe flow through and out of the engineered barrier and ensure that they are sufficient to bound the effects of backfill, excavation-induced changes, and thermally induced mechanical changes that affect flow.

If in-package criticality or external-to-package criticality is included in the Total System Performance Assessment, examine the methods and parameters used by DOE to calculate the effective neutron multiplication factor (k_{eff}).

Verify that DOE uses an appropriate range of time-history of temperature, humidity, and dripping to constrain the probability for microbial effects.

Ensure that DOE adequately considers the uncertainties in the characteristics of the natural system and engineered materials, such as the type, quantity, and reactivity of material, in establishing initial and boundary conditions for conceptual models and simulations of thermal-hydrologic-chemical coupled processes that affect radionuclide release.

Determine whether expert elicitations were used as a basis for data uncertainty for this abstraction and whether they were conducted in accordance with appropriate guidance.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for radionuclide release rates and solubility limits. Examine the model parameters in the context of available site characterization data, design data (engineered barrier system, waste packages, and waste forms), laboratory experiments, field measurements, natural analog research, and process-level modeling studies. When practical, use an alternative Total System Performance Assessment model to evaluate the effect of alternative conceptual models on the assessment of repository performance.

Ensure that DOE uses appropriate models, tests, and analyses that are sensitive to the processes modeled for both natural and engineering systems. Verify that conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed.

Examine the mathematical models included in the analyses of coupled thermal-hydrologic-chemical effects on the chemical environment for radionuclide release. Evaluate the bases for excluding alternative conceptual models and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of radionuclide release rates and solubility limits and ensure that DOE has compared the results with an appropriate combination of site characterization and design data, process-level modeling, laboratory testing, field measurements, and natural analog data.

Examine the analytical and numerical models used in the thermal-mechanical analyses for consistency with site-specific or natural analog data. Evaluate predicted changes in hydrologic properties and the magnitudes and distributions of changes resulting from effects of thermal-mechanical processes for consistency with results of thermal-mechanical analyses of the underground facility. To the extent practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction and to evaluate the effects of the quantity and chemistry of water contacting the waste packages and waste forms on repository performance.

Examine the output from the mathematical models for abstractions of coupled processes effects on radionuclide release for consistency with conceptual models. Compare the output from the abstractions with inferences about the near-field environment, field data and natural alteration observed at the site, and expected engineered materials properties.

Evaluate where DOE will rely on performance confirmation for this model abstraction, whether specific plans for monitoring radionuclide release are adequate for further testing to acquire additional necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

4.2.1.3.4.3 Acceptance Criteria

The following acceptance criteria are based on meeting the relevant requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) as they relate to the radionuclide release rates and solubility limits model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System Description and Model Integration are Adequate

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the radionuclide release rates and solubility limits abstraction process.

- The Total System Performance Assessment abstraction of radionuclide release rates and solubility limits uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for this model abstraction are consistent with the Total System Performance Assessment abstractions of degradation of engineered barriers (section 4.2.1.3.1), mechanical disruption of waste packages (section 4.2.1.3.2), quantity and chemistry of water contacting waste packages and waste forms (section 4.2.1.3.3), climate and infiltration (section 4.2.1.3.5), and flow paths in the unsaturated zone (section 4.2.1.3.6). The descriptions and technical bases provide transparent and traceable support for the abstraction of radionuclide release rates and solubility limits.

- The Total System Performance Assessment abstraction on radionuclide release rates and solubility limits provides sufficient, consistent design information on waste packages and engineered barrier systems. For example, inventory calculations and selected radionuclides are based on the detailed information provided on the distribution (both spatially and by compositional phase) of the radionuclide inventory within the various types of HLW.

- The DOE reasonably accounts for the range of environmental conditions expected inside breached waste packages and in the engineered barrier environment surrounding the waste package. For example, DOE should provide a description and sufficient technical bases for its abstraction of changes in hydrologic properties in the near field due to coupled thermal-hydrologic-mechanical-chemical processes.

- The description of process-level conceptual and mathematical models is sufficiently complete with respect to thermal-hydrologic processes affecting radionuclide release from the emplacement drifts. For example, if DOE uncouples coupled processes, the demonstration that uncoupled model results bound predictions of fully coupled results is adequate.

- Technical bases for inclusion of any thermal-hydrologic-mechanical-chemical couplings and FEPs in the radionuclide release rates and solubility limits model abstraction are adequate. For example, technical bases may include activities such as independent modeling, laboratory or field data, or sensitivity studies.

- The abstraction of in-package criticality or external-to-package criticality within the emplacement drift provides an adequate technical basis for screening these events. If either event is included in the Total System Performance Assessment then DOE uses acceptable technical bases for selecting the design criteria that mitigate the potential impact of in-package criticality on the repository performance, identifies the FEPs that may increase the reactivity of the system inside the waste package, identifies the configuration classes and configurations that have potential for nuclear criticality, and includes changes in thermal conditions and degradation of engineered barriers in the abstraction of radionuclide release rates and solubility limits.

- DOE reviews follow the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches.

AC2 Data are Sufficient for Model Justification

- Geological, hydrological, and geochemical values used in the safety case are adequately justified. Adequate description of how the data were used, interpreted, and appropriately synthesized into the parameters is provided.

- Sufficient data have been collected on the characteristics of the natural system and engineered materials to establish initial and boundary conditions for conceptual models and simulations of thermal-hydrologic-chemical coupled processes. For example, sufficient data should be provided on design features such as the type, quantity, and reactivity of materials that may affect radionuclide release for this abstraction.

- Where DOE uses data supplemented by models to support abstraction of solubility limits, the anticipated range of proportions and compositions of phases under the various physicochemical conditions expected are supported by experimental data (NRC, 1984).

- The corrosion and radionuclide release testing program for HLW waste forms intended for disposal provides consistent, sufficient, and suitable data for the in-package and in-drift chemistry used in the abstraction of radionuclide release rates and solubility limits. For expected environmental conditions, DOE provides sufficient justification for the use of test results not specifically collected from the YM site for engineered barrier components such as HLW waste forms, drip shield and backfill.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data Uncertainty is Characterized and Propagated Through the Model Abstraction

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- Parameter values, assumed ranges, probability distributions, and bounding assumptions used in the abstractions of radionuclide release rates and solubility limits in the Total System Performance Assessment are technically defensible and reasonable based on data from the YM region, laboratory tests, and natural analogs. For example, parameter values, assumed ranges, probability distributions and bounding assumptions adequately reflect the range of environmental conditions expected inside breached waste packages.

- DOE uses reasonable or conservative ranges of parameters or functional relations to determine effects of coupled thermal-hydrologic-chemical processes on radionuclide release. These values are consistent with the initial and boundary conditions and the assumptions for the conceptual models and design concepts for natural and engineered barriers at the YM site. If any correlations between the input values exist, they are adequately established in the Total System Performance Assessment. For example, estimations are based on a thermal loading and ventilation strategy, engineered barrier system design (including drift liner, backfill, and drip-shield), and natural system masses and fluxes that are consistent with those used in other abstractions.

- Uncertainty is adequately represented in parameter development for conceptual models, process models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of radionuclide release rates and solubility limits, either through sensitivity analyses or use of bounding analyses.

- Parameters used to describe flow through and out of the engineered barrier sufficiently bound the effects of backfill, excavation-induced changes, and thermally induced mechanical changes that affect flow.

- If criticality cannot be excluded from Total System Performance Assessment, then DOE provides an appropriate range of input parameters for calculating the effective neutron multiplication factor (k_{eff}).

- DOE uses an appropriate range of time-history of temperature, humidity, and dripping to constrain the probability for microbial effects, such as production of organic by-products that act as complexing ligands for actinides and microbial-enhanced dissolution of the HLW glass form.

- DOE adequately considers the uncertainties in the characteristics of the natural system and engineered materials, such as the type, quantity, and reactivity of material, in establishing initial and boundary conditions for conceptual models and simulations of thermal-hydrologic-chemical coupled processes that affect radionuclide release.

- Where sufficient data do not exist, the definition of parameters values and conceptual models is based on appropriate other sources such as expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996).

AC4 Model Uncertainty is Characterized and Propagated Through the Model Abstraction

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- In considering alternative conceptual models for radionuclide release rates and solubility limits, DOE uses appropriate models, tests, and analyses that are sensitive to the processes modeled for both natural and engineering systems. Conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed. For example, in modeling flow and radionuclide release from the drifts, DOE represents significant discrete features such as fault zones separately, or demonstrates that their inclusion in the equivalent continuum model produces a conservative effect on calculated performance.

- The effects of thermal-hydrologic-chemical coupled processes that may occur in the natural setting or due to interactions with engineered materials or their alteration products on radionuclide release are appropriately considered.

AC5 Model Abstraction Output is Supported by Objective Comparisons

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Results of thermal-hydrologic process-level models are verified by demonstrating consistency with observations and results from laboratory and field-scale thermohydrologic tests. In particular, DOE demonstrates that sufficient physical evidence exists to support conceptual models used to predict thermally driven flow in the near field.

- DOE adopts well-documented procedures that have been accepted by the scientific community to construct and test the numerical models used to simulate coupled thermal-hydrologic-chemical effects on radionuclide release. For example, DOE demonstrates that the numerical models used for HLW degradation and dissolution, and radionuclide release from the engineered barrier system are adequate representations, include consideration of uncertainties, and are not likely to underestimate dose to the critical group.

- If DOE will rely on the performance confirmation program to assess whether the natural system and engineered materials are functioning as intended, an adequate program for monitoring radionuclide release from the waste packages during the performance confirmation period is established using assumptions and calculations of radionuclide release from the waste packages that are appropriately substantiated (the acceptability of the performance confirmation program is reviewed using section 4.4 of the YMRP).

4.2.1.3.4.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to radionuclide release rates and solubility limits and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of radionuclide release rates and solubility limits have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.4.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

Nuclear Regulatory Commission (U.S.) (NRC). *Determination of Radionuclide Solubility in Groundwater for Assessment of High-Level Waste Isolation*. Technical Position. NRC: Washington, DC. 1984.

4.2.1.3.5 Climate and Infiltration

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on climate and infiltration to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon climate and infiltration to provide significant delay (on the order of thousands of years) in the transport of radionuclides or a significant dilution in dose to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the delay (on the order of hundreds of years) in the transport of radionuclides to the critical group or insignificant dilution, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.5.1 Areas of Review

This section reviews climate and net infiltration. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i), (ii) and (vi), and (13) that is relevant to the abstraction of climate and infiltration.

The staff will evaluate the following parts of the abstraction of climate and infiltration using the review methods and acceptance criteria in sections 4.2.1.3.5.2 and 4.2.1.3.5.3.

- Description of the climatological, hydrological, geological, and geochemical aspects of net infiltration in the unsaturated zone and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;
- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and
- Use of expert elicitation.

4.2.1.3.5.2 Review Methods

To review the abstraction of climate and infiltration, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of physical phenomena and couplings and the descriptions of the geological, hydrological, geochemical, paleohydrological, paleoclimatological, and climatological aspects of the abstraction of the climate and net infiltration that contribute to waste isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in this abstraction.

Evaluate whether the description of aspects of geology, hydrology, geochemistry, physical phenomena, and couplings that may affect climate and net infiltration is adequate. Verify that conditions and assumptions used in this abstraction are consistent with the body of data presented in the description.

Examine assumptions, technical bases, data, and models used by DOE in this abstraction for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for this abstraction.

Verify that, given the excluded set of phenomena, DOE estimates of expected doses to the critical group are reasonable. For example, determine whether the conditions and assumptions used to generate lookup tables or regression equations to describe initial and boundary conditions are consistent with other conditions and assumptions in this abstraction.

Examine the FEPs related to climate and net infiltration that have been included in the Total System Performance Assessment abstraction. Evaluate the technical bases for their inclusion.

Confirm that the DOE abstractions employ adequate spatial and temporal variability of model parameters and boundary conditions to estimate infiltration flux.

Ensure that averages of parameter estimates used in process-level models over time and space scales are appropriate for the model discretization.

Verify that paleoclimate information is evaluated over the past 500,000 years as the basis for projections of future climate change. For example, confirm that numerical climate models, if used for projection of future climate, are calibrated based on such paleoclimate data.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the data used to support conceptual models, process-level models, and alternative conceptual model considered in this abstraction and the parameters used for each of these models. Evaluate the basis for the data on physical phenomena, couplings, climatology, geology, hydrology, and geochemistry. This basis may include a combination of techniques such as laboratory experiments, site-specific field measurements, natural analog research, process-level modeling studies, and expert elicitation. Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model.

Verify that the mathematical model estimates of present-day net infiltration are at appropriate time and space scales. Assure adequate site-specific climatic, surface, and subsurface information is used.

Verify that net infiltration is not underestimated. Assure adequate representation of the effects of fracture properties, fracture distributions, heterogeneities, time-varying boundary conditions, evapotranspiration, depth of soil cover, and surface-water runoff is incorporated in this abstraction.

Confirm the use of adequate sensitivity or uncertainty analyses to assess data sufficiency and determine the possible need for additional data.

Assure adequate accepted and well-documented procedures are applied to develop and calibrate numerical models.

Verify that reasonably complete process-level conceptual and mathematical models are used in the analyses. Assure the mathematical models are consistent with conceptual models and site characteristics. Confirm that a comparison of the robustness of results from different mathematical models is provided.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

Evaluate the methods used by DOE in conducting expert elicitation.

RM3 Data Uncertainty

Verify that parameter values reasonably account for uncertainties and variabilities for the assumed ranges, probability distributions, and/or bounding assumptions. Evaluate the DOE assessment of uncertainty and variability in parameters used in the model abstraction. Determine whether uncertainty in data due to both temporal and spatial variations in conditions affecting climate and net infiltration is incorporated into the parameter ranges. For example, evaluate the climatic and hydrostratigraphic parameters used in the abstracted model to verify that they are consistent with site characterization data and sufficiently detailed to capture heterogeneities that may influence the distribution and rate of liquid-water flux that has moved beyond the zone of evapotranspiration.

Examine the technical bases for parameter values and ranges, probability distributions, or bounding values in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction. Determine whether the parameter values are derived from site-specific data or an analysis is included to show that the assumed parameter values lead to a conservative assessment of performance. Evaluate the assessment of uncertainty and variability in these parameters.

Determine if DOE appropriately establishes possible statistical correlations between parameters. Verify that an adequate technical basis or bounding argument is provided for neglected correlations.

Confirm that performance assessments incorporate the hydrologic effects of future climate change that could alter the rates and patterns of present-day infiltration into the unsaturated zone.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for climate and net infiltration. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies. Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of climate and net infiltration.

Verify that the bounds of uncertainty created by the process-level models are adequately reflected in this abstraction. Where appropriate, use an alternative Total System Performance Assessment model to verify that DOE's Total System Performance Assessment approach reflects or bounds the uncertainties in the process-level models.

Assure the conceptual model uncertainties are defined and documented, including their effects on conclusions regarding performance.

RM5 Model Support

Evaluate the output from the abstraction of climate and net infiltration. Compare the results with an appropriate combination of site characterization data, process-level modeling, laboratory testing, field measurements, and natural analog data.

Assure adequate justification and technical bases exist to conservatively bound process-level models. In particular, verify that if DOE uses an abstracted model to predict water flux into the unsaturated zone, the abstracted model is shown to bound process-level model predictions of the net infiltration flux. Use detailed models of geological, hydrological, geochemical, and climatological processes to evaluate the Total System Performance Assessment abstractions of climate and net infiltration.

Evaluate the output of model abstractions against results produced by process-level models. Where practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction and to evaluate the effects of climate and net infiltration on repository performance.

4.2.1.3.5.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the climate and net infiltration model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- The Total System Performance Assessment adequately incorporates, or bounds, important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the climate and net infiltration abstraction process.

- The aspects of geology, hydrology, geochemistry, physical phenomena, and couplings that may affect climate and net infiltration are adequately considered. Conditions and assumptions in the Total System Performance Assessment abstraction of climate and net infiltration are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of climate and net infiltration uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for climate and net infiltration are consistent with the Total System Performance Assessment abstractions of flow paths in the unsaturated zone and flow paths in the saturated zone (sections 4.2.1.3.6 and 4.2.1.3.8 of the YMRP, respectively). The descriptions and technical bases provide transparent and traceable support for the abstraction of climate and net infiltration.

- Reasonable estimates of expected dose to the critical group are provided.

- Sufficient data and technical bases to assess the degree to which FEPs have been included for this abstraction are provided.

- Adequate spatial and temporal variability of model parameters and boundary conditions are employed to model the different parts of the system.

- Average parameter estimates are used in process-level models over time and space scales that are appropriate for the model discretization.

- Projections of future climate change are based on evaluation of paleoclimate information over the past 500,000 years. For example, numerical climate models, if used for projection of future climate, are calibrated based on such paleoclimate data.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Climatological and hydrological values used in the safety case (e.g., time of onset of climate change, mean annual temperature, mean annual precipitation, mean annual infiltration, etc.) are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Estimates of present-day net infiltration using mathematical models at appropriate time and space scales are reasonably verified with site-specific climatic, surface, and subsurface information.

- The effects of fracture properties, fracture distributions, matrix properties, heterogeneities, time-varying boundary conditions, evapotranspiration, depth of soil cover, and surface-water runoff and runon are considered such that net infiltration is not underestimated.

- Sensitivity or uncertainty analyses are performed to assess data sufficiency and determine the possible need for additional data.

- Accepted and well-documented procedures are used to construct and calibrate numerical models.

- Reasonably complete process-level conceptual and mathematical models are used in the analyses. In particular, (i) mathematical models are provided that are consistent with conceptual models and site characteristics; and (ii) the robustness of results from different mathematical models are compared.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

- Any expert elicitation conducted is in accordance with NUREG–1563 (Kotra, et al., 1996) or other acceptable approaches.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- The technical bases for the parameter values used in this abstraction are provided.

- Possible statistical correlations are established between parameters in this abstraction. An adequate technical basis or bounding argument is provided for neglected correlations.

- The hydrologic effects of future climate change that may alter the rates and patterns of present-day net infiltration into the unsaturated zone are addressed. Such effects may include changes in soil depths, fracture-fill material, and types of vegetation.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs consistent with available data and current scientific understanding are investigated. The results and limitations are appropriately considered in the abstraction.

- The bounds of uncertainty created by the process-level models are considered in this abstraction.

- Conceptual model uncertainties and their effects on conclusions regarding performance are defined and documented.

AC5 Model abstraction output is supported by objective comparisons.

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testing and/or natural analogs).

- Abstractions of process-level models may conservatively bound process-level predictions.

- Comparisons are provided of Total System Performance Assessment abstractions of climate and net infiltration with output of sensitivity studies, detailed process-level models, natural analogs, and empirical observations, as appropriate.

4.2.1.3.5.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to climate and infiltration and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of climate and net infiltration have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.5.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.6 Flow Paths in the Unsaturated Zone

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on flow paths in the unsaturated zone to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon flow paths in the unsaturated zone to provide significant delay and/or dilution (on the order of thousands of years) in the transport of radionuclides to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the delay (on the order of hundreds of years) of radionuclides to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.6.1 Areas of Review

This section reviews flow paths in the unsaturated zone. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i), (ii) and (vi), and (13) that is relevant to the abstraction of flow paths in the unsaturated zone.

The staff will evaluate the following parts of the abstraction of flow paths in the unsaturated zone and seepage using the review methods and acceptance criteria in sections 4.2.1.3.6.2 and 4.2.1.3.6.3.

- Description of the climatological, hydrological, geological, and geochemical aspects of flow paths in the unsaturated zone and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies to support the intermediate output through; and

- Use of expert elicitation.

4.2.1.3.6.2 Review Methods

To review the abstraction of flow paths in the unsaturated zone, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of physical phenomena and couplings, and the descriptions of the geological, hydrological, geochemical, and thermal-hydrological-mechanical-chemical aspects of the abstraction of the flow paths in the unsaturated zone that contribute to waste isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in this abstraction.

Evaluate whether the descriptions of aspects of geology, hydrology, geochemistry, physical phenomena, and couplings that may affect flow paths in the unsaturated zone are adequate.

Verify that conditions and assumptions used in this abstraction are consistent with the body of data presented in the description.

Examine assumptions, technical bases, data, and models used by DOE in this abstraction for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for this abstraction.

Verify that DOE estimates of expected dose to the critical group are reasonable. For example, determine whether the conditions and assumptions used to generate lookup tables or regression equations to describe initial and boundary conditions are consistent with other conditions and assumptions in this abstraction.

Examine the FEPs related to flow paths in the unsaturated zone that have been included in the Total System Performance Assessment abstraction. Evaluate the technical bases for their inclusion.

Verify that the DOE abstractions employ adequate spatial and temporal variability of model parameters and boundary conditions to estimate flow paths in the unsaturated zone and percolation flux.

Verify that appropriate averages of parameter estimates are used in process-level models over time and space scales that are appropriate for the model discretization.

Confirm that potential reduction in unsaturated zone transport distances are accounted for following a climate-induced water table rise.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the data used to support conceptual models, process-level models, and alternative conceptual models considered in this abstraction and the parameters used for each of these models. Evaluate the basis for the data on physical phenomena, couplings, climatology, geology, hydrology, and geochemistry. This basis may include a combination of techniques such as laboratory experiments, site-specific field measurements, natural analog research, process-level modeling studies, and expert elicitation. Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model.

Verify that acceptable techniques, which may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies, are used in collecting and interpreting the data regarding the geology, hydrology, and geochemistry, structural features, and stratigraphy.

Assure that estimates of deep-percolation flux rates constitute an upper bound or reasonably represent the physical system. Verify that the flow model is calibrated using site-specific hydrologic, geologic, and geochemical data. Confirm that the mathematical model estimates of deep-percolation flux are at appropriate time and space scales.

Verify that appropriate thermohydrologic processes are evaluated by testing.

Confirm the use of adequate sensitivity or uncertainty analyses to assess data sufficiency and determine the possible need for additional data.

Assure adequate accepted and well-documented procedures are applied to develop and calibrate numerical models.

Verify that reasonably complete process-level conceptual and mathematical models are used in the analyses. Assure the mathematical models are consistent with conceptual models and site characteristics. Confirm that a comparison of the robustness of results from different mathematical models is provided.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

Evaluate the methods used by DOE in conducting expert elicitation.

RM3 Data Uncertainty

Verify that parameter values reasonably account for uncertainties and variabilities for the assumed ranges, probability distributions, and/or bounding assumptions. Evaluate the DOE assessment of uncertainty and variability in parameters used in the model abstraction. Determine whether uncertainty in data due to both temporal and spatial variations in conditions affecting flow paths in the unsaturated zone is incorporated into the parameter ranges.

Examine the technical bases for parameter values and ranges, probability distributions, or bounding values in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction. Determine whether the parameter values are derived from site-specific data or an analysis is included to show that the assumed parameter values lead to a reasonable assessment of performance. Evaluate the assessment of uncertainty and variability in these parameters.

Determine if DOE appropriately established possible statistical correlations between parameters. Verify that an adequate technical basis or bounding argument is provided for neglected correlations.

Examine the initial conditions, boundary conditions, and computational domain used in sensitivity analyses and/or similar analyses for consistency with available data.

Verify that coupled thermal-hydrologic-mechanical-chemical processes are properly evaluated. Ensure that uncertainties in the characteristics of the natural system and engineered materials are considered.

Confirm that parameter values are consistent with the initial and boundary conditions and the assumptions of the conceptual models for the YM site.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for flow paths in the unsaturated zone. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies. Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of flow paths in the unsaturated zone.

Verify that the bounds of uncertainty created by the process-level models are adequately reflected in this abstraction. Where appropriate, use an alternative Total System Performance Assessment model to verify that DOE's Total System Performance Assessment approach reflects or bounds the uncertainties in the process-level models.

Assure the conceptual model uncertainties are defined and documented, including their effects on conclusions regarding performance.

RM5 Model Support

Evaluate the output from the abstraction of flow paths in the unsaturated zone. Compare the results with an appropriate combination of site characterization data, process-level modeling, laboratory testing, field measurements, and natural analog data.

Assure adequate justification and technical basis exists to conservatively bound process-level models. Use detailed models of geological, hydrological, geochemical, and thermal-hydrologic-mechanical-chemical processes to evaluate the Total System Performance Assessment abstractions of flow paths in the unsaturated zone.

Evaluate the output of model abstractions against results produced by process-level models. Where practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction and to evaluate the effects of flow paths in the unsaturated zone on repository performance.

4.2.1.3.6.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the flow paths in the unsaturated zone model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- The Total System Performance Assessment adequately incorporates, or bounds, important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the flow paths in the unsaturated zone abstraction process. Couplings include thermal-hydrologic-mechanical-chemical effects, as appropriate.

- The aspects of geology, hydrology, geochemistry, physical phenomena, and couplings that may affect flow paths in the unsaturated zone are adequately considered. Conditions and assumptions in the Total System Performance Assessment abstraction of flow paths in the unsaturated zone are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of flow paths in the unsaturated zone uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for flow paths in the unsaturated zone are consistent with the Total System Performance Assessment abstractions of quantity and chemistry of water contacting waste packages and waste forms, climate and infiltration, and flow paths in the saturated zone (sections 4.2.1.3.3, 4.2.1.3.5, and 4.2.1.3.8 of the YMRP, respectively). The descriptions and technical bases are transparent and traceable to site and design data.

- Reasonable overall estimates of performance and the bases and justification for modeling assumptions and approximations for flow paths in the unsaturated zone and thermal-hydrologic-mechanical-chemical effects are provided.

- Sufficient data and technical bases to assess the degree to which FEPs have been included in this abstraction are provided.

- Adequate spatial and temporal variability of model parameters and boundary conditions are employed in process-level models to estimate flow paths in the unsaturated zone and percolation flux.

- Average parameter estimates are used in process-level models are representative of the temporal and spatial discretizations considered in the model.

- Reduction in unsaturated zone transport distances following a climate-induced water table rise is considered.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Hydrological and thermal-hydrological-mechanical-chemical values used in the safety case are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- The data on the geology, hydrology, and geochemistry of the unsaturated zone, are collected using acceptable techniques.

- Estimates of deep-percolation flux rates constitute an upper bound or are based on a technically defensible unsaturated zone flow model that reasonably represents the physical system. The flow model is calibrated using site-specific hydrologic, geologic, and geochemical data. Deep-percolation flux is estimated using the appropriate spatial and temporal variability of model parameters, and boundary conditions that consider climate-induced change in soil depths and vegetation.

- Appropriate thermohydrologic tests are designed and conducted so that critical thermohydrologic processes can be observed and values for relevant parameters estimated.

- Sensitivity or uncertainty analyses are performed to assess data sufficiency and determine the possible need for additional data.

- Accepted and well-documented procedures are used to construct and calibrate numerical models.

- Reasonably complete process-level conceptual and mathematical models are used in the analyses. In particular, (i) mathematical models are provided that are consistent with conceptual models and site characteristics; and (ii) the robustness of results from different mathematical models are compared.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

- Any expert elicitation conducted is in accordance with NUREG–1563 (Kotra, et al., 1996) or other acceptable approaches.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- The technical bases for the parameter values used in this abstraction are provided.

- Possible statistical correlations are established between parameters in this abstraction. An adequate technical basis or bounding argument is provided for neglected correlations.

- The initial conditions, boundary conditions, and computational domain used in sensitivity analyses and/or similar analyses are consistent with available data. Parameter values are consistent with the initial and boundary conditions and the assumptions of the conceptual models for the YM site.

- Coupled processes are adequately represented.

- Uncertainties in the characteristics of the natural system and engineered materials are considered.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs consistent with available data and current scientific understanding are investigated. The results and limitations are appropriately considered in the abstraction.

- The bounds of uncertainty created by the process-level models are considered in this abstraction.

- Conceptual model uncertainties and their effects on conclusions regarding performance are defined and documented.

AC5 Model abstraction output is supported by objective comparisons.

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testing and/or natural analogs).

- Abstractions of process-level models conservatively bound process-level predictions.

- Comparisons are provided of Total System Performance Assessment abstractions of flow paths in the unsaturated zone with output of sensitivity studies, detailed process-level models, natural analogs, and empirical observations, as appropriate.

4.2.1.3.6.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to flow paths in the unsaturated zone and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of flow paths in the unsaturated zone and seepage have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.6.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.”   Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.”   Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.”   Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.7 Radionuclide Transport in the Unsaturated Zone

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on radionuclide transport through the unsaturated zone to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon the unsaturated zone to provide significant delay (on the order of thousands of years) in the transport of radionuclides and/or dilution of concentration to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the delay (on the order of hundreds of years) or a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.7.1 Areas of Review

This section reviews radionuclide transport in the unsaturated zone. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i), (ii) and (vi), and (13) that is relevant to the abstraction of radionuclide transport in the unsaturated zone.

The staff will evaluate the following parts of the abstraction of radionuclide transport in the unsaturated zone using the review methods and acceptance criteria in sections 4.2.1.3.7.2 and 4.2.1.3.7.3.

- Description of the geological, hydrological, and geochemical aspects of radionuclide transport in the unsaturated zone and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;
- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and
- Use of expert elicitation.

4.2.1.3.7.2 Review Methods

To review the abstraction of radionuclide transport in the unsaturated zone, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings, and the description of the geological, hydrological, and geochemical aspects of the unsaturated zone included in the abstraction of radionuclide transport in the unsaturated zone that contribute to waste isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone.

Evaluate whether the description of aspects of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect radionuclide transport in the unsaturated zone is adequate. Verify that conditions and assumptions used in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone are consistent with the data presented in the description.

Examine assumptions, technical bases, data, and models used by DOE in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for the abstraction of radionuclide transport in the unsaturated zone.

Confirm that DOE has propagated boundary and initial conditions used in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone throughout its abstraction approaches.

Examine the FEPs related to radionuclide transport in the unsaturated zone that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion.

Verify that DOE follows guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, hydrological, and geochemical data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone. Assess the sufficiency, transparency, and traceability of the data to used to support the technical bases for FEPs that have been included in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone.

Verify whether sufficient data have been collected on the characteristics of the geology, hydrology, and geochemistry of the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone.

Evaluate and confirm that data used to support the DOE Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone are based on appropriate techniques and are adequate for the accompanying sensitivity/uncertainty analyses. Evaluate the need for additional data based on the sensitivity analyses.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Determine whether DOE has used flow and transport parameters that are based on techniques that may include laboratory experiments, field measurements, natural analog research, and process-level modeling studies conducted under conditions relevant to the unsaturated zone at YM. Examine the results of DOE field transport tests and confirm that DOE has provided adequate models.

If criticality in the unsaturated zone is included in the Total System Performance Assessment, examine the methods and parameters used by DOE to calculate the effective neutron multiplication factor (k_{eff}). Evaluate the consequences calculated by DOE criticality in the unsaturated zone.

Assess how uncertainty is represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for radionuclide transport in the unsaturated zone. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency.

Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of radionuclide transport in the unsaturated zone. Examine the effects of the alternative conceptual model(s) on repository performance and evaluate how model uncertainties are defined, documented, and assessed.

Examine the mathematical models included in the analyses of radionuclide transport in the unsaturated zone. Examine and evaluate the bases for excluding alternative conceptual models, and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of radionuclide transport in the unsaturated zone and compare the results with an appropriate combination of site characterization data, process modeling, laboratory testing, field measurements, and natural analog research. Evaluate the sensitivity analyses used to support the abstraction of radionuclide transport in the unsaturated zone in the Total System Performance Assessment.

Use detailed models of geochemical, hydrological, and geological processes to evaluate the Total System Performance Assessment abstractions of radionuclide transport in the unsaturated zone. If practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of radionuclide transport in the unsaturated zone and evaluate the effects on repository performance. Compare results of the DOE abstraction to approximations shown to be appropriate for closely analogous natural systems or experimental systems.

Examine the procedures used by DOE to develop and test its mathematical and numerical models.

As appropriate, use an alternative Total System Performance Assessment model to evaluate the DOE sensitivity or bounding analyses and confirm that DOE has used ranges consistent with available site characterization data, field and laboratory tests, and natural analog research.

4.2.1.3.7.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the radionuclide transport in the unsaturated zone model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the radionuclide transport in the unsaturated zone abstraction process.

- The description of the aspects of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect radionuclide transport in the unsaturated zone is adequate. For example, the description includes changes in transport properties in the unsaturated zone due to water-rock interaction. Conditions and assumptions in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone uses assumptions, technical bases, data and models that are appropriate and consistent with other related DOE abstractions. For example, assumptions used for radionuclide transport in the unsaturated zone are consistent with the Total System Performance Assessment abstractions of radionuclide release rates and solubility limits and flow paths in the unsaturated zone (section 4.2.1.3.4 and 4.2.1.3.6 of the YMRP, respectively). The descriptions and technical bases provide transparent and traceable support for the abstraction of radionuclide transport in the unsaturated zone.

- Boundary and initial conditions used in the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone are propagated throughout its abstraction approaches. For example, the conditions and assumptions used to generate transport parameter values are consistent with other geological, hydrological, and geochemical conditions in the Total System Performance Assessment abstraction of the unsaturated zone.

- Sufficient data and technical bases for the inclusion of FEPs related to radionuclide transport in the unsaturated zone in the Total System Performance Assessment abstraction are provided.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Geological, hydrological, and geochemical values used in the safety case are adequately justified (e.g., flow path length, sorption coefficients, retardation factors, colloid concentrations, etc.). Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data have been collected on the characteristics of the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone.

- Data on the geology, hydrology, and geochemistry of the unsaturated zone, including the influence of structural features, fracture distributions, fracture properties, and stratigraphy, used in the Total System Performance Assessment abstraction are based on appropriate techniques. These techniques may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies. As appropriate, sensitivity or uncertainty analyses used to support the DOE Total System Performance Assessment abstraction are adequate to determine the possible need for additional data.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- For those radionuclides where the Total System Performance Assessment abstraction indicates transport in fractures and matrix in the unsaturated zone is important to performance, (i) estimated flow and transport parameters are appropriate and valid based on techniques that may include laboratory experiments, field measurements, natural analog research, and process-level modeling studies conducted under conditions relevant to the unsaturated zone at YM, and (ii) models are demonstrated to adequately predict field transport test results. For example, if a sorption coefficient (K_d) approach is used, the assumptions implicit in that approach are validated.

- If criticality in the unsaturated zone far field is included in the Total System Performance Assessment, an appropriate range of input parameters for calculating the effective neutron multiplication factor (k_{eff}) is used. The effects on performance of criticality in the unsaturated zone are adequately evaluated.

- Uncertainty is adequately represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone. This may be done either through sensitivity analyses or use of conservative limits.

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed.

- Appropriate alternative modeling approaches are consistent with available data and current scientific knowledge, and appropriately consider their results and limitations using tests and analyses that are sensitive to the processes modeled. For example, for radionuclide transport through fractures, the DOE adequately considers alternative modeling approaches to develop its understanding of fracture distributions and ranges of fracture flow and transport properties in the unsaturated zone.

AC5 Model abstraction output is supported by objective comparisons.

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Outputs of radionuclide transport in the unsaturated zone abstractions reasonably produce or bound the results of corresponding process-level models, empirical observations, or both. DOE abstracted models for radionuclide transport in the unsaturated zone are based on the same hydrological, geological, and geochemical assumptions and approximations shown to be appropriate for closely analogous natural systems or experimental systems.

- Well-documented procedures that have been accepted by the scientific community to construct and test the mathematical and numerical models are used to simulate radionuclide transport through the unsaturated zone.

- Sensitivity analyses or bounding analyses are provided to support the Total System Performance Assessment abstraction of radionuclide transport in the unsaturated zone that cover ranges consistent with site data, field or laboratory experiments and tests, and natural analog research.

4.2.1.3.7.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to radionuclide transport in the unsaturated zone and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of radionuclide transport in the unsaturated zone have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.7.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.8 Flow Paths in the Saturated Zone

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on flow paths in the saturated zone to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon saturated zone flow to provide significant delay or dilution (on the order of thousands of years) in the transport of radionuclides to the critical group, then perform a review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.8.1 Areas of Review

This section reviews flow paths in the saturated zone. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of flow paths in the saturated zone.

The staff will evaluate the following parts of the abstraction of flow paths in the saturated zone using the review methods and acceptance criteria in sections 4.2.1.3.8.2 and 4.2.1.3.8.3.

- Description of the geological, hydrological, and geochemical aspects of flow paths in the saturated zone and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and
- Use of expert elicitation.

4.2.1.3.8.2 Review Methods

To review the abstraction of flow paths in the saturated zone, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings and the description of the geological, hydrological, and geochemical aspects of the saturated zone included in the abstraction of flow paths in the saturated zone that contribute to waste isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of flow paths in the saturated zone.

Evaluate whether the description of aspects of geology, hydrology, geochemistry, design features, physical phenomena, and couplings that may affect flow paths in the saturated zone is adequate. Verify that conditions and assumptions used in the Total System Performance Assessment abstraction of flow paths in the saturated zone are consistent with the body of data presented in the description.

Examine assumptions, technical bases, data, and models used by DOE in the Total System Performance Assessment abstraction of flow paths in the saturated zone for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for the abstraction of flow paths in the saturated zone.

Confirm that DOE has propagated boundary and initial conditions used in the Total System Performance Assessment abstraction of flow paths in the saturated zone throughout its abstraction approaches.

Examine the FEPs related to flow paths in the saturated zone that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion or exclusion.

Ensure that DOE delineates the flow paths in the saturated zone considering natural site conditions.

Verify that DOE evaluates long-term climate change based on known patterns of climatic cycles during the Quaternary period, particularly the last 500,000 years, and other paleoclimate data.

Confirm that DOE considers potential geothermal and seismic effects on the ambient saturated zone flow system.

Ensure that DOE considers the impact of the expected water table rise on potentiometric heads and flow directions, and consequently on repository performance.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, hydrological, geochemical, and climatological data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of flow paths in the saturated zone. Evaluate the basis for the data on physical phenomena, couplings, climatology, geology, hydrology, and geochemistry used in the Total System Performance Assessment abstraction of flow paths in the saturated zone. This basis may include a combination of techniques such as laboratory experiments, site-specific field measurements, natural analog research, process-level modeling studies, and expert elicitation.

Verify that sufficient data have been collected on the characteristics of the geology, hydrology, and geochemistry of the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of flow paths in the saturated zone.

Evaluate and confirm that data used to support the DOE Total System Performance Assessment abstraction of flow paths in the saturated zone are based on appropriate techniques and are adequate for the accompanying sensitivity/uncertainty analyses. Evaluate the need for additional data based on sensitivity analyses.

Ensure that DOE provides sufficient information to substantiate that the proposed mathematical groundwater modeling approach and proposed model(s) are applicable to site conditions.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of flow paths in the saturated zone. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Confirm that model abstractions incorporate uncertainty in hydrologic effects of climate change based on a reasonably complete search of paleoclimate data.

Assess how uncertainty is represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of flow paths in the saturated zone.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for flow paths in the saturated zone. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency. Confirm that DOE has adequately addressed comments from external reviews of the model abstraction.

Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of flow paths in the saturated zone. Examine the effects of the alternative conceptual model(s) on repository performance and evaluate how model uncertainties are defined, documented, and assessed.

Examine the mathematical models included in the analyses of flow paths in the saturated zone. Also examine and evaluate the bases for excluding alternative conceptual models, and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of flow paths in the saturated zone and compare the results with an appropriate combination of site characterization data, process-level modeling, laboratory testing, field measurements, and natural analog research.

Use detailed models of geological, hydrological, and geochemical processes to evaluate the Total System Performance Assessment abstractions of flow paths in the saturated zone. If practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of flow paths in the saturated zone and evaluate the effects on repository performance. Compare results of the DOE abstraction to approximations shown to be appropriate for closely analogous natural systems or experimental systems.

Examine the procedures used by DOE to develop and test its mathematical and numerical models.

As appropriate, use an alternative Total System Performance Assessment model to evaluate the DOE sensitivity or bounding analyses and confirm that DOE has used ranges consistent with available site characterization data, field and laboratory tests, and natural analog research.

4.2.1.3.8.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the flow paths in the saturated zone model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the flow paths in the saturated zone abstraction process.

- The description of the aspects of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect flow paths in the saturated zone is adequate. Conditions and assumptions in the Total System Performance Assessment abstraction of flow paths in the saturated zone are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of flow paths in the saturated zone uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the assumptions used for flow paths in the saturated zone are consistent with the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping (section 4.2.1.3.12 of the YMRP). The descriptions and technical bases provide transparent and traceable support for the abstraction of flow paths in the saturated zone.

- Boundary and initial conditions used in the Total System Performance Assessment abstraction of flow paths in the saturated zone are propagated throughout its abstraction approaches. For example, abstractions are based on initial and boundary conditions consistent with site-scale modeling and regional models of the Death Valley groundwater flow system.

- Sufficient data and technical bases to assess the degree to which FEPs have been included in this abstraction are provided.

- Flow paths in the saturated zone are adequately delineated considering natural site conditions.

- Long-term climate change based on known patterns of climatic cycles during the Quaternary period, particularly the last 500,000 years, and other paleoclimate data are adequately evaluated.

- Potential geothermal and seismic effects on the ambient saturated zone flow system are adequately described and accounted for.

- The impact of the expected water table rise on potentiometric heads and flow directions, and consequently on repository performance is adequately considered.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Geological, hydrological, and geochemical values used in the safety case to evaluate flow paths in the saturated zone are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data have been collected on the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of flow paths in the saturated zone.

- Data on the geology, hydrology, and geochemistry of the saturated zone used in the Total System Performance Assessment abstraction are based on appropriate techniques. These techniques may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies. As appropriate, sensitivity or uncertainty analyses used to support the DOE Total System Performance Assessment abstraction are adequate to determine the possible need for additional data.

- Sufficient information is provided to substantiate that the proposed mathematical groundwater modeling approach and proposed model(s) are calibrated and applicable to site conditions.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities. For example, DOE provides sufficient bases for selection of hydrologic parameter values and statistical distributions.

- Uncertainty is appropriately incorporated in model abstractions of hydrologic effects of climate change based on a reasonably complete search of paleoclimate data.

- Uncertainty is adequately represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of flow paths in the saturated zone. This may be done either through sensitivity analyses or use of conservative limits. For example, sensitivity analyses and/or similar analyses are sufficient to identify saturated zone flow parameters that are expected to significantly affect the abstraction model outcome.

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed. For example, uncertainty in data interpretations is considered by analyzing reasonable conceptual flow models that are supported by site data, or by demonstrating through sensitivity studies that the uncertainties have little impact on repository performance.

- Appropriate alternative modeling approaches are consistent with available data and current scientific knowledge, and appropriately consider their results and limitations using tests and analyses that are sensitive to the processes modeled.

AC5 Model abstraction output is supported by objective comparisons.

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Outputs of flow paths in the saturated zone abstractions reasonably produce or bound the results of corresponding process-level models, empirical observations, or both.

- Well-documented procedures that have been accepted by the scientific community to construct and test the mathematical and numerical models are used to simulate flow paths in the saturated zone.

- Sensitivity analyses or bounding analyses are provided to support the Total System Performance Assessment abstraction of flow paths in the saturated zone that cover ranges consistent with site data, field or laboratory experiments and tests, and natural analog research.

4.2.1.3.8.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to flow paths in the saturated zone and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a Performance assessment in the area of flow paths in the saturated zone have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the Performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.8.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.9 Radionuclide Transport in the Saturated Zone

To review this model abstraction, the staff will evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on radionuclide transport through the saturated zone to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon the saturated zone to provide significant delay (on the order of thousands of years) in the transport of radionuclides and/or dilution of concentration to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.9.1 Areas of Review

This section reviews radionuclide transport in the saturated zone. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of radionuclide transport in the saturated zone.

The staff will evaluate the following parts of the abstraction of radionuclide transport in the saturated zone using the review methods and acceptance criteria in sections 4.2.1.3.9.2 and 4.2.1.3.9.3.

- Description of the geological, hydrological, and geochemical aspects of radionuclide transport in the saturated zone and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.9.2 Review Methods

To review the abstraction of radionuclide transport in the saturated zone, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings, and the description of the geological, hydrological, and geochemical aspects of the saturated zone included in the abstraction of radionuclide transport in the saturated zone that contribute to waste isolation. Assess the adequacy of the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone.

Evaluate whether the description of aspects of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect radionuclide transport in the saturated zone is adequate. Verify that conditions and assumptions used in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone are consistent with the body of data presented in the description.

Examine assumptions, technical bases, data and models used by DOE in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone for consistency with other related DOE abstractions. Evaluate whether the descriptions and technical bases provide transparent and traceable support for the abstraction of radionuclide transport in the saturated zone.

Confirm that DOE has propagated boundary and initial conditions used in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone throughout its abstraction approaches.

Examine the FEPs related to radionuclide transport in the saturated zone that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion.

Verify that DOE follows guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alterative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, hydrological, and geochemical data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone. Assess the sufficiency, transparency, and traceability of the data to used to support the technical bases for FEPs that have been included in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone.

Verify whether sufficient data have been collected on the characteristics of the geology, hydrology, and geochemistry of the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone.

Evaluate and confirm that data used to support the DOE Total System Performance Assessment abstraction of radionuclide transport in the saturated zone are based on appropriate techniques and are adequate for the accompanying sensitivity/uncertainty analyses. Evaluate the need for additional data based on the sensitivity analyses.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Evaluate the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Determine whether DOE has used flow and transport parameters that are based on techniques that may include laboratory experiments, field measurements, natural analog research, and process-level modeling studies conducted under conditions relevant to the saturated zone at YM. Examine the results of DOE field transport tests and confirm that DOE has provided adequate models.

If criticality in the saturated zone is included in the Total System Performance Assessment, examine the methods and parameters used by DOE to calculate the effective neutron multiplication factor (k_{eff}). Evaluate te consequences calculated by DOE for criticality in the saturated zone.

Assess how uncertainty is represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the DOE alternative conceptual models used in developing the Total System Performance Assessment abstraction for radionuclide transport in the saturated zone. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency.

Where appropriate, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of radionuclide transport in the saturated zone. Examine the effects of the alternative conceptual model(s) on repository performance and evaluate how model uncertainties are defined, documented, and assessed.

Examine the mathematical models included in the analyses of radionuclide transport in the saturated zone. Examine and evaluate the bases for excluding alternative conceptual models, and the limitations and uncertainties of the chosen model.

RM5 Model Support

Evaluate the output from the abstraction of radionuclide transport in the saturated zone and compare the results with an appropriate combination of site characterization data, process modeling, laboratory testing, field measurements, and natural analog research. Evaluate the sensitivity analyses used to support the abstraction of radionuclide transport in the saturated zone in the Total System Performance Assessment.

Use detailed models of geochemical, hydrological, and geological processes to evaluate the Total System Performance Assessment abstractions of radionuclide transport in the saturated zone. If practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of radionuclide transport in the saturated zone and evaluate the effects on repository performance. Compare results of the DOE abstraction to approximations shown to be appropriate for closely analogous natural systems or experimental systems.

Examine the procedures used by DOE to develop and test its mathematical and numerical models.

As appropriate, use an alternative Total System Performance Assessment model to evaluate the DOE sensitivity or bounding analyses and confirm that DOE has used ranges consistent with available site characterization data, field and laboratory tests, and natural analog research.

4.2.1.3.9.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the radionuclide transport in the saturated zone model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the radionuclide transport in the saturated zone abstraction process.

- The description of the aspects of hydrology, geology, geochemistry, design features, physical phenomena, and couplings that may affect radionuclide transport in the saturated zone is adequate. For example, the description includes changes in transport properties in the saturated zone due to water-rock interaction. Conditions and assumptions in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone are readily identified and consistent with the body of data presented in the description.

- The Total System Performance Assessment abstraction of radionuclide transport in the saturated zone uses assumptions, technical bases, data and models that are appropriate and consistent with other related DOE abstractions. For example, assumptions used for radionuclide transport in the saturated zone are consistent with the Total System Performance Assessment abstractions of radionuclide release rates and solubility limits, and flow paths in the saturated zone (sections 4.2.1.3.4 and 4.2.1.3.8 of the YMRP, respectively). The descriptions and technical bases provide transparent and traceable support for the abstraction of radionuclide transport in the saturated zone.

- Boundary and initial conditions used in the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone are propagated throughout its abstraction approaches. For example, the conditions and assumptions used to generate transport parameter values are consistent with other geological, hydrological, and geochemical conditions in the Total System Performance Assessment abstraction of the saturated zone.

- Sufficient data and technical bases for the inclusion of FEPs related to radionuclide transport in the saturated zone in the Total System Performance Assessment abstraction are provided.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Geological, hydrological, and geochemical values used in the safety case are adequately justified (e.g., flow path lengths, sorption coefficients, retardation factors, colloid concentrations, etc.). Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data have been collected on the characteristics of the natural system to establish initial and boundary conditions for the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone.

- Data on the geology, hydrology, and geochemistry of the saturated zone, including the influence of structural features, fracture distributions, fracture properties, and stratigraphy, used in the Total System Performance Assessment abstraction are based on appropriate techniques. These techniques may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies. As appropriate, sensitivity or uncertainty analyses used to support the DOE Total System Performance Assessment abstraction are adequate to determine the possible need for additional data.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- For those radionuclides where the Total System Performance Assessment abstraction indicates transport in fractures and matrix in the saturated zone is important to performance, (i) estimated flow and transport parameters are appropriate and valid based on techniques that may include laboratory experiments, field measurements, natural analog research, and process-level modeling studies conducted under conditions relevant to the saturated zone at YM, and (ii) models are demonstrated to adequately predict field transport test results. For example, if a sorption coefficient (K_d) approach is used, the assumptions implicit in that approach are validated.

- If criticality in the saturated zone is included in the Total System Performance Assessment, an appropriate range of input parameters for calculating the effective neutron multiplication factor (k_{eff}) is used. The effects on performance of criticality in the saturated zone are adequately evaluated.

- Parameter values for processes such as matrix diffusion, dispersion, and groundwater mixing are based on reasonable assumptions about climate, aquifer properties, and groundwater volumetric fluxes (section 4.2.1.3.8 of the YMRP).

- Uncertainty is adequately represented in parameter development for conceptual models, process-level models, and alternative conceptual models considered in developing the

Total System Performance Assessment abstraction of radionuclide transport in the saturated zone. This may be done either through sensitivity analyses or use of conservative limits.

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of other sources such as expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Conceptual model uncertainties are adequately defined and documented and effects on conclusions regarding performance are properly assessed.

- Appropriate alternative modeling approaches are consistent with available data and current scientific knowledge, and appropriately consider their results and limitations using tests and analyses that are sensitive to the processes modeled. For example, for radionuclide transport through fractures, the DOE adequately considers alternative modeling approaches to develop its understanding of fracture distributions and ranges of fracture flow and transport properties in the saturated zone.

AC5 Model abstraction output is supported by objective comparisons.

- The models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Outputs of radionuclide transport in the saturated zone abstractions reasonably produce or bound the results of corresponding process-level models, empirical observations, or both. DOE abstracted models for radionuclide transport in the saturated zone are based on the same hydrological, geological, and geochemical assumptions and approximations shown to be appropriate for closely analogous natural systems or experimental systems.

- Well-documented procedures that have been accepted by the scientific community to construct and test the mathematical and numerical models are used to simulate radionuclide transport through the saturated zone.

- Sensitivity analyses or bounding analyses are provided to support the Total System Performance Assessment abstraction of radionuclide transport in the saturated zone that cover ranges consistent with site data, field or laboratory experiments and tests, and natural analog research.

4.2.1.3.9.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to radionuclide transport in the saturated zone and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of radionuclide transport in the saturated zone have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.9.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.10 Volcanic Disruption of Waste Packages

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on volcanic disruption of waste packages to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon waste packages integrity to have a significant effect on dose to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.10.1 Areas of Review

This section reviews volcanic disruption of waste packages. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of volcanic disruption of waste packages.

The staff will evaluate the following parts of the abstraction of volcanic disruption of waste packages using the review methods and acceptance criteria in sections 4.2.1.3.10.2 and 4.2.1.3.10.3.

- Description of the geological, hydrological, geochemical and design aspects of volcanic disruption of waste packages and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.10.2 Review Methods

To review the abstraction of volcanic disruption of waste packages, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings and the description of the geology, geophysics, and geochemistry included in the abstraction of volcanic disruption of waste packages. Assess the adequacy and consistency of the technical bases for these descriptions and for incorporating them into the Total System Performance Assessment abstraction for volcanic disruption of waste packages. Confirm that models and assumptions used to evaluate volcanic disruption of waste packages are consistent with models and assumptions used elsewhere in the license application.

Determine that models used to assess volcanic disruption of waste packages are consistent with physical processes generally interpreted from igneous features in the YM region. Verify that models of active igneous processes are consistent with processes generally observed at active igneous features.

Evaluate the technical bases used to assess the effects of interactions between engineered repository systems and igneous systems.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, geophysical, and geochemical data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of volcanic disruption of waste packages.

Determine whether the technical bases for these data are adequately justified and that data used to model processes affecting volcanic disruption of waste packages are derived to the extent possible from adequately documented techniques. Such techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments.

Determine that sufficient data are available to integrate FEPs relevant to volcanic disruption of waste packages into process-level models. Determine that appropriate interrelationships and correlations between relevant FEPs are adequately considered in resulting model abstractions.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM3 Data Uncertainty

Examine the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of volcanic disruption of waste packages. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Examine the technical bases used to quantify uncertainty in parameter values observed in site data and the available literature (i.e., data precision), and the uncertainty in abstracting parameter values to process-level models (i.e., data accuracy), to ensure that adequate measures of uncertainty and variability have been considered.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the alternative conceptual models used in developing the Total System Performance Assessment abstraction for volcanic disruption of waste packages. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency.

Determine that uncertainties in abstracted models are adequately defined and documented. Verify that effects of these uncertainties are assessed in the Total System Performance Assessment. Where appropriate, use an alternative Total System Performance Assessment model to evaluate the effects of alternative models on repository performance.

RM5 Model Support

Evaluate the output from the abstraction of volcanic disruption of waste packages and compare the results with an appropriate combination of site characterization data, detailed process-level modeling, laboratory testing, field measurements, and natural analog research.

Determine that inconsistencies between abstracted models and comparative data are explained and quantified. Confirm that the resulting uncertainty is accounted for in the model results.

4.2.1.3.10.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3), and (5)–(7) relating to the volcanic disruption of waste packages model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the volcanic disruption of waste packages abstraction process.

- Models used to assess volcanic disruption of waste packages are consistent with physical processes generally interpreted from igneous features in the YM region and/or observed at active igneous systems.

- Models account for changes in igneous processes that may occur from interactions with engineered repository systems.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Parameter values used in the safety case to evaluate volcanic disruption of waste packages are sufficient and adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Data used to model processes affecting volcanic disruption of waste packages are derived from appropriate techniques. These techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments.

- Sufficient data are available to integrate FEPs relevant to volcanic disruption of waste packages into process-level models, including determination of appropriate interrelationships and parameter correlations.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

- Where sufficient data do not exist, the definition of parameter values and associated conceptual models is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- Parameter uncertainty accounts quantitatively for the uncertainty in parameter values observed in site data and the available literature (i.e., data precision), and the uncertainty in abstracting parameter values to process-level models (i.e., data accuracy).

- Where sufficient data do not exist, the definition of parameter values and associated uncertainty is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches to volcanic disruption of the waste package are consistent with available data and current scientific understandings, and consider the results and limitations appropriately in the abstraction.

- Uncertainties in abstracted models are adequately defined and documented, and effects of these uncertainties are assessed in the Total System Performance Assessment.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in the volcanic disruption of waste packages abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Inconsistencies between abstracted models and comparative data are documented, explained, and quantified. The resulting uncertainty is accounted for in the model results.

4.2.1.3.10.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to volcanic disruption of waste packages and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 in this section. Technical requirements for conducting a performance assessment in the area of volcanic disruption of waste packages have been met. In particular, the NRC staff found reasonable assurance that in regard to volcanic disruption of the waste package:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.10.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.2.1.3.11 Airborne Transport of Radionuclides

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which DOE relies on airborne transport of radionuclides to demonstrate its safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE relies upon waste package integrity to provide significant delay or dilution (on the order of thousands of years) in the transport of radionuclides to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the delay (on the order of hundreds of years) of radionuclides to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.11.1 Areas of Review

This section reviews airborne transport of radionuclides. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of airborne transport of radionuclides.

The staff will evaluate the following parts of the abstraction of airborne transport of radionuclides using the review methods and acceptance criteria in sections 4.2.1.3.11.2 and 4.2.1.3.11.3.

- Description of the geological, hydrological, geochemical, and meteorological aspects of airborne transport of radionuclides and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;
- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;
- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and
- Use of expert elicitation.

4.2.1.3.11.2 Review Methods

To review the abstraction of airborne transport of radionuclides, recognize that models used in the Total System Performance Assessment may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings and the description of the geology, geophysics, geochemistry, and meteorological conditions included in the abstraction of airborne transport of radionuclides. Assess the adequacy and consistency of the technical bases for these descriptions and for incorporating them into the Total System Performance Assessment abstraction for airborne transport of radionuclides. Confirm that models and assumptions used to evaluate airborne transport of radionuclides are consistent with models and assumptions used elsewhere in the license application.

Determine that models used to assess airborne transport of radionuclides are consistent with physical processes generally interpreted from igneous features in the YM region. Verify that models of active igneous processes are consistent with processes generally observed at active igneous features.

Evaluate the technical bases used to assess the effects of engineered repository systems on the consequences of igneous processes.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or make an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate the sufficiency of the geological, geophysical, geochemical, and meteorological data used to support parameters used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of airborne transport of radionuclides.

Determine that the technical bases for these data are adequately justified and that data used to model processes affecting airborne transport of radionuclides are derived from adequately documented techniques. Such techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments.

Determine that sufficient data are available to integrate FEPs relevant to airborne transport of radionuclides into process-level models. Determine that appropriate interrelationships and correlations between relevant FEPs are adequately considered in resulting model abstractions.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM3 Data Uncertainty

Examine the technical bases for parameter values, assumed ranges, probability distributions, and bounding assumptions used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of airborne transport of radionuclides. Evaluate the assessment of uncertainty and variability in these parameters and verify that the technical bases reasonably account for uncertainties and variabilities in the data.

Examine the technical bases used to quantify uncertainty in parameter values observed in site data and the available literature (i.e., data precision), and the uncertainty in abstracting parameter values to process-level models (i.e., data accuracy), to ensure that adequate measures of uncertainty and variability have been considered.

Evaluate the methods used by DOE in conducting expert elicitation to define parameter values.

RM4 Model Uncertainty

Evaluate the alternative conceptual models used in developing the Total System Performance Assessment abstraction for airborne transport of radionuclides. Examine the model parameters considering available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies and evaluate their consistency.

Determine that uncertainties in abstracted models are adequately defined and documented. Verify that effects of these uncertainties are assessed in the Total System Performance Assessment. Where appropriate, use an alternative Total System Performance Assessment model to evaluate the effects of alternative models on repository performance.

RM5 Model Support

Evaluate the output from the abstraction of airborne transport of radionuclides and compare the results with an appropriate combination of site characterization data, detailed process-level modeling, laboratory testing, field measurements, and natural analog research.

Determine that inconsistencies between abstracted models and comparative data are explained and quantified. Confirm that the resulting uncertainty is accounted for in the model results.

4.2.1.3.11.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) relating to the airborne transport of radionuclides model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena, and couplings and uses consistent and appropriate assumptions throughout the airborne transport of radionuclides abstraction process.

- Models used to assess airborne transport of radionuclides are consistent with physical processes generally interpreted from igneous features in the YM region and/or observed at active igneous systems.

- Models account for changes in igneous processes that may occur from interactions with engineered repository systems.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Parameter values used in the safety case to evaluate airborne transport of radionuclides are sufficient and adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Data used to model processes affecting airborne transport of radionuclides are derived from appropriate techniques. These techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments.

- Sufficient data are available to integrate FEPs relevant to airborne transport of radionuclides into process-level models, including determination of appropriate interrelationships and parameter correlations.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

- Where sufficient data do not exist, the definition of parameter values and associated conceptual models is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities.

- Parameter uncertainty accounts quantitatively for the uncertainty in parameter values derived from site data and the available literature (i.e., data precision), and the uncertainty introduced by model abstraction (i.e., data accuracy).

- Where sufficient data do not exist, the definition of parameter values and associated uncertainty is based on appropriate use of expert elicitation conducted in accordance with NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches to airborne transport of radionuclides are consistent with available data and current scientific understandings, and consider the results and limitations appropriately in the abstraction.

- Uncertainties in abstracted models are adequately defined and documented, and effects of these uncertainties are assessed in the Total System Performance Assessment.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in the airborne transport of radionuclides abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs).

- Inconsistencies between abstracted models and comparative data are documented, explained, and quantified. The resulting uncertainty is accounted for in the model results.

4.2.1.3.11.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material relevant to the airborne transport of radionuclides and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 for model abstraction in this section. Technical requirements for conducting a performance assessment in the area of airborne transport of radionuclides have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the Performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.3.11.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission : Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission : Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission : Washington, DC. 1996.

4.2.1.3.12 Dilution of Radionuclides in Groundwater due to Well Pumping

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which dilution of radionuclides in groundwater due to well pumping affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE indicates that dilution due to well pumping significantly reduces the concentration of radionuclides in water used by the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.12.1 Areas of Review

This section reviews dilution of radionuclides in groundwater due to well pumping. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to dilution of radionuclides in groundwater due to well pumping.

The staff will evaluate the following parts of the abstraction of the dilution of radionuclides in groundwater due to well pumping using the review methods and acceptance criteria in sections 4.2.1.3.12.2 and 4.2.1.3.12.3.

- Description of the geological and hydrological aspects of dilution of radionuclides in groundwater due to well pumping and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.12.2 Review Methods

To review the abstraction of dilution of radionuclides in groundwater due to well pumping, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models, such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of design features, physical phenomena, and couplings, and the description of the geological, hydrological, and geochemical aspects of the abstraction of dilution of radionuclides in groundwater due to well pumping that contribute to repository performance.

Assess whether the technical bases for the descriptions of the aspects of dilution due to well pumping that are important to repository performance are adequate.

Evaluate whether the description of the aspects of hydrology and geology that may affect dilution of radionuclides in groundwater due to well pumping is adequate. Evaluate whether the descriptions provide transparent and traceable support for the abstraction.

Examine the assumptions, technical bases, data, and models used by DOE in the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping to determine whether they are appropriate and consistent with other related DOE abstractions.

Examine the FEPs related to dilution of radionuclides in groundwater due to well pumping that have been included in the Total System Performance Assessment abstraction, and evaluate the technical bases for their inclusion. As appropriate, examine the technical bases for the inclusion of FEPs from the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping.

Verify that the DOE has followed the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Evaluate whether sufficient justification has been provided for climatological and hydrological values used in the safety case and whether the description of how the data are used, interpreted, and appropriately synthesized into the parameters is sufficiently transparent and traceable.

Evaluate whether sufficient data have been used to support the definition of conceptual models used in the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping, as well as the parameters used for each of these models. Determine whether sufficient data have been used in characterizing relevant FEPs and incorporating these FEPs into the abstraction of dilution of radionuclides in groundwater due to well pumping.

Determine whether the quality and quantity of data are sufficient for those parameter groups considered important for developing the model abstraction including groups such as well classification and design, aquifer parameters, and transport parameters. Where applicable, determine whether reliable statistical estimates can be obtained from the relevant parameter data that can be used to either establish meaningful confidence limits or set meaningful bounding estimates and determine whether the scales of measured data are appropriately factored into the abstraction.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Determine whether the use of parameter values, assumed ranges, probability distributions, and bounding assumptions reasonably account for uncertainties and variabilities in the repository system.

Examine the technical bases for parameter values and ranges used in conceptual models, process models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping. Assess whether these parameters values and distributions are consistent with site characterization data, laboratory experiments, field measurements, and natural analog research.

Assess whether uncertainty is adequately represented in parameters of conceptual models, process models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping, either through sensitivity analyses, conservative limits, or bounding values supported by data.

Examine the parameters that are identified as being important for the abstraction and ensure that the level of support for the parameter values and distributions is commensurate with the effect that the parameter has on the Total System Performance Assessment results. Consider whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. To the extent feasible, use the Total-system Performance Assessment code (Mohanty and McCartin, 1998) to test the sensitivity of the repository performance to the parameter value or model.

Examine DOE's use of expert elicitation and confirm that where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of other sources, such as expert elicitation conducted in accordance with appropriate guidance, such as NUREG–1563 (Kotra, et al., 1996).

RM4 Model Uncertainty

Evaluate whether appropriate alternative conceptual models are used in developing the Total System Performance Assessment abstraction for dilution of radionuclides in groundwater due to well pumping and examine the model parameters in the context of available data. Compare the results of alternate process models to results from process models used by the DOE to assess the uncertainty, limitations, and the degree of conservatism present in the DOE model. Ascertain whether any limitations identified in the DOE process model through this comparison are adequately accounted for in the DOE abstraction. Confirm that DOE has adequately addressed comments from external reviews of the model abstraction.

Determine whether the results of plausible alternative conceptual models have been considered appropriately in the abstraction in the context of site characterization data, laboratory experiments, field measurements, natural analog research, and process modeling studies. In particular, use an alternative Total System Performance Assessment model to evaluate the effect of the alternative conceptual model(s) on repository performance.

RM5 Model Support

Evaluate the output from the Total System Performance Assessment model abstraction of dilution of radionuclides in groundwater due to pumping and determine whether DOE compares the results with an appropriate combination of site characterization data, process modeling, laboratory testing, field measurements, and natural analog research. Use detailed models of geochemical, hydrological, and geological processes and the Total-system Performance Assessment code (Mohanty and McCartin, 1998) to selectively probe DOE Total System Performance Assessment analyses and evaluate selected parts of the DOE abstraction of dilution of radionuclides in groundwater due to pumping.

4.2.1.3.12.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3), and (5)–(7) and 10 CFR 63.115 relating to the dilution of radionuclides in groundwater due to well pumping abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important design features, physical phenomena and couplings, and use consistent and appropriate assumptions throughout the dilution of radionuclides in groundwater due to well pumping abstraction process.

- The Total System Performance Assessment model abstraction of dilution of radionuclides in groundwater due to well pumping adequately identifies and describes aspects of dilution due to well pumping that are important to repository performance and includes the technical bases for these descriptions.

- The description of aspects of hydrology and geology that may affect dilution of radionuclides in groundwater due to well pumping is adequate and identifies those parameters to which the abstraction is sensitive.

- The Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping uses assumptions, technical bases, data, and models that are appropriate and consistent with other related DOE abstractions. For example, the approach for modeling dilution due to well pumping adequately accounts for observed well design practices and is consistent with the approach used to model radionuclide transport from the source to the pumping well.

- Sufficient data and technical bases for the inclusion of FEPs related to dilution of radionuclides in groundwater due to well pumping in the Total System Performance Assessment abstraction are provided.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches is followed.

AC2 Data are sufficient for model justification.

- Climatological and hydrological values used in the safety case are adequately justified (e.g., well classification and design, aquifer parameters, transport parameters, etc.). Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data (field, laboratory, and/or natural analog data) are available to adequately define relevant parameters and conceptual models necessary for developing the dilution of radionuclides in groundwater due to well pumping abstraction in Total System Performance Assessment.

- The quality and quantity of data are sufficient for those parameter groups considered important for developing and calibrating the abstraction model including groups such as well classification and design, aquifer parameters, and transport parameters.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities and are consistent with the definition of the critical group in 10 CFR Part 63.

- The technical bases for the parameter values and ranges in performance assessment and process models used for estimating dilution of radionuclides in groundwater due to well pumping, such as pumping rates, well depths, and screen lengths are consistent with site characterization data, laboratory experiments, field measurements, and natural analog research, as appropriate.

- Uncertainty is adequately represented in parameters of conceptual models, process models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of dilution of radionuclides in groundwater due to well pumping, either through sensitivity analyses, conservative limits, or bounding values supported by data, as necessary.

- Parameters that are important for the abstraction through Total System Performance Assessment and sensitivity analyses are identified.

- Where sufficient data do not exist the definition of parameter values and conceptual models is based on appropriate use of expert elicitation conducted in accordance with appropriate guidance, such as NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction.

- Sufficient evidence is provided that existing alternative conceptual models of features and processes have been considered, that the models are consistent with available data (e.g., field, laboratory, and natural analog) and current scientific understanding, and that the effects of these alternative conceptual models on Total System Performance Assessment results are adequately evaluated.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (e.g., laboratory testing, field measurements, and/or natural analogs).

4.2.1.3.12.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114. Technical requirements for conducting a performance assessment with respect to the dilution of radionuclides in groundwater due to well pumping have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

The NRC staff has reviewed the SAR and other docketed material relevant to dilution in groundwater due to well pumping and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.115. The required characteristics of the reference biosphere and critical group have been satisfied. In particular the NRC staff found reasonable assurance that:

- The FEPs used to describe the reference biosphere, the biosphere pathways, the evolution of climate, and the evolution of the geologic setting are consistent with present knowledge of the region, conditions, and past processes in the YM region as required by 10 CFR 63.115(a)(1)–(4).

- The critical group is within a farming community of approximately 100 individuals, about 20-km south of the underground facility near Lathrop Wells, which lies about 20-km south of the underground facility and has behaviors and characteristics consistent with current conditions of the region surrounding the YM site. The critical group characteristics and behaviors are the mean value of the groups variability range, and the average member of the group is an adult with metabolic and physical characteristics consistent with present knowledge of adults as required by 10 CFR 63.115(b)(1)–(5).

4.2.1.3.12.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

Mohanty, S., and T.J. McCartin, coords. “Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User’s Guide (Draft).” Center for Nuclear Waste Regulatory Analyses: San Antonio, TX. 1998.

4.2.1.3.13 Redistribution of Radionuclides in Soil

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which redistribution of radionuclides in soil affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information determined in the multiple barriers section (4.2.1.1). For example, if DOE indicates that redistribution of radionuclides in soil reduces dose to the critical group, then perform a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then conduct a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.13.1 Areas of Review

This section reviews redistribution of radionuclides in soil in the biosphere. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of redistribution of radionuclides in soil.

The staff will evaluate the following parts of the abstraction of the redistribution of radionuclides in soil using the review methods and acceptance criteria in sections 4.2.1.13.2 and 4.2.1.3.13.3.

- Description of the geological, hydrological, pedological, and geochemical aspects of redistribution of radionuclides in soil and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.13.2 Review Methods

To review the abstraction of the redistribution of radionuclides in soil, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Examine the description of features, physical phenomena, and couplings between different models and determine whether they have been appropriately incorporated in the redistribution of radionuclides in soil abstraction. Confirm that consistent and appropriate assumptions have been made throughout the abstraction.

Examine the aspects of redistribution of radionuclides in soil that have been identified as being important to repository performance and ensure that these aspects are reasonable. Assess the technical bases for these descriptions and for incorporating them in the Total System Performance Assessment abstraction of redistribution of radionuclides in soil. Evaluate whether the descriptions provide transparent and traceable support for the abstraction.

Examine the FEPs related to redistribution of radionuclides in soil that have been included in the Total System Performance Assessment abstraction, and evaluate whether they have been appropriately modeled in the abstraction of redistribution of radionuclides in soil.

Verify that DOE reviews follow guidance such as NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Ensure that the data on the pedology, hydrology, and soil chemistry used in the Total System Performance Assessment abstraction are based on a combination of techniques that may include laboratory experiments, site-specific field measurements, natural analog research, and process modeling studies. Examine how data were used, interpreted, and synthesized into parameter values and ensure that it was done appropriately.

Evaluate the sufficiency of the data used to support conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of redistribution of radionuclides in soil. Examine and confirm the sufficiency of the data that support the technical bases for FEPs related to redistribution of radionuclides in soil that have been included in the Total System Performance Assessment abstraction.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Examine the parameter values, ranges, distributions, and bounding assumptions used in conceptual models, process models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of redistribution of radionuclides in soil and evaluate the assessment of uncertainty and variability in these parameters. Evaluate DOE's input values by comparison with the corresponding input values in the NRC data set to the extent feasible. However, direct comparison of input values may not be possible if the NRC and DOE models are substantially different.

Examine the technical basis used to support parameter values and ranges and confirm that the selected parameter ranges and distributions adequately represent the conditions in the YM region.

Assess whether uncertainty is adequately represented in parameters of conceptual models, process models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of dilution of radionuclides in soil due to surface processes, either through sensitivity analyses, conservative limits, or bounding values supported by data. Assess whether correlations between parameters in the abstraction have been appropriately established.

Evaluate DOE's determination of the sensitivity of the performance of the system to the parameter value or model and verify that the level of adequacy of data required for justification of parameters or models is commensurate with the impact that the parameter or model has on the performance of the system. Consider whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. To the extent feasible, use the Total-system Performance Assessment code (Mohanty and McCartin, 1998) to test the sensitivity of the repository performance to the parameter value or model.

Examine DOE's use of expert elicitation and confirm that where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of other sources, such as expert elicitation conducted in accordance with appropriate guidance, such as NUREG–1563 (Kotra, et al., 1996).

RM4 Model Uncertainty

Determine whether DOE evaluated all appropriate alternative conceptual models for redistribution of radionuclides in soil. Compare the results of alternate process models to results from process models used by the DOE to assess the uncertainty, limitations, and the degree of conservatism present in the DOE model. Ascertain whether any limitations identified in the DOE process model through this comparison are adequately accounted for in the DOE abstraction.

Determine whether the results of appropriate alternative conceptual models have been considered in the abstraction in the context of site characterization data, laboratory experiments, field measurements, natural analog research, and process modeling studies. In particular, use an alternative Total System Performance Assessment model to evaluate the effect of the alternative conceptual model(s) on repository performance.

RM5 Model Support

Evaluate the output from the abstraction of redistribution of radionuclides in soil and compare the results with an appropriate combination of site characterization data, process modeling, laboratory testing, field measurements, and natural analog research. As appropriate, the reviewer should use the Total-system Performance Assessment code (Mohanty and McCartin, 1998) to evaluate selected parts of the DOE abstraction of redistribution of radionuclides in soil.

4.2.1.3.13.3 Acceptance Criteria

The following acceptance criteria are based on meeting the relevant requirements of 10 CFR 63.114(a)(1)–(3), and (5)–(7) and 10 CFR 63.115 as they relate to the redistribution of radionuclides in soil abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important features, physical phenomena and couplings between different models, and use consistent and appropriate assumptions throughout the abstraction of redistribution of radionuclides in soil abstraction process.

- The Total System Performance Assessment model abstraction identifies and describes aspects of redistribution of radionuclides in soil that are important to repository performance, including the technical bases for these descriptions. For example, the abstraction should include modeling of the deposition of contaminated material in the soil and determination of the depth distribution of the deposited radionuclides.

- Relevant site FEPs have been appropriately modeled in the abstraction of redistribution of radionuclides due to surface processes and sufficient technical bases are provided.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches for peer reviews is followed.

AC2 Data are sufficient for model justification.

- Pedological, hydrological, and geochemical values used in the safety case are adequately justified (e.g., irrigation and precipitation rates, erosion rates, radionuclide solubility values, etc.). Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Sufficient data (e.g., field, laboratory, and natural analog data) are available to adequately define relevant parameters and conceptual models necessary for developing the abstraction of redistribution of radionuclides in soil in the Total System Performance Assessment.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data Uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities and are consistent with the definition of the critical group in 10 CFR Part 63.

- The technical bases for the parameter values and ranges in the Total System Performance Assessment abstraction are consistent with data from the YM region [e.g., Amargosa Valley survey (Cannon Center for Survey Research, 1997)], studies of surface processes in the Fortymile Wash drainage basin, applicable laboratory testings, natural analogs, or other valid sources of data. For example, soil types, crop types, plow depths, and irrigation rates should be consistent with current farming practices and data on the airborne particulate concentration should be based on the resuspension of appropriate material in a climate and level of disturbance similar to that which is expected to be found at the location of the critical group during the compliance time period.

- Uncertainty is adequately represented in parameters for conceptual models, process models, and alternative conceptual models considered in developing the Total System Performance Assessment abstraction of dilution of radionuclides in soil, either through sensitivity analyses, conservative limits, or bounding values supported by data, as necessary. Correlations between input values are appropriately established in the Total System Performance Assessment.

- Parameters or models that most influence repository performance based on the performance measure and time period of compliance specified in 10 CFR Part 63 are identified.

- Where sufficient data do not exist, the definition of parameter values and conceptual models on appropriate use of other sources, such as expert elicitation conducted in accordance with appropriate guidance, such as NUREG–1563 (Kotra, et al., 1996).

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding consider the results and limitations appropriately in the abstraction.

- Sufficient evidence is provided that appropriate alternative conceptual models of FEPs have been considered, that the preferred models (if any) are consistent with available data (e.g., field, laboratory, and natural analog) and current scientific understanding, and that the effect on Total System Performance Assessment of uncertainties due to these alternative conceptual models has been evaluated.

AC5 Model abstraction output is supported by objective comparisons.

- Models implemented in the abstraction provide results consistent with output from detailed process-level models and/or empirical observations (e.g., laboratory testing, field measurements, and/or natural analogs).

4.2.1.3.13.4 Evaluation Findings

These evaluation findings are only with respect to this part of the Total System Performance Assessment model abstraction.

The NRC staff has reviewed the SAR and other docketed material relevant to redistribution of radionuclides in soil and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114. Technical requirements for conducting a Performance

assessment in the area of redistribution of radionuclides in soil have been met. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

The NRC staff has reviewed the SAR and other docketed material relevant to redistribution of radionuclides in soil and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.115. The required characteristics of the reference biosphere and critical group have been satisfied. In particular the NRC staff found reasonable assurance that:

- The FEPs used to describe the reference biosphere, the biosphere pathways, the evolution of climate, and the evolution of the geologic setting are consistent with present knowledge of the region, conditions, and past processes in the YM region as required by 10 CFR 63.115(a)(1)–(4).

- The critical group is within a farming community of approximately 100 individuals, about 20-km south of the underground facility near Lathrop Wells, which lies about 20-km south of the underground facility and has behaviors and characteristics consistent with current conditions of the region surrounding the YM site. The critical group characteristics and behaviors are the mean value of the groups variability range, and the average member of the group is an adult with metabolic and physical characteristics consistent with present knowledge of adults as required by 10 CFR 63.115(b)(1)–(5).

4.2.1.3.13.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, "Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories." Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories." Nuclear Regulatory Commission: Washington, DC. 1988b.

Cannon Center for Survey Research, University of Nevada. *Identifying and Characterizing the critical Group Results of a Pilot Study of Amargosa Valley*. Las Vegas, NV: Cannon Center for Survey Research. 1997

Kotra, J.P., et al. NUREG–1563, "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program." Nuclear Regulatory Commission: Washington, DC. 1996.

Mohanty, S., and T.J. McCartin, coords. "Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User's Guide (Draft)." Center for Nuclear Waste Regulatory Analyses: San Antonio, TX. 1998.

4.2.1.3.14 Critical Group Lifestyle and Reference Biosphere

To review this model abstraction, evaluate the adequacy of the DOE license application relative to the degree to which the lifestyle of the critical group affects the DOE safety case. Determine whether the supporting bases for the safety case clearly and explicitly indicate the degree of reliance on various parts of the system. Review this model abstraction considering the risk information evaluated in the multiple barriers section (4.2.1.1). For example, if DOE indicates that the critical group lifestyle and reference biosphere has a strong effect on performance, then conduct a detailed review of this abstraction. If, on the other hand, DOE demonstrates this abstraction to have a minor impact on the dose to the critical group, then perform a simplified review focusing on the bounding assumptions. The review methods and acceptance criteria provided here are for a detailed review. Some of the review methods and acceptance criteria may not be necessary in a simplified review for those abstractions that have a minor impact on performance. The demonstration of compliance with the overall performance objective is evaluated using section 4.2.1.4.1 of the YMRP.

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.3.14.1 Areas of Review

This section reviews the critical group lifestyle and reference biosphere. Reviewers will also evaluate information required by 10 CFR 63.21(c)(1), (9)(i) and (vi), and (13) that is relevant to the abstraction of critical group lifestyle and reference biosphere.

The staff will evaluate the following parts of the abstraction of critical group lifestyle and reference biosphere using review methods and acceptance criteria in sections 4.2.1.3.14.2 and 4.2.1.3.14.3.

- Description of the geological, hydrological, geochemical, sociological, and economical aspects of critical group lifestyle and reference biosphere and the technical bases DOE provides to support model integration across the Total System Performance Assessment abstractions;

- Sufficiency of the data and parameters used to justify the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize data uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Methods DOE uses to characterize model uncertainty and propagate the effects of this uncertainty through the Total System Performance Assessment model abstraction;

- Approaches DOE uses to compare output from the Total System Performance Assessment model abstraction to process-level outputs and empirical studies; and

- Use of expert elicitation.

4.2.1.3.14.2 Review Methods

For the abstraction of critical group lifestyle and reference biosphere, recognize that models used in the Total System Performance Assessments may range from highly complex process-level models to simplified models such as response surfaces or lookup tables. Evaluate model adequacy regardless of the level of complexity.

RM1 Model Integration

Determine whether the abstraction includes all important site features, physical phenomena and couplings and whether consistent and appropriate assumptions have been used through the abstraction.

Verify that the description is adequate and that the conditions and assumptions in the Total System Performance Assessment abstraction are consistent with the body of data presented in the description. Determine whether the technical bases for these descriptions and for incorporating them in the abstraction are appropriate. Evaluate whether the descriptions provide transparent and traceable support for the abstraction.

Consider important physical phenomena and couplings with other abstractions and examine them for consistency.

Determine whether the DOE has used an acceptable approach for peer reviews, such as the guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or makes an acceptable case for using alternative approaches.

RM2 Data and Model Justification

Determine whether the parameter values used in the safety case are adequately justified and consistent with the critical group definition in proposed 10 CFR part 63. Evaluate how the data were used, interpreted, and appropriately synthesized into the parameters.

Evaluate the sufficiency of the data used to support the modeling of FEPs in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of critical group lifestyle and reference biosphere, as well as the parameters used for each of these models. Alternative conceptual models do not apply to behaviors and characteristics of the critical group because behaviors and characteristics of the critical group have been defined in 10 CFR 63.115. Ensure that the data used in the DOE Total System Performance Assessment abstraction are based on a combination of techniques that may include laboratory experiments, site-specific field measurements, natural analog research, and process-level modeling studies. When evaluating whether the data is sufficient, consider whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Investigate the effects of any differences in model and implementation approach on dose results by running the Total-system Performance Assessment code (Mohanty and McCartin, 1998) with DOE input parameters and comparing calculated dose results with those reported by DOE. Confirm that any differences or identified limitations in model selection and implementation that significantly decrease dose results are adequately justified in the DOE analysis.

Evaluate whether additional data are likely to provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model. Evaluate whether specific plans are adequate for further testing to acquire the necessary information as part of the performance confirmation program using section 4.4 of the YMRP.

RM3 Data Uncertainty

Examine the technical bases for parameter values and ranges used in conceptual models, process-level models, and alternative conceptual models considered in the Total System Performance Assessment abstraction of critical group lifestyle and reference biosphere. Alternative conceptual models do not apply to behaviors and characteristics of the critical group because behaviors and characteristics of the critical group have been defined in 10 CFR 63.115. Evaluate the assessment of uncertainty and variability in these parameters. Verify that DOE has a technically defensible basis to support the determination that the behaviors and characteristics of the critical group are based on the mean value of the critical group's variability range, as specified in proposed 10 CFR Part 63.

Evaluate whether the parameters, values, and distributions used to describe FEPs of the biosphere are technically defensible and are consistent with present knowledge of conditions in the region surrounding YM.

Evaluate the effects of including uncertainty and variability ranges (for important parameters) in Total-system Performance Assessment runs if DOE ranges differ from NRC preferred values. Such tests can provide information on the effects of including these ranges in the Total System Performance Assessment (e.g., sensitivity and uncertainty analyses) and/or demonstrate the effects different ranges may have on dose results. Verify that any differences or identified limitations in the DOE analysis that significantly decrease dose results are adequately justified.

Evaluate, methods used by DOE in conducting expert elicitation to define parameter values.

Examine the sensitivity of Total System Performance Assessment results to identify parameter differences by comparing Total-system Performance Assessment results based on DOE and NRC parameter selections. Emphasize those parameters known to be important in biosphere and critical group calculations, such as consumption rates, intake-to-dose conversion factors, plant and animal transfer factors, mass loading factors, and crop interception fractions.

RM4 Model Uncertainty

Examine the model parameters in the context of available site characterization data, laboratory experiments, field measurements, natural analog research, and process-level modeling studies. To the extent practical, use an alternative Total System Performance Assessment model to evaluate selected parts of the DOE abstraction of critical group lifestyle and reference biosphere and evaluate the effect of the alternative conceptual model(s) on repository performance. Alternative conceptual models do not apply to behaviors and characteristics of the critical group because behaviors and characteristics of the critical group have been defined in 10 CFR 63.115.

Determine whether sufficient evidence has been presented that existing alternative conceptual models of processes that are important to performance have been considered in the abstraction.

RM5 Model Support

Evaluate the output from the abstraction of critical group lifestyle and reference biosphere and compare the results with an appropriate combination of site characterization data, process-level modeling, laboratory testing, field measurements, and natural analog research. Examine the sensitivity analyses used to support the abstraction of critical group lifestyle and reference biosphere in the Total System Performance Assessment. To the extent practical, use the Total-system Performance Assessment code (Mohanty and McCartin, 1998) to evaluate selected parts of the DOE abstraction of critical group lifestyle and reference biosphere. Compare DOE biosphere dose conversion factors with the results of dose modeling using a code such as GENII-S (Leigh, et al., 1993) and DOE input parameter data. The reviewer should conduct confirmatory runs using alternative dose calculation codes and DOE input parameters, as necessary.

4.2.1.3.14.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.114(a)(1)–(3) and (5)–(7) and 10 CFR 63.115 (a) and (b) relating to the critical group lifestyle and reference biosphere model abstraction. The NRC staff should apply the following acceptance criteria according to the level of importance established in the DOE risk-informed safety case.

AC1 System description and model integration are adequate.

- Total System Performance Assessment adequately incorporates important site features, physical phenomena and couplings, and consistent and appropriate assumptions throughout the abstraction of critical group lifestyle and reference biosphere process.

- The Total System Performance Assessment model abstraction identifies and describes aspects of the critical group lifestyle and reference biosphere that are important to repository performance, and includes the technical bases for these descriptions. For example, the reference biosphere should be consistent with the arid or semi-arid conditions in the vicinity of YM

- Assumptions are consistent between the critical group lifestyle abstraction and other abstractions. For example, DOE should ensure that the modeling of FEPs such as climate change, soil types, K_ds, volcanic ash properties, and the physical and chemical properties of radionuclides are consistent with assumptions in other Total System Performance Assessment abstractions.

- Guidance in NUREG–1297 and NUREG–1298 (Altman, et al., 1988a,b), or other acceptable approaches for peer reviews is followed.

AC2 Data are sufficient for model justification.

- The parameter values used in the safety case are adequately justified (e.g., behaviors and characteristics of the farming community, characteristics of the reference biosphere, etc.) and consistent with the critical group definition in proposed 10 CFR Part 63. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

- Data are sufficient to assess the degree to which FEPs related to critical group lifestyle and reference biosphere have been characterized and incorporated in the abstraction. As specified in proposed 10 CFR Part 63, DOE should demonstrate that FEPs that describe the biosphere are consistent with present knowledge of conditions in the region surrounding YM. As appropriate, DOE sensitivity and uncertainty analyses (including consideration of alternative conceptual models) are adequate for determining additional data needs and evaluating whether additional data would provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model.

- If additional data are required to support the DOE safety case, or if sensitivity and uncertainty analyses indicate additional data are necessary, specific plans for further testing to acquire the necessary information are provided as part of the performance confirmation program described in section 4.4 of the YMRP.

AC3 Data uncertainty is characterized and propagated through the model abstraction.

- Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible and reasonably account for uncertainties and variabilities and are consistent with the definition of the critical group in 10 CFR Part 63.

- The technical bases for the parameter values and ranges in the abstraction, such as consumption rates, plant and animal uptake factors, mass loading factors, and biosphere dose conversion factors, and are consistent with site characterization data and are technically defensible.

- Process-level models used to determine parameter values for critical group lifestyle and reference biosphere and are consistent with site characterization data, laboratory experiments, field measurements, and natural analog research.

- Uncertainty is adequately represented in parameter development for conceptual models and process-level models considered in developing the Total System Performance Assessment abstraction of critical group lifestyle and reference biosphere, either through sensitivity analyses, conservative limits, or bounding values supported by data as necessary. Correlations between input values are appropriately established in the Total System Performance Assessment and the implementation of the abstraction does not inappropriately bias results to a significant degree.

- Where sufficient data do not exist, the definition of parameter values and conceptual models is based on appropriate use of expert elicitation conducted in accordance with appropriate guidance, such as NUREG–1563 (Kotra, et al., 1996). If other approaches are used, DOE adequately justifies their use.

- Parameters or models that most influence repository performance based on the performance measure and time period of compliance specified in 10 CFR Part 63 are identified.

AC4 Model uncertainty is characterized and propagated through the model abstraction.

- Alternative modeling approaches of FEPs are consistent with available data and current scientific understanding and consider the results and limitations appropriately in the abstraction. However, alternative conceptual models do not apply to behaviors and characteristics of the critical group because behaviors and characteristics of the critical group have been defined in proposed 10 CFR 63.115.

- Sufficient evidence is provided that existing alternative conceptual models of features and processes that are important to performance, such as plant uptake of radionuclides from soil, soil resuspension, and the inhalation dose model for igneous events, have been considered.

AC5 Model abstraction output is supported by objective comparisons.

- Dose calculations pertaining to this Total System Performance Assessment abstraction provide results consistent with output from detailed process-level models and/or empirical observations (e.g., laboratory testing, field measurements, and/or natural analogs).

4.2.1.3.14.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.114 regarding abstraction of critical group lifestyle and reference biosphere in performance assessment. In particular, the NRC staff found reasonable assurance that:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternative conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases have been provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.115. The required characteristics of the reference biosphere and critical group have been justified. In particular the NRC staff found reasonable assurance that:

- The FEPs used to describe the reference biosphere, the biosphere pathways, the evolution of climate, and the evolution of the geologic setting are consistent with present knowledge of the region, conditions, and past processes in the YM region as required by 10 CFR 63.115(a)(1)–(4).

- The critical group is within a farming community of approximately 100 individuals, near Lathrop Wells, which lies about 20-km south of the underground facility and has behaviors and characteristics consistent with current conditions of the region surrounding the YM site. The critical group characteristics and behaviors are the mean value of the groups variability range, and the average member of the group is an adult with metabolic and physical characteristics consistent with present knowledge of adults as required by 10 CFR 63.115(b)(1)–(5).

4.2.1.3.14.5 References

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1297, “Generic Technical Position on Peer-Review for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988a.

Altman, W.D., J.P. Donnelly, and J.E. Kennedy. NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” Nuclear Regulatory Commission: Washington, DC. 1988b.

Kotra, J.P., et al. NUREG–1563, “Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

Leigh, C.D., et al. “User’s Guide for GENII-S: A Code for Statistical and Deterministic Simulation of Radiation Doses to Humans from Radionuclides in the Environment.” SAND 91-0561. Albuquerque, NM: Sandia National Laboratories. 1993.

Mohanty, S., and T.J. McCartin, coords. “Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User’s Guide (Draft).” Center for Nuclear Waste Regulatory Analyses: San Antonio, TX. 1998.

4.2.1.4 Demonstration of the Overall Performance Objective

4.2.1.4.1 Analysis of Repository Performance That Demonstrates Compliance With the Overall Performance Objective

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.4.1.1 Areas of Review

This section reviews the analysis of repository performance that demonstrates compliance with the overall performance objective. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(9).

The staff will evaluate the following parts of the analysis of repository performance that demonstrates compliance with the overall performance objective using the review methods and acceptance criteria in sections 4.2.1.4.1.3 and 4.2.1.4.1.4.

- Scenario classes that have been included in a set of Total System Performance Assessment calculations;
- Calculations of the expected annual dose curve;
- Credibility of the Total System Performance Assessment results based on an understanding of assumptions and parameters of the Total System Performance Assessment and consideration of uncertainties of the analysis; and
- Consideration given to alternative designs.

4.2.1.4.1.2 Review Methods

RM1 Scenarios used in the Calculation of the Average Annual Dose as a Function of Time

Confirm that the expected annual dose as a function of time includes all scenario classes that have been determined to be sufficiently probable or to have a sufficient effect on overall performance that they could not be screened from the Total System Performance Assessment analyses based on the results of the review conducted using section 4.2.1.2 of the YMRP.

Confirm that DOE's calculation of the average annual dose curve appropriately sums the contribution of each of the scenario classes. Verify that the contribution to the expected annual dose from each scenario class calculation properly accounts for the effects that the time of occurrence of the disruptive events comprising the scenario class has on the consequences. Also verify that the annual probability of occurrence of the events used to calculate the contribution to the expected annual dose is consistent with the results of the review conducted using section 4.2.1.2.2 of the YMRP. The probabilities of occurrence of all scenario classes included in the expected annual dose curve should sum to 1.

RM2 Demonstration that the Average Annual Dose to the Average Member of the Critical Group in any Year During the Compliance Period Does not Exceed 25 mrem TEDE

Confirm that DOE has conducted a sufficient number of realizations for each scenario class using the Total System Performance Assessment computer code to ensure that the results of the Total System Performance Assessment are statistically stable. Use simulations of the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998) to confirm that the appropriate number of realizations were performed to achieve stable results.

Confirm that overall repository performance and the performance of individual components or subsystems are consistent and reasonable. Verify that results of the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998) confirm overall repository performance. The results should be consistent with the results examined using Section 4.2.1.1 (System Description and Demonstration of Multiple Barriers) of the YMRP.

Confirm that the Total System Performance Assessment results show that the repository performance results in an average annual dose to the average member of the critical group in any year during the compliance period that does not exceed 25 mrem TEDE.

RM3 Credibility of the Total System Performance Assessment Code Representation of Repository Performance

In coordination with the reviewers of the model abstractions (using section 4.2.1.3 of the YMRP), ensure that assumptions and parameters used in the Total System Performance Assessment are acceptable. Verify that assumptions made within the Total System Performance Assessment are consistent among different modules of the code. Confirm that the use of assumptions and parameter values that differ among modules of the code is adequately documented.

Confirm that the Total System Performance Assessment code is properly verified such that there is confidence that the code is modeling the physical processes in the repository system in the manner that was intended (i.e., individual modules of the Total System Performance

Assessment code produce results consistent with the results of the reviews of sections 4.2.1.1, 4.2.1.2, and 4.2.1.3). Verify that the transfer of data between modules of the code is conducted properly (i.e., units are the same in both modules and the data are assigned to proper variables). Confirm the results from the outputs of individual models using the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998).

Examine the DOE estimate of the uncertainty in the performance assessment results (i.e., timing and magnitude of the expected annual dose) and confirm that it is reasonable considering the uncertainties in modeling assumptions and parameter values reviewed using sections 4.2.1.2 and 4.2.1.3 of the YMRP. Use the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998) to confirm the results for the individual modules.

Confirm that DOE has used an appropriate approach for sampling parameters in the Total System Performance Assessment code across their ranges of uncertainty.

RM4 Comparative Evaluation of Alternatives to the Major Design Features that are Important to Repository Performance

Confirm that the description of alternative designs includes the impact of each alternative on demonstrating compliance with the overall performance objective, any additional cost, and other considerations associated with the design (e.g., worker safety for implementation of each alternative, complications to waste retrieval).

4.2.1.4.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.113(b) and (c), and 10 CFR 63.114(a) relating to the analysis of repository performance that demonstrates compliance with the overall performance objective.

AC1 Scenarios used in the calculation of the expected annual dose as a function of time are adequate.

- The expected annual dose as a function of time includes all scenario classes that have been determined to be sufficiently probable or to have a sufficient effect on overall performance that they could not be screened from the Total System Performance Assessment analyses.

- The calculation of the expected annual dose curve appropriately sums the contribution of each of the disruptive event scenario classes. The contribution to the expected annual dose from each scenario class calculation properly accounts for the effects that the time of occurrence of the disruptive events comprising the scenario class has on the consequences. The annual probability of occurrence of the events used to calculate the contribution to the expected annual dose is consistent with the results of the scenario analysis. The probabilities of occurrence of all scenario classes included in the expected annual dose curve sum to 1.

AC2 An adequate demonstration is provided that the average annual dose to the average member of the critical group in any year during the compliance period does not exceed 25 mrem TEDE.

- A sufficient number of realizations has been run for each scenario class using the Total System Performance Assessment code to ensure that the results of the calculations are statistically stable.

- Overall repository performance and the performance of individual components or subsystems are consistent and reasonable.

- The Total System Performance Assessment results confirm that the repository performance results in average annual dose to the average member of the critical group in any year during the compliance period that does not exceed 25 mrem TEDE.

AC3 The Total System Performance Assessment code provides a credible representation of repository performance.

- Assumptions made within the Total System Performance Assessment code are consistent among different modules of the code. The use of assumptions and parameter values that differ among modules of the code is adequately documented.

- The Total System Performance Assessment code is properly verified such that there is confidence that the code is modeling the physical processes in the repository system in the manner that was intended. The transfer of data between modules of the code is conducted properly.

- The estimate of the uncertainty in the performance assessment results is consistent with the model and parameter uncertainty.

- The Total System Performance Assessment sampling method ensures that sampled parameters have been sampled across their ranges of uncertainty.

AC4 An adequate comparative evaluation of alternatives to the major design features that are important to repository performance is provided.

- The description of alternative designs includes the impact of each alternative on demonstrating compliance with the overall performance objective, any additional cost, and other considerations associated with the design.

4.2.1.4.1.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.113(b) and (c). The performance objectives for the geologic repository after permanent closure have been met. In particular:

- The engineered barrier system is designed so that, working in combination with the natural barriers, the expected annual dose to the annual member of the critical group meets the exposure standard during the first 10,000 years after permanent closure as required by 10 CFR 63.113(b).

- The ability of the geologic repository to limit radiological exposures has been demonstrated through a performance assessment meeting the requirements of 10 CFR 63.114(a) and that uses the reference biosphere and critical group and excludes the effects of human intrusion as required by 10 CFR 63.113(c).

The NRC staff has reviewed the SAR and other docketed material and has found that they satisfy the requirements of 10 CFR 63.114(a). Technical requirements for conducting a performance assessment have been met. In particular:

- Appropriate data from the site and surrounding region, uncertainties and variabilities in parameter values, and alternate conceptual models have been used in the analyses in compliance with 10 CFR 63.114(a)(1)–(3).

- The DOE has considered those events that have at least one chance in 10,000 of occurring over 10,000 years in compliance with 10 CFR 63.114(a)(4).

- Specific FEPs have been included in the analyses, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(5).

- Specific degradation, deterioration, and alteration processes have been included in the analyses, taking into consideration their affect on annual dose, and appropriate technical bases have been provided for inclusion or exclusion in compliance with 10 CFR 63.114(a)(6).

- Adequate technical bases are provided for models used in the performance assessment, as required by 10 CFR 63.114(a)(7).

4.2.1.4.1.5 References

Mohanty, S., and T.J. McCartin, coords. “Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User’s Guide *(Draft).* San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1998.

4.2.1.4.2 Analysis of Performance in the Event of Limited Human Intrusion

Review Responsibilities—High-Level Waste Branch and Environmental and Performance Assessment Branch

4.2.1.4.2.1 Areas of Review

This section reviews the analysis of performance in the event of limited human intrusion. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(9)(v).

The staff will evaluate the following parts of the analysis of performance in the event of limited human intrusion using the review methods and acceptance criteria in sections 4.2.1.4.2.2 and 4.2.1.4.2.3.

- Results of the separate Total System Performance Assessment performed for human intrusion;

- Credibility of the evaluation of human intrusion based on an understanding of assumptions and parameters of the Total System Performance Assessment, characteristics of the intrusion event, and consideration of uncertainties in the analysis.

4.2.1.4.2.2 Review Methods

RM1 Evaluation of An Intrusion Event that Demonstrates that the Average Annual Dose to the Average Member of the Critical Group in any Year During the Compliance Period is Acceptable

Confirm that the Total System Performance Assessment for human intrusion is performed separately from the overall Total System Performance Assessment and meets the requirements for performance assessments specified in 10 CFR 63.114(a). Verify that the Total System Performance Assessment for human intrusion is identical to the overall Total System Performance Assessment, except that it assumes the occurrence of a postulated human intrusion event with characteristics as defined in 10 CFR 63.113(e). If the DOE proposes alternative characteristics, verify that adequate justification is provided for the use of the alternative characteristics.

Confirm that a sufficient number of realizations has been run for each scenario class using the Total System Performance Assessment code to ensure that the results of the calculations statistically stable.

Verify that the estimated repository performance is reasonable and consistent with the results evaluated during the review using section 4.2.1.4.1 of the YMRP and with the characteristics of the postulated intrusion event. Use results of the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998) to confirm overall repository performance with the postulated intrusion event.

Verify that the expected annual dose curve for limited human intrusion confirms that the repository system meets performance objectives specified in 10 CFR 63.113(e) for limited human intrusion events.

RM2 The Total System Performance Assessment Code Representation of the Intrusion Event

In coordination with the reviewers of the model abstractions (using section 4.2.1.3 of the YMRP), ensure that assumptions made within the Total System Performance Assessment for evaluating the postulated intrusion event are consistent among different modules of the code. Verify that any use of assumptions and parameter values that differ among modules of the code is adequately documented.

Confirm that the Total System Performance Assessment code is properly verified such that there is confidence that the code is modeling the physical processes in the repository system in the manner that is consistent with the characteristics of the postulated intrusion event. Verify that the transfer of data between modules of the code is conducted properly (i.e., units are the same in both modules and the data are assigned to proper variables). Use the NRC Total-system Performance Assessment code (Mohanty and McCartin, 1998) to confirm DOE results for the outputs of individual modules.

Verify that the estimate of the uncertainty in the performance assessment results (i.e., timing and magnitude of expected annual dose) is consistent with the uncertainties considered in the characteristics of the postulated intrusion event and the uncertainties (i.e., model and parameter uncertainty) evaluated using sections 4.2.1.2 and 4.2.1.3 of the YMRP.

Confirm that the Total System Performance Assessment sampling method ensures that sampled parameters of the postulated intrusion event have been sampled across their ranges of uncertainty.

4.2.1.4.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.113(e) relating to analysis of performance in the event of limited human intrusion.

AC1 Evaluation of an intrusion event demonstrates that the average annual dose to the average member of the critical group in any year during the compliance period is acceptable.

- The Total System Performance Assessment for human intrusion is performed separately from the overall Total System Performance Assessment and meets the requirements for performance assessments specified in 10 CFR 63.114(a). The Total System Performance Assessment for human intrusion is identical to the overall Total System Performance Assessment, except that it assumes the occurrence of a postulated human intrusion event with characteristics as defined in 10 CFR 63.113(e). Adequate justification is provided if alternative characteristics are used.

- A sufficient number of realizations has been run for each scenario class using the Total System Performance Assessment code to ensure that the results of the calculations are statistically stable.

- The estimated repository performance is reasonable and consistent with the analysis of overall repository performance and with the characteristics of the postulated intrusion event.

- The expected annual dose curve for limited human intrusion confirms that the repository system meets performance objectives specified in 10 CFR 63.113(e) for limited human intrusion events.

AC2 The Total System Performance Assessment code provides a credible representation of the intrusion event.

- Assumptions made within the Total System Performance Assessment for evaluating the postulated intrusion event are consistent among different modules of the code. The use of assumptions and parameter values that differ among modules of the code is adequately documented.

- The Total System Performance Assessment code is properly verified such that there is confidence that the code is modeling the physical processes in the repository system in the manner that is consistent with the characteristics of the postulated intrusion event. The transfer of data between modules of the code is conducted properly.

- The estimate of the uncertainty in the performance assessment results is consistent with the uncertainties considered in the characteristics of the postulated intrusion event and with model and parameter uncertainty.

- The Total System Performance Assessment sampling method ensures that sampled parameters of the postulated intrusion event have been sampled across their ranges of uncertainty.

4.2.1.4.2.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.113(e). The requirements for demonstrating repository performance in the event of limited human intrusion have been met.

4.2.1.4.2.5 References

Mohanty, S., and T.J. McCartin, coords. "Total-system Performance Assessment (TPA) Version 3.2 Code: Module Descriptions and User's Guide (Draft)." San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1998.

4.3 RESEARCH AND DEVELOPMENT PROGRAM TO RESOLVE SAFETY QUESTIONS

Review Responsibilities—High-Level Waste Branch

4.3.1 Areas of Review

This section reviews the research and development program for resolving safety questions related to SSCs important to safety and engineered or natural barriers important to waste isolation. Reviewers will evaluate the information required by 10 CFR 63.21(c)(10). The program is required to identify, describe, and discuss those safety features or components for which further technical information is required to confirm the adequacy of site characterization, design, or natural barriers.

The staff will evaluate the following parts of the research and development program to resolve safety questions using the review methods and acceptance criteria in sections 4.3.2 and 4.3.3.

- Identification and description of safety questions,

- Identification and description of the research and development programs that will be conducted to resolve any safety questions for SSCs important to safety and the engineered and natural barriers important to waste isolation,

- A schedule for completion of the program as related to the projected startup date of repository operation, and

- The design alternatives or operational restrictions available in the event that the results of the program do not demonstrate acceptable resolution of the safety question problem(s).

4.3.2 Review Methods

RM1 Identification and Description of Safety Questions

Verify the license application identifies safety questions. If there are deficiencies, examine the rationale for them to determine whether it is adequate.

RM2 Identification and Detailed Description of the Research and Development Programs to Resolve Any Safety Questions for SSCs Important to Safety and the Engineered and Natural Barriers Important to Waste Isolation

Verify that for each safety question identified, a detailed research and development program has been established. Verify there is a description of the specific technical information that must be obtained to demonstrate acceptable resolution of the safety question. The description of the program should be of sufficient detail to show how the information will be obtained. Verify that criteria described in the research and development program to resolve safety questions incorporate appropriate scientific or engineering techniques to address the scope of the issues. Examine the specific programs to ensure that appropriate analyses, experiments, data collection, field tests, or other techniques have been identified and that the timing and sequence of these activities have been specified.

RM3 Schedule for Completion of the Program as Related to the Projected Startup Date of Repository Operation, and Commitment to Include Resolved Questions in Amendments to the License Application

Verify schedules for resolution of safety questions specify a date by which the issues should be resolved. Schedules should include intermediate dates or events at which decisions relating to the issue resolution program implementation will be made. The program and schedule should be detailed enough to show the interface with the repository design, construction activities, schedule proposed for receipt and emplacement of wastes, and any other related activities. In conducting this verification, consider the accessibility of underground locations, conditions that are likely to exist at the GROA, and other interferences that might exist during construction. Evaluate the research and development program for compatibility with other site activities and any schedule proposed for receipt and emplacement of wastes. The schedule must be compatible with: (i) other site activities and schedules, including the performance confirmation program (10 CFR Part 63, subpart F); (ii) repository design; and (iii) site characteristics. It should also satisfy the requirements of any license conditions established under 10 CFR Part 63.32 and 63.42.

Verify a commitment in the license application to include resolved questions in amendments to the license application.

RM4 Design Alternatives or Operational Restrictions Available in the Event That the Results of the Program Do Not Demonstrate Acceptable Resolution of the Problem

Verify there is an alternative plan to demonstrate acceptable resolution of the safety questions. Design alternatives or operational restrictions should be discussed in the alternative plan. Ensure there is a discussion of any programs that will be conducted during operation to demonstrate the acceptability of contemplated future changes in design or operation.

4.3.3 Acceptance Criteria

The following acceptance criteria meet the requirements of 10 CFR 63.21(c)(10).

AC1 The identification and descriptions of safety questions are adequate.

AC2 DOE adequately identifies and describes in detail a research and development program that will be conducted to resolve any safety questions, in a reasonable time period, for SSCs important to safety and the engineered and natural barriers important to waste isolation.

AC3 DOE provides a reasonable schedule for the completion of the program as related to the projected startup date of repository operation and the date when items are expected to be resolved. DOE makes a commitment to include resolved questions in requested amendments to the license application, as appropriate.

AC4 DOE provides the design alternatives or operational restrictions available in the event that the results of the program do not demonstrate acceptable resolution of the problem.

4.3.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(10). Requirements for identification and description of safety questions related to SSCs and the engineered and natural barriers have been met. DOE has provided a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved. The design alternatives or operational restrictions available in the event that the results of the program do not demonstrate acceptable resolution of the problem have been provided. Repository construction can proceed considering the scope of the safety questions and the programs and schedules for their resolution.

4.3.5 References

None.

4.4 PERFORMANCE CONFIRMATION PROGRAM

Review Responsibilities—High-Level Waste Branch

4.4.1 Areas of Review

Subpart F of 10 CFR Part 63 provides the requirements for the performance confirmation program. The staff defines performance confirmation as the program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives in subpart E (refer to 10 CFR 63.2). The need for a performance confirmation program is unique to HLW. This reflects the uncertainties in estimating geologic repository performance over thousands of years. At permanent closure, 10 CFR 63.51(a)(1) requires the DOE to present an update of the postclosure performance assessment. The updated assessment includes any performance confirmation data collected and relevant to post-closure performance. The Commission will then decide whether the DOE's comprehensive program of testing, monitoring and confirmation suggests the repository will work as planned. Unless the DOE designs the repository to preserve the option to retrieve the waste before permanent closure, an action reserved to the Commission could be foreclosed, and an unsafe condition could be transmitted to future generations. Therefore, the broad reference to the performance objectives under subpart E in the performance confirmation definition reflects the need to consider retrievability when monitoring subsurface conditions and that preserving the retrieval option is a preclosure performance requirement. The general requirements for the performance confirmation program do not require testing and monitoring to confirm preclosure performance in other contexts (that is, testing and monitoring SSCs important to safety). The general requirements at 10 CFR 63.131 focus on subsurface conditions as well as the natural and engineered systems and components required for repository operation and that are designed or assumed to operate as barriers after permanent closure. The bases for the acceptance criteria are the requirements for performance confirmation in 10 CFR Part 63, which are performance-based. Where suitable, the acceptance criteria are also risk-informed because performance confirmation focuses on those parameters and natural and engineered barriers important to performance.

The staff will evaluate the following parts of the performance confirmation program using the review methods and acceptance criteria in sections 4.4.2 and 4.4.3.

- General requirements for the performance confirmation program including:
  - Objectives of the performance confirmation program to acquire data by identified *in situ* monitoring, laboratory and field testing, and *in situ* experiments to indicate whether: (i) actual subsurface conditions (that is, specific geotechnical and design parameters, including natural processes, pertaining to the geologic setting) encountered and changes in those conditions (including any interactions between natural and engineered systems) during construction and waste emplacement operations are within the limits assumed in the licensing review;

and (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated;

— Overall schedule for performance confirmation;

— Plans to implement the performance confirmation program so the program: (i) does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives; (ii) provides baseline information and analysis of that information on those parameters and natural processes of the geologic setting that may change due to site characterization, construction, and operations; and (iii) monitors and analyzes changes from the baseline condition of parameters that could affect the performance of the geologic repository; and

— Administrative procedures.

- Confirmation of geotechnical and design parameters including:

  — Technical measuring, testing, and geologic mapping program during repository construction and operation to confirm geotechnical and design parameters;

  — Technical program to monitor natural systems and components that are designed or assumed to operate as barriers after permanent closure, to ensure they are functioning as intended and expected;

  — Technical program to monitor, *in situ*, the thermomechanical response of the underground facility until permanent closure to ensure the performance of the geologic and engineering features is within design limits; and

  — Surveillance program to evaluate subsurface conditions against design assumptions, including procedures to: (i) compare measurements and observations with original design bases and assumptions; (ii) determine the need for changes to the design or construction methods if significant differences exist between the measurements and observations and the original design bases and assumptions; and (iii) report significant differences between measurements and observations and the original design bases and assumptions, their significance to repository performance and recommended changes to the Commission.

- Design testing including:

  — Technical program to test engineered systems and components, other than waste packages, used in the design during the early or developmental stages of construction. This includes, for example, borehole and shaft seals, backfill, and drip shields;

— Technical program to evaluate the thermal and chemical interaction effects of waste packages, backfill, drip shields, rock, and groundwater;

— Schedule for starting tests of engineered systems and components used in the design;

— Plan to conduct a test, before permanent backfill placement begins, to evaluate the effectiveness of backfill placement and compaction procedures against design requirements, if the DOE includes backfill in the repository design; and

— Plan for conducting tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing.

- Monitoring and testing waste packages including:

  — Plan for monitoring the condition of waste packages at the geologic repository operations area including an evaluation of the (i) representativeness of those waste packages chosen for monitoring, and (ii) representativeness of the waste package environment of the waste packages chosen for monitoring;

  — Plan for laboratory experiments that focus on the internal condition of the waste packages including an evaluation of the degree the environment experienced by the emplaced waste packages within the underground facility is duplicated in the laboratory experiments;

  — Duration of the waste package monitoring and testing program; and

  — Plans for testing the fabrication of containers including closure welding and any post-weld heat treatment.

4.4.2 Review Methods

RM1 Compliance with General Requirements for the Performance Confirmation Program

- Verify that DOE’s performance confirmation plan provides the program objectives. Determine whether those objectives are sufficient to meet the general requirements for the performance confirmation program. This includes verifying that enough technical information exists and plans for specific *in situ* monitoring, laboratory, and field testing, and *in situ* experiments are identified to carry out stated objectives. Specifically, verify the DOE performance confirmation plan:

  — Identifies the geotechnical and design parameters, including natural processes, pertaining to the geologic setting the DOE selected to monitor and analyze;

  — Includes the method used to select the geotechnical and design parameters, including natural processes, pertaining to the geologic setting the DOE will monitor and analyze;

— Identifies the natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure, including their specific functions, the DOE selected to monitor and test to ensure they are functioning as intended and expected;

— Includes the method used to select the natural and engineered systems and components, that are designed or assumed to operate as barriers after permanent closure, the DOE will monitor and test to ensure they are functioning as intended and expected;

— Identifies any interactions between natural and engineered systems and components the DOE has selected to measure or observe;

— Includes the method used to select the interactions between natural and engineered systems and components to be measured or observed;

— Includes specific *in situ* monitoring, laboratory and field testing, and *in situ* experiments to acquire needed data;

— Specifies which *in situ* monitoring, laboratory and field testing, or *in situ* experimental methods the DOE will apply to the selected: (i) geotechnical and design parameters, including natural processes, pertaining to the geologic setting; (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure; and (iii) interactions between natural and engineered systems and components;

— Includes the expected changes (that is, design bases and assumptions) from baseline for the selected geotechnical and design parameters, including natural processes, pertaining to the geologic setting that will result from construction and waste emplacement operations; and

— Includes the intended and expected performance limits (that is, design assumptions) for the selected natural and engineered systems and components, which are designed or assumed to operate as barriers after permanent closure.

- Verify the DOE's performance confirmation plan includes a schedule for planned activities and assess whether the schedule is sufficient to meet the general requirements for the performance confirmation program.

- Assess DOE's approach to implement the performance confirmation program. This includes verifying DOE's performance confirmation plan includes the information necessary to determine whether the DOE will implement the program as required and to complete the detailed technical reviews using RM2, 3, and 4 of this section. Specifically, verify the DOE performance confirmation plan includes:

— Procedures to ensure that performance confirmation activities do not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives;

— Baseline information for selected geotechnical and design parameters, including natural processes, pertaining to the geologic setting;

— Methods used to establish the baseline information for selected geotechnical and design parameters, including natural processes, pertaining to the geologic setting;

— A commitment to monitor and analyze changes from the baseline condition of selected geotechnical and design parameters, including natural processes, pertaining to the geologic setting that could affect the performance of a geologic repository;

— A commitment to monitor natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure to indicate whether they are functioning as intended and expected; and

— Terms for periodic assessment and update of the performance confirmation plan.

- Verify the DOE’s performance confirmation plan includes administrative procedures related to records and reports, construction records, reports of deficiencies, and inspections. Determine whether the DOE administrative procedures to implement the performance confirmation program are adequate.

RM2 Compliance with Requirements to Confirm Geotechnical and Design Parameters

- Determine whether the DOE’s performance confirmation plan provides an acceptable program of measuring, testing and geologic mapping during repository construction and operation to confirm geotechnical and design parameters (including natural processes) pertaining to the geologic setting. Specifically:

— Evaluate the adequacy of the method the DOE used to select the geotechnical and design parameters to monitor and analyze;

— Determine whether the DOE’s list of selected geotechnical and design parameters is reasonable and complete;

— Evaluate the adequacy of the method the DOE used to establish the baseline values of the selected geotechnical and design parameters;

— Determine whether the baseline values of the selected geotechnical and design parameters established by the DOE are reasonable;

  - Determine whether the DOE's estimates of the expected changes (that is, original design bases and assumptions) from baseline for the selected geotechnical and design parameters are reasonable; and

  - Determine whether the monitoring, testing or experimental methods are suitable for each geotechnical or design parameter the DOE will monitor and analyze.

- Determine whether the DOE's performance confirmation plan provides an adequate technical program to monitor or test natural systems and components, that are designed or assumed to operate as barriers after permanent closure, to ensure they are functioning as intended and expected. Specifically:

  - Evaluate the adequacy of the method the DOE used to select the natural systems and components, that are designed or assumed to operate as barriers after permanent closure, to be monitored or tested;

  - Determine whether the DOE's list of selected natural systems and components is reasonable and complete;

  - Determine whether the monitoring or testing methods are suitable for each natural system or component the DOE will monitor or test; and

  - Determine whether the intended and expected performance limits (that is, design assumptions) for the selected natural systems and components are reasonable.

- Verify the DOE's performance confirmation program includes plans to monitor, *in situ*, the thermomechanical response of the underground facility until permanent closure and evaluate the adequacy of those plans. Specifically:

  - Evaluate the adequacy of the method the DOE used to select the *in situ* thermomechanical response parameters to monitor and analyze;

  - Determine whether the DOE's list of selected *in situ* thermomechanical response parameters is reasonable and complete;

  - Evaluate the adequacy of the method the DOE used to establish the baseline values of the selected *in situ* thermomechanical response parameters;

  - Determine whether the baseline values of *in situ* thermomechanical response parameters established by the DOE are reasonable;

  - Determine whether the DOE's estimates of the anticipated changes (i.e., original design bases and assumptions) from baseline for the selected *in situ* thermomechanical response parameters are reasonable; and

   - Determine whether the monitoring, testing or experimental methods are suitable for each *in situ* thermomechanical response parameter the DOE will monitor and analyze.

- Determine whether the DOE's performance confirmation plan provides an adequate surveillance program to monitor and evaluate subsurface conditions against design assumptions. Specifically:

   - Verify the DOE's performance confirmation plan includes procedures to compare measurements and observations with original design bases and assumptions. Evaluate the adequacy of those procedures;

   - Verify the DOE's performance confirmation plan includes procedures to determine the need for modifications to the design or construction methods if significant differences exist between the measurements and observations and the original design bases and assumptions. Evaluate the adequacy of those procedures; and

   - Verify the DOE's performance confirmation plan includes procedures to report significant differences between measurements and observations and the original design bases and assumptions, their significance to repository performance and recommended changes to the Commission. Evaluate the adequacy of those procedures.

RM3 Compliance with Requirements for Design Testing

- Determine whether the DOE's performance confirmation plan provides an adequate program of testing engineered systems and components, other than waste packages, used in the design. Specifically:

   - Evaluate the adequacy of the method the DOE used to select the engineered systems and components, that are designed or assumed to operate as barriers after permanent closure, the DOE will monitor and test;

   - Determine whether the DOE's list of selected engineered systems and components is reasonable and complete;

   - Determine whether the monitoring, testing, or experimental methods are suitable for each engineered system or component the DOE will monitor or test; and

   - Determine whether the intended and expected performance limits (that is, design assumptions) for the selected engineered systems and components are reasonable.

- Verify whether DOE included thermal and chemical interaction effects of waste packages, rock, groundwater, and other engineered systems and components in the design testing program. Determine whether the testing program for thermal interaction effects is adequate. Specifically:

— Evaluate the adequacy of the method the DOE used to select the thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components in the design testing program;

— Determine whether the DOE's list of selected thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components is reasonable and complete;

— Determine whether the monitoring, testing or experimental methods are suitable for each thermal interaction effect of waste packages, rock, groundwater, and other engineered systems and components the DOE will monitor or test; and

— Determine whether the intended and expected performance limits (that is, design assumptions) for the selected thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components are reasonable.

- Determine whether the schedule for testing engineered systems and components used in the design is sufficient to meet the requirements for the design testing program.

- Determine whether the DOE's performance confirmation plan provides an adequate program of tests to evaluate the effectiveness of backfill placement and compaction procedures against design requirements (only if the DOE included backfill in the repository design). Specifically:

— Evaluate the adequacy of the method the DOE used to select the backfill placement and compaction procedures in the design testing program;

— Determine whether the DOE's list of selected backfill placement and compaction procedures is reasonable and complete;

— Determine whether the monitoring, testing or experimental methods are suitable for the backfill placement and compaction procedures the DOE will monitor or test; and

— Determine whether the intended and expected performance limits (that is, design assumptions) for the selected backfill placement and compaction procedures are reasonable.

- Determine whether the DOE performance confirmation plan provides an adequate program of tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing (only if the DOE included seals for borehole, shaft, and ramp in the repository design). Specifically:

- — Evaluate the adequacy of the method the DOE used to select the program of tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing in the design testing program;

- — Determine whether the DOE's program of tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing is reasonable and complete;

- — Determine whether the monitoring, testing or experimental methods are suitable for the program of tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing; and

- — Determine whether the intended and expected performance limits (that is, design assumptions) for the selected program of tests to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale sealing are reasonable.

RM4 Compliance with Requirements for Monitoring and Testing Waste Packages

- Determine whether the DOE's performance confirmation plan provides an adequate program for monitoring the condition of waste packages at the geologic repository operations area. Verify the plan requires an evaluation of the: (i) representativeness of those waste packages chosen for monitoring and (ii) representativeness of the waste package environment of the waste packages chosen for monitoring. Specifically:

  - — Evaluate the waste packages the DOE will monitor and test to ensure that they are representative of those to be emplaced in terms of materials, design, structure, fabrication and inspection methods;

  - — Determine whether the environment of the waste packages the DOE will monitor and test is representative of the emplacement environment, consistent with safe operations, and includes variations in environmental factors that encompass the range of expected uncertainties;

  - — Ensure the environmental conditions the DOE will monitor and evaluate include, but are not limited to, those describing water chemistry;

  - — Determine whether monitoring and testing includes evaluation of fabrication defects and post-fabrication damage, in particular damage that may occur during handling operations; and

  - — Verify the program is technically feasible, taking into consideration whether the methods proposed are suitable and practicable and the sensors and devices to be used are either able to sustain the prevailing environmental conditions (e.g., temperature, humidity, radiation) during the required period of repository operation or will be replaceable.

- Determine whether the DOE's performance confirmation plan provides an adequate program of laboratory experiments that focus on the internal condition of the waste packages. Verify the plan includes an evaluation of the degree the environment experienced by the emplaced waste packages within the underground facility is duplicated in the laboratory as well as determine whether this evaluation is adequate. Specifically:

  — Determine whether the program and plan provide data needed to design the waste package and confirm performance assessment models and assumptions;

  — Verify that experiments will incorporate scale-model waste package testing that includes the effects of welding and other fabrication processes (e.g., stress relief treatment); and

  — Determine whether corrosion monitoring and testing includes, but is not limited to, the use of corrosion coupons.

- Verify adequate testing of fabrication processes including closure welds and post-weld heat treatment.

- Determine whether the schedule for the waste package monitoring and testing program is sufficient to meet the requirements for such a program.

4.4.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.131, 63.132, 63.133, and 63.134 for the performance confirmation program.

AC1 The performance confirmation program meets the general requirements established for such a program.

- The objectives of the performance confirmation program are consistent with the general requirements in that the program will provide data to indicate whether: (i) actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review and (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and expected. The performance confirmation plan provides sufficient technical information and plans for *in situ* monitoring, laboratory and field testing, and *in situ* experiments to carry out the objectives in that:

  — It identifies the geotechnical and design parameters, including natural processes, pertaining to the geologic setting selected for monitoring and analysis;

  — It includes the method used to select the geotechnical and design parameters, including natural processes, pertaining to the geologic setting the DOE will monitor and analyze;

- It identifies the natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure, including their specific functions, the DOE selected to monitor and test to ensure they are functioning as intended and expected;

- It includes the method used to select the natural and engineered systems and components, which are designed or assumed to operate as barriers after permanent closure, the DOE will be monitor and test to ensure they are functioning as intended and expected;

- It identifies any interactions between natural and engineered systems and components the DOE selected to be measure or observe;

- It includes the method used to select the interactions between natural and engineered systems and components the DOE will measure or observe;

- It includes specific *in situ* monitoring, laboratory and field testing, and *in situ* experiments to acquire needed data;

- It specifies which *in situ* monitoring, laboratory and field testing, or *in situ* experimental methods the DOE will apply to the selected: (i) geotechnical and design parameters, including natural processes, pertaining to the geologic setting; (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure; and (iii) interactions between natural and engineered systems and components;

- It includes the expected changes (that is, design bases and assumptions) from baseline for the selected geotechnical and design parameters, including natural processes, pertaining to the geologic setting that will result from construction and waste emplacement operations; and

- It includes the intended and expected performance limits (that is, design assumptions) for the selected natural and engineered systems and components, which are designed or assumed to operate as barriers after permanent closure.

• The schedule for the performance confirmation program is consistent with the general requirements. The program started during site characterization and will continue until permanent closure.

• The DOE will implement the performance confirmation program in a manner consistent with the general requirements in that:

  - Procedures require the DOE to consider adverse effects on the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives prior to initiating any *in situ* monitoring, tests or experiments to acquire data;

- It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operations;

- It commits to monitoring and analyzing changes from the baseline condition for those parameters that could affect the performance of a geologic repository. Exceptions from this commitment for any particular parameter are identified and technically justified (refer to AC2 of this section);

- It commits to monitoring natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure to indicate whether they are functioning as intended and expected. Exceptions from this commitment for any particular system or component are identified and technically justified (refer to AC2 of this section); and

- It provides terms for periodic assessment and update of the performance confirmation plan.

- The performance confirmation plan includes procedures to manage the program. These procedures meet the requirements for records and reports, construction records, reports of deficiencies, and inspections specified at 10 CFR 63.71, 63.72, 63.73 and 63.75, respectively.

AC2 The performance confirmation program to confirm geotechnical and design parameters meets the requirements established for such a program.

- The performance confirmation plan establishes a program for measuring, testing, and geologic mapping to confirm geotechnical and design parameters. The DOE will implement the program during repository construction and operation. The program is consistent with the requirements in that:

    - Geotechnical and design parameters the DOE will monitor and analyze are selected using a performance-based method that focuses on those parameters that could affect the performance of the geologic repository. The DOE also considered the need to preserve the retrieval option.

    - Results of performance assessments confirm the list of selected geotechnical and design parameters is reasonable and complete. The DOE has justified excluding any geotechnical and design parameter that is important to performance. Acceptable justification factors include the certainty provided by existing baseline information and the low likelihood of changes in that parameter as a result of construction, waste emplacement operations or interactions between natural and engineered systems.

    - The baseline “value” of selected geotechnical and design parameters was determined using analytical or statistical methods appropriate for the particular parameter.

- — The baseline “value” of selected geotechnical and design parameters considered all data available at the time of the submittal.

- — The effects of construction, waste emplacement operations and interactions between natural and engineered systems are considered in the original design bases and assumptions for the geotechnical and design parameters.

- — Monitoring, testing and experimental methods are suitable for the nature of individual parameters in terms of time, space, resolution, and technique. Instrumentation reliability and replacement requirements are considered.

• The performance confirmation plan establishes a technical program to monitor natural systems and components, that are designed or assumed to operate as barriers after permanent closure, to ensure they are functioning as intended and expected. The program is consistent with the requirements in that:

- — Natural systems and components the DOE will monitor or test are selected using a performance-based method that focuses on those systems and components important to performance.

- — Results of performance assessments confirm the list of selected natural systems is reasonable and complete. The DOE has justified excluding any natural system and component that is designed or assumed to operate as a barrier after permanent closure from this program. Acceptable justification factors include the certainty in the natural system or component(s) capacity to perform its intended function or the degree the system and component is represented by parameter(s) being confirmed under the geotechnical and design parameter monitoring program.

- — Monitoring and testing methods are suitable for the nature of individual natural systems and components in terms of time, space, resolution, and technique. Instrumentation reliability and replacement requirements is considered.

- — The effects of construction, waste emplacement operations and interactions between natural and engineered systems are considered in estimates of the intended and anticipated performance limits (that is, design assumptions).

• The program includes adequate plans to monitor, *in situ*, the thermomechanical response of the underground facility until permanent closure. The program is consistent with the requirements in that:

- — *In situ* thermomechanical response parameters the DOE will monitor and analyze are selected using a performance-based method that focuses on those parameters that could affect the performance of the geologic repository. The DOE also considered the need to preserve the retrieval option.

- Results of performance assessments confirm the list of selected *in situ* thermomechanical response parameters is reasonable and complete. The DOE has justified excluding any *in situ* thermomechanical response parameter that is important to performance. Acceptable justification factors include the certainty provided by existing baseline information and the low likelihood of changes in that parameter as a result of construction, waste emplacement operations or interactions between natural and engineered systems.

- The baseline “value” of selected *in situ* thermomechanical response parameters was determined using analytical or statistical methods appropriate for the particular parameter.

- The baseline “value” of selected *in situ* thermomechanical response parameters considered all data available at the time of the submittal.

- The effects of construction, waste emplacement operations and interactions between natural and engineered systems are considered in the original design bases and assumptions for the *in situ* thermomechanical response parameters.

- Monitoring, testing and experimental methods are suitable for the nature of individual parameters in terms of time, space, resolution and technique. Instrumentation reliability and replacement requirements are considered.

• The performance confirmation plan sets up a surveillance program to evaluate subsurface conditions against design assumptions. The program is consistent with the requirements in that:

  - It includes procedures for comparing measurements and observations with original design bases and assumptions. Comparisons are done routinely and in a timely manner to ensure that if any significant differences exist between the measurements and observations and the original design bases and assumptions, their significance to repository performance and the need for design changes can be determined quickly and efficiently;

  - It includes procedures for determining the need for modifications to the design or construction methods if significant differences exist between measurements and observations and original design bases and assumptions. Acceptable variations in the design bases and assumptions the design would accommodate without an adverse impact on performance have been provided. If construction methods or design needs to be modified to address changed conditions, the DOE design control process used in the design phase may be used; and

  - It includes procedures to report significant differences between measurements and observations and the original design bases and assumptions, their significance to repository performance and recommended changes to the Commission. These procedures meet the requirements for reports of deficiencies specified at 10 CFR 63.73.

AC3 The performance confirmation program for design testing meets the requirements established for such a program.

- The performance confirmation plan establishes a program for design testing. The program is consistent with the requirements in that:

  — Engineered systems and components the DOE will test are selected using a performance-based method that focuses on those systems and components important to performance;

  — Results of performance assessments confirm the list of selected engineered systems and components is reasonable and complete. The DOE has justified excluding any engineered system or component that is important to performance from this program. An acceptable justification factor is the certainty in the system or components ability to perform its intended function;

  — Testing methods are suitable for the particular engineered system or component being tested in terms of time, space, resolution, and technique. Testing methods are selected, in part, by considering the data needed to design the engineered systems and components. Test locations are selected considering compatibility with the environment in which the components or systems are to function. Instrumentation reliability and replacement requirements have been considered; and

  — The effects of waste emplacement operations and interactions between natural and engineered systems are considered in estimates of the intended and expected performance limits (i.e., design assumptions).

- Thermal interaction effects of waste packages, rocks, groundwater, and other engineered systems and components used in the design, rock, and groundwater are included in the design testing program. The program is consistent with the requirements in that:

  — Thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components the DOE will test are selected using a performance-based method that focuses on those systems and components important to performance;

  — Results of performance assessments confirm the list of selected thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components is reasonable and complete. The DOE has justified excluding any thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components that is important to performance from this program. An acceptable justification factor is the certainty in the system or components ability to perform its intended function;

— Testing methods are suitable for the particular thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components being tested in terms of time, space, resolution and technique. Testing methods are selected, in part, by considering the data needed to design the thermal interaction effects of waste packages, rock, groundwater, and other engineered systems and components. Test locations are selected considering compatibility with the environment in which the components or systems are to function. Instrumentation reliability and replacement requirements have been considered; and

— The effects of waste emplacement operations and interactions between natural and engineered systems are considered in estimates of the intended and anticipated performance limits (that is, design assumptions).

- Design testing will begin during the early or developmental stages of construction. The testing schedule allows the results to be available in time for use in the design of engineered systems and components.

- The design testing program requires the effectiveness of backfill placement and compaction procedures against design requirements be demonstrated in an *in situ* test if backfill is included in the design. The importance of the contribution of the backfill to the long-term performance of the repository is considered in specifying testing requirements such as backfill material, gradation, and placement density, which are an indication of the water tightness or permeability of the backfill. Specifically:

— Backfill placement and compaction procedures the DOE will test are selected using a performance-based method that focuses on those systems and components important to performance.

— Results of performance assessments confirm the list of selected backfill placement and compaction procedures is reasonable and complete. The DOE has justified excluding any backfill placement and compaction procedures that are important to performance from this program. An acceptable justification factor is the certainty in the backfill and compaction to perform its intended function.

— Testing methods are suitable for the particular backfill placement and compaction procedures being tested in terms of time, space, resolution and technique. Testing methods are selected, in part, by considering the data needed to design the backfill placement and compaction procedures. Test locations are selected considering compatibility with the environment in which the components or systems are to function. Instrumentation reliability and replacement requirements have been considered.

— The effects of waste emplacement operations and backfill placement and compaction procedures interactions between natural and engineered systems are considered in estimates of the intended and anticipated performance limits (that is, design assumptions).

- The design testing program requires the effectiveness of borehole, shaft, and ramp seals be demonstrated in a test before full-scale sealing. The importance of seals to the long-term performance of the repository is considered in planning the seal test program. Specifically:

  — The program of tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing was selected using a performance-based method that focuses on those systems and components important to performance.

  — Results of performance assessments confirm the program of tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing is reasonable and complete. The DOE has justified excluding any tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing that are important to performance from this program. An acceptable justification factor is the certainty in the ability of the seals to perform their intended function.

  — Testing methods are suitable for the particular program of tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing in terms of time, space, resolution and technique. Testing methods are selected, in part, by considering the data needed to design the program of tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing. Test locations are selected considering compatibility with the environment in which the components or systems are to function. Instrumentation reliability and replacement requirements have been considered.

  — The effects of waste emplacement operations and the program of tests to evaluate the effectiveness of borehole, shaft, and ramps seals before full-scale sealing on interactions between natural and engineered systems are considered in estimates of the intended and anticipated performance limits (that is, design assumptions).

AC4 The performance confirmation program for monitoring and testing waste packages meets the requirements established for such a program.

- The performance confirmation plan establishes a program for monitoring and testing the condition of waste packages at the geologic repository operations area. Further, the program is adequate because:

  — The waste packages the DOE will monitor and test are representative of those to be emplaced in terms of materials, design, structure, fabrication, and inspection methods.

  — The environment of the waste packages the DOE will monitor and test is representative of the emplacement environment, consistent with safe operations, and includes variations in environmental factors that encompass the range of expected uncertainties.

- The environmental conditions the DOE will monitor and evaluate include, but are not limited to, those describing water chemistry.

- Monitoring and testing includes evaluation of fabrication defects and post-fabrication damage, in particular damage that may occur during handling operations.

- The program is technically feasible, taking into consideration the methods proposed are suitable and practicable and the sensors and devices to be used are either able to sustain the prevailing environmental conditions (e.g., temperature, humidity, radiation) during the required period of repository operation or are replaceable.

• The performance confirmation plan establishes a program of laboratory experiments that focus on the internal condition of the waste packages. The environment experienced by the emplaced waste packages is duplicated in the laboratory experiments to the extent practicable. The laboratory experiments are adequate because:

  - They provide data needed to design the waste package and confirm performance assessment models and assumptions.

  - Experiments will incorporate scale-model waste package testing that includes the effects of welding and other fabrication processes (e.g., stress relief treatment).

  - Corrosion monitoring and testing includes, but is not limited to, the use of corrosion coupons.

• An adequate testing of fabrication processes including fabrication and post-weld heat treatment will be conducted.

• The schedule for the waste package program requires monitoring and testing to begin as soon as practicable. Monitoring and testing will continue up to the time of permanent closure.

4.4.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance that they satisfy the requirements of 10 CFR 63.74(b) and 10 CFR Part 63, Subpart F—Performance Confirmation Program. The performance objectives of subpart E are met. In particular, the staff found reasonable assurance that an acceptable performance confirmation program will be conducted to evaluate the adequacy of information supporting the granting of the construction authorization.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.131. The general requirements for a performance confirmation program will be met. In particular, the staff found reasonable assurance that:

- The performance confirmation program will provide data to indicate whether: (i) actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement are within limits assumed in the licensing review and (ii) natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure are functioning as intended and expected.

- The performance confirmation program will include *in situ* monitoring, laboratory and field testing, and *in situ* experiments, as appropriate.

- The performance confirmation program was started during site characterization and will continue until permanent closure.

- The performance confirmation program will be implemented such that it: (i) does not adversely affect the performance of the geologic and engineered elements of the repository; (ii) provides adequate baseline information on parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities; (iii) monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository; and (iv) monitors natural and engineered systems and components that are designed or assumed to operate as barriers after permanent closure.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.132. The requirements to confirm geotechnical and design parameters will be met. In particular, the staff found with reasonable assurance that::

- An adequate continuing program of measuring, testing and geologic mapping during repository construction and operation will be conducted to confirm geotechnical and design parameters (including natural processes) pertaining to the geologic setting.

- An adequate program to monitor or test natural systems and components that are designed or assumed to operate as barriers after permanent closure will be conducted to ensure they are functioning as intended and expected.

- An adequate program to monitor, *in situ*, the thermomechanical response of the underground facility will be conducted until permanent closure.

- An adequate surveillance program will be conducted to monitor and evaluate subsurface conditions against design assumptions. The surveillance program will: (i) compare measurements and observations with original design bases and assumptions, (ii) determine the need for modifications to the design or construction methods if significant differences exist between measurements and observations and the original design bases and assumptions, and (iii) report significant differences between measurements and observations and the original design bases and assumptions, their significance to repository performance and recommended changes to the Commission.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.133. The requirements for design testing will be met. In particular, the staff found with reasonable assurance that:

- An adequate program for testing engineered systems and components will be conducted.
- An adequate program for evaluating the thermal interaction effects of waste packages, other engineered systems and components used in the design, rock and groundwater will be conducted.
- Testing will begin during the early or developmental stages of construction.
- Backfill placement and compaction procedures will be tested against design requirements before permanent backfill placement begins.
- The effectiveness of borehole, shaft, and ramp seals will be tested before full-scale sealing proceeds.

The NRC staff has reviewed the SAR and other docketed material and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.134. The requirements for monitoring and testing waste packages will be met. In particular, the staff found with reasonable assurance that::

- An adequate program for monitoring and testing the condition of waste packages at the geologic repository operations area will be conducted. Waste packages will be representative of those to be emplaced and the environment will be representative of the emplacement environment.
- The waste package monitoring and testing program will include appropriate laboratory experiments that focus on the internal condition of the waste packages. The laboratory experiments will duplicate the environment of the emplaced waste packages to the extent practicable.
- The waste package monitoring program will begin as soon as practicable and continue up to the time of permanent closure.

4.4.5 References

None.

4.5 ADMINISTRATIVE AND PROGRAMMATIC REQUIREMENTS

4.5.1 Quality Assurance Program

Review Responsibilities—High-Level Waste Branch

Quality assurance comprises all those planned and systematic actions necessary to provide adequate confidence that the geologic repository and its SSCs important to safety, the design and characterization of engineered and natural barriers important to waste isolation, and activities related thereto will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, system, or component that provide a means to control the quality of the material, structure, system, or component to predetermined requirements.

The purpose of this review is to determine whether the DOE has a quality assurance program that complies with the requirements of 10 CFR Part 63. Additionally, this section (4.5.1) of the YMRP will be used to determine if changes to the NRC approved quality assurance program meet the specific quality assurance program change control requirements of 10 CFR 63.144. The basis for these determinations is a review and evaluation of the DOE quality assurance program and changes to it submitted in accordance with 10 CFR Part 63. The results of the review and evaluation will be documented in the safety evaluation report.

This review plan is written to accommodate the use of graded quality assurance controls for SSCs and barriers important to safety or waste isolation that have been categorized as low safety/risk significant. If a graded quality assurance process is selected, the review provisions contained in this YMRP section must be applied to SSCs and barriers categorized as high safety/risk significant. As provided for in AC2 of this section (4.5.1.2), DOE may propose reduced quality assurance controls for selected elements of the quality assurance program, for SSCs and barriers categorized as low safety/risk significant. This categorization process must be risk-informed. If graded quality assurance is not used, the review provisions contained in this section (4.5.1) of the YMRP would apply to all SSCs and barriers subject to the quality assurance requirements contained in 10 CFR Part 63. As provided for in this section (4.5.1) of the YMRP, DOE may propose alternatives to these review provisions.

4.5.1.1 Areas of Review

This section addresses review of the DOE quality assurance program. In determining compliance with the requirements specified in 10 CFR 63.21(c)(14) and 10 CFR Part 63, subpart G (10 CFR 63.141–144), the reviewers will evaluate information specified in 10 CFR 63.21(c)(14).

The following elements of the quality assurance program will be evaluated using the review methods and acceptance criteria in sections 4.5.1.2 and 4.5.1.3.

- Quality Assurance Organization;
- Quality Assurance Program;

- Design Control;
- Procurement Document Control;
- Instructions, Procedures, and Drawings;
- Document Control;
- Control of Purchased Material, Equipment, and Services;
- Identification and Control of Materials, Parts, and Components;
- Control of Special Processes;
- Inspection;
- Test Control;
- Control of Measuring and Test Equipment;
- Handling, Storage, and Shipping;
- Inspection, Test, and Operating Status;
- Nonconforming Materials, Parts, or Components;
- Corrective Action;
- Quality Assurance Records;
- Audits;
- Software;
- Sample Control;
- Scientific Investigation; and
- Field Surveys.

4.5.1.2 Review Methods

The review should be conducted as follows.

Each element of the quality assurance program description will be reviewed against the acceptance criteria specified in section 4.5.1.3 of the YMRP and the documents and positions contained in section 4.5.1.5 of the YMRP. The assigned High-Level Waste Branch quality assurance program reviewer will interface with the other High-Level Waste Branch reviewers to ensure that they have documented the acceptability of the identification of SSCs and barriers covered by the quality assurance program (e.g., the identification of these SSCs and barriers is typically compiled in a list referred to as the Q-List). Further, if the graded quality assurance process is used, the assigned reviewer will interface with other High-Level Waste Branch reviewers to ensure that they have documented the acceptability of any safety/risk significance categorization process used to support the graded quality assurance process.

If required, the High-Level Waste Branch will process the necessary request(s) for additional information to DOE and coordinate the response with the appropriate branches for acceptance. Changes to the quality assurance program will be evaluated to assure at a minimum that such changes have not degraded the previously approved program. Consideration should be given to the current regulatory position(s) in the area of the change in determining acceptability of the change. The reviewer's judgment during the evaluation process is to be based on an assessment of the material presented. Any exceptions or proposed alternatives to the YMRP section, including the documents and positions cited in section 4.5.1.5 of the YMRP, will be carefully reviewed to assure that they are clearly defined and that an adequate basis exists for acceptance.

The acceptability of the quality assurance program is determined by the following review procedures:

- The quality assurance program description should be reviewed in detail to determine if each of the criteria of 10 CFR 63.142 has been acceptably addressed (by the quality assurance program describing how the applicable criteria are satisfied) and if there is an adequate commitment to comply with the documents and positions contained in section 4.5.1.5 of the YMRP. The quality assurance program description should also be reviewed to ensure that the DOE approach to meeting the quality assurance criteria and commitments is acceptable.

- The measures described to implement 10 CFR 63.142 should be evaluated to determine if management support exists (e.g., does it appear that the quality assurance program controls have adequate review, approval, and endorsement of management?).

- The duties, responsibilities, and authority of personnel performing quality assurance functions should be reviewed to assure that they provide sufficient independence to effectively perform these functions.

- Based on (i) review of information provided in the license application and any subsequent quality assurance program changes; (ii) meetings with DOE; (iii) assessment of the ongoing quality assurance program activities; and (iv) the results of inspections, a judgment is made and documented in the safety evaluation report that DOE is capable of implementing quality assurance responsibilities in accordance with an effective quality assurance program.

- The review of program commitments and descriptions of how the commitments will be met, organizational arrangements, and capabilities to fulfill quality assurance requirements should lead to a conclusion regarding acceptability of the program, as described in subsection 4.5.1.4.

  The review will assure that the commitments and the description of how the commitments are implemented, to the extent necessary, are objective and stated in inspectable terms.

4.5.1.3 Acceptance Criteria

General Acceptance Criteria

The criteria in the following introductory paragraphs and the 22 numbered acceptance criteria are based on meeting the relevant requirements of 10 CFR Part 21, 63.21(c)(14), 63.44, 63.73, and 63.141–144 as they relate to the quality assurance program.

The DOE quality assurance program description document must describe how the applicable requirements of 10 CFR 63.142 will be satisfied.

The DOE quality assurance program and associated quality assurance program controls and implementing procedures regarding activities performed must be in place before activities begin.

It is not sufficient for DOE documents to assert that particular requirements are met or provided for. The description of the quality assurance program submitted in the license application and any subsequent quality assurance program changes must identify individuals and organizations that are responsible for meeting particular requirements in order to allow the reviewer to understand the process by which DOE expects to meet specific requirements and to determine whether or not following that process would lead to compliance with requirements. Defining a process involves establishing authorities, assigning responsibilities, and issuing instructions and procedures.

The DOE shall establish a quality assurance program for site characterization; acquisition, control, and analysis of samples and data; tests and experiments; scientific studies; facility and equipment design and construction; facility operation; performance confirmation; permanent closure; and decontamination and dismantling of surface facilities in accordance with 10 CFR 63.21(c)(14) and 10 CFR 63.142. Applicable provisions contained in the DOE quality assurance program must be incorporated into the quality assurance programs of the principal contractors as related to their applicable scope of work. The DOE quality assurance program must describe how each criterion of 10 CFR 63.142 will be met. Further, if DOE chooses to implement a graded quality assurance program, the specific graded quality assurance controls for each quality assurance program element would need to be identified. The acceptance criteria used by the High-Level Waste Branch to evaluate this quality assurance program are specified in this section (4.5.1.3) of the YMRP.

AC1 through AC18 are organized to reflect the 18 criteria contained in 10 CFR 63.142. Acceptance criteria for certain subelements of the 18 criteria that are considered important are also provided as AC19 through AC22. Each of the 22 listed acceptance criteria specifies the relevant area of review. The subelement AC links to 10 CFR 63.142 are as follows: AC19, Software—10 CFR 63.142(d), Design Control; AC20, Sample Control—10 CFR 63.142(i), Identification and Control of Material, Parts, and Components; AC21, Scientific Investigation—10 CFR 63.142(d), Design Control; and AC22, Field Surveys—10 CFR 63.142(k), Inspection.

The acceptance criteria include a commitment to comply with the documents and positions contained in section 4.5.1.5 of the YMRP. Where appropriate, the quality assurance program description may reference a commitment to comply with certain provisions of a document identified in section 4.5.1.5 of the YMRP and not repeat the text of the document in the quality assurance program. For example, it may be appropriate for DOE to indicate compliance with NQA–1–1983 and the exceptions noted in AC 17 of this section (4.5.1) of the YMRP for the section of its quality assurance program that addresses records. In certain instances, when the quality assurance program description section references other documents (e.g., NQA–1–1983) as commitments, additional text may be needed because there may be provisions of the YMRP section that are not addressed in the referenced documents. Thus, the commitment constitutes an integral part of the quality assurance program description and requirements.

Exceptions and alternatives to these acceptance criteria and the documents and positions contained in section 4.5.1.5 of the YMRP may be adopted by DOE, provided adequate justification is given. The High-Level Waste Branch review allows for flexibility in defining methods and controls while still satisfying pertinent regulations. If the quality assurance program description meets the applicable acceptance criteria of this section (4.5.1.3) of the YMRP and the commitments contained in section 4.5.1.5 of the YMRP or provides acceptable exceptions or alternatives, then the program will be considered to be in compliance with pertinent NRC regulations.

<u>Specific Acceptance Criteria</u>

AC1 The organizational elements responsible for the quality assurance program are acceptable provided that:

- Responsibility for the overall quality assurance program is retained and exercised by DOE.

- DOE identifies and describes major delegation of work involved in establishing and implementing the quality assurance program or any part thereof to other organizations.

- When major portions of the DOE quality assurance program are delegated:

  — DOE describes how responsibility is exercised for the overall program. The extent of management oversight is addressed including the location, qualifications, and number of personnel performing these functions and the bases for them.

  — DOE evaluates the performance (frequency and method stated once per year, although a longer cycle may be acceptable with other evaluations of individual elements) of work by the delegated organization.

  — Qualified individual(s) or organizational element(s) are identified within the DOE organization as responsible for the quality of the delegated work prior to initiation of activities.

- Clear management controls and effective lines of communication exist for quality assurance activities among the DOE and the principal contractors to assure proper management, direction, and implementation of the quality assurance program.

- Organization charts clearly identify all onsite and offsite organizational elements that function under the cognizance of the quality assurance program [e.g., design, engineering, procurement, shipping, receiving, storage, manufacturing, construction, inspection, auditing, testing, instrumentation and control, engineering, maintenance and preclosure (operations), modifications, dismantling, etc.], the lines of responsibility, and a description of the bases for determining the size of the quality assurance organization, including the inspection staff.

- DOE (and principal contractors) describes the quality assurance responsibilities of each of the organizational elements noted on the organization charts. The authorities and duties of individuals and organizations performing activities important to safety or waste isolation are clearly established and delineated in writing.

- DOE (and principal contractors) identifies a management position that retains overall authority and direct responsibility for the definition, direction, and effectiveness of the overall quality assurance program. (Normally, this position is the quality assurance manager.) This position has the following characteristics:

  — Is at the same or higher organization level as the highest line manager directly responsible for performing activities affecting quality (such as engineering, procurement, construction, and operation) and is sufficiently independent from cost and schedule,

  — Has effective communication channels with other senior management positions,

  — Has responsibility for approval of quality assurance manual(s),

  — Has no other duties or responsibilities unrelated to quality assurance that would prevent his/her full attention to quality assurance matters,

  — Has sufficient authority to effectively implement responsibilities, and

  — Is sufficiently free from cost and schedule responsibilities.

  Qualification requirements for this position are established in a position description that includes the following prerequisites: management experience through assignments to responsible positions; indepth knowledge of quality assurance regulations, policies, practices, and standards; and appropriate experience working in quality assurance or related activity in nuclear related design, construction, or operation or in a similar technically based industry. The qualifications for this position should be at least equivalent to those described in ANSI/ANS, ANS–3.1–1993, Selection and Training of Nuclear Power Plant Personnel [ANSI/ANS, as endorsed by the regulatory positions in Regulatory Guide 1.8, Revision 3 (NRC, 2000)].

- Verification of conformance to established requirements is accomplished by individuals or groups within the quality assurance organization who do not have direct responsibility for performing the work being verified or by individuals or groups trained and qualified in quality assurance concepts and practices and independent of the organization responsible for performing the task.

- Individuals and organizations performing quality assurance functions have direct access to management levels that will assure the ability to identify quality problems; initiate, recommend, or provide solutions through designated channels; and verify implementation of solutions.

- The individuals and organizations with the above authority are identified, procedures for reporting are described, and clear lines of authority are provided.

- Designated quality assurance personnel, sufficiently free from direct pressures for cost/schedule, have the responsibility delineated in writing to stop unsatisfactory work and control further processing, delivery, installation, or use of nonconforming material until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

- The organizational positions with stop work authority are identified.

- Provisions are established for the resolution of disputes involving quality, arising from a difference of opinion between quality assurance personnel and other department (e.g., engineering, procurement, construction, etc.) representatives.

- Designated quality assurance individuals are involved in day-to-day facility activities important to safety or important to waste isolation. For example, the quality assurance organization routinely attends and participates in daily work schedule and status meetings to assure that they are kept abreast of day-to-day work assignments. There is adequate quality assurance coverage relative to procedural and inspection controls, acceptance criteria, and quality assurance staffing and qualification of personnel to carry out quality assurance assignments.

- Policies regarding the implementation of the quality assurance program are documented and made mandatory. These policies are established at the DOE Office of Civilian Radioactive Waste Management level.

- If the quality assurance organizational structure of DOE or its principal contractors identifies a position for an individual at the construction site or the GROA that is responsible for directing and managing the site quality assurance program, there must be controls identified for this position in the quality assurance program. These controls must assure that the individual assigned to this position has: (i) an appropriate level within the organizational structure, (ii) identified responsibilities, and (iii) authority to exercise proper control over the quality assurance program. These controls must also assure that this individual is free from nonquality assurance duties and can thus give full attention to ensuring that the quality assurance program at the repository site is being effectively implemented.

AC2 The activities related to the quality assurance program are acceptable provided that:

- The scope of the quality assurance program includes:

  — A commitment that SSCs important to safety, design and characterization of engineered and natural barriers important to waste isolation, and activities related thereto will be subject to the applicable controls of the quality assurance program. Such activities include, but are not limited to: site characterization; acquisition and analyses of samples and data; tests and experiments; scientific studies; facility and equipment design and construction; facility operation; performance confirmation; permanent closure; and decontamination and dismantlement of surface facilities. The SSCs, barriers, and related consumables covered by the quality assurance program are identified in the Q-list as addressed in Section 4.1.1.6, Identification of Structures, Systems, and Components Important to Safety; Safety Controls; and Measures to Ensure Availability of the Safety Systems, and Section 4.2.1.1, System Description and Demonstration of Multiple Barriers, of the YMRP.

— A commitment that the preoperational test program (prior to the start of preclosure operations) will be conducted in accordance with the quality assurance program and a description of how the quality assurance program will be applied.

— A commitment that the development, control, and use of computer software will be conducted in accordance with the quality assurance program and a description of how the quality assurance program will be applied.

— A commitment that special equipment, environmental conditions, skills, or processes will be provided as necessary.

- A brief summary of DOE Office of Civilian Radioactive Waste Management quality assurance policies is given. The organizational group or individual having responsibility for each policy statement is identified.

- Provisions are established to assure that quality-affecting procedures required to implement the quality assurance program are: (i) consistent with quality assurance program commitments and corporate policies, (ii) are properly documented and controlled, and (iii) made mandatory through a policy statement or equivalent document signed by the responsible official.

- The quality assurance organization reviews and documents concurrence with these quality-related procedures.

- The quality-affecting procedural controls of the principal contractors should be provided with documented agreement of acceptance prior to initiation of activities affected by the quality assurance program.

- Provisions are included for notifying NRC of changes for review and acceptance of the accepted description of the quality assurance program in accordance with 10 CFR 63.144. Changes to the NRC approved quality assurance program must be processed in accordance with the applicable requirements of 10 CFR 63.144 and revisions to DOE quality assurance program documentation should be forwarded to NRC.

  DOE should inform the High-Level Waste Branch of changes in the quality assurance program organizational elements, when possible, within 30 days after announcement.

- DOE (and its principal contractors) commits to comply with: (i) the requirements in 10 CFR 63.44, 63.73, and 63.141–144; and (ii) the documents and regulatory positions and documents contained in section 4.5.1.5 of the YMRP and any exceptions contained in the acceptance criteria. Further, DOE (and its principal contractors) commits to conduct activities under 10 CFR 63.73 and 10 CFR Part 21 commercial grade item dedication activities in accordance with the quality assurance program.

  The quality assurance organization and the necessary technical organizations should participate early in the quality assurance program definition stage to determine and identify the extent that quality assurance controls are to be applied to specific SSCs and barriers important to waste isolation. This effort may involve applying a defined graded approach to certain SSCs in accordance with their safety/risk significance and affects such disciplines as design, procurement, document control, inspection tests, special processes, records, and audits.

- <u>The Graded Quality Assurance Process:</u> A graded application of quality assurance, if used, requires DOE justification and NRC reviewer acceptance. A graded quality assurance program is structured to apply quality assurance measures and controls to all items and activities in proportion to their importance to safety or importance to waste isolation. The graded approach for the application of quality assurance controls must be adequately described. The quality assurance program should identify items and activities that are important to safety or important to waste isolation and their degree of importance based on the safety/risk significance of the items and activities. High safety/risk significant items and activities should have a high level of control (e.g., the full application of the quality assurance controls), and less safety/risk significant items and activities may have reduced quality assurance controls applied. However, DOE may chose to apply the highest level of quality assurance controls to all items and activities.

  If DOE decides to apply quality assurance controls in a graded manner, its quality assurance program must address the various elements of the graded quality assurance process. The activities related to the graded quality assurance process include:

  — The safety/risk significance categorization process is adequately described and is subject to review in accordance with section 4.1.1.6 (for preclosure) and section 4.2.1.1 (for postclosure) of the YMRP. Although this review is performed using other sections of the YMRP, the quality assurance program should describe, at a high level, the safety/risk significance categorization process.

    Provisions for reassessing the safety/risk significance categorization when new information becomes available should be appropriately described.

  — DOE may select two or more safety/risk significance categories (e.g., high, low, or medium). The quality assurance program describes each safety/risk significance category selected.

— The selection of graded quality assurance controls to be applied to each safety/risk significant category must be described in adequate detail. Section 3.2, Potential Areas for Implementing Graded Quality Assurance Program Controls, of Regulatory Guide 1.176, An Approach for Plant-Specific, Risk-Informed Decision-Making: Graded Quality Assurance (NRC, 1998), provides guidance on acceptable application of graded quality assurance controls. In proposing reduced quality assurance controls, the following two basic objectives should be kept in mind: (i) the graded quality assurance program should be sufficient to reasonably ensure the design integrity and ability of the SSC or barrier to successfully perform its intended important to safety or waste isolation function, and (ii) the graded quality assurance program should include processes and documentation that support an effective corrective action program. The selection of graded quality assurance controls may be applied to any element of the quality assurance program.

— Provisions for a feedback process to adjust graded quality assurance controls should be described. Provisions for reassessing the quality assurance controls when new information becomes available through adverse trends or nonconformance reporting should be described.

DOE quality assurance program description should discuss elements specifically related to effective corrective actions and causal analysis. Because it is not completely understood at the onset of the graded quality assurance program how changes will ultimately affect SSC fabrication, construction, installation, testing, and performance, and given that the categorization process cannot address these changes in a quantitative manner, it is important that DOE have an effective process in place so that adjustments can be made in the graded quality assurance program on the basis of repository and industry experiences. Within this area, DOE process controls should have the capability to determine whether SSCs have been treated properly in the graded quality assurance program. Failures, or adverse performance degradations, of low safety/risk significant SSCs should be identified in accordance with DOE corrective action programs so that DOE can ascertain whether the reduction of the quality assurance controls has resulted in excessive nonconformances and an unacceptable decrease in performance of SSCs and barriers.

DOE should employ techniques such as monitoring, surveillance, and trend analysis to identify when an SSC is found to be unacceptable or the reliability and availability of low safety/risk significant SSCs are trending toward unacceptable levels. SSC monitoring approaches should be used to accomplish this goal.

— Provisions for an effective root-cause analysis and corrective action as a result of the feedback process should be described. Provisions should also be described for evaluating common cause/mode failures. DOE corrective action efforts should determine, as a minimum, the apparent cause of repetitive failures of SSCs under the graded quality assurance controls so that it can be decided whether graded quality assurance controls should be adjusted. In some instances, a failure may result in an unanticipated event and may cause the categorization of the SSC to be changed.

— Provisions should also be in place for DOE to obtain documented NRC approval before implementing any quality assurance program changes that reduce previous commitments.

— The use of reduced sampling plans for low safety/risk significance SSCs and related activities is required to be documented in accordance with AC3 of this section.

- Existing or proposed quality assurance procedures are identified that reflect that the documents and regulatory positions contained in section 4.5.1.5 of the YMRP. The requirements in 10 CFR Part 21 and 10 CFR 63.73, and each criterion of 10 CFR 63.142 will be met by documented procedures. In addition, activities conducted under 10 CFR 63.73 and commercial grade item dedication activities conducted under 10 CFR Part 21 must conform to the applicable provisions of the quality assurance program.

- A description is provided that emphasizes how the docketed quality assurance program description controls, particularly the requirements in 10 CFR 63.21(c)(14), 63.44, 63.73, and 63.141–144 and the regulatory positions and documents contained in section 4.5.1.5 of the YMRP, will be implemented properly.

- A description is provided of how management (either above or outside the quality assurance organization) regularly assesses the scope, status, and adequacy of the quality assurance program and its compliance with 10 CFR Part 63, subpart G. These measures should include: (i) frequent contact with program status through reports, meetings, and/or audits and observations; and (ii) performance of an annual assessment that is preplanned and documented, with corrective action identified and tracked.

- Quality-related activities (such as design and procurement) initiated prior to NRC issuance of the construction authorization are controlled under an NRC-approved quality assurance program in accordance with the requirements of 10 CFR Part 63, subpart G. Approved procedures and a sufficient number of trained personnel should be available to implement the applicable portion of the quality assurance program prior to the initiation of the activity.

- A summary description is provided on how responsibilities and control of quality-related activities are transferred from principal contractors to DOE during any phaseout of principal contractor activities.

- A provision is included to establish any additional quality assurance program provisions for preclosure operations and to establish that such provisions should be implemented prior to commencement of startup activities and startup testing.

- Confirmation is provided to: (i) commit to continued implementation of the quality assurance program for any design or site modification or construction activities that occur during preclosure, and (ii) commit that the preoperational test program or an acceptable alternative will continue to be applied during preclosure following site modification or construction activities.

- Indoctrination, training, and qualification programs are established such that:

  — Personnel responsible for performing quality-affecting activities are instructed as to the purpose, scope, and implementation of quality-related manuals, instructions, and procedures;

  — Personnel verifying activities affecting quality are trained and qualified in the principles, techniques, and requirements of the activity being performed;

  — For formal training and qualification programs, documentation includes the objective, content of the program, attendees, and date of attendance;

  — Proficiency tests are given to personnel performing and verifying activities affecting quality, and acceptance criteria are developed to determine if individuals are properly trained and qualified;

  — A certificate of qualifications clearly delineates: (i) the specific functions personnel are qualified to perform and (ii) the criteria used to qualify personnel in each function;

  — Proficiency of personnel performing and verifying activities affecting quality is maintained by retraining, reexamining, and/or recertifying as determined by management or program commitment;

  — Appropriate management personnel monitor the performance of individuals involved in activities affecting quality and determine the need for retraining. A system of annual appraisal and evaluation can satisfactorily accomplish this;

  — Qualified personnel, when required, are certified in accordance with applicable codes and standards; and

  — For the qualification of inspection and test personnel, Appendix 2A–1 of NQA–1–1983, Nonmandatory Guidance on the Qualification of Inspection and Test Personnel (ASME, 1983), provides guidance. The provisions of appendix 2A–1 (or acceptable alternatives) must be met as part of Supplement 2-1, Supplementary Requirements for the Qualification of Inspection and Test Personnel.

- A readiness review program has been established and procedures are in place to assure that it is executed at appropriate major milestones to complement the inspection program.

- Provisions are established that effectively demonstrate through a matrix system or alternative means that each criterion of 10 CFR 63.142 is properly documented, described, and addressed by implementing procedures and/or instructions.

AC3 The activities related to design control are acceptable provided that:

- The scope of the design control program includes design activities associated with the preparation and review of design documents, including the correct translation of applicable regulatory requirements and design bases into design, procurement, and procedural documents. Included in the scope are such activities as field design engineering; physics (including criticality physics), seismic, stress, thermal, and hydraulic analyses; radiation shielding; compatibility of materials; delineation of acceptance criteria for inspections and tests; the SAR accident analyses; associated computer software; features to facilitate decontamination; suitability and compatibility of materials; accessibility for in-service inspection, maintenance, and repair; and quality standards.

- The term “design” includes specifications; drawings; design criteria; design bases; SSC performance requirements for preclosure; and natural and engineered barriers of the repository system. It also includes inputs and outputs at each stage of design development (e.g., from conceptual design to final design). Design information and design activities also refer to data collection and analyses and computer software that is used in supporting design development and verification. Design information and activities include general plans and detailed procedures for data collection and analyses and related information such as test and analyses results. Data analyses include the initial step data reduction, as well as broad system analyses (such as performance assessments), that integrate other data and analyses for individual parameters.

- The design control program provides for the correct translation of applicable regulatory requirements and design bases into design, procurement, and procedural documents.

- Measures are established to assure that applicable regulatory requirements, design bases, and design features developed through the site characterization phase activities for SSCs and software are correctly translated into specifications, drawings, instructions, and plans.

- Design control measures are established and are applied to: (i) the design of SSCs that are important to safety, (ii) engineered and natural barriers that are important to waste isolation, (iii) the description of the geologic setting and the plans for data collection and analysis activities that will generate information pertinent to the repository design and that will be relied on in licensing and performance confirmation, and (iv) computer software used in such activities. These design measures must apply to the design inputs, outputs, and site characterization activities and performance confirmation activities.

- Organizational responsibilities are described for preparing, reviewing, approving, and verifying design documents such as system descriptions, design input and criteria, design drawings, design analyses, related computer software, specifications, and procedures.

- Errors and deficiencies in approved design documents, including design methods (such as computer software), that could adversely affect SSCs important to safety or waste isolation are documented, and action is taken to assure that all errors and deficiencies are corrected.

- Deviations from specified quality standards are identified and formally documented, and procedures are established to assure their control.

- Internal and external design interface controls, procedures, and lines of communication among participating design organizations and across technical disciplines are established and described for the review, approval, release, distribution, and revision of documents involving design interfaces to assure that SSCs are compatible geometrically, functionally, and with processes and environment.

- Procedures are established and described, requiring a documented check to verify the dimensional accuracy and completeness of design drawings and specifications.

- Procedures are established and described requiring that design drawings and specifications be reviewed by the quality assurance organization to assure that the documents: (i) are prepared, reviewed, and approved in accordance with DOE procedures; and (ii) contain the necessary quality assurance requirements such as inspection and test requirements, acceptance requirements, and the extent to which inspection and test results are required to be documented.

- Guidelines or criteria are established and described for determining the method of design verification (e.g., design review, alternate calculations, or tests).

- Procedures are established and described for design verification activities that assure the following:

  — The verifier is qualified and is not directly responsible for the design (i.e., neither the performer nor his/her immediate supervisor). In exceptional circumstances, the designer's immediate supervisor can perform the verification provided: the supervisor is the only technically qualified individual; the need is individually documented and approved in advance by the supervisor's management; and that quality assurance audits cover frequency and effectiveness of the use of supervisors as design verifiers to guard against abuse.

  — Design verification, if other than by qualification testing of a prototype, is completed prior to release: (i) for procurement, manufacturing, or construction; or (ii) to another organization for use in other design activities. In cases where this timing cannot be satisfied, the design verification may be deferred, providing that the justification for this action is documented and the unverified portion of the design output document and all design output documents, based on the unverified data, are appropriately identified and controlled. Construction site activities associated with a design or design change should not proceed without verification past the point where the installation would become irreversible (i.e., require extensive demolition and rework). In all cases, the design verification must be complete prior to waste package placement in the repository, or prior to reliance on the structure, system, or component to perform its function.

— Procedural control is established for design documents that reflect the commitments of the SAR; this control differentiates between documents that receive formal design verification by interdisciplinary or multiorganizational teams and those that can be reviewed by a single individual (a signature and date is acceptable documentation for personnel certification). Design documents subject to procedural control include, but are not limited to, specifications, calculations, associated computer software, system descriptions, parts of the SAR when used as a design document, and drawings, including flow diagrams, piping and instrument diagrams, control logic diagrams, electrical single line diagrams, structural systems for major facilities, site arrangements, and equipment locations. Specialized reviews should be used when uniqueness or special design considerations warrant.

— The responsibilities of the verifier, the areas and features to be verified, the pertinent considerations to be verified, and the extent of documentation are identified in procedures.

- The following provisions are included if the design verification method is by test only:

  — Procedures provide criteria that specify when verification should be by test.

  — Prototype, component, or feature testing is performed as early as possible prior to installation of facility equipment, or prior to the point when the installation would become irreversible.

  — Verification by test is performed under conditions that simulate the full range, including the most adverse anticipated, design conditions as determined by analysis.

- Procedures are established to assure that verified computer software is certified for use in design and that such use is specified.

- Design and specification changes, including field changes, are subject to the same design controls that were applicable to the original design.

- Measures are provided to assure that responsible repository site personnel are notified of design changes/modifications that may affect performance of their duties.

- Sampling: The basis, including any supporting analyses, for the use of sampling plans for SSCs and barriers and activities related thereto such as inspection and commercial grade item dedication is required to be documented. The following apply for the use of sampling plans: (i) sampling plans used for high safety/risk significant activities are expected to use criteria that provide 95 percent confidence that there are only 5 percent defective items in a lot (95/5), (ii) reduced sampling plans may be used for low safety/risk significance activities, and (iii) lots sampled are essentially homogenous.

- The applicable change control requirements of 10 CFR 63.44 are described.

- Procedures are established describing methods of reviewing and qualifying data used in design that were collected without a fully implemented 10 CFR Part 63 quality assurance program [NUREG–1298 (NRC, 1987)].

AC4 The activities related to procurement document control are acceptable provided that:

- Procedures are established for the review of procurement documents to determine that quality requirements are correctly stated, inspectable, and controllable; there are adequate acceptance and rejection criteria; and procurement documents have been prepared, reviewed, and approved in accordance with quality assurance program requirements. To the extent necessary, procurement documents should require contractors and subcontractors to provide an acceptable quality assurance program. The review and documented concurrence of the adequacy of quality requirements stated in procurement documents is performed by independent personnel trained and qualified in quality assurance practices and concepts.

- Procedures are established to assure that procurement documents include a statement of work to be performed by the contractor and identify requirements such as: (i) applicable regulatory, design, technical, administrative, and reporting requirements; (ii) drawings; (iii) specifications; (iv) codes and industry standards; (v) test and inspection and acceptance requirements; (vi) access for audit or inspection by the purchaser; (vii) identification of documentation to be submitted to the purchaser or retained by the supplier (including any retention times); (viii) requirements for reporting and disposition of nonconformances; and (ix) special process instructions that should be complied with by suppliers.

- Organizational responsibilities are described for: (i) procurement planning; (ii) the preparation, review, approval, and control of procurement documents; (iii) supplier selection; (iv) bid evaluations; and (v) review and concurrence of supplier quality assurance programs prior to initiation of activities affected by the program. The involvement of the quality assurance organization is described.

AC5 The activities related to instructions, procedures, and drawings are acceptable provided that:

- Organizational responsibilities are described for ensuring that activities affecting quality are: (i) prescribed by documented instructions, procedures, and drawings; and (ii) accomplished through implementation of these documents.

- Procedures are established to assure that instructions, procedures, and drawings include quantitative (e.g., dimensions, tolerances, operating limits) and qualitative (e.g., workmanship samples) acceptance criteria for determining that important activities have been satisfactorily accomplished.

- Procedures are established for controlling changes to field and laboratory procedures associated with exploratory investigations for site characterization and performance confirmation to assure that such changes are subsequently documented and verified in a timely manner by authorized personnel.

AC6 The activities related to document control are acceptable provided that:

- The scope of the document control program is described, and the types of controlled documents are identified. Controlled documents are required to include, as a minimum, design documents (e.g., calculations, drawings, specifications, analyses), including documents related to computer software; procurement documents; instructions and procedures for such activities as fabrication, construction, modification, installation, testing, and inspection; as-built documents; quality assurance and quality control manuals and quality-affecting procedures; SARs; nonconformance/deficiency reports; and corrective action reports, including changes thereto.

- Procedures for the review, approval, and issuance of documents and changes thereto are established and described to assure technical adequacy and inclusion of appropriate quality requirements prior to implementation. The quality assurance organization, or an individual other than the one who generated the document but qualified in quality assurance, reviews and concurs with these documents with respect to quality assurance-related aspects.

- Procedures are established to assure that changes to documents are reviewed and approved by the same organizations that performed the initial review and approval or by other qualified responsible organizations delegated by DOE.

- Procedures are established to assure that documents are available at the location where the activity will be performed prior to commencing the work.

- Procedures are established and described to assure that obsolete or superseded documents are removed and replaced by applicable revisions in work areas in a timely manner.

- A master list or equivalent document control system is established to identify the current revision of instructions, procedures, specifications, drawings, and procurement documents. When such a list is used, it should be updated and distributed to predetermined responsible personnel.

- Procedures are established and described to provide for the preparation of as-built drawings and related documentation in a timely manner to accurately reflect the actual repository design.

- Maintenance, modification and inspection procedures are reviewed by qualified personnel knowledgeable in the quality assurance discipline (normally the quality assurance organization) to determine: (i) the need for inspection, identification of inspection personnel, and documentation of inspection results; and (ii) that the necessary inspection requirements, methods, and acceptance criteria have been identified.

AC7 The activities related to control of purchased material, equipment, and services are acceptable provided that:

- Organizational responsibilities are described for the control of purchased material, equipment, software, and services including interfaces between design, procurement, and quality assurance organizations.

- Verification of suppliers' activities during fabrication, inspection, testing, and shipment of material, equipment, and components is planned and performed with quality assurance organization participation in accordance with written procedures to assure conformance to the purchase order requirements. These procedures, as applicable to the method of procurement, provide for:

  — Specification of the characteristics or processes to be witnessed, inspected, or verified, and accepted; the method of surveillance and the extent of documentation required; and individuals responsible for implementing these procedures; and

  — Audits, surveillance, or inspections that assure that the supplier complies with the quality requirements. The quality assurance program requires that the effectiveness of quality control by contractors and subcontractors be assessed.

- Selection of suppliers is documented, filed, and maintained as a record.

- Procurement of spare or replacement parts for SSCs and parts thereof important to safety and engineered barriers important to waste isolation are subject to present quality assurance program controls, codes and standards, and technical requirements equal to or better than the original technical requirements, or as required to preclude repetition of defects.

- Receiving inspection is performed to assure that:

  — Material, components, and equipment are properly identified in correspondence to identification on purchase documents and receiving documentation.

- Material, components, equipment, and acceptance records satisfy inspection instructions prior to installation or use.

- Specified inspection, testing, and other records (such as certificates of conformance attesting that the material, components, and equipment conform to specified requirements) are available at the facility prior to installation or use.

• Items accepted and released are identified as to their inspection status prior to forwarding them to a controlled storage area or releasing them for installation or further work.

• The supplier furnishes the following records to the purchaser:

- Documentation that identifies the purchased item and the specific procurement requirements (e.g., codes, standards, and specifications) met by the item.

- Documentation identifying any procurement requirements that have not been met.

- A description of nonconformances from the procurement requirements that are dispositioned “accept as is” or “repair.”

The review and acceptance of these documents should be described in the purchaser's quality assurance program.

• Commercial Grade Item Dedication: For commercial “off-the-shelf” items where specific quality assurance controls appropriate for nuclear applications cannot be imposed in a practicable manner, special quality verification requirements must be established and described to provide the necessary assurance of an acceptable item by the purchaser.

For procurement of commercial grade items, Section 10, Commercial Grade Items, of Supplement 7S–1 of NQA–1–1983, Supplementary Requirements for Control of Purchased Items and Services (ASME, 1983), does not adequately address commercial grade item dedication. The guidance provided in this acceptance criteria should be used for commercial grade item dedication.

Where DOE elects to purchase commercial grade items and dedicate the items for use as basic components, as permitted by the requirements contained in 10 CFR Part 21, the quality assurance program must provide for the following to assure that the dedicated item will perform its intended safety or waste-isolation function:

- When applied to facilities licensed pursuant to 10 CFR Part 63, commercial grade item means an item that is: (i) not subject to design or specification requirements that are unique to that facility or activities, (ii) used in applications other than that facility or activities, and (iii) to be ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published product description (e.g., catalog). This definition must meet the requirements specified in 10 CFR Part 21.

— Important terms having specific meaning that are used in the dedication process, such as "critical characteristics," "dedication," "dedicating entity," "commercial grade item," etc., are defined. DOE should use the following definitions when dedicating commercial grade items for use as basic components (it is noted that additional definitions such as "commercial grade survey" may also need to be defined):

  – "Critical characteristics" are those important design, material, and performance characteristics of a commercial grade item that, once verified, will provide reasonable assurance that the item will perform its intended safety or waste-isolation function.

  – "Dedicating entity" means the organization that performs the dedication process. Dedication may be performed by the manufacturer of the item, a third-party dedicating entity, or DOE itself. The dedicating entity pursuant to 10 CFR 21.21(c) is responsible for identifying and evaluating deviations, reporting defects and failures to comply for the dedicated item, and maintaining auditable records of the dedicating process.

  – "Dedication" is an acceptance process undertaken to provide reasonable assurance that a commercial grade item to be used as a basic component will perform its intended safety or waste-isolation function and, in this respect, is deemed equivalent to an item designed and manufactured under a 10 CFR Part 63, subpart G, quality assurance program. This assurance is achieved by identifying the critical characteristics of the item and verifying their acceptability by inspection, tests, or analyses performed by a purchaser or third-party dedicating entity after delivery, supplemented as necessary by one or more of the following: commercial grade surveys; product inspections or witnessing at hold points at the manufacturer's facilities; and analyses of historical records for acceptable performance. In all cases, the dedication process should be conducted in accordance with the applicable requirements of 10 CFR Part 63, subpart G. Final dedication of an item occurs after receipt and final acceptance by DOE or its contractor when the item is designated for use as a basic component.

If these definitions are used, DOE commits to comply with all of the provisions associated with the definitions.

Additional definitions are contained in 10 CFR 21.3 that are specifically applicable to 10 CFR Part 63 and are required to be applied to DOE commercial grade item dedication activities.

It is preferred that the above definitions be used. However, additional definitions and guidance for commercial grade item dedication are provided in Electric Power Research Institute (1988), NP–5652, as endorsed by NRC Generic Letter 89-02 (NRC, 1989) and Generic Letter 91-05 (NRC, 1991). Although these documents are applicable for 10 CFR Part 50 licensees, certain elements of these documents may be appropriate for 10 CFR Part 63 commercial grade item dedication activities.

Sampling plans used for commercial grade item dedication activities are required to satisfy the requirements for sampling under AC3 of this section.

- Suppliers' certificates of conformance are periodically evaluated by audits, independent inspections, or tests to assure that they are valid, and the results are documented.

- The quality assurance program describes the responsibilities for and requires instructions and procedures for accepting services such as third-party audits and inspections; engineering and consulting services; installation, repair, overhaul, or maintenance work; commercial grade item dedication; and testing. It may be necessary for the acceptance methods to include one or more activities similar to the following: (i) technical verification of data; (ii) surveillance, auditing, or source inspection; and (iii) review of certifications and reports from approved suppliers.

- For the purchase of ASME Section III Code items, NRC considers the referenced edition of NQA–1 in the endorsed versions of the Code to be acceptable only for the construction of ASME Section III items when the referenced edition of NQA–1 is used in conjunction with the other quality assurance, administrative, and reporting requirements contained in the ASME Section III Code. Further, applicable provisions contained in the DOE quality assurance program and requirements contained in the regulations also need to be met and must be used in conjunction with the ASME Section III Code.

- For audits of ASME Section III Code suppliers, NRC Information Notice 86-21 and its two supplements discusses the NRC recognition of the ASME accreditation program for N Stamp Holders, and the guidance provided therein should be used by DOE.

AC8 The activities related to identification and control of materials, parts, and components (including samples) are acceptable provided that:

- Controls are established and described to identify and control materials (including consumables), software, parts, and components, including samples and partially fabricated subassemblies. The description should include organizational responsibilities.

- Procedures are established that assure identification is maintained either on the item, software, or sample or in records traceable to them to preclude use of incorrect or defective items.

- Identification of materials and parts important to the function of SSCs important to safety can be traced to the appropriate documentation such as drawings, specifications, purchase orders, technical reports, drilling locations and logs (including well bore and depth), test records, installation and use records, manufacturing and inspection documents, deviation reports, and physical and chemical mill test reports.

- Correct identification of materials, parts, and components is verified and documented prior to release for fabrication, assembling, shipping, and installation.

- Correct identification of samples is verified and documented before release for use or analysis.

- Procedures are established for providing traceability of items (when required by codes, standards, or specifications) to: (i) applicable specification and grade of material; (ii) heat, batch, lot, part, or serial number; and (iii) specified inspection, test, or other records such as drawings, purchase orders, deviation reports, or reports of nonconformance and their disposition.

- Responsibilities are assigned and procedures or instructions are issued for maintaining identification of items in prolonged storage or storage under adverse conditions by: (i) protecting markings and identification records of items in storage from deterioration due to environmental exposure or adverse storage conditions, and (ii) restoring or replacing markings or identification records that are damaged due to aging or storage conditions.

- Responsibilities are assigned and procedures or instructions are issued for: (i) identifying items with limited calendar or operating life cycles; (ii) establishing records of shelf life or operating life or cycles remaining; (iii) preventing the use of items whose shelf life has expired; and (iv) preventing further use of items, components, or materials that have reached the end of their operating life or cycle.

- Controls are established to preclude the inadvertent use of incorrect or defective items, software, or samples.

AC9 The activities related to control of special processes are acceptable provided that:

- The criteria for determining those processes that are controlled as special processes are described. As complete a listing as possible of special processes, which are generally those processes where direct inspection is impossible or disadvantageous, should be provided. Examples of special processes include welding, heat treating, nondestructive examination, and chemical cleaning.

- Organizational responsibilities including those for the quality assurance organization are described for qualification of special processes, equipment, and personnel.

- Procedures, equipment, and personnel associated with special processes are qualified and are in conformance with applicable codes, standards, procedures, and specifications. The quality assurance organization is involved in the qualification activities to assure they are satisfactorily performed.

- Procedures are established for recording evidence of acceptable accomplishment of special processes using qualified procedures, equipment, and personnel.

- Qualification records of procedures, equipment, and personnel associated with special processes are established, filed, and maintained to be current.

- When no applicable codes, standards, or specifications address methods for qualifying special processes associated with scientific investigations, the following methods may be considered: (i) the conducting of a prototype test, if possible, that demonstrates that the process maintains quality or produces a quality product; and (ii) a combination of methods such as peer reviews, technical reviews, models, and testing that provides reasonable assurance that the process maintains quality or produces a quality product.

  In all cases, measures are established to assure that special processes associated with scientific investigations are controlled and accomplished by qualified personnel using qualified procedures.

- Special processes associated with NDE should be performed in accordance with ASNT–TC–1A (American Society for Nondestructive Testing, 1980). In all cases, the qualification and certification of NDE personnel includes a performance demonstration as part of the practical examination. In lieu of the 3-year recertification interval specified in ASNT–TC–1A, Level III nondestructive examination personnel may be recertified on a 5-year interval.

AC10 The activities related to inspection are acceptable provided that:

- The scope of the inspection program is described that indicates that an effective inspection program has been established for verifying conformance of items or activities to specified requirements. Program procedures provide criteria for determining the accuracy requirements of inspection equipment and criteria for determining when inspections are required and defining how and when inspections are performed. The quality assurance organization participates in the above functions.

- Organizational responsibilities for inspection are adequately described. Individuals performing inspections are other than those who performed or directly supervised the activity being inspected and do not report directly to the immediate supervisors who are responsible for the activity being inspected. If the individuals performing inspections are not part of the quality assurance organization, the inspection procedures, personnel qualification criteria, and independence from undue pressure such as cost and schedule should be reviewed and found acceptable by the quality assurance organization prior to the initiation of the activity.

- A qualification program for inspectors (including nondestructive examination personnel) is established and documented, and the qualifications and certifications of inspectors are maintained to be current.

- Inspection procedures, instructions, or checklists provide for the following: identification of characteristics and activities to be inspected; description of the method of inspection; identification of the individuals or groups responsible for performing the inspection operation in accordance with the provisions of the second bullet under this acceptance criteria; acceptance and rejection criteria; identification of required procedures, drawings, specifications, and revisions thereof; records of the identity of the inspector or data recorder and the results of the inspection operation; and specification of necessary measuring and test equipment including accuracy requirements.

- Procedures are established and described to identify, in pertinent documents, mandatory inspection hold points beyond which work may not proceed until inspected by a designated inspector.

- Inspection results are documented and evaluated, and their acceptability is determined by a responsible individual or group.

- When inspections associated with normal operations of the site (e.g., routine maintenance, surveillance, tests) are performed by individuals other than those who performed or directly supervised the work, but are within the same group, the following controls are required: (i) the qualification criteria for the inspection personnel are reviewed and found acceptable by the quality assurance organization prior to initiating the inspection, and (ii) the quality of the work can be objectively demonstrated through a functional test when the activity involves breaching a pressure-retaining item.

- Sampling plans used for inspection activities are required to meet the requirements for sampling under AC3 of this section.

AC11 The activities related to test control are acceptable provided that:

- The scope of the test control program is described that indicates that an effective program has been established for testing activities for verifying conformance of items or activities to specified requirements and demonstrating that items will perform satisfactorily in service. The test control program encompasses, but is not limited to, such testing activities as: acquiring data from samples, prototype qualifications tests, production tests, proof tests prior to installation, preoperational tests, tests supporting site characterization, tests supporting scientific investigations, tests of software, construction phase tests, and operational tests. Program procedures provide criteria for determining the accuracy requirements of test equipment and criteria for determining when tests are required and defining how and when testing activities are performed. Tests must be performed in accordance with written test procedures that identify test acceptance criteria and that incorporate, as appropriate, requirements and acceptance limits contained in applicable design documents.

- Test procedures or instructions provide, as required, for the following:

  — The requirements and acceptance limits contained in applicable design and procurement documents;

  — Instructions for performing the test;

  — Test prerequisites such as calibrated instrumentation, adequate test equipment and instrumentation including their accuracy requirements, completeness of item to be tested, suitable and controlled environmental conditions, and provisions for data collection and storage;

  — Mandatory inspection hold points for witnessing by DOE, contractor, or inspector (as required);

  — Acceptance and rejection criteria; and

  — Methods of documenting or recording test data and results, and provisions for ensuring that test prerequisites have been met.

- Test results, including computer software and supporting data, are documented and evaluated, and their acceptability is determined by a responsible individual or group.

AC12 The activities related to control of measuring and test equipment are acceptable provided that:

- The scope of the program for the control of measuring and test equipment is adequately described and the types of equipment to be controlled are established.

- Responsibilities of quality assurance and other organizations are adequately described for establishing, implementing, and ensuring effectiveness of the calibration program.

- Procedures are established and described in sufficient detail for calibration (technique and frequency), maintenance, and control of the measuring and test equipment (instruments, tools, gages, fixtures, reference and transfer standards, and nondestructive test equipment) that is used in the measurement, inspection, and monitoring of SSCs. The review and documented concurrence of these procedures is described and the organization responsible for these functions is identified.

- Measuring and test equipment is identified and traceable to the calibration test data.

- Measuring and test equipment is labeled or tagged or “otherwise controlled” to indicate the due date of the next calibration, and such methods of control should be adequately described.

- Measuring and test equipment is calibrated at specified intervals based on the required accuracy, purpose, degree of usage, stability characteristics, and other conditions affecting the measurement. Calibration of this equipment should be against standards that have an accuracy of at least four times the required accuracy of the equipment being calibrated or, when this is not possible, that have an accuracy that assures that the equipment being calibrated will be within required tolerance. The basis of acceptance is documented and authorized by responsible management. The management authorized to perform this function is identified.

- Calibration standards have greater accuracy than the standards being calibrated. Calibration standards with the same accuracy may be used if this level of accuracy can be demonstrated to be adequate for the requirements and provided that the basis of acceptance is documented and authorized by responsible management. The management authorized to perform this function is identified.

- Reference and transfer standards are traceable to nationally recognized standards. Where national standards do not exist, provisions are established to document the basis for calibration.

- When measuring and test equipment is found to be out of calibration, measures are taken and documented to determine the validity of previous inspections performed and the acceptability of items inspected or tested since the last calibration. Inspections or tests are repeated on items determined to be suspect.

- Procedures are established for selecting measuring and test equipment for use in processes, inspections, and tests that: (i) is of the type appropriate for measuring specified characteristics of items being processed, inspected, or tested; and (ii) has sufficient range, accuracy, and tolerance to determine conformance to specified requirements.

AC13 The activities related to handling, storage, and shipping are acceptable provided that:

- Special handling, preservation, storage, cleaning, packaging, and shipping requirements and procedures are established and accomplished by suitably trained and, when appropriate, qualified individuals in accordance with predetermined work and inspection instructions.

- Procedures are established and described to control the cleaning, handling, storage, packaging, and shipping of items, samples, materials, components, and systems in accordance with design and procurement requirements to preclude damage, loss, or deterioration due to environmental conditions such as temperature or humidity.

- Provisions are described for the storage (including the control of shelf life) of chemicals, reagents, lubricants, and other consumable materials.

- Provisions are described for identifying special handling tools and equipment that are required for safe handling of items. Provisions are established for inspection and testing of such tools and equipment, including specification of procedures to be implemented at specified intervals to verify that such tools and equipment are adequately maintained.

- Provisions are described for marking or labeling items being shipped, handled, or stored, for the purpose of identifying the items and any special environments or controls required by such items.

AC14 The activities related to inspection, test, and operating status are acceptable provided that:

- Procedures are established to indicate the inspection, test, and operating status of SSCs and software throughout fabrication, installation, testing, and operation.

- The status of inspection, test activities, and software controls should be identified either on the items or in documents traceable to the items where it is necessary to assure that required inspections and tests are performed and to assure that items which have not passed the required inspections and tests are not inadvertently installed, used, or operated.

- Inspection, test, and operating status of SSCs and software should be identified by status indicators, such as physical location tags, markings, labels, travelers, stamps, inspection records, or other suitable means.

- Procedures and authority are established and described to control the application and removal of inspection and welding stamps and status indicators such as those listed in previous bullet.

- Procedures are established and described to control alteration of the sequence of required tests, inspections, and other operations important to waste isolation or important to safety. Such actions should be subject to the same controls as the original review and approval.

- The status of nonconforming, inoperative, or malfunctioning SSCs is documented and identified to prevent inadvertent use. The organization responsible for this function is clearly identified.

- Procedures are established to prevent inadvertent use or operations of a structure, system, or component that is out of service by indicating its operating status by the use of tags or markings on control panels, switches, breakers, and other locations where its use or operation can be initiated.

AC15 The activities related to nonconforming materials, parts, or components are acceptable provided that:

- Procedures are established and described for identification, documentation, segregation, review, disposition, and notification to affected organizations of nonconforming materials, parts, SSCs, and services (as applicable), including computer software, if disposition is other than disposal. The procedures provide identification of authorized individuals for independent review of nonconformances, including disposition and closeout.

- Procedures are established for preventing the inadvertent use or installation of nonconforming items.

- Quality assurance and other organizational responsibilities are described for the definition and implementation of activities related to nonconformance control, including identification of individuals or groups with authority for the disposition of nonconforming items.

- Documentation identifies the nonconforming item; describes the nonconformance, the disposition of the nonconformance, and the inspection requirements; and includes signature approval of the disposition. Nonconformances are corrected or resolved prior to the initiation of the preoperational test program on the item.

- Reworked, repaired, and replacement items are inspected and tested in accordance with the original inspection and test requirements or acceptable alternatives. Design control measures commensurate with those applied to the original design are applied when dispositioning nonconformance as “use-as-is” or “repair,” and the technical basis for such dispositions are documented.

- Nonconformance reports are periodically analyzed by the quality assurance organization to show quality trends, and the significant results are reported to upper management for review and assessment.

- Items reworked or repaired are retested or reinspected against the original acceptance criteria unless the disposition of the nonconforming item established alternate acceptance criteria. (If the latter is the case, then a design change may be required to support the disposition.)

AC16 The activities related to corrective action are acceptable provided that:

- Procedures are established and described indicating an effective corrective action program has been established. The quality assurance organization reviews and documents concurrence with the procedures.

- Corrective action is documented and initiated following the determination of a condition adverse to quality, such as a nonconformance, failure, malfunction, deficiency, deviation, or defect in material, equipment, or samples, and procedures and records are established to preclude recurrence. Conditions adverse to quality should be identified promptly and corrected as soon as practical. The quality assurance organization is involved in the documented concurrence of the adequacy of the corrective action. Followup action is taken by the quality assurance organization to verify proper implementation of corrective action and to close out the corrective action in a timely manner.

- Significant conditions adverse to quality, the cause of the conditions, and the corrective actions taken to preclude repetition are documented and reported to immediate management and upper levels of management for review and assessment.

- A program for determining adverse quality trends is established and includes: (i) evaluation of nonconformance and other related documents to identify adverse quality trends and assist in identifying root causes, (ii) prompt identification of adverse trends, and (iii) prompt reporting of adverse trends to management.

- Significant conditions adverse to quality include repetitive conditions that are less significant, but when taken collectively: (i) indicate a programmatic failure to properly implement the quality assurance program, (ii) may be precursors for a significant technical deficiency or problem, or (iii) may reduce the margin of safety.

  In addition, significant conditions adverse to quality also include, but are not limited to: (i) loss of or potential loss of a safety or waste-isolation function to the extent that there is a reduction in the degree of protection provided to the public health and safety, (ii) loss or potential loss of a safety or waste-isolation function to the extent that there is a major reduction in the degree of protection provided for worker safety, (iii) programmatic or technical adverse quality trends, (iv) common cause failures, and (v) adverse trends.

AC17 The activities related to quality assurance records are acceptable provided that:

- Quality assurance records that furnish documentary evidence of quality must be specified, prepared and maintained. These records must be legible, identifiable and retrievable. Requirements and responsibilities for quality assurance record transmittal, distribution, retention, maintenance, and disposition must be established and documented.

- The scope of the quality assurance records program is described. Quality assurance records include scientific, engineering, and operational data and logs; results of reviews, inspections, tests, audits, and material analyses; monitoring of work performance; maintenance and modification procedures and related inspection results; reportable occurrences; computer software; qualification of personnel, procedures, and equipment; and other documentation such as design records, drawings, specifications, procurement documents, calibration procedures and reports, design review reports, peer review reports, nonconformance reports, corrective action reports, as-built drawings, and other records required by preclosure and postclosure operating conditions.

- Quality assurance and other organizations are identified and their responsibilities are described for the definition and implementation of activities related to quality assurance records, particularly in the retention and duration of record storage.

- Criteria are established and described in procedures for determining when a document becomes a quality assurance record, subject to the controls of this section, and the retention period for such records.

- Procedures are established describing methods for documenting/recording, reviewing, and confirming the accuracy of quality assurance records, including laboratory and field notebooks and logbooks, data sheets, data reduction documents, and software.

- Inspection and test records contain the following, where applicable: a description of the type of observation; date and results of the inspection or test; information related to conditions adverse to quality; identification of inspector or data recorder; evidence as to the acceptability of the results; and action taken to resolve any discrepancies noted.

- Provisions are made for the disposition of quality assurance records, including: ensuring that disposition of records is governed by the most stringent regulatory requirements that apply to records (this may be an agency other than NRC); ensuring that suppliers' nonpermanent records are properly controlled and retained for required periods; and ensuring that quality assurance records are protected against damage, deterioration, or loss.

- Suitable controls are established and described for controlling, protecting, and maintaining quality assurance records before they are entered and stored in a quality assurance record storage area.

- Suitable facilities for the storage, preservation, and safekeeping of quality assurance records are described and satisfy the provisions contained in Section 4, Storage, Preservation, and Safekeeping, of Supplement 17S–1 of NQA–1–1983 (ASME, 1983), Supplementary Requirements for Quality Assurance Records.

- Guidance for storing quality assurance records using electronic media is provided in Generic Letter 88-18 (NRC, 2000), supplement 1.

- The additional records provisions referenced in subsection 4.5.1.5 of the YMRP are described.

- For quality assurance records, Section 2.8, Retention of Records, of Supplement 17S–I of NQA–1–1983 (ASME, 1983), Supplementary Requirements for Quality Assurance Records, states that the retention period for nonpermanent records is required to be established in writing. Programmatic nonpermanent records should be retained for at least 10 years or the life of the item if less than 10 years. For programmatic nonpermanent records, the retention period should be considered to begin upon completion of the activity. For product nonpermanent records generated prior to facility licensing, the retention period should be considered to begin upon completion of delivery. In addition, product and programmatic nonpermanent records should be retained at least until the date of the start of preclosure site operational activities. Table 1 of Regulatory Guide 1.28, Revision 3 (NRC, 1985), provides a list of nonpermanent and lifetime records and their respective retention times. Records similar to those identified in table 1 of Regulatory Guide 1.28 are required to be maintained for the repository for the durations identified. Although table 1 is intended to be a comprehensive list, it is the responsibility of DOE to assure itself, in accordance with the Records section of 10 CFR 63.142, that sufficient records are maintained to furnish evidence of activities affecting quality. Table 1 is not applicable for preoperational test or operational phase records at this time because the final design and operating practices have not been developed. Further, table 1 does not address site characterization records. It should be recognized that the nomenclature of these records may vary. For records not listed in table 1, the type of record most nearly describing the record in question should be followed with respect to its retention period. The following definitions apply to the records:

— Programmatic nonpermanent records are those documents that were used to prescribe activities affecting quality but that are not considered permanent records. Such records include documents prescribing the planning, execution, and auditing of activities affecting quality. Records such as audit checklists, audit results, and actual examinations used to qualify inspection and test personnel are included in this category.

— Product nonpermanent records document that specific SSCs of the repository site have been designed and constructed in accordance with applicable requirements but are such that is it not necessary to retain them as lifetime records. These records include design, verification data, receiving records, calibration records, maintenance records, inspection records, radiographs not associated with in-service inspection, and test records that are not otherwise designated as lifetime records.

- This acceptance criteria (i.e., AC17 relating to quality assurance records) may be updated to address records for site characterization, preoperational testing, and operations. This update is contingent upon the level of detail of records included in the DOE quality assurance program for these activities. [NOTE: potential licensing condition.]

AC18 The activities related to audits are acceptable provided that:

- Responsibilities and procedures are established for audits, for documenting and reviewing audit results, and for designating management levels to review and assess audit results.

- Internal and external audits to assure that procedures and activities comply with all aspects of the overall quality assurance program are performed by:

  — The quality assurance organization to provide a comprehensive independent verification and evaluation of quality-related procedures and activities.

  — DOE (and principal contractors) to verify and evaluate the quality assurance programs, procedures, and activities of suppliers. NOTE: Internal and external audits are carried out by DOE and its contractors to verify that products, services, and activities comply with all aspects of the overall quality assurance program and to determine the effectiveness of the quality assurance program. DOE and its contractors should perform audits of the prime contractor and subcontractors, consultants, vendors, and laboratories.

- The audit program should address planning and performance of audits to: (i) verify compliance with drawings, instructions, specifications, and other requirements affecting quality; and (ii) determine the effectiveness of the quality assurance program.

- An audit plan is prepared identifying audits to be performed, their frequencies, and schedules. Audits should be regularly scheduled based on the status and safety importance of the activities being performed and should be initiated early enough to assure effective quality assurance during design, procurement, manufacturing, construction, installation, inspection, testing, and performance confirmation. For scheduling audits, Section 2, Scheduling, of supplement 18S–1 of NQA–1–1983 (ASME, 1983), Supplementary Requirements for Audits, requires audits to be scheduled in a manner that provides coverage and coordination with ongoing quality assurance program activities. The guidelines provided in Regulatory Position C.3.1, Internal Audits, and C.3.2, External Audits, of Regulatory Guide 1.28, Revision 3 (NRC, 1985), are considered acceptable and should be used for scheduling audits and related audit activities.

- Audits include: (i) an objective programmatic and technical evaluation of quality-related practices, procedures, instructions, activities, and items; and (ii) a review of documents and records, including software and test data from samples. Audits are conducted in order to assure that the abovementioned in (i) and (ii) are acceptable and to assure that the quality assurance program is effective and properly implemented.

- Provisions are established requiring that audits be performed in all areas where the requirements of 10 CFR Part 63, subpart G are applicable. However, the results of the audit process indicate that the following areas have either been omitted or not emphasized to the extent necessary.

  — The determination of site features that affect site safety (e.g., site characterization, performance confirmation, core sampling, site and foundation preparation, and methodology);

  — The preparation, review, approval, and control of early procurements;

  — Indoctrination and training programs;

  — Interface control among DOE and principal contractors;

  — Corrective action, calibration, and nonconformance control systems;

  — SAR commitments;

  — Activities associated with computer software;

  — The purchase of ASME Section III Code items. For the purchase of such items, NRC has only endorsed certain editions and addenda of the ASME Section III Code (ASME, 1998) and in doing so has indirectly endorsed quality assurance standards referenced in the Code. NRC considers the referenced edition of NQA–1 (ASME, 1983) in the endorsed versions of the Code to be acceptable only for the construction of ASME Section III items when the referenced edition of NQA–1 is used in conjunction with the other quality assurance, administrative, and reporting requirements contained in the ASME Section III Code. Applicable provisions contained in the DOE quality assurance program and requirements contained in the regulations also need to be met; and

— Audits of ASME Section III Code suppliers. NRC Information Notice 86-21 (NRC, 1986) discusses the NRC recognition of the ASME accreditation program for N Stamp Holders, and the guidance provided therein should be used by DOE.

- Audit data are analyzed by the quality assurance organization and, as appropriate, the technical staff. The resulting reports describing any quality problems and the effectiveness of the quality assurance program, including the need for an audit of deficient areas, are reported to management for review and assessment.

- Audits are performed in accordance with pre-established written procedures or checklists and are conducted by trained, qualified, competent quality assurance and technical personnel having expertise that encompasses the area being audited. Audit team members must not have been directly involved with the work being audited.

- Where the onsite quality assurance organization does not report to the offsite organization:

  — The offsite quality assurance organization conducts audits sufficient to verify adequacy of activities conducted by the onsite quality assurance organization;

  — The offsite quality assurance organization reviews and concurs in the schedule and scope of audits performed by the onsite quality assurance organization; and

  — Results of audits performed by the onsite quality assurance organization are provided to the offsite quality assurance organization for review and assessment.

- A tracking system for audit findings is established to help assure that all findings are appropriately addressed, prioritized, and trended.

- The audited organization describes in a formal report the corrective action to be taken to address findings. This report is submitted to the auditing organization and responsible management of the audited organization.

- Provisions are established and described to assure that the cause of each finding is identified, resulting corrective action is described, and followup action is accomplished to assure proper closeout of deficiencies.

AC19 The activities related to software are acceptable provided that:

- Software is defined as computer programs, procedures, rules, and associated documentation.

- Software should perform all intended functions, provide correct solutions, and not perform or cause any adverse unintended functions.

- Controls should be established to permit authorized access and prevent unauthorized access to computer systems.

- Software verification and validation activities are planned, documented, and performed for each item of software, software changes, and system configurations that are determined to affect software. Specifically:

  — Software verification of the various software life cycle phases (e.g., the requirement, design, implementation, and testing life cycle phases, as discussed below) is performed to assure that the products of a given life cycle phase are traceable and fulfill the requirements of the previous phase and/or previous phases.

  — Verification reviews identify reviewers and their specific review responsibilities.

  — Software verification and validation activities are performed by individuals not directly involved with the development of the software. In cases where this level of independence may not be achieved, an individual associated with the development of the software may perform these activities with a higher level of management approval and documented justification.

- A plan or similar document addressing software quality assurance is in existence for each new software project at the start of the software life cycle. The plan for software identifies:

  — A description of the overall nature and purpose of the software;

  — The software products to which it applies;

  — The organization responsible for performing the work and achieving software quality and the tasks and responsibilities of that organization;

  — Required documentation;

  — Standards, conventions, techniques, or methodologies that should guide the software activity;

  — Required software reviews; and

  — Methods for error reporting and corrective action.

- The software development and maintenance process should proceed in a planned, traceable, and orderly manner utilizing a defined software life cycle methodology, which should address the following phases:

  — Requirement Phase

  Software requirements such as functionality, performance, design constraints, attributes, and external interfaces are specified, documented, and reviewed.

  — Design Phase

  Software design is developed, documented, and reviewed based on the requirements depicted in the requirements document.

  — Implementation Phase

  The design is translated into source code and resulting executables necessary to perform the functions required.

  The source code and resulting executables should adhere to the design specifications.

  User information is developed, documented, and reviewed in accordance with the design to delineate how the software is to be used.

  — Testing Phase

  Software activities are performed, documented, and verified at the end of the implementation phase to assure that the software installs properly and satisfies the requirements for its intended use.

  Testing to an approved plan or process is the primary method of software validation to assure adherence to requirements and to assure that the software produces correct results for test cases.

  Software validation documentation describes the task and specifies criteria for accomplishing the validation of the software at the end of the development cycle.

  Modifications to released software are subjected to regression testing to detect errors introduced during modification of the software, to verify that modifications have not caused unintended adverse affects, and to verify that modified software still meets specified requirements.

  — Operations and Maintenance Phase

  Upon acceptable validation of the software, the software is designated as baselined and placed under configuration management controls.

— Installation and Checkout Phase

  Software installation and checkout activities are performed and documented when the software is installed on a computer, or when there are changes in the operating system, to assure that the software installs properly and satisfies requirements for its intended use.

— Retirement Phase

  The support for a software product is terminated and use of the software is prevented.

- A software configuration management system should be established that consists of the following:

  — A configuration identification that includes:

    – A definition of the baseline elements of each software baseline;

    – A unique identification of each software item, including version or revision, to be placed under software configuration management; and

    – Assignment of unique identifiers that relate baseline documents to their associated software items. Cross references between baseline documents and associated software should be maintained.

  — A configuration change control that includes:

    – A release and control process for baseline elements;

    – A formal process to control and document changes to baseline elements;

    – A formal evaluation of the baseline element or change to the baseline element, and approval by the organization responsible for approving the baseline element;

    – A process of transmitting information concerning approved changes to all organizations affected by the changes; and

    – A software verification and validation process to assure that software changes are appropriately reflected in software documentation and to assure that document traceability is maintained.

  — A configuration status accounting that includes:

    – A listing of approved baseline elements and unique identifiers;

- The status of proposed, in-process, or approved changes to baseline elements; and
- A history of changes to software items, including descriptions of changes between versions of software items.

• Requirements controlling software procurement and services are established to assure proper verification and validation support, software maintenance, configuration control, and performance of software audits, assessments, or surveys. Requirements for the supplier's reporting of software errors to the purchaser and, as appropriate, the purchaser's reporting of software errors to the supplier are identified.

• Software engineering elements must define the baseline documents that are to be maintained as records.

• Provisions for defect reporting and resolution specify that:

— A software defect reporting and resolution system is implemented for software errors and failures in order to assure that problems are promptly reported to affected organizations and to assure formal processing of problem resolutions.

— If a defect is identified in software that adversely affects previous applications, the condition adverse to quality is documented and controlled in accordance with AC16 of this section.

• Provisions for control of the use of software specify that:

— Affected organizations control and document the use of released software items such that comparable results can be obtained, with any differences explained, through independent replication of the process.

— Use of software is independently reviewed and approved to assure that the software selected is suitable to the problem being solved.

— Documentation for the receipt of software is obtained from software configuration management and maintained for all software in operation or use.

• As applicable, other requirements of the DOE quality assurance program apply to the control of software.

AC20 The activities related to the control of physical samples for activities such as scientific investigations, performance confirmation, material testing, and similar activities are acceptable provided that:

• Identification requirements include the following:

- Samples are identified and controlled in a manner consistent with their intended use.
- Identification is maintained on the samples or in a manner that assures identification is established and maintained.
- Samples are identified from their initial collection through final use.
- Sample identification is documented and checked before release of samples for use.
- Sample identification methods include use of physical markings.
- If physical markings are either impractical or insufficient, other appropriate means should be employed, such as physical separation, labels or tags attached to bags, containers, or procedural control.

• Traceability requirements include the following provisions:

- Sample identification methods assure that traceability is established and maintained from the samples to applicable implementing documents or other specifying documents.
- Sample traceability assures that the sample can be traced at all times from its collection through final use and any post-test retention that may be appropriate.

• Requirements are established to control the physical markings of samples.

- Physical markings are applied using materials and methods that provide clear and legible identification.
- Physical markings do not detrimentally affect sample content or form.
- Physical markings are transferred to each identified sample portion when the sample is subdivided.
- Physical markings are not obliterated or hidden by surface treatments or sample preparations, unless other means of identification are substituted.

• Implementing documents specify the representative samples to be archived if the need to archive samples is identified.

• Handling, storage, and shipping requirements include the following:

- Handling, storage, cleaning, packaging, shipping, and preserving samples are conducted in accordance with established implementing documents or other specified documents.

- — Specific measures for handling, storage, cleaning, packaging, shipping, and preserving are identified and used for critical, sensitive, perishable, or high-value samples.

- — Measures are established for the marking and labeling for packaging, shipping, handling, and storing samples, as necessary, to adequately identify, maintain, and preserve samples.

- — Markings and labels indicate the presence of special environments or the necessity for special controls.

- — Special equipment (e.g., containers) and special protective environments (e.g., inert gas, moisture and temperature limits) should be required for particular samples.

- — Special handling tools and equipment are used and controlled, as necessary, to assure safe and adequate handling.

  Special handling tools and equipment are inspected and tested in accordance with implementing documents and at specified time intervals to verify that the tools and equipment are adequately maintained.

  Experience and training is specified for operators of special handling and lifting equipment.

• Samples that do not meet requirements specified in work controlling documents (such as job packages, travelers, or work requests) are documented, evaluated, and segregated in accordance with AC15 of this section.

• The disposition for nonconforming samples is identified and documented and should be limited to “use-as-is,” “discard,” or, where appropriate, “rework.”

• As applicable, other requirements of the DOE quality assurance program apply to the control of samples.

AC21 The activities related to scientific investigation are acceptable provided that:

• Scientific notebooks include:

- — Statement of objective and description of work performed;

- — Identification of method(s) and computer software used;

- — Identification of samples and measuring and test equipment used;

    — Description of work as it was performed, results obtained, names of individuals performing the work, and dated initials or signatures, as appropriate, of individuals making entries; and

    — Description of changes made to methods used, as appropriate.

- Independent review of scientific notebooks is performed.

- Data are identified in a manner that facilitates traceability to: (i) associated documentation and (ii) qualification status of the data.

- Identification and traceability is maintained throughout the lifetime of the data.

- Requirements for data reduction are described in sufficient detail, to permit independent reproducibility by another qualified individual.

- Data that are directly relied on to address safety or waste-isolation issues must be qualified from origin, classified as accepted data, or undergo an NRC-approved qualification process [e.g., NUREG–1298 (NRC, 1987)].

- Unqualified data directly relied on to address safety or waste-isolation issues must be qualified or it can not be used in the license application.

- Model development and approaches to validation are planned, controlled, and documented.

- Documentation is transparent and identifies principal lines of investigation considered.

- Documentation is legible and in a form suitable for reproduction, filing, and retrieval.

- Computer software used to develop or execute models is qualified in accordance with the requirements under AC19 of this section, and such models are used and validated.

- As applicable, other requirements of the DOE quality assurance program apply to the control of scientific investigations.

- Procedures are established describing methods of reviewing and qualifying data that were collected without a fully implemented 10 CFR Part 63 quality assurance program [NUREG–1298 (NRC, 1987)].

- Procedures are established describing the use of expert elicitation. The procedure complies with NUREG–1563, Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program (NRC,1996) as addressed in section 4.5.4 of this review plan.

AC22 The activities related to field surveys are acceptable provided that:

- The field survey system:
  - Is a permanent system of horizontal and vertical controls;
  - Is used in accordance with implementing documents to obtain the accurate location and relocation of designated features, including locations of sample or data collection; and
  - Is subject to proper administrative controls and program requirements.
- Pertinent survey documents are identified, maintained, and verified for completeness as work progresses.
- As applicable, other requirements of the DOE quality assurance program apply to the control of field surveys.
- Procedures are established describing methods of reviewing and qualifying data that were collected without a fully implemented 10 CFR Part 63 quality assurance program [NUREG–1298 (NRC, 1987)].

4.5.1.4 Evaluation Findings

The reviewer will prepare evaluation findings based on satisfying the applicable regulatory requirements relating to the DOE quality assurance program. If the reviewer concludes that information provided with the initial application or a subsequent quality assurance program change submittal shows that the quality assurance program meets the acceptance criteria (or acceptable alternative) provided, the quality assurance program should be considered acceptable. During the review process, clarification may be obtained by DOE providing additional information in response to requests by the reviewer. The reviewer will verify that sufficient information has been provided and that the review is sufficiently complete and adequate to support conclusions of the following type to be included in the safety evaluation report.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 21.3. Applicable definitions have been appropriately applied to DOE commercial grade item dedication.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.44. Adequate procedures for control of changes, tests, and experiments have been provided.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.73. Adequate procedures have been established for reporting deficiencies.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.21(c)(14). Requirements for the content of the license application have been met in that an adequate description of the quality assurance program to be applied to the SSCs important to safety and to the engineered and natural barriers important to waste isolation has been provided, including a discussion of how the applicable requirements of 10 CFR 63.142 will be satisfied.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.141. The description of the quality assurance program provided is within the proper scope and includes quality control.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.142. The quality assurance program described in the license application satisfies requirements of applicability and specified criteria and applies to all SSCs important to safety, to design and characterization of barriers important to waste isolation, and to activities related thereto.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.143. The description of the quality assurance program satisfies requirements for the implementation of a program based on the criteria required by 10 CFR 63.142.

NRC staff has reviewed the SAR and other docketed materials and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.144. The description of the quality assurance program satisfies requirements and follows procedures for implementation of changes to a previously accepted quality assurance program for cases in which NRC approval either is or is not required.

Based on detailed review and evaluation of the quality assurance program description contained in the DOE license application, the NRC staff finds, with reasonable assurance, that:

- The organizations and individuals performing quality assurance functions have the required independence and authority to effectively carry out the quality assurance program without undue influence from those directly responsible for costs and schedules.

- The quality assurance program describes requirements, procedures, and controls that, when properly implemented, comply with the requirements of 10 CFR Part 63, subpart G; the requirements of 10 CFR 63.73; the criteria contained in this section (4.5.1) of the YMRP; and the regulatory requirements, documents, and positions presented in this section (4.5.1) of the YMRP.

  A brief description of the DOE quality assurance program may be provided along with the more important aspects of the program.

- The quality assurance program covers activities affecting SSCs important to safety and barriers important to waste isolation as identified in the SAR. Accordingly, the staff concludes that the DOE description of the quality assurance program is in compliance with applicable NRC regulations and industry standards and that the quality assurance program can be implemented for the (specify: design, procurement, construction, operation, etc.) phases of the repository life cycle.

- The DOE quality assurance program description is in compliance with applicable NRC regulations.

4.5.1.5 References

Commitments

The DOE is expected to commit to the use of the staff positions and provisions contained in the following documents in conjunction with any exceptions or clarifications provided in the acceptance criteria. However, as provided for in this section (4.5.1) of the YMRP, exceptions and alternatives to these acceptance criteria and the documents and positions contained in section 4.5.1.5 of the YMRP may be adopted by DOE, provided adequate justification is given.

American Society of Mechanical Engineers (ASME). “Quality Assurance Program Requirements for Nuclear Power Plants.” NQA–1–1983. ASME: New York. July 1983. Note: The exceptions to and NRC positions on the use of NQA–1–1983 provided in the acceptance criteria in section 4.5.1.3 of the YMRP apply. Also, the NRC positions provided in section C of NRC Regulatory Guide 1.28, Revision 3, apply.

American National Standards Institute (ANSI)/American Nuclear Society (ANS). “Selection and Training of Nuclear Power Plant Personnel.” ANSI/ANS–3.1–1993. ANSI: New York. 1993, as endorsed by the regulatory positions in Regulatory Guide 1.8, Revision 3, May 2000. Note: The exceptions to and NRC positions on the use of NQA–1–1983 provided in the acceptance criteria in section 4.5.1.3 and in this section (4.5.1.5) of the YMRP apply.

American Society for Nondestructive Testing. “Recommended Practice for Nondestructive Testing Personnel Qualification and Certification.” ASNT–TC–1A–1980. Columbus, OH: American Society for Nondestructive Testing. June 1980. Note: The exceptions to and NRC positions on the use of ASNT–TC–1A provided in the acceptance criteria in section 4.5.1.3 of the YMRP apply.

Nuclear Regulatory Commission (U.S.) (NRC). NRC Regulatory Positions C.1, C.2, C.3, C.3.1, C.3.2 (1,2,and 3) contained in Section C, “Regulatory Position.” Regulatory Guide 1.28, “Quality Assurance Requirements (Design and Construction),” Revision 3. NRC: Washington, DC: August 1985.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1298, “Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories.” NRC: Washington, DC. 1987.

Nuclear Regulatory Commission (U.S.) (NRC). *Recognition of American Society of Mechanical Engineers Accreditation Program for N Stamp Holders*. Information Notice 86-21. NRC:

Washington, DC. March 31, 1986. Including Supplement 1, December 4, 1986, and Supplement 2, April 16, 1991.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.8, "Personnel Selection and Training." Revision 3. NRC: Washington, DC. May 2000.

Noncommitments

Electric Power Research Institute. "Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications (NCIG–07)." EPRI NP–5652. Palo Alto, CA. June 1988. [Endorsed by Nuclear Regulatory Commission Generic Letter 89-02 and 91-05)]

Nuclear Regulatory Commission (U.S.) (NRC). *Actions to Improve Detection of Counterfeit and Fraudulently Marketed Products*. Generic Letter 89-02. NRC: Washington, DC. 1989.

Nuclear Regulatory Commission (U.S.) (NRC). *Licensee Commercial-Grade Procurement and Dedication Programs*. Generic Letter 91-05. NRC: Washington, DC. 1991.

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1563, "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program." NRC: Washington, DC. 1996.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.176, "An Approach for Plant-Specific, Risk-Informed Decision-Making: Graded Quality Assurance." NRC: Washington, DC. August 1998.

Nuclear Regulatory Commission (U.S.) (NRC). *Plant Record Storage on Optical Disks. Supplement 1: Guidance on Managing Quality Assurance Records in Electronic Media.* Generic Letter 88-18. NRC: Washington, DC. 2000.

4.5.2 Records, Reports, Tests, and Inspections

Although DOE is not expected to have prepared procedures and plans for records, reports, tests and inspections at the time of the application for the construction authorization, DOE should commit to developing and implementing these plans and procedures to meet or exceed the acceptance criteria in this section.

Review Responsibilities—High-Level Waste Branch

4.5.2.1 Areas of Review

This section reviews procedures for records, reports, tests, and inspections. Reviewers will evaluate the information required by 10 CFR 63.21(c)(17).

The staff will evaluate the following parts of DOE procedures for managing records, reports, tests, and inspections using the review methods and acceptance criteria in sections 4.5.2.2 and 4.5.2.3.

- Proposed records of receipt, handling, and disposition of radioactive waste;
- Records of construction;
- Ways to ensure use of records by future generations;
- Means to evaluate and notify NRC of deficiencies found in the characteristics, design, and construction of the site and the GROA;
- Means to support tests needed to administrate Commission regulations;
- Programs to support Commission inspections;
- Availability of records for licensed activities; and
- Provisions for Commission office space at the GROA.

4.5.2.2 Review Methods

RM1 Records and Reports

Confirm that DOE has committed to maintain records and reports required by conditions of the license or rules, regulations, and orders of the Commission.

Determine that records of receipt, handling, and disposition of radioactive waste at the GROA will contain enough information to provide a complete history of waste movement from the shipper through all phases of storage and disposal.

Determine that records of construction of the GROA at the YM site will contain enough information to adequately describe the construction and the resulting as-built configuration. Verify construction records will include the following, as a minimum:

- Surveys of the underground facility excavations, shafts, ramps, and boreholes referenced to easily identified surface features or monuments;
- A description of the geologic materials and structures encountered;
- Geologic maps and geologic cross sections;
- Locations and amounts of seepage;
- Details of construction equipment, methods, progress, and sequence of work;
- Descriptions of construction problems;
- Anomalous conditions encountered;

- Instrument locations, readings, and analyses;
- Locations and descriptions of structural support systems;
- Locations and descriptions of dewatering systems;
- Details, methods of emplacement, and location of monuments used to identify the site after permanent closure;
- Details, methods of emplacement, and location of seals used; and
- GROA design records such as specifications and as-built drawings.

Determine that records of construction of the GROA and receipt, handling, and disposition of radioactive waste will be kept in a way to ensure their use by future generations in accordance with 10 CFR 63.51(a)(3).

RM2 Reports of Deficiencies

Verify that DOE will establish a program to evaluate and report deviations and failures to comply with requirements of 10 CFR 50.55(e). This applies to the construction authorization and design of the GROA. Confirm that deficiencies to be reported are those that, should they remain uncorrected, could result in:

- Substantial safety hazard;
- Significant deviation from the conditions stated in the construction authorization, including license conditions and technical specifications; and
- Deviation from the design criteria and design bases stated in the construction authorization.

Verify that DOE will implement a program to report specific events and conditions that is the same as specified in 10 CFR 72.75.

Determine that DOE will document deficiencies in a written report as specified in the applicable regulation. The deficiencies may include substantial safety hazards, significant deviations from conditions and technical specifications in the construction authorization and design criteria, and bases. Copies will be sent to the NRC Operations Center, Document Control Desk, NRC; the Director of Nuclear Material Safety and Safeguards, NRC; and to the NRC on-site representative.

RM3 Ability of the Commission to Conduct Tests

Verify either that DOE will perform tests or the Commission will be allowed to perform tests necessary to administer the regulations at 10 CFR Part 63. Tested items may include:

- Radioactive waste;
- Geologic setting and the repository SSCs;
- Radiation detection and monitoring instruments;
- Equipment and devices used for the receipt, handling, or storage of radioactive waste; and
- Aspects of the performance confirmation program.

RM4 Commission Access to the GROA and Adjacent Areas

Confirm the Commission will be allowed to inspect the premises of the GROA and adjacent areas where DOE has rights of access. Verify that NRC inspectors will have immediate and unfettered access to the GROA, equivalent to the access provided regular DOE employees, after proper identification and compliance with access control measures for security, radiation protection, and personal safety.

Verify that records related to activities licensed under 10 CFR Part 63 will be available for Commission inspection on reasonable notice.

Confirm that DOE will provide adequate rent-free office space for the exclusive use of the Commission inspection team. Verify that:

- Heat, air-conditioning, light, electrical outlets, and janitorial services will be furnished.
- Office space will be conveniently located with full access to the GROA.
- Office space will provide visual and acoustic privacy.
- Office space will accommodate two NRC full-time inspectors and other transient NRC personnel and will be commensurate with other office facilities at the GROA. (A space of 250-square feet will be acceptable.)

4.5.2.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.71, 63.72, 63.73, 63.74, and 63.75 relating to records, reports, tests, and inspections.

AC1 DOE will maintain adequate records and reports required by the conditions of the license or by rules, regulations, and orders of the Commission.

- The DOE commits to maintain adequate records and reports that may be required by conditions of the license or rules, regulations, and orders of the Commission.

- The records of receipt, handling, and disposition of radioactive waste at the GROA will contain enough information to provide a complete history of the movement of the waste from the shipper through all phases of storage and disposal.

- The records of construction of the GROA at the YM site will contain enough information to give an adequate description of the construction and the resulting as-built configuration. The construction records will include the following, as a minimum:

  — Surveys of the underground facility excavations, shafts, ramps, and boreholes referenced to readily identifiable surface features or monuments;

  — A description of the geologic materials and structures encountered;

  — Geologic maps and geologic cross sections;

  — Locations and amounts of seepage;

  — Details of construction equipment, methods, progress, and sequence of work;

  — Descriptions of construction problems;

  — Anomalous conditions encountered;

  — Instrument locations, readings, and analyses;

  — Locations and descriptions of structural support systems;

  — Locations and descriptions of dewatering systems;

  — Details, methods of emplacement, and location of monuments used to identify the site after permanent closure;

  — Details, methods of emplacement, and location of seals used; and

  — Facility design records such as specifications and as-built drawings.

- DOE will retain the records of construction of the GROA and receipt, handling, and disposition of radioactive waste in a way that ensures their use by future generations in accordance with 10 CFR 63.51(a)(3).

AC2 DOE will submit adequate reports of deficiencies found in the characterization, design, and construction of the YM site.

- DOE has an adequate program to evaluate and report deviations and failures to comply with applicable requirements of 10 CFR 50.55(e). This applies to the construction authorization and design of the GROA. Deficiencies to be reported are those that, should they remain uncorrected, could result in:

— Substantial safety hazard;

— Significant deviation from the conditions stated in the construction authorization, including license conditions and technical specifications; and

— Deviation from the design criteria and design bases stated in the construction authorization.

- The DOE will implement a program to report specific events and conditions that is the same as specified in 10 CFR 72.75.

- DOE will document deficiencies in a written report as specified in the applicable regulation. The deficiencies may include substantial safety hazards, significant deviations from conditions and technical specifications in the construction authorization, and design criteria and bases. Copies will be sent to the NRC Operations Center, Document Control Desk, NRC; the Director of Nuclear Material Safety and Safeguards, NRC; and to the NRC on-site representative.

AC3 The Commission will be able to conduct tests to administer regulations at the YM site.

- DOE will perform tests or the Commission will be allowed to perform tests deemed necessary to administer the regulations at 10 CFR Part 63. Tested items may include:

— Radioactive waste;

— Geologic setting and the repository SSCs;

— Radiation detection and monitoring instruments;

— Equipment and devices used along with the receipt, handling, or storage of radioactive waste; and

— Aspects of the performance confirmation program.

AC4 The Commission is allowed to inspect the premises of the GROA and adjacent areas where DOE has rights of access.

- The Commission will be allowed to inspect the premises of the GROA and adjacent areas where DOE has rights of access. NRC inspectors will have immediate and unfettered access to the GROA, equivalent to the access provided regular DOE employees, after proper identification and compliance with applicable access control measures for security, radiation protection, and personal safety.

- On reasonable notice, DOE will make available records pertaining to activities licensed under 10 CFR Part 63.

- DOE will provide adequate rent-free office space for the exclusive use of the Commission inspection team.

4.5.2.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.71. DOE has provided an adequate description of the recordkeeping and reporting programs for receipt, handling, and disposal of radioactive waste. These programs also support requirements imposed by license conditions or other rules, records, and orders of the Commission. Therefore, DOE meets the requirements for recordkeeping and reporting of repository operations.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.72. DOE has provided an adequate description of the construction records and recordkeeping programs. Therefore, DOE meets the requirements to maintain records of construction of the GROA.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.73. DOE has an adequate program to report deficiencies to the Commission that includes substantial safety hazards, deviations from the design criteria or design basis, and deviations from the conditions and technical specifications stated in the construction authorization. Therefore, DOE meets the requirements to report deficiencies found in the characteristics, design, and construction of the YM site.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.74. DOE will permit tests associated with radioactive waste, the GROA and its SSCs; radiation detection and monitoring equipment; other equipment and devices used to receive, handle, and store radioactive waste; and the performance confirmation program. Therefore, DOE meets the requirements for tests by DOE or NRC to satisfy Commission testing needs at the GROA.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 63.75. DOE has provided an adequate description of the inspection program and associated DOE-provided infrastructure. Therefore, DOE meets the requirements to facilitate Commission inspections at the GROA.

4.5.2.5 References

None.

4.5.3 Training and Certification of Personnel

Although DOE is not expected to have prepared procedures and a program for training and certification of personnel at the time of the application for the construction authorization, DOE should commit to developing and implementing them to meet or exceed the acceptance criteria in this section.

4.5.3.1 Organizational Structure of U.S. Department of Energy as it Pertains to Construction and Operation of Geologic Repository Operations Area

Review Responsibilities—High-Level Waste Branch

4.5.3.1.1 Areas of Review

This section reviews the organizational structure of DOE as it pertains to construction and operation of the GROA. Reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(i).

The staff will evaluate the following parts of the organizational structure of DOE as it pertains to construction and operation of the GROA using the review methods and acceptance criteria in sections 4.5.3.1.2 and 4.5.3.1.3.

- DOE delineation of responsibilities and decision making authority to on-site and headquarters staff, major contractors, sub-contractors, principal consultants, service organizations, and other affected organizations;

- Address of the office of record and the identity of the point of contact of each organizational entity; and

- Procedure for delegation of authority.

4.5.3.1.2 Review Methods

RM1 Definition of Responsibilities

Determine that DOE provides an adequate delineation of responsibility and decision-making authority during construction and operation of the GROA so responsibility for actions can be traced through the management and staff hierarchy (onsite and at headquarters), contractors, subcontractors, consultants, service organizations, and other affected organizations.

Verify that the address of the office of record for each entity, a point of contact, and a telephone number, fax number, or email address are provided in the license application.

RM2 Procedure for Delegation of Authority

Determine that an adequate authority delegation procedure is in place for positions having responsibility to act in routine or emergency situations. Confirm that an identified party always has responsibility and sufficient authority to act, and the appropriate qualifications. The development and maintenance of procedures are reviewed using section 4.5.6 of the YMRP.

4.5.3.1.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(16)(i)

AC1 Responsibilities are adequately defined.

- DOE provides an adequate delineation of assignments of responsibility and decision-making authority during construction and operation of the GROA is provided so that responsibility for actions can be traced through the management and staff hierarchy of DOE (onsite and at headquarters), contractors, subcontractors, consultants, service organizations, and other affected organizations.

- The address of the office of record for each entity, a point of contact, and a telephone number, fax number, or email address are provided in the license application.

AC2 An adequate procedure for delegation of authority situations is in place.

- There is an adequate authority delegation procedure is in place for positions having responsibility to act in routine or emergency situations. An identified party will always have responsibility and sufficient authority to act, and the appropriate qualifications.

4.5.3.1.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements at 10 CFR 63.21(c)(16)(i). DOE has provided an adequate organizational structure as it pertains to the construction and operation of the GROA, including the delegation of authority and assignment of responsibilities.

4.5.3.1.5 References

None.

4.5.3.2 Key Positions Assigned Responsibility for Safety and Operations of Geologic Repository Operations Area

Review Responsibilities—High-Level Waste Branch

At the time of the application for the construction authorization, DOE is not expected to have identified specific individuals to fill key positions. Therefore, portions of the review defined in this section may be delayed at the time of application for the construction authorization. At the time of application to receive, posses, process, store, or dispose HLW, DOE is required to have identified specific individuals to fill key positions.

4.5.3.2.1 Areas of Review

This section reviews key positions assigned responsibility for safety and operations of the GROA. Reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(i).

The staff will evaluate the following parts of key positions assigned responsibility for safety and operations of GROA using the review methods and acceptance criteria in sections 4.5.3.2.2 and 4.5.3.2.3.

- Descriptions of the key positions assigned responsibility for safety at the GROA including minimum skills and experience for each position,

- Qualifications of personnel assigned to key positions important to safety at the GROA, and

- Identification of alternates for persons in key positions.

4.5.3.2.2 Review Methods

RM1 Descriptions of Key Positions

Verify that DOE provides an adequate description of each key position at the GROA that includes the minimum skills and experience necessary to hold each position. These positions include, but are not limited to, those with responsibilities in health physics, nuclear criticality safety, training and certification, emergency planning and response, operations, maintenance, engineering, and quality assurance.

Evaluate the qualifications of the personnel assigned to GROA key positions important to safety based on the minimum skills and experience necessary to hold each key position.

Confirm that qualified alternates are identified to act in the absence of individuals assigned to GROA key positions based on minimum skills and experience necessary to hold each key position.

4.5.3.2.3 Acceptance Criteria

The following acceptance criterion is based on meeting the requirements of 10 CFR 63.21(c)(16)(ii).

AC1 Description of key positions are adequate for safety at the GROA.

- DOE provides an adequate description of each key position at the GROA that includes the minimum skills and experience necessary to hold each position.

- DOE provides an acceptable description of the qualifications of the personnel assigned to GROA key positions important to safety based on the minimum skills and experience necessary to hold each key position.

- Qualified alternates are identified to act in the absence of individuals assigned to GROA key positions based on minimum skills and experience necessary to hold each key position.

4.5.3.2.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(16)(ii). DOE provides an adequate description of the key positions assigned responsibility for safety and operations of the GROA and the qualifications of the persons occupying these positions.

4.5.3.2.5 References

None.

4.5.3.3 Personnel Qualifications and Training Requirements

Review Responsibilities—High-Level Waste Branch

At the time of application for a construction authorization, DOE is not required to have an NRC-approved personnel training and qualification program in place. A commitment to have such an approved program before receipt of waste is sufficient for granting the construction authorization. At the time of application to receive, possess, process, store, or dispose HLW, DOE is required to have an NRC-approved personnel training and qualification program in place.

4.5.3.3.1 Areas of Review

This section reviews personnel qualifications and training requirements. Reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(iii).

The staff will evaluate the following parts of personnel qualifications and training requirements using the review methods and acceptance criteria in sections 4.5.3.3.2 and 4.5.3.3.3.

- Standards used for selection, training, and certification of personnel;
- Program for general training, proficiency testing, and certification of GROA personnel;
- Procedures for managing and maintaining the training program;
- Preoperational and operational radioactive materials training program;
- Operator and supervisor training and certification programs and requirements for SSCs important to safety;
- Operator and supervisor requalification program;
- Physical requirements for personnel operating equipment and controls that are important to safety;
- Methods for selecting and training security guards; and
- Methods used to evaluate operator testing procedures.

4.5.3.3.2 Review Methods

RM1 Standards for Selection, Training, and Certification of Personnel

Confirm that any standards used for the programs for selection, training, and certification of personnel are adequate. For example, DOE may use a systems approach to training such as described at 10 CFR 55.4.

RM2 Programs for General Training, Proficiency Testing, and Certification of GROA Personnel

Additional guidance to support a review of training programs for nuclear facility operators is in Regulatory Guide 1.8, Qualification and Training of Personnel for Nuclear Power Plants (NRC, 1996).

Determine that the training program establishes the bases for GROA personnel qualification and defines the qualification requirements of operators, supervisors, and other staff. The characteristics of this program should be consistent with ANSI/ANS 3.1, Section 5.1, General Aspects; Section 5.3, Training of Personnel Not Requiring NRC Licenses; Section 5.4, General Employee Training; and Section 5.5, Retraining. Confirm that the training program is approved by NRC prior to receipt of waste at the GROA.

Verify DOE has procedures to manage and maintain the training program. These procedures should include identification of the personnel responsible for developing of training programs, conducting training, retraining employees (including new employee orientations), and maintaining up-to-date records on the status of trained personnel. Development and maintenance of procedures are reviewed using section 4.5.6 of the YMRP.

Confirm DOE specifies training requirements for each job category.

Verify DOE will train new hires on a timely schedule.

RM3 Preoperational and Operational Radioactive Materials Training Program

Additional guidance to support a review of the radioactive materials training program for nuclear facility operators is in Regulatory Guide 8.29, Instructions Concerning Risks from Occupational Radiation Exposure (NRC, 1996); NUREG–0713, Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities (Raddatz and Hagemayer, 1995); ASTM E 1168, Guide for Radiation Protection Training for Nuclear Facility Workers (ASTM, 1995); and Regulatory Guide 8.8, Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Reasonably Achievable, paragraph C.1.c (NRC, 1984).

Verify DOE will implement the radioactive materials training program before conduct of operations involving radioactive material (i.e., preoperational training). Confirm that DOE commits to substantial completion of operator training and certification before receipt of radioactive material.

Determine that operator radiation safety training includes such topics as the nature and sources of radiation, methods for controlling contamination, interactions of radiation with matter, biological effects of radiation, use of monitoring equipment, ALARA concepts, facility access and visitor controls, decontamination procedures, use of personal monitoring and protective equipment, regulatory and administrative exposure and contamination limits, site-specific hazards, and principles of criticality hazards control.

Determine that individuals who in the course of their employment are likely to receive a yearly occupational dose in excess of 100 mrem (1 mSv) are instructed in the health protection issues associated with exposure to radioactive materials or radiation in accordance with 10 CFR 19.12.

Determine that individuals involved are informed of estimated doses and associated risks before any special exposures occur in accordance with 10 CFR 20.1206.

Verify DOE will provide training in radiation protection and facility exposure control procedures for all personnel whose duties require: (i) working with radioactive materials, (ii) entering radiation areas, and (iii) directing the activities of others who work with radioactive materials or enter radiation areas.

Determine that facility personnel whose duties do not require entering radiation areas or working with radioactive materials receive sufficient instructions in radiation protection and facility rules and regulations to understand why they should not enter such areas.

RM4 Operation of Equipment and Controls Important to Safety

Confirm that operators of equipment and controls identified as important to safety are either trained and certified in the operations or will be under the direct visual supervision of an individual who is trained and certified.

Determine that supervisory personnel who personally direct the operation of equipment and controls that are important to safety are trained and certified in such operations.

Verify that operational training includes topics such as installation, design, and operation of SSCs; decontamination procedures; and emergency procedures.

RM5 Operator and Supervisor Requalification Program for SSCs Important to Safety

Determine that DOE defines an adequate program for requalification of operators, supervisors, and other staff.

Verify that the frequency of retraining and the nature and duration of training and testing records have been specified. Confirm that retraining will be periodic and conducted at least every 2 years.

RM6 Physical Condition and General Health of Personnel

Additional guidance to support this review is in Regulatory Guide 1.134, Medical Evaluation of Licensed Personnel for Nuclear Power Plants (NRC, 1998).

Confirm that any condition that might impair judgement or motor coordination resulting in the inability of an operator to perform activities that are important to safety has been considered in selecting personnel to operate such equipment and controls. Such impaired judgement or motor coordination conditions need not categorically disqualify a person from operating equipment and controls important to safety provided appropriate provisions are made to accommodate any such condition.

RM7 Methods for Selecting, Training, and Qualifying Security Guards

Verify that the process by which security guards (including watchmen, armed response persons, etc.) will be selected and qualified is described as required by 10 CFR 73.55(b)(4)(ii). This information will be submitted as part of the physical security plan and reviewed using section 3.3 of the YMRP. Confirm that selection and training criteria will conform to the general criteria for security personnel contained in 10 CFR Part 73, appendix B. Regulatory Guide 5.20, Training, Equipping, and Qualifying of Guards and Watchmen (NRC, 1974) provides additional guidance.

RM8 Methods for Evaluating Operator Testing Procedures

Verify the methods for evaluating the effectiveness of the training program are described and that program effectiveness is determined by comparison to established objectives and criteria.

4.5.3.3.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.151, 63.152, and 63.153.

AC1 Adequate standards are used for selection, training, and certification of personnel.

- Any standards used for the programs for selection, training, and certification of personnel are adequate.

AC2 Programs for general training, proficiency testing, and certification of GROA personnel are acceptable.

- The training program adequately establishes the bases for GROA personnel qualification and defines the qualification requirements of operators, supervisors, and other staff. The characteristics of this program are consistent with ANSI/ANS 3.1, Section 5.1 General Aspects; Section 5.3 Training of Personnel Not Requiring NRC Licenses; Section 5.4, General Employee Training; and Section 5.5, Retraining. The training program will be approved by NRC prior to receipt of waste at the GROA.

- DOE establishes adequate procedures for managing and maintaining the training program. These procedures include identification of the personnel responsible for developing training programs, conducting training, retraining employees (including new employee orientations) and maintaining up-to-date records on the status of trained personnel.

- DOE specifies training requirements for each job category.

- DOE will train new hires on a timely schedule.

AC3 An acceptable preoperational and operational radioactive materials training program is provided.

- DOE will implement the radioactive materials training program before conduct of operations involving radioactive material (i.e., preoperational training). DOE commits to substantial completion of such operator training and certification before receipt of the radioactive material.

- The operator radiation safety training includes such topics as the nature and sources of radiation, methods for controlling contamination, interactions of radiation with matter, biological effects of radiation, use of monitoring equipment, ALARA concepts, facility access and visitor controls, decontamination procedures, use of personal monitoring and protective equipment, regulatory and administrative exposure and contamination limits, site-specific hazards, and principles of criticality hazards control.

- DOE will instruct all individuals who in the course of their employment are likely to receive a yearly occupational dose in excess of 100 mrem (1 mSv) in the health protection issues associated with exposure to radioactive materials or radiation per 10 CFR 19.12.

- Before any special exposures occur, DOE will inform the individuals involved of estimated doses and associated risks in accordance with 10 CFR 20.1206.

- DOE will provide adequate training in radiation protection and facility exposure control procedures for personnel whose duties require: (i) working with radioactive materials, (ii) entering radiation areas, and (iii) directing the activities of others who work with radioactive materials or enter radiation areas.

- The facility personnel whose duties do not require entering radiation areas or working with radioactive materials will receive sufficient instructions in radiation protection and facility rules and regulations to understand why they should not enter such areas.

AC4 Operation of equipment and controls identified as important to safety is limited to trained and certified personnel or is under the direct visual supervision of an individual with training and certification in their operation.

- Operators of all equipment and controls identified as important to safety are either trained and certified in the operations or will be under the direct visual supervision of an individual who is trained and certified in the operations.

- Supervisory personnel who personally direct the operation of equipment and controls that are important to safety are trained and certified in such operations.

- Operational training includes topics such as installation, design, and operation of SSCs; decontamination procedures; and emergency procedures.

AC5 An acceptable operator and supervisor requalification program for SSCs important to safety is provided.

- DOE defines an adequate program for requalification of operators, supervisors, and other staff.

- Frequency of retraining and the nature and duration of training and testing records are specified. Retraining will be periodic and conducted at least every 2 years.

AC6 The physical condition and the general health of personnel certified for the operation of equipment and controls important to safety are such that operational errors that could endanger other in-plant personnel or the public health and safety will not occur.

- Conditions that might impair judgement or motor coordination resulting in the inability of an operator to perform activities that are important to safety are adequately considered in the selection of personnel to operate such equipment and controls.

AC7 Methods for selecting, training, and qualifying security guards are acceptable.

- The process by which security guards (including watchmen, armed response persons, etc.) will be selected and qualified is adequate as required by 10 CFR 73.55(b)(4)(ii). Selection and training criteria conform to the general criteria for security personnel contained in 10 CFR Part 73, appendix B.

AC8 Methods used to evaluate operator testing procedures are acceptable.

- Methods for evaluating the effectiveness of the training program are described and program effectiveness is determined by comparison to established objectives and criteria.

4.5.3.3.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.151. Operation of systems and components important to safety will be performed only by trained and certified personnel or by personnel under the direct supervision of an individual with training and certification in such operation. Supervisory personnel will also be certified in the operations they supervise.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.152. DOE has established an adequate program for training, proficiency testing, certification, and requalification of operating and supervisory personnel.

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.153. DOE has established an adequate program for evaluating the physical condition and general health of personnel certified for operations that are important to safety. Conditions that might cause impaired judgment or motor coordination are adequately considered in the selection of personnel for activities important to safety.

4.5.3.3.5 References

American National Standards Institute (ANSI)/American Nuclear Society (ANS). “Selection, Qualification and Training of Personnel for Nuclear Power Plants.” ANSI/ANS 3.1. November 1981.

American Society of Testing and Materials (ASME). “Guide for Radiation Protection Training for Nuclear Facility Workers.” E 1168. 1995

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 5.20, “Training, Equipping, and Qualifying of Guards and Watchmen.” NRC: Washington, DC. January 1974.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.8, “Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable (ALARA).” Draft OP–618–4. Second Proposed Revision 4. NRC: Washington, DC. May 1984.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 8.29, “Instructions Concerning Risks from Occupational Radiation Exposure.” Revision 1. NRC: Washington, DC. February 1996.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.8, “Qualification and Training of Personnel for Nuclear Power Plants.” Revision 3. NRC: Washington, DC. November 1996.

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 1.134, “Medical Evaluation of Licensed Personnel for Nuclear Power Plants.” Revision 3. NRC: Washington, DC. March 1998.

Raddatz, C.T. and D. Hagemayer. NUREG–0713, “Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities.” Volume 15. NRC: Washington, DC. January 1995.

4.5.4 Expert Elicitation

Review Responsibilities—High-Level Waste Branch

4.5.4.1 Areas of Review

This section reviews expert elicitation. Reviewers will evaluate the information required by 10 CFR 63.21(c)(13).

DOE can use expert elicitation when data are hard to obtain through normal means or within the timeframe required. Generally, DOE should not use expert elicitation in place of normal data collection unless sufficient justification exists.

The staff will evaluate the following parts of expert elicitation using the review methods and acceptance criteria in sections 4.5.4.2 and 4.5.4.3.

- Techniques to conduct expert elicitations;
- Extent to which guidance in NUREG–1563, Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program (Kotra, et al., 1996) was used to perform expert elicitations; and
- Rationales for any discrepancies between staff guidance in NUREG–1563 (Kotra, et al., 1996) and the DOE conduct of expert elicitations.

4.5.4.2 Review Methods

RM1 Use of NUREG–1563 (Kotra, et al., 1996) or Equivalent Procedures

Verify that expert elicitations followed the nine-step procedure suggested in NUREG–1563 (Kotra, et al., 1996). Specifically:

- Objectives were defined;
- Criteria used to select normative experts and generalists included experts who:
    - Possessed the required knowledge and expertise;
    - Showed ability to apply their knowledge and expertise;
    - In aggregate represented a broad diversity of independent opinion and approaches to address the topic(s);
    - Were willing to be identified publically with their judgments; and
    - Were willing to publically disclose potential conflicts of interest.
- Participants refined the issues and decomposed the problem to clearly and precisely specify more focused and simpler subissues;

- Basic information was adequately assembled and was circulated uniformly to the experts;
- The experts received preelicitation training that included:
  - Familiarization with the subject matter,
  - Familiarization with the elicitation process,
  - Education in uncertainty and probability encoding and the expression of expert judgment using subjective probability,
  - Practice in formally stating judgments and clearly identifying their associated assumptions and rationales, and
  - Identification of biases that could unduly influence judgments.
- The conduct of expert elicitations included the following:
  - An appropriate setting;
  - the presence of generalists and normative experts;
  - A summary of issues, definitions, and assumptions;;
  - Uniform questioning of subject-matter experts; and
  - Documentation of responses.
- Each subject-matter expert got timely feedback from the elicitation team. The rationale for any revisions to elicited judgments was thoroughly documented.
- If expert judgments were combined, differing views were treated appropriately as suggested in staff guidance (Kotra, et al., 1996). For combined judgments, the reviewer should confirm that:
  - DOE provided a rationale for the technique used to combine differing views,
  - DOE provided enough documentation to trace the impact of an individual expert's judgment on the consolidated judgment, and
  - DOE discussed effects that the disparate views have had on GROA design or repository performance. DOE should present significantly different views as individual outputs of the elicitations so that such views may be directly used in the technical assessments or used to condition the extremes in sensitivity analyses.

- DOE properly documented the expert elicitation, including what was done, why it was done, and who did it.

Verify that DOE provided an adequate explanation for any variance from NUREG–1563 (Kotra, et al., 1996) guidance.

4.5.4.3 Acceptance Criteria

The following acceptance criterion is based on meeting the requirements of 10 CFR 63.21(c)(13).

AC1 DOE used NUREG–1563 (Kotra, et al., 1996) or equivalent procedures.

- Expert elicitations follow the nine-step procedure in NUREG–1563 (Kotra, et al., 1996). Specifically:
    - Objectives are defined;
    - Criteria used to select normative experts and generalists include:
        - Experts possess the required knowledge and expertise;
        - Experts demonstrate ability to apply their knowledge and expertise;
        - Experts, as a group, represent a broad diversity of independent opinion and approaches to address the topic(s);
        - Experts are willing to be identified publically with their judgments; and
        - Experts are willing to publically disclose potential conflicts of interest.
    - Participants refined the issues and broke down the problem to clearly specify more focused and simpler subissues;
    - DOE adequately assembled and uniformly distributed the basic information to the experts;
    - The experts received preelicitation training that included:
        - Familiarization with the subject matter,
        - Familiarization with the elicitation process,
        - Education in uncertainty and probability encoding and how to express expert judgment using subjective probability,

    - Practice in formally articulating judgments and explicitly identifying their associated assumptions and rationales, and

    - Identification of biases that could unduly affect judgments.

  - The conduct of expert elicitations includes the following:

    - An appropriate setting;

    - The presence of generalists and normative experts;

    - A summary of issues, definitions, and assumptions;

    - Uniform questioning of subject-matter experts; and;

    - Documentation of responses.

  - Each subject-matter expert received timely feedback from the elicitation team. The rationale for revising elicited judgments is thoroughly documented;

  - If expert judgments are combined, differing views are treated as suggested in staff guidance (Kotra, et al., 1996). Specifically:

    - DOE provided a rationale for the technique used to combine differing views, DOE included enough documentation to trace the impact of an individual expert's judgment on the combined judgment, and

    - DOE discussed the effects of differing views on facility design or repository performance. DOE presented significantly different views as individual outputs of the elicitations so that such views are directly used in the technical assessments or used to condition the extremes in sensitivity analyses.

  - DOE properly documented the expert elicitation including what is done, why it is done, and who did it.

- DOE adequately explained any variance from the guidance and techniques in NUREG–1563 (Kotra, et al., 1996).

4.5.4.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(13). DOE met the requirements for the content of the license application. In particular, the SAR explains how and the extent to which expert elicitation was used to characterize: (i) FEPs; (ii) response of geomechanical, hydrogeological, and geochemical systems to thermal loadings;

(iii) performance of the geologic repository after permanent closure; (iv) ability of the repository to limit radiological exposures in the event of limited human intrusion into the engineered barrier system; and (v) any other use of expert elicitation to evaluate performance.

4.5.4.5 References

Kotra, J.B., et al. NUREG–1563, “Branch Technical Position on the Use Of Expert Elicitation in the High-Level Radioactive Waste Program.” Nuclear Regulatory Commission: Washington, DC. 1996.

4.5.5 Plans for Startup Activities and Testing

Although DOE is not expected to have prepared plans for startup activities and testing at the time of the application for the construction authorization, DOE should commit to developing and implementing these plans to meet or exceed the acceptance criteria in this section.

Review Responsibilities—High-Level Waste Branch

4.5.5.1 Areas of Review

This section reviews plans for startup activities and testing. The reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(iv).

The staff will evaluate the following parts of plans for startup activities and testing using the review methods and acceptance criteria in sections 4.5.5.2 and 4.5.5.3.

A review of plans for pre-startup testing and startup activities to be used to evaluate the readiness to receive, possess, process, store, and dispose HLW should include assessment of planned tests and operations for the SSCs of the GROA. DOE is not required to have conducted testing and startup activities or to have detailed procedures in place at the time of application for the construction authorization. A commitment to have an approved testing and startup activities program for SSCs important to safety in place before receipt of waste is sufficient for granting the construction authorization. DOE is required to have either conducted testing and startup activities or to have detailed procedures in place for such testing and startup activities at the time of application to receive, possess, process, store, or dispose HLW.

- Systems used to develop, review, approve, and execute individual test procedures to evaluate, document, and approve test results;

- Pre-startup test program and objectives;

- Type and source of design performance information;

- Format and content of test procedures and individual test descriptions;

- Pre-startup test program compatibility with regulatory guides (if any);

- Use of prior experience in developing pre-startup tests;
- Assessment of whether initial operating procedures will endanger worker and public health and safety;
- Planned user testing for operating, emergency, and surveillance procedures;
- Schedules for the testing program relative to the first fuel receipt, repackaging, storage, and disposal, including any overlaps in component and system testing;
- Plans for initial startup; and
- Evaluation of safety of aggregate of facility functions and associated activities.

4.5.5.2 Review Methods

RM1 Systems Used to Develop, Review, and Approve Pre-startup Test Procedures

Determine, based on a summary description, that systems used to develop, review, and approve individual test procedures for each GROA component important to safety are acceptable. The summary description should include:

- Responsibilities and functions of organizational units for development, review, and approval of test procedures;
- Qualification requirements for people assigned responsibilities for test procedure development; and
- A description of the general steps for developing, reviewing, approving, and executing tests and for documenting test results.

RM2 Summaries of Pre-startup Test Programs and Objectives

Verify, based on a summary, that test programs and objectives for each GROA SSC important to safety are acceptable. Evaluate the adequacy of the (i) type of tests to be performed, (ii) expected response to the tests, (iii) acceptable margin of difference from the expected response, (iv) method of test validation, and (v) appropriateness of proposed corrective action for unexpected or unacceptable test results.

RM3 Incorporation of Design Performance Information in Pre-startup Testing Plans

Confirm that design information and data from preconstruction performance assessments have been adequately considered in developing pre-startup testing plans. Specifically, functions or parameters of SSCs important to safety should be tested to the extent feasible.

RM4 Format and Content of Test Procedures

Evaluate the format and content of test procedures for GROA SSCs important to safety and determine if they are acceptable.

RM5 Test Descriptions

Verify test descriptions are provided for SSCs that (i) will be used to establish conformance with safety limits or limiting conditions for operation in the GROA technical specifications (review technical specifications using section 4.5.10 of the YMRP), (ii) are classified as engineered safety features or will be used to support or ensure the operations of engineered safety features within design limits, (iii) are assumed to function or for which credit is taken in event sequence analyses in the PCSA, or (iv) will be used to process, store, control, measure, or limit the release of radioactive materials. Review the conduct of the PCSA using section 4.1.1 of the YMRP.

Determine that test descriptions contain objectives for each test and a summary of prerequisites, test method(s), and acceptance criteria that will ensure the functional adequacy of SSCs important to safety and that design features will be demonstrated by the tests.

Verify that test descriptions are consistent with the design requirements. Coordinate with the reviewer of Section 4.1.1.7 (Design of Structures, Systems, and Components Important to Safety and Safety Controls) of the YMRP to confirm the design requirements.

Confirm that test descriptions contain sufficient information to justify the test method used, particularly if the test method for an SSC important to safety will not subject the item or system to the range of design operating conditions.

RM6 Compatibility of Test Programs with Applicable Regulatory Guidance

Verify that pre-startup test programs for GROA SSCs are consistent with applicable guidance in Regulatory Guide 3.48 (Nuclear Regulatory Commission, 1989). Determine that, if DOE takes positions inconsistent with guidance, it provides suitable justification for the inconsistencies. For specific components, check for regulatory guidance that may be pertinent.

RM7 Use of Experience from Similar Facilities

Confirm the license application provides an assessment of testing results and operational lessons learned from similar facilities. This assessment should be used to develop testing procedures of adequate scope.

RM8 Protection of Worker and Public

Verify procedures that will guide initial operation of GROA SSCs important to safety and any prerequisites and precautionary measures associated with these procedures are acceptable. Make this determination based on evaluations of procedures using system diagrams and reviewer experience. Initial operating procedures should include the following:

- Purpose and role of test in evaluating performance of SSC function;

- Prerequisites for normal readiness testing, such as:
  - — Calibrations should be performed or checked;
  - — Instrumentation should be on hand for necessary performance evaluations;
  - — Tools and special equipment should be on hand to facilitate evaluations;
  - — Notifications with lead times necessary to eliminate unnecessary downtime during performance evaluations;
  - — Checking/setting equipment controls (e.g., physical travel limits for overhead crane);
  - — Checks of radiation, environmental, or other monitors for acceptable range;
  - — Identification of subject(s) of tests (e.g., fuel rods to be loaded, cask to be retrieved); and
  - — Logs and forms to be completed.
- Description of preceding function and relationship to function;
- Description of series of operations, including expected results, projected times, projected instrument and gauge readings, controls to be used in performance (e.g., torque, time at pressure), and threshold limits requiring contingency actions (such as hold, initiating a contingency sequence, notification);
- Requirements for records, including forms to be completed during operation (if any);
- Disposition of records and identification of parties to be notified upon successful or unsuccessful completion (may be different parties) of function evaluation; and
- Identification of following function and relation to function being evaluated.

RM9 Schedules

Verify that DOE provides schedules for conducting each phase of the testing program and that these schedules are compatible with schedules for HLW receipt, repackaging, storage, and disposal, including any schedule overlaps. Pay particular attention to start-up-sequence timing and the time available between approval of test procedures and their intended use.

RM10 Testing and Evaluating Functional Adequacy of SSCs

Verify that new SSCs important to safety, or untested configurations of such components, will be tested and evaluated before receipt of radioactive waste and that their performance is acceptable. Review schedules and programs for unresolved safety issues using section 4.3.2 of the YMRP.

RM11 Plans for Initial Startup of GROA SSCs and Integrated Operation of the GROA

Verify DOE has acceptable plans for a dry run (cold test) of each operation involving radioactive material to be received, handled, stored, or disposed. Confirm DOE will use the results of these to make necessary changes to equipment and procedures to ensure public and worker health and safety.

Determine that DOE has acceptable plans to conduct routine full load tests of equipment that is to carry HLW containers to ensure public and worker health and safety.

For ALARA considerations, verify that as many operating startup actions as feasible will be performed during preoperational testing before sources of radiation exposure are present.

Confirm that plans for operating start-up of the GROA SSCs and subsequent integrated operation of the entire facility are acceptable. The operating start-up plan should include, but not be limited to, the following elements:

- Tests and confirmations of procedures and exposure times involving actual radioactive sources (e.g., radiation monitoring, repackaging operations);
- Direct radiation monitoring of casks and shielding for radiation dose rates, streaming, and surface hot-spots;
- Verification of effectiveness of heat removal procedures;
- Tests of SSCs important to safety as identified by the PCSA (review identification of SSCs important to safety using section 4.1.1.6 of the YMRP); and
- Documentation of results and test evaluations.

RM12 Overall GROA Safety Supported by Startup and Testing Plans

Confirm that the overall evaluation of GROA safety for workers and the public is supported by the aggregate effects of planned start-up activities and associated testing.

4.5.5.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(16)(iv).

AC1 Systems used to develop, review, and approve individual pre-startup test procedures are acceptable.

- Based on a summary description, the systems used to develop, review, and approve individual test procedures for each GROA component important to safety are acceptable. The summary adequately defines:

  — Responsibilities and functions of organizational units for development, review, and approval of test procedures;

  — Qualification requirements for people assigned responsibilities for test procedure development; and

  — General steps to be followed when developing, reviewing, approving, and executing tests and for documenting test results.

AC2 Summaries of pre-startup test programs and objectives are adequate.

- Based on a summary description, the test programs and objectives for each GROA SSC important to safety are acceptable. The summary adequately presents (i) type of tests to be performed, (ii) expected response to the tests, (iii) acceptable margin of difference from the expected response, (iv) method of test validation, and (v) appropriateness of proposed corrective action for unexpected or unacceptable test results.

AC3 Design performance information is adequately incorporated in pre-startup testing plans.

- The design information and data from preconstruction performance assessments is adequately considered in the development of pre-startup testing plans. Specifically, functions or parameters of SSCs that are important to safety are tested to the extent feasible.

AC4 The format and content of test procedures is acceptable.

- The format and content of the test procedures for GROA SSCs important to safety are acceptable.

AC5 Test descriptions are acceptable.

- Adequate test descriptions are provided for those SSCs that: (i) will be used to establish conformance with safety limits or limiting conditions for operation in the GROA technical specifications; (ii) are classified as engineered safety features or will be used to support or ensure the operations of engineered safety features within design limits; (iii) are assumed to function or for which credit is taken in event sequence analyses in the PCSA; or (iv) will be used to process, store, control, measure, or limit the release of radioactive materials.

- The test descriptions contain acceptable objectives for each test and a summary of prerequisites, test method(s), and specific acceptance criteria for each test that will ensure that the functional adequacy of SSCs important to safety and that design features are demonstrated by the tests.

- The test descriptions are consistent with the design requirements.

- The test descriptions contain sufficient information to justify the test method used, particularly if the test method for a given SSC important to safety will not subject the item or system under test to the range of design operating conditions.

AC6 Test programs are compatible with applicable regulatory guidance.

- The pre-startup test programs for GROA SSCs are consistent with applicable regulatory guidance in Regulatory Guide 3.48 (NRC, 1989). If DOE takes positions inconsistent with guidance, a suitable justification for the inconsistencies is provided.

AC7 Adequate use is made of experience from similar facilities.

- The license application provides an assessment of testing results and operational lessons learned from similar facilities, and this assessment is used to develop testing procedures of adequate scope.

AC8 Initial operating procedures will protect worker and public.

- Procedures that will guide initial operation of the GROA SSCs important to safety and any prerequisites and precautionary measures associated with these procedures are acceptable.

AC9 Schedules for each phase of the testing program are acceptable.

- DOE provides schedules for conducting each phase of the testing program and these schedules are compatible with schedules for HLW receipt, repackaging, storage, and disposal, including any schedule overlaps.

AC10 SSCs important to safety whose functional adequacy has not been demonstrated by prior use or otherwise validated are tested and evaluated before the receipt of radioactive waste.

- The new SSCs important to safety, or untested configurations of such components, are tested and evaluated before receipt of radioactive waste, and their performance is acceptable.

AC11 Plans for initial start up of GROA SSCs important to safety and integrated operation of the GROA are acceptable.

- DOE has acceptable plans to perform a dry run (cold test) of each operation involving radioactive material to be received, handled, stored, or disposed. The results of these tests will be used to make necessary changes to equipment and procedures to ensure public and worker health and safety.

- DOE has acceptable plans to conduct routine full load tests of any equipment that is to carry HLW containers to ensure public and worker health and safety.

- For ALARA considerations, as many of the operating startup actions as feasible are performed during preoperational testing before sources of radiation exposure are present.

- Plans for operating startup of the GROA SSCs and subsequent integrated operation of the entire facility are acceptable.

AC12 Overall GROA safety is adequately supported by facility startup and testing plans.

- The overall evaluation of safety of the facility for workers and the public is supported by the aggregate of planned startup activities and associated testing.

4.5.5.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(16)(iv). Requirements for the content of the license application have been met. In particular, the plans for testing and startup of SSCs important to safety of the GROA to receive, possess, store, process, and dispose of SNF and HLW are acceptable.

4.5.5.5 References

Nuclear Regulatory Commission (U.S.) (NRC). Regulatory Guide 3.48, “Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage).” Revision 1. NRC: Washington, DC. August 1989.

4.5.6 Plans for Conduct of Normal Activities Including Maintenance, Surveillance, and Periodic Testing

Although DOE is not expected to have prepared procedures and plans for conduct of normal activities including maintenance, surveillance, and periodic testing at the time of the application for the construction authorization, DOE should commit to developing and implementing these procedures and plans to meet or exceed the acceptance criteria in this section.

Review Responsibilities—High-Level Waste Branch

4.5.6.1 Areas of Review

This section reviews plans for conduct of normal activities including maintenance, surveillance, and periodic testing. Reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(v).

The staff will evaluate the following parts of plans for conduct of normal activities including maintenance, surveillance, and periodic testing using the review methods and acceptance criteria in sections 4.5.6.2 and 4.5.6.3.

Normal operations at the GROA may include among other operations: (i) acceptance of waste, (ii) storage of waste prior to repackaging, (iii) repackaging of waste, (iv) removal/reuse of transport containers, (v) storage of repackaged waste prior to disposal, and (vi) disposal of waste. Each activity important to safety should have written procedures in place for normal operations, maintenance, surveillance, and periodic testing.

- Procedures and plans;
- Descriptions of activities;
- Administrative procedures for review, change, and approval; and
- Independence of review of procedure development by persons outside the operating management function.

4.5.6.2 Review Methods

RM1 Plans and Procedures for Normal Operations

Verify that DOE has provided adequate written procedures for normal operation of SSCs important to safety, as identified in the PCSA and reviewed in section 4.1 of the YMRP, to include routine and contingency operations and any procedural requirements necessitated by technical specifications. Normal operating procedures should include the following:

- Purpose of the procedure;
- Responsibilities, training, and qualifications of personnel;
- Prerequisites such as:
  - — Calibrations to be performed or checked;
  - — Instrumentation;
  - — Tools and special equipment;
  - — Notifications to other operations personnel with associated lead times;

- — Checks or settings for equipment or controls (e.g., physical travel limits for overhead crane);
- — Operational checks of radiation, environmental, or other monitors; and
- — Logs and records associated with the test.

- Description of the series of operations including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used (e.g., torque, time at pressure), and threshold limits requiring contingency actions (such as hold points, corrective action sequences, and notifications);
- Disposition of records and identification of parties to be notified upon completion of the operation; and
- Identification of any required follow-on actions.

Verify that administrative procedures for the review, change, and approval of normal operating procedures for SSCs important to safety are adequate and that these procedures have adequate management controls.

Confirm that appropriate industry or NRC standards are used as the basis for the operating procedures for SSCs important to safety.

Verify that normal operations of SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews should be specified, in both number and technical disciplines, and should collectively have the experience and competence required to review problems in the following areas:

- Nuclear engineering;
- Chemistry and radiochemistry;
- Metallurgy;
- Nondestructive testing;
- Instrumentation and control;
- Radiological safety;
- Mechanical, civil, and electrical engineering;
- Administrative controls and quality assurance practices; and
- Other appropriate fields associated with the characteristics of a repository for HLW.

An individual may possess competence in more than one speciality area.

RM2 Plans and Procedures for Maintenance

Verify that written procedures are provided for maintenance of SSCs important to safety and include the following:

- Purpose of the maintenance procedure;
- Responsibilities, training, and qualifications of personnel;
- Prerequisites such as:
  - Calibrations to be performed or checked;
  - Instrumentation;
  - Tools and special equipment;
  - Notifications to other operations or maintenance personnel with associated lead times;
  - Checks or settings for equipment or controls;
  - Operational checks of radiation, environmental, or other monitors; and
  - Logs and records associated with the maintenance.
- Description of the maintenance activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used, and threshold limits requiring contingency actions; and
- Disposition of records and identification of parties to be notified upon completion.

Verify that administrative procedures for the review, change, and approval of maintenance procedures for SSCs important to safety are adequate and that these procedures have adequate management controls.

Confirm that appropriate industry or NRC standards are used as the basis for the maintenance procedures for SSCs important to safety.

Verify that maintenance activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews should be specified, in both number and technical disciplines, and should collectively have the experience and competence required to review problems in the following areas:

- Nuclear engineering;
- Chemistry and radiochemistry;
- Metallurgy;
- Nondestructive testing;
- Instrumentation and control;
- Radiological safety;

- Mechanical, civil, and electrical engineering;
- Administrative controls and quality assurance practices; and
- Other appropriate fields associated with the characteristics of a repository for HLW.

An individual may possess competence in more than one speciality area.

RM3 Plans and Procedures for Surveillance

Verify that written procedures are provided to routinely evaluate, through surveillance, the proper functioning of SSCs important to safety and include the following:

- Purpose of the routine surveillance;

- Responsibilities, training, and qualifications of personnel;

- Prerequisites such as:

  — Calibrations to be performed or checked;

  — Instrumentation;

  — Tools and special equipment;

  — Notifications to operations personnel with associated lead times;

  — Checks or settings for equipment or controls;

  — Operational checks of radiation, environmental, or other monitors; and

  — Logs or records associated with the surveillance.

- Description of the surveillance activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be assessed; and

- Disposition of records and identification of parties to be notified upon completion.

Verify that if SSCs important to safety are found operating outside the tolerance for normal operation during surveillance, adequate procedures are in place to assure they will be restored to normal conditions in a reasonably short time so worker and public health and safety are protected.

Verify that administrative procedures for the review, change, and approval of surveillance procedures for SSCs important to safety are adequate and that these procedures have adequate management controls.

Confirm that appropriate industry or NRC standards, if applicable, are used as the basis for the surveillance procedures for SSCs important to safety.

Verify that surveillance activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews should be specified, in both number and technical disciplines, and should collectively have the experience and competence required to review problems in the following areas:

- Nuclear engineering;
- Chemistry and radiochemistry;
- Metallurgy;
- Nondestructive testing;
- Instrumentation and control;
- Radiological safety;
- Mechanical, civil, and electrical engineering;
- Administrative controls and quality assurance practices; and
- Other appropriate fields associated with the characteristics of a repository for HLW.

An individual may possess competence in more than one speciality area.

RM4 Plans and Procedures for Routine Periodic Testing

Verify that written procedures for periodic testing designed to ensure that SSCs important to safety will perform their design function during normal operations are in place. This testing should be accomplished on a defined schedule and at a frequency sufficient to ensure protection of worker and public safety. The reviewer should verify that procedures for periodic testing of SSCs important to safety include the following:

- Purpose of testing;

- Responsibilities, training, and qualifications of personnel;

- Prerequisites such as:

    — Calibrations to be performed or checked;
    — Instrumentation;
    — Tools and special equipment;
    — Notifications to other operations or testing personnel with associated lead times;
    — Checks or settings for equipment or controls;
    — Operational checks of radiation, environmental, or other monitors; and
    — Logs or records associated with the testing.

- Description of the testing activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used, and threshold limits requiring contingency actions; and

- Disposition of records and identification of parties to be notified upon completion.

Verify that if SSCs important to safety are found operating outside the tolerance for normal operation during periodic testing, adequate procedures are in place to assure that they will be restored to normal conditions in a reasonably short time such that worker and public health and safety are protected.

Verify that administrative procedures for the review, change, and approval of periodic testing procedures for SSCs important to safety are adequate and that these procedures have adequate management controls.

Confirm that appropriate industry or NRC standards, if applicable, are used as the basis for the periodic testing procedures for SSCs important to safety.

Verify that periodic testing activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews should be specified, in both number and technical disciplines, and should collectively have the experience and competence required to review problems in the following areas:

- Nuclear engineering;
- Chemistry and radiochemistry;
- Metallurgy;
- Nondestructive testing;
- Instrumentation and control;
- Radiological safety;
- Mechanical, civil, and electrical engineering;
- Administrative controls and quality assurance practices; and
- Other appropriate fields associated with the characteristics of a repository for HLW.

An individual may possess competence in more than one speciality area.

4.5.6.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(16)(v).

AC1 Plans for normal operation of SSCs of the GROA that are important to safety are acceptable.

- Acceptable written procedures are provided for normal operation of SSCs important to safety, as identified in the PCSA and reviewed in section 4.1 of the YMRP, to include routine and contingency operations as well as any procedural requirements necessitated by technical specifications. Normal operating procedures include the following:

    — Purpose of the procedure;

— Responsibilities, training, and qualifications of personnel;

— Prerequisites such as:

  – Calibrations to be performed or checked;

  – Instrumentation;

  – Tools and special equipment;

  – Notifications to other operations personnel with associated lead times;

  – Checks or settings for equipment or controls (e.g., physical travel limits for overhead crane);

  – Operational checks of radiation, environmental, or other monitors; and

  – Logs and records associated with the test.

— Description of the series of operations to be performed including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used (e.g., torque, time at pressure), and threshold limits requiring contingency actions (such as hold points, corrective action sequences, and notifications);

— Disposition of records and identification of parties to be notified upon completion of the operation; and

— Identification of any required follow-on actions.

- Administrative procedures for the review, change, and approval of normal operating procedures for SSCs important to safety are adequate, and these procedures have adequate management controls.

- Appropriate industry or NRC standards are used as the basis for the operating procedures for SSCs important to safety.

- Normal operations of SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews are specified, in both number and technical disciplines, and collectively have the experience and competence required to review problems in the following areas:

— Nuclear engineering;
— Chemistry and radiochemistry;
— Metallurgy;

- — Nondestructive testing;
- — Instrumentation and control;
- — Radiological safety;
- — Mechanical, civil, and electrical engineering;
- — Administrative controls and quality assurance practices; and
- — Other appropriate fields associated with the characteristics of a repository for HLW.

AC2 Plans and procedures for maintenance of SSCs of the GROA that are important to safety are acceptable.

- Written procedures are provided for maintenance of SSCs important to safety and include the following:

  - — Purpose of the maintenance procedure;

  - — Responsibilities, training, and qualifications of personnel;

  - — Prerequisites such as:

    - – Calibrations to be performed or checked;

    - – Instrumentation;

    - – Tools and special equipment;

    - – Notifications to other operations or maintenance personnel with associated lead times;

    - – Checks or settings for equipment or controls;

    - – Operational checks of radiation, environmental, or other monitors; and

    - – Logs and records associated with the maintenance.

  - — Description of the maintenance activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used, and threshold limits requiring contingency actions; and

  - — Disposition of records and identification of parties to be notified upon completion.

- Administrative procedures for the review, change, and approval of maintenance procedures for SSCs important to safety are adequate, and these procedures have adequate management controls.

- Appropriate industry or NRC standards are used as the basis for the maintenance procedures for SSCs important to safety.

- Maintenance activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews are specified, in both number and technical disciplines, and collectively have the experience and competence required to review problems in the following areas:

  — Nuclear engineering;
  — Chemistry and radiochemistry;
  — Metallurgy;
  — Nondestructive testing;
  — Instrumentation and control;
  — Radiological safety;
  — Mechanical, civil, and electrical engineering;
  — Administrative controls and quality assurance practices; and
  — Other appropriate fields associated with the characteristics of a repository for HLW.

AC3 Plans and procedures for surveillance of SSCs of the GROA that are important to safety are acceptable.

- Written procedures are provided to routinely evaluate, through surveillance, the proper functioning of SSCs important to safety and include the following:

  — Purpose of the routine surveillance;

  — Responsibilities, training, and qualifications of personnel;

  — Prerequisites such as:

    – Calibrations to be performed or checked;
    – Instrumentation;
    – Tools and special equipment;
    – Notifications to operations personnel with associated lead times;
    – Checks or settings for equipment or controls;
    – Operational checks of radiation, environmental, or other monitors; and
    – Logs or records associated with the surveillance.

  — Description of the surveillance activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be assessed; and

  — Disposition of records and identification of parties to be notified upon completion.

- If SSCs important to safety are found operating outside the tolerance for normal operation during surveillance, adequate procedures are in place to assure that they will be restored to normal conditions in a reasonably short time such that worker and public health and safety are protected.

- Administrative procedures for the review, change, and approval of surveillance procedures for SSCs important to safety are adequate, and these procedures have adequate management controls.

- Appropriate industry or NRC standards, if applicable, are used as the basis for the surveillance procedures for SSCs important to safety.

- Surveillance activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews are specified, in both number and technical disciplines, and collectively have the experience and competence required to review problems in the following areas:

  — Nuclear engineering;
  — Chemistry and radiochemistry;
  — Metallurgy;
  — Nondestructive testing;
  — Instrumentation and control;
  — Radiological safety;
  — Mechanical, civil, and electrical engineering;
  — Administrative controls and quality assurance practices; and
  — Other appropriate fields associated with the characteristics of a repository for HLW.

AC4 Plans and procedures for routine periodic testing of SSCs of the GROA that are important to safety are acceptable.

- Written procedures for periodic testing designed to ensure that SSCs important to safety will perform their design function during normal operations are in place. This testing will be accomplished on a defined schedule and at a frequency sufficient to ensure protection of worker and public safety. Procedures for periodic testing of SSCs important to safety include the following:

  — Purpose of testing;

  — Responsibilities, training, and qualifications of personnel;

  — Prerequisites such as:

    – Calibrations to be performed or checked;

        – Instrumentation;

        – Tools and special equipment;

        – Notifications to other operations or testing personnel with associated lead times;

        – Checks or settings for equipment or controls;

        – Operational checks of radiation, environmental, or other monitors; and

        – Logs or records associated with the testing.

    — Description of the testing activities including expected results, expected radiation dose, projected times for completion, expected instrument and gauge readings, controls to be used, and threshold limits requiring contingency actions; and

    — Disposition of records and identification of parties to be notified upon completion.

- If SSCs important to safety are found operating outside the tolerance for normal operation during periodic testing, adequate procedures are in place to assure that they will be restored to normal conditions in a reasonably short time such that worker and public health and safety are protected.

- Administrative procedures for the review, change, and approval of periodic testing procedures for SSCs important to safety are adequate, and these procedures have adequate management controls.

- Appropriate industry or NRC standards, if applicable, are used as the basis for the periodic testing procedures for SSCs important to safety.

- Periodic testing activities on SSCs that are important to safety are performed according to written procedures that are reviewed by health, safety, and quality assurance personnel who are independent of the operating management function. Personnel assigned responsibility for these independent reviews are specified, in both number and technical disciplines, and collectively have the experience and competence required to review problems in the following areas:

    — Nuclear engineering;
    — Chemistry and radiochemistry;
    — Metallurgy;
    — Nondestructive testing;
    — Instrumentation and control;
    — Radiological safety;
    — Mechanical, civil, and electrical engineering;
    — Administrative controls and quality assurance practices; and

— Other appropriate fields associated with the characteristics of a repository for HLW.

4.5.6.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they meet the requirements of 10 CFR 63.21(c)(16)(v). DOE has provided an adequate plan for conducting normal activities including operations, maintenance, surveillance, and periodic testing of SSCs important to safety at the GROA.

4.5.6.5 References

None.

4.5.7 Emergency Planning

Although DOE is not expected to have prepared an emergency plan at the time of the application for the construction authorization, DOE should commit to developing and implementing an emergency plan to meet or exceed the acceptance criteria in this section.

Review Responsibilities—High-Level Waste Branch

4.5.7.1 Areas of Review

This section reviews emergency planning. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(15).

The staff will evaluate the following parts of emergency planning using the review methods and acceptance criteria in sections 4.5.7.2 and 4.5.7.3.

- Descriptions of the GROA and nearby areas;
- Types and classifications of potential radioactive materials accidents;
- Means for detection of key initiating events and accident conditions;
- Actions to mitigate consequences of accidents;
- Methods and equipment to assess radioactive materials releases;
- Responsibilities of facility personnel during emergencies;
- Responsibilities for developing, maintaining, and updating the emergency plan;
- Means to notify and coordinate with offsite response organizations;
- Information to be communicated to offsite organizations;
- Training plans for emergency response;
- Means for restoring the facility to a safe condition;
- Provisions for quarterly communications checks;
- Plans for biennial emergency response exercises;
- Plans for semiannual radiological/health physics, medical, and fire drills;
- Certification that hazardous chemicals responsibilities are met under the Emergency Planning and Community Right-to-Know Act of 1986;

- Comments and their resolution on the emergency plan from offsite emergency response organizations;
- Assignments for offsite assistance; and
- Arrangements for providing information to the public.

4.5.7.2 Review Methods

Additional guidance for conducting this review is found in NUREG–1567, Standard Review Plan for Spent Fuel Storage Facilities (NRC, 2000). Criteria for an acceptable emergency plan are in 10 CFR 72.32(b).

RM1 Emergency Plan

Confirm that DOE has included a description of the GROA and the area near the site sufficient to support an evaluation of the emergency plan.

Verify that the application identifies each plausible type of radioactive materials accident. The radiological emergencies and accidents identified in the emergency plan should be the same as those identified during the review of event sequences conducted using section 4.1.1.4 of the YMRP.

Verify that DOE defines an adequate classification system to identify accidents as “alerts” or “site area emergencies.”

Assess the adequacy of the means (instruments, equipment, procedures, etc.) to detect key initiating events and accident conditions. Assess the rationale for the locations and types of detection devices deployed.

Assess the adequacy of planned means to mitigate the consequences of each type of accident, including the means to protect site workers and the program to maintain mitigative equipment.

Verify that methods and equipment planned to be used to assess releases of radioactive materials are adequate to support effective emergency response.

Verify that DOE clearly defines the responsibilities of facility personnel during a radiological accident and identifies personnel responsible for prompt notification of offsite response organizations and the NRC.

Confirm the adequacy of information provided for offsite response organizations including the point of contact; address; and phone number, fax, and e-mail addresses.

Ensure that DOE assigns responsibilities for developing, maintaining, and updating the emergency plan.

Verify that DOE provides a commitment to and a brief description of the means to promptly notify offsite response organizations and request offsite assistance, including medical assistance for the treatment of contaminated injured onsite workers. Confirm that:

- A control point will be established;
- The unavailability of some personnel, parts of the facility, and some equipment will not prevent the notification of and coordination with offsite response organizations; and
- The NRC operations center will be notified within 1 hour after an emergency is declared.

Assess the description of the types of information to be provided on GROA status, radioactive releases, and recommended protective actions (if necessary). Confirm that this information will be adequate and that it will be provided in a timely manner to offsite response organizations and the NRC.

Confirm that emergency response training provided to workers and any special instructions and orientation tours offered for fire, police, medical, and other offsite-based emergency personnel are adequate to support effective actions. Review the GROA training program using Section 4.5.3 (Training and Certification of Personnel) of the YMRP.

Confirm that means to restore the GROA to a safe condition after an accident will be adequate.

Confirm that quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies are planned and include the following:

- A check and update of all necessary phone numbers, fax numbers, and email addresses;
- An invitation to offsite response organizations to participate in the biennial exercises (participation of offsite organizations in biennial exercises is recommended but not required);
- A commitment to use scenarios not known to most exercise participants;
- A plan for critiques of each exercise by individuals not having direct implementation responsibility for conducting the exercise. Verify that critiques will evaluate the appropriateness of the plan, emergency procedures, facilities and equipment, training of personnel, and the overall effectiveness of the response; and
- Provisions to correct deficiencies identified by the critiques.

Confirm that onsite exercises to test response to simulated emergencies will be conducted biennially.

Confirm that radiological/health physics, medical, and fire drills are planned semiannually.

Verify that DOE commits that GROA operations will satisfy the Emergency Planning and Community Right-to-Know Act of 1986, with respect to hazardous materials at the facility.

Confirm that offsite response organizations were allowed 60 days to comment on the initial submittal of the emergency plan before it was transmitted to the NRC. Verify that subsequent plan changes will have a 60-day comment period if the changes affect the offsite response organizations. Confirm that any comments received during the 60 days comment period and licensee responses were submitted to NRC with the emergency plan.

Verify that plans for use of offsite assistance include:

- Arrangements for requesting and effectively using offsite assistance and provisions for using other organizations that can augment the planned onsite response, as required;

- Provisions for prompt communication among principal response organizations to offsite personnel who would be responding onsite;

- Provision of adequate emergency facilities and equipment to support the emergency response onsite;

- Specification of methods, systems, and equipment for assessing and monitoring consequences of radiological emergency conditions;

- Arrangements for medical services for onsite contaminated and injured individuals; and

- Training in radiological emergency response for offsite personnel who may be called to assist in an emergency.

Confirm that adequate arrangements for providing timely information to the public exist.

4.5.7.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.161.

AC1 An adequate emergency plan for responding to potential radiological materials and other accidents at the GROA is provided.

- A description of the GROA and the area near the site sufficient to support an evaluation of the emergency plan is included.

- DOE identifies each plausible type of radioactive materials accident. The radiological emergencies and accidents identified in the emergency plan are the same as those identified in event sequences.

- The classification system to identify accidents as “alerts” or “site area emergencies” is adequate.

- The means (instruments, equipment, procedures, etc.) used to detect key initiating events and accident conditions are adequate. The rationale for the locations and types of detection devices deployed is acceptable.

- The planned means for mitigating the consequences of each type of accident, including the means provided to protect site workers and the program to maintain mitigative equipment, are adequate.

- The methods and equipment planned to be used to assess releases of radioactive materials to support effective emergency response actions are adequate.

- The responsibilities and identities of facility personnel during a radiological accident and of personnel responsible for prompt notification of offsite response organizations and the NRC are adequately defined.

- Information provided for offsite response organizations including the point of contact; address; and phone number, fax, and e-mail addresses is adequate.

- Responsibilities for developing, maintaining, and updating the emergency plan are acceptably defined.

- A commitment to and a brief description of the means to promptly notify offsite response organizations and request offsite assistance, including medical assistance for the treatment of contaminated injured onsite workers, are provided. The description also includes sufficient information to verify that:

  — A control point will be established;

  — The unavailability of some personnel, parts of the facility, and some equipment will not prevent the notification of and coordination with offsite response organizations; and

  — The NRC operations center will be notified within 1 hour after an emergency is declared.

- The types of information to be provided on facility status, radioactive releases, and recommended protective actions (if necessary) are adequate and this information will be provided in a timely manner to offsite response organizations and the NRC.

- The emergency response training provided to workers and any special instructions and orientation tours offered for fire, police, medical, and other offsite-based emergency personnel are adequate to support effective actions.

- The means to restore the facility to a safe condition after an accident are adequate.

- Quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies are planned and include the following:

  — A check and update of all necessary phone numbers, fax numbers, and email addresses;

  — An invitation to offsite response organizations to participate in the biennial exercises;

  — A commitment to use scenarios not known to most exercise participants;

  — A plan for critiques of each exercise by individuals not having direct implementation responsibility for conducting the exercise. Critiques will evaluate the appropriateness of the plan, emergency procedures, facilities and equipment, training of personnel, and the overall effectiveness of the response; and

  — Provisions to correct deficiencies identified by the critiques.

- Onsite exercises to test response to simulated emergencies are conducted biennially.

- Radiological/health physics, medical, and fire drills are planned semiannually.

- DOE commits that GROA operations will satisfy the Emergency Planning and Community Right-to-Know Act of 1986, with respect to hazardous materials at the facility.

- The offsite response organizations are allowed 60 days to comment on the initial submittal of the emergency plan before transmittal to the NRC. Subsequent plan changes will have a 60-day comment period if the changes affect the offsite response organizations. Comments received during the 60-days-comment period and licensee responses are submitted to the NRC with the emergency plan.

- Plans for use of offsite assistance include:

  — Arrangements for requesting and effectively using offsite assistance and provisions for using other organizations that can augment the planned onsite response, as required;

  — Provisions for prompt communication among principal response organizations to offsite personnel who would be responding onsite;

  — Provision of adequate emergency facilities and equipment to support the emergency response onsite;

- — Specification of methods, systems, and equipment for assessing and monitoring consequences of radiological emergency conditions;
- — Arrangements for medical services for onsite contaminated and injured individuals; and
- — Training in radiological emergency response for offsite personnel who may be called to assist in an emergency.

- Adequate arrangements for providing timely information to the public exist.

4.5.7.4 Evaluation Findings

The NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.161. An acceptable emergency plan for coping with radiological accidents through permanent closure, including dismantlement and decontamination of the surface facilities at the GROA, is provided in accordance with 10 CFR 72.32(b). Aspects of this plan include:

- Facility and nearby area descriptions;
- Types and classifications of radioactive materials accidents;
- Means for detection of accident conditions;
- Means for mitigation of consequences of accidents;
- Adequate assessment of radioactive materials releases;
- Definition of responsibilities for facility personnel during an emergency;
- Responsibilities for developing, maintaining, and updating the emergency plan;
- Identification of offsite response organizations;
- Notification and coordination with offsite response organizations;
- Information to be communicated to offsite response organizations;
- Training of onsite emergency response staff;
- Safe condition restoration;
- Exercises to demonstrate readiness to act in emergency situations;
- Hazardous chemicals responsibilities under the Emergency Planning and Community Right-to-Know Act of 1986;
- Comments on the emergency plan from offsite emergency response team members;
- Offsite assistance requirements; and
- Arrangements for providing information to the public.

4.5.7.5 References

Nuclear Regulatory Commission (U.S.) (NRC). NUREG–1567, “Standard Review Plan for Spent Fuel Storage Facilities.” NRC, Spent Fuel Project Office: Washington, DC. March 2000.

4.5.8 Controls to Restrict Access and Regulate Land Uses

Review Responsibilities—High-Level Waste Branch

4.5.8.1 Areas of Review

This section reviews controls to restrict access and regulate land uses. Reviewers will also evaluate the information required by 10 CFR 63.21(c)(18).

Controls to restrict access and regulate land uses are implemented to reduce the likelihood of adverse human actions that could reduce the ability of the repository to isolate waste.

The staff will evaluate the following parts of controls to restrict access and regulate land uses using the review methods and acceptance criteria in sections 4.5.8.2 and 4.5.8.3.

- Extent and adequacy of GROA land acquisition or withdrawal,
- Compatibility of GROA boundaries in the GROA design and natural features,
- Means used to identify encumbrances or subsurface interests within the GROA,
- Acceptability of additional controls for permanent closure,
- Acceptability of additional controls through permanent closure,
- Adequacy of water rights,
- Control over surface and subsurface estates,
- Means used to identify encumbrances outside the GROA, and
- Acceptability of monument design.

4.5.8.2 Review Methods

RM1 Ownership of Land

Verify that steps within DOE purview to establish effective jurisdiction and control and legislative or other transfer activities underway will be completed prior to the completion of NRC review and decision on the license application.

Confirm that the land area of the GROA is either land acquired by DOE, or is permanently withdrawn and is reserved for DOE's use, and is held by DOE free and clear of all significant encumbrances including: (i) rights arising under the general mining laws; (ii) easements for right-of-way; and (iii) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

Confirm that legal documentation of ownership for the GROA includes sufficient indexes of ownership and/or control to satisfy a purchaser-of-record such as: a recorded title search showing any and all interests in the land, or a Bureau of Land Management Master Title Plan that indicates all recorded interests and claims.

If a statutory withdrawal of the GROA land has been enacted, verify that the license application includes a copy of the legislation and that the legal descriptions of the land area contained in the statute and the description in the application agree. Since the land area of the proposed repository site would be totally in federal ownership, the statutory withdrawal would constitute complete ownership documentation, subject to subordinate interests.

RM2 Additional Controls for Permanent Closure

Evaluate whether any controls established over surface and subsurface estates, at the GROA or outside the GROA, to prevent adverse human actions that could reduce the ability of the geologic repository to isolate the waste are acceptable and sufficient. Such controls may take the form of (i) possessory interests, (ii) servitudes, (iii) water rights, (iv) withdrawals from location or patent under the general mining laws, and (v) land use restrictions.

Confirm that the size and boundaries of the GROA and the affected area outside the GROA are consistent with the design or natural features to assure the ability of the repository to achieve isolation and to reduce the risk of human activity that could adversely impact waste isolation. Collaborate with the reviewers of the site characteristics completed using Sections 3.1 (General Description) and 4.2 (Repository Safety after Permanent Closure) of the YMRP.

Verify that legal documentation of ownership and/or control of the area outside the GROA includes sufficient indexes of ownership and control to satisfy a purchaser-of-record such as: a recorded title search showing any and all interests in the land, or the Bureau of Land Management Master Title Plan, which indicates all recorded interests and claims.

Verify that if a statutory withdrawal has not been enacted for land outside the GROA, DOE has taken or plans to take appropriate steps within its purview to establish effective jurisdiction and control. Legislative or other transfer activities underway should be completed prior to the completion of NRC review and decision on the license application.

Confirm that any existing or proposed permissible rights or encumbrances that exist and may be continued, or that should be established outside the GROA are identified, and the nature of any activities that may permissibly occur under these rights are assessed adequately.

Evaluate the DOE plan for administering and controlling its ownership rights or oversight of land. Verify that the means, such as title search and Bureau of Land Management records search, utilized to identify any existing or future encumbrances or other surface or subsurface interests of record in the land area outside the GROA were appropriate.

RM3 Additional Controls Through Permanent Closure

Evaluate whether any controls necessary to ensure the requirements at 10 CFR 63.111(a) and (b) are met are acceptable and sufficient. Such controls, if necessary, should include land use restrictions and the authority to exclude members of the public.

Confirm that the size and boundaries of the GROA and the affected area outside the GROA are consistent with the design or natural features, to ensure the requirements at 10 CFR 63.111(a) and (b) are met. Collaborate with the reviewers of Section 4.1 of the YMRP (Repository Safety Prior to Permanent Closure) and with the reviewers of the site characteristics completed using Sections 3.1 (General Description) and 4.2 (Repository Safety after Permanent Closure) of the YMRP.

Verify that legal documentation of ownership and/or control of the area outside the GROA includes sufficient indexes of ownership and/or control to satisfy a purchaser-of-record such as:

a recorded title search showing any and all interests in the land, or the Bureau of Land Management Master Title Plan, which indicates all recorded interests and claims.

Verify that if a statutory withdrawal has not been enacted for land outside the GROA, DOE has taken appropriate steps within its purview to establish effective jurisdiction and control. Legislative or other transfer activities underway should be completed prior to the completion of NRC review and decision on the license application.

Confirm that any existing or proposed permissible rights or encumbrances that exist and may be continued, or that should be established outside the GROA are identified, and the nature of any activities that may permissibly occur under these rights are assessed adequately.

Evaluate the DOE plan for administering and controlling its ownership rights or oversight of land. Verify that the means, such as title search and Bureau of Land Management records search, utilized to identify any existing or future encumbrances or other surface or subsurface interests of record in the land area outside the GROA were appropriate.

RM4 Water Rights

Confirm that DOE has obtained such water rights as may be necessary to accomplish the purpose of the GROA. Coordinate with the reviewers of the GROA design conducted using Section 4.1 (Repository Safety Prior to Permanent Closure) of the YMRP to determine the water use requirements.

RM5 Conceptual Design of Monuments

Confirm that the conceptual design of monuments planned to identify the site after permanent closure is adequate. The monuments should accurately identify the location of the repository, be designed to be as permanent as practicable, convey a warning against intrusion into the underground repository because of risk to public health and safety from radioactive wastes, and have a design life of at least a few hundred years.

4.5.8.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.121 and 10 CFR 63.21(c)(18) regarding controls to restrict access and regulate land use and conceptual design of monuments.

AC1 Ownership of land is adequately demonstrated.

- Steps within DOE purview to establish effective jurisdiction and control and legislative or other transfer activities underway are complete.

- The land area of the GROA is either land acquired by DOE, or is permanently withdrawn and is reserved for DOE’s use, and is held by DOE free and clear of all significant encumbrances.

- Legal documentation of ownership for the GROA includes sufficient indexes of ownership and control to satisfy a purchaser-of-record.

- If a statutory withdrawal of the GROA land has been enacted, the license application includes a copy of the legislation, and the legal descriptions of the land area contained in the statute and the description in the application agree.

AC2 Additional controls for permanent closure are acceptable.

- Any additional controls established over surface and subsurface estates, at the GROA or outside the GROA, to prevent adverse human actions that could reduce the ability of the geologic repository to isolate the waste are acceptable and sufficient.

- The size and boundaries of the GROA and the affected area outside the GROA are consistent with the design or natural features to assure the ability of the repository to achieve isolation and to reduce the risk of human activity that could adversely impact waste isolation.

- Legal documentation of ownership and/or control of the area outside the GROA includes sufficient indexes of ownership and control to satisfy a purchaser-of-record such as: a recorded title search showing any and all interests in the land, or the Bureau of Land Management Master Title Plan.

- If a statutory withdrawal has not been enacted for land outside the GROA, DOE has taken appropriate steps within its purview to establish effective jurisdiction and control. Legislative or other transfer activities are complete.

- Any existing or proposed permissible rights or encumbrances that exist and may be continued, or that should be established outside the GROA are identified, and the nature of any activities that may permissibly occur under these rights are assessed adequately.

- The means, such as title search and Bureau of Land Management records search, utilized to identify any existing or future encumbrances or other surface or subsurface interests of record in the land area outside the GROA were appropriate.

AC3 Additional controls through permanent closure are adequate.

- Any additional controls necessary to ensure the requirements at 10 CFR 63.111(a) and (b) are met are acceptable and sufficient.

- The size and boundaries of the GROA and the affected area outside the GROA are consistent with the design or natural features to ensure the requirements at 10 CFR 63.111(a) and (b) are met.

- Legal documentation of ownership and/or control of the area outside the GROA includes sufficient indexes of ownership and control to satisfy a purchaser-of-record such as: a recorded title search showing any and all interests in the land, or the Bureau of Land Management Master Title Plan.

- If a statutory withdrawal has not been enacted for land outside the GROA, DOE has taken appropriate steps within its purview to establish effective jurisdiction and control. Legislative or other transfer activities are complete.

- Any existing or proposed permissible rights or encumbrances that exist and may be continued, or that should be established outside the GROA are identified, and the nature of any activities that may permissibly occur under these rights are assessed adequately.

- The means, such as title search and Bureau of Land Management records search, utilized to identify any existing or future encumbrances or other surface or subsurface interests of record in the land area outside the GROA were appropriate.

AC4 The description of water rights is adequate.

- DOE has obtained such water rights as may be necessary to accomplish the purpose of the GROA.

AC5 The conceptual design of monuments is adequate.

- The conceptual design of monuments planned to identify the site after permanent closure is adequate.

4.5.8.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.121 and 10 CFR 63.21(c)(18). Requirements for the ownership and control of interests in land and use of permanent monuments to identify the site after permanent closure have been met. In particular:

- The GROA will be located in and on lands that are either acquired lands under the jurisdiction and control of DOE or are permanently withdrawn and reserved for its use. These lands will be held free and clear of encumbrances such as rights arising under the general mining laws, easements for right-of-way, and other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

- Additional controls will be applied for permanent closure to include areas outside the GROA. These controls will consist of jurisdiction and control over surface and subsurface estates as necessary to prevent adverse human actions that could significantly reduce the repository’s ability to achieve isolation.

- Additional controls will be applied through permanent closure including for areas outside the GROA. DOE will exercise jurisdiction as required to ensure that the preclosure performance objectives in 10 CFR 63.111 are met. The controls include the authority to exclude members of the public.

- DOE has obtained water rights to accomplish the purposes of the GROA.

- DOE has provided the conceptual design of monuments to identify the location of the repository after permanent closure.

4.5.8.5 References

None.

4.5.9 Uses of Geologic Repository Operations Area for Purposes Other Than Disposal of Radioactive Wastes

Review Responsibilities—High-Level Waste Branch

4.5.9.1 Areas of Review

This section reviews the uses of the GROA for purposes other than disposal of radioactive wastes. Reviewers will evaluate the information required by 10 CFR 63.21(c)(16)(vii).

The staff will evaluate the following parts of uses of the GROA for purposes other than disposal of radioactive wastes using the review methods and acceptance criteria in sections 4.5.9.2 and 4.5.9.3.

- Proposed activities other than disposal of HLW and their impacts, and
- Procedures for conduct and continuing oversight of proposed activities.

4.5.9.2 Review Methods

RM1 Proposed Activities

Determine whether any proposed activities at the GROA, other than the disposal of HLW, will potentially impact SSCs important to safety and engineered and natural barriers important to waste isolation. Activities to be considered include, but are not limited to:

- Long-term interim storage of HLW;

- Access for approved purposes unrelated to the disposal of HLW such as Native American cultural activities, protection of flora and fauna under appropriate regulations, recreation, and resource exploitation (e.g., minerals, geothermal, groundwater); and

- Performance monitoring or confirmation by groups other than NRC or DOE.

RM2 Procedures for Proposed Activities that Potentially Affect SSCs

Assess the adequacy of procedures for the continuing oversight of proposed activities, other than disposal of HLW at the GROA, that might affect SSCs important to safety and engineered and natural barriers important to waste isolation. These procedures should include (i) purpose of activity, (ii) detailed description of activity, (iii) radiation safety of workers, and (iv) disposition of records and identification of parties to be notified upon completion.

4.5.9.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(16)(vii), regarding uses of the GROA for purposes other than disposal of radioactive wastes.

AC1 Proposed activities other than disposal of radioactive wastes are acceptable.

- Proposed activities at the GROA, other than the disposal of HLW, are adequately evaluated for their potential impacts on SSCs important to safety and engineered and natural barriers important to waste isolation, and the impacts of these activities are acceptable.

AC2 Procedures for proposed activities other than disposal of HLW are acceptable.

- Procedures for the continuing oversight of proposed activities, other than disposal of HLW, at the GROA, that might affect SSCs important to safety and engineered and natural barriers important to waste isolation are adequate.

4.5.9.4 Evaluation Findings

NRC staff has reviewed the SAR and other docketed material and finds, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(16)(vii). Requirements for the content of the license application have been met in that plans for any uses of the GROA for purposes other than disposal of radioactive wastes have been adequately described. These plans include an analysis of the effects, if any, that such uses may have on the operation of the SSCs important to safety and the engineered and natural barriers important to waste isolation.

4.5.9.5 References

None.

4.5.10 License Specifications

Review Responsibilities—High-Level Waste Branch

This section reviews the variables, conditions, or other items determined by DOE to be probable subjects of license specification. The reviewers will evaluate the information required by 10 CFR 63.21(c)(12).

The review of variables, conditions, or other items that are probable subjects of license specifications, is to be integrated with reviews conducted using other sections of the YMRP.

The acceptability of proposed variables, conditions, and other items is assessed in conjunction with a determination that the repository performance objectives will be met, because these specifications and conditions define or constrain the operation and construction of the repository. Reviewers should give special attention to items that significantly influence the final design of the GROA.

4.5.10.1 Areas of Review

The staff will evaluate the following parts of license specifications using the review methods and acceptance criteria in sections 4.5.10.2 and 4.5.10.3.

- License conditions proposed in the following areas, as appropriate:
  - Physical and chemical form and radioisotopic content of radioactive waste;
  - Shape, size, and materials and methods of construction for radioactive waste packaging;
  - Amount of waste permitted per unit volume of storage space;
  - Requirements for test, calibration, inspection, surveillance, and monitoring;
  - Characteristics of drifts, drip shields, backfill, ventilation systems, and other SSCs;
  - Controls to restrict access and avoid disturbance; and
  - Administrative controls.
- Technical basis for each proposed variable, condition, or other item with emphasis given to those items that may significantly influence the final design.

4.5.10.2 Review Methods

RM1 Identification and Technical Bases for Proposed License Conditions

Confirm that proposed license conditions and their technical bases have been identified and justified.

RM2 Plans for Meeting License Conditions

Ensure that DOE has provided plans for meeting the license conditions and that these plans are consistent with the repository systems designs based on the results of the reviews conducted using sections 4.1 and 4.2 of the YMRP.

4.5.10.3 Acceptance Criteria

The following acceptance criteria are based on meeting the requirements of 10 CFR 63.21(c)(12) and 10 CFR 63.43 for license specifications.

AC1 Variables, conditions, and other items that are the subject of proposed license conditions are adequately identified and acceptable technical bases have been provided.

AC2 Plans for meeting the proposed license conditions and their technical bases are adequately identified in the following categories, where appropriate.

— Physical and chemical form and radioisotopic content of radioactive waste;

— Shape, size, and materials and methods of construction for radioactive waste packaging;

— Amount of waste permitted per unit volume of storage space;

— Requirements relating to test, calibration, or inspection to ensure that the foregoing restrictions are observed;

— Controls to be applied to restrict access and avoid disturbance to areas that might affect repository performance; and

— Administrative controls necessary to assure that facility activities are conducted safely and in conformity with other license conditions.

4.5.10.4 Evaluation Findings

The staff has reviewed the SAR and other docketed materials and has found, with reasonable assurance, that they satisfy the requirements of 10 CFR 63.21(c)(12) and 10 CFR 63.43. Requirements for the content of the license application have been met in that those variables, conditions, or other items that are probable subjects of license conditions have been identified and justified. Plans for meeting the license conditions have been specified. Special attention has been given to those items that may significantly influence the final design of the GROA.

4.5.10.5 References

None.