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DRAFT REGULATORY GUIDE

Contact: C.W. Prichard (301) 492-3884

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FORMAT AND CONTENT

FOR THE LICENSE APPLICATION FOR

THE HIGH-LEVEL WASTE REPOSITORY

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review and does not represent an official NRC staff position.

Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Regulatory Publications Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by

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INTRODUCTION

Section 60.21 of Title 10, Part 60 (10 CFR 60), of the Code of Federal Regulations requires the U. S. Department of Energy (DOE) to provide certain information in its license application (LA) for a high-level nuclear waste (HLW) repository. In addition, 10 CFR 60.21 states, in general terms, the information to be supplied in the LA. Section 60.21(a) requires that an environmental impact statement must accompany the LA.

The LA describes the HLW repository, the plans for its use, and the safety analyses that have been performed to demonstrate that the repository can be constructed and operated without undue risk to the health and safety of the public. The information contained in the LA should be timely, accurate, complete, and organized in a format that provides easy access. The LA is to include general information in Chapter 1, and the Safety Analysis Report (SAR) will present details in the other chapters. Any classified or national security information should be submitted separately. The LA should be as complete as possible in light of the information available at the time of submittal.

PURPOSE OF THE REGULATORY GUIDE

The purpose of this regulatory guide, the "Format and Content for the License Application for the High-Level Waste Repository," is to indicate the information to be provided in the LA and to establish a format acceptable to the NRC staff for presenting the information. Use of this format will help ensure the completeness of the information provided, will assist the NRC staff and others in locating the information, and will shorten the time needed for the review process. This guide is being issued as a draft to afford DOE, government agencies, and members of the public an opportunity to submit comments on the guide.

APPLICABILITY OF THE REGULATORY GUIDE

This regulatory guide applies to the LA that will be provided by DOE for the HLW repository.

USE OF THE REGULATORY GUIDE

The format for the LA presented in this regulatory guide is acceptable to the NRC staff. Conformance with the format, however, is not required. An LA with a different format will be acceptable to the staff if it provides an adequate basis for the findings requisite to the issuance of a construction authorization or license. However, because it may be more difficult to locate needed information, the staff review time for such a report may be longer, and there is a greater likelihood that the staff may regard the report as incomplete.

A repository systems-based format was chosen for this regulatory guide so that information can be organized logically with minimum need for repetition or inclusion of extraneous information. The repository is described in terms of the systems that compose it, namely the natural systems, the geologic repository operations area (GROA), and the engineered barrier systems (Chapters 2 through 4). The overall system performance assessment of the repository system is in Chapter 5 and the remaining generic or non-system-specific information on the repository is in Chapters 6 through 10. Appendix B of this regulatory guide correlates the requirements of 10 CFR 60 to the sections of this guide. This systems-based approach allows for each chapter of the LA to be developed and reviewed individually, while providing for sharing information among chapters, as appropriate.

All the applicable 10 CFR 60 requirements for a particular system or subsystem are considered within the pertinent part of the guide. By doing this, all the necessary considerations are presented in one area. For example, for each of the subsystems of the GROA, all the necessary design requirements should be in that section. This would include steps taken to consider the radiation protection aspects of the design as well as other design requirements. An example of how this approach allows the sharing of information can be found in Section 2.3 and Chapter 5. Section 2.3 of this regulatory guide calls for an analysis of the natural systems of the geologic setting that includes analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized and the extent to which it contributes to or detracts from isolation. In order to demonstrate this, the analyses to be conducted would be the same as those done as part of the performance assessment done in Chapter 5. While in Chapter 2 it is necessary to demonstrate compliance with the applicable requirements of 10 CFR 60, the analyses carried out as part of the performance assessment need not be repeated. Rather, the actual analyses would only be presented in Chapter 5 and referenced in Chapter 2.

Upon receipt of the LA, the NRC staff will perform a preliminary review to determine, in accordance with 10 CFR 2.101(f)(3), if it provides a reasonably complete presentation of the information needed to form a basis for the findings required before issuance of a construction authorization or license. If the LA does not provide a reasonably complete presentation of the necessary information, further review of the application may not be initiated until a reasonably complete presentation is provided. The information provided in the LA should be up to date with respect to the state of scientific knowledge and technology and should take into account recent changes in the NRC regulations and guides and in relevant industry codes and standards.

STYLE AND COMPOSITION

DOE should strive for clear, concise presentation of the information provided in the LA. Confusing or ambiguous statements and unnecessarily verbose descriptions do not contribute to expeditious technical review. Positions, conclusions, and claims of adequacy of designs or design methods should be supported by technical bases.

Duplication of information should be avoided. Similar or identical information may be requested in various sections of this guide because it is relevant to more than one repository system; however, this information should be presented in the principal section and appropriately referenced in the other applicable sections of the SAR. For example, where diagrams containing the same information are requested in more than one section of this regulatory guide, duplicate diagrams need not be submitted provided all the information requested in all sections is included on the diagrams and is appropriately identified and referenced.

When numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. If possible, estimated limits of error or uncertainty should be given.

Abbreviations should be consistent throughout the LA and should be consistent with generally accepted usage. Any abbreviations, symbols, or special terms unique to the proposed design or not in general usage should be defined in each chapter of the LA where they are used.

Drawings, maps, diagrams, sketches, and charts should be employed where the information can be presented more adequately or conveniently by such means. Due concern should be taken to ensure that all information presented in drawings is legible, symbols are defined, and drawings are not reduced to the extent that visual aids are necessary to interpret pertinent items of information presented in the drawings.

Reports or other documents referenced in the text of the LA should be listed at the end of the section in which they are referenced. If proprietary documents are referenced, a nonproprietary summary of the document should also be referenced. Material incorporated into the application by reference should be listed in Chapter 2 in the SAR (see Section 2.2 of this guide).

REVISIONS

Data and text should be updated or revised by replacing pages. "Pen and ink" or "cut and paste" changes should not be used.

The changed or revised portion on each page should be highlighted by a "change indicator" mark consisting of a bold vertical line drawn in the margin opposite the binding margin. The line should be the same length as the portion actually changed.

All pages submitted to update, revise, or add pages to the report should show the date of change and a change or amendment number. A guide page listing the pages to be removed should accompany the revised pages. Special care should be taken to ensure that the main sections of the report are revised to reflect any design changes reported in supplemental information, i.e., responses to NRC staff requests for information or responses to regulatory positions.

PHYSICAL SPECIFICATIONS

In general, material submitted as part of the LA should conform to specific standards for page size, quality of paper and inks, and numbering of pages, exhibits, and attachments. More specifically:

Paper Size (not to exceed)

Text pages: 8-1/2 x 11 inches.

Drawings and graphics: 8-1/2 x 11 inches preferred; however, a larger size is acceptable provided:

a. The bound side does not exceed 11 inches except where required for legibility, and

b. The finished copy when folded does not exceed 8-1/2 x 11 inches.

Paper Stock

Weight or substance: 20 pound for printing on both sides 16 to 20 pound for printing on one side only.

Composition: Wood chemical sulphite (no groundwood) and a pH of 5.5.

Color: White is preferred, but pastel colors are acceptable provided the combination of paper stock and ink is suitable for microfilming.

Ink: The color should be sufficiently dense to record on microfilm or image-copying equipment.

Page Margins: A margin of no less than one inch should be maintained on the top, bottom, and binding side of all pages.

Printing.

Composition: Text pages should be single spaced.

Type font and style: Must be suitable for microfilming and optical scanning.

Reproduction: May be mechanically or photographically reproduced. Text pages should be printed on two sides with the image printed head to head.

Binding: Pages should be punched for standard 3-hole loose-leaf binders.

Page Numbering: Pages should be numbered with the two digits corresponding to the chapter and first-level section numbers followed by a hyphen and a sequential number within the section, i.e., the third page in Section 4.1 of Chapter 4 should be numbered 4.1-3. Do not number the entire report sequentially. (Note that because of the small number of pages in many sections, this regulatory guide is numbered sequentially within each chapter.)

LICENSING SUPPORT SYSTEM

The Licensing Support System (LSS), established under 10 CFR 2, Subpart J, is an electronic information management system containing all the relevant HLW documentary material from DOE and its contractors as well as all other parties, including the NRC. The LSS database will expand through the licensing process and will include the DOE LA.

A copy of the LA must be submitted to the LSS Administrator in machine readable ASCII format identical to the hard copy version, header (bibliographic) information, and an image. The following guidelines are provided for ASCII submission. Guidelines for header and image submission will be provided later. For further information about the LA submission requirement under 10 CFR 2 Subpart J, contact the Office of the LSS Administrator, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

If normal electronic transmission procedures cannot be followed, the NRC Document Control Center may approve the submission of documentary material by floppy disks or magnetic tape. If one of these methods is authorized by the NRC Document Control Center, the following format should be used:

Floppy Disks (ANSI draft standard X3B 8.1-1986*)

IBM PC/DOS format: 5.25 inch; double-sided, double density, nine sectors; the new 3.5 inch diskettes are also acceptable;

ASCII character code, with each paragraph ended with a carriage return and line feed (HEX OD OA);

*ANSI standards may be obtained from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

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Each line also may end with a carriage return and line feed;

Each sentence must end with a period followed by two spaces;

Maximum of 80 characters per line (with 69 characters preferred);

Remove all underline and hyphen characters;

External disk label to identify content and date of preparation.

Magnetic Tape (ANSI X 3.39-1973*)

Nine track, standard reel-to-reel, 1600 or 6250 BPI;

ASCII character code, with each paragraph ended with a carriage return and line feed (HEX OD QA);

Each line may also end with a carriage return and line feed, but this is not preferred;

Each sentence must end with a period followed by two spaces;

No internal tape label;

Maximum of 80 characters per line (with 69 characters preferred);

Fixed block size (maximum of 2048 characters per block);

External tape label to identify content and date of preparation.

All files on one physical tape must each have the same number of characters per record and characters per block. Tapes must not be generated using system independent copy routines that would not permit them to be transportable from one computer to another.

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*ANSI standards may be obtained from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

For both diskette and tape formats, if the document contains footnotes that are not included on the page of text to which they refer, they must be placed in numerical sequence at the end of the document text. For diskette, tape, or electronic transmission, the concluding sequence for the completed text transmission of each individual document should be the words "end of document," preceded by and followed by three asterisks (i.e., ***end of document***).

LICENSE APPLICATION

1. GENERAL INFORMATION

The first chapter of the license application (LA) should present an introduction to the report and a general description of the high-level nuclear waste (HLW) repository. This chapter should enable the reader to obtain a basic understanding of the overall facility without having to refer to the subsequent chapters. Review of the detailed chapters that follow can then be accomplished with a better perspective, with recognition of the relative safety importance of each individual item to the repository design.

This section should briefly present the principal aspects of the overall LA, including (1) an overview of the proposed project (broadly describing the project in terms of the systems organizational approach of this regulatory guide); (2) a description of the proposed repository location; (3) the general layout and design of the repository; and (4) supporting information for the LA. The LA is to include general information in Chapter 1 and the SAR will present details in the other chapters.

1.1 GENERAL FACILITY DESCRIPTION

DOE should present an overall introduction to the LA and a general description of the repository and its location. This should include a description of both the site and the geologic setting, a description of the geologic repository operations area (GROA) and all structures, engineered barriers, roads, and transportation links on the site. Boundaries, both natural and man-made, should be discussed and depicted on simple drawings or maps. A general discussion of outstanding geologic, hydrologic, meteorologic or climatologic, and geochemical features of the site should be included. The design of major above- and below-ground structures with a designation of whether they are permanent or temporary is to be included. Briefly discuss plans for operation, decommissioning, and permanent closure of the site. This section should enable the reader to obtain a basic understanding of the proposed repository layout and operation without having to refer to other sections. The information in the other sections can then be reviewed from a better perspective.

1.2 BASIS FOR LICENSING AUTHORITY

This section should refer to applicable sections of the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974, and the Nuclear Waste Policy Act of 1982 (NWPA), all as amended. Explain that DOE's conduct of the proposed activities is subject to NRC regulations, and cite the applicable specific sections.

1.3 SCHEDULES

DOE should provide the proposed schedules for construction, operations, receipt of waste, first emplacement of wastes, and permanent closure. The information should also set forth the time requirements in the NWPA, as amended, including appropriate information from DOE's Mission Plans and Project Decision Schedules.

1.4 CERTIFICATION OF SAFEGUARDS

If applicable, this section should note that DOE's plans for physical protection of the facility are described in a separate part of the application withheld from public disclosure pursuant to 10 CFR 2.790(d).

This section should contain a certification that DOE will provide at the GROA such safeguards as it requires at comparable surface facilities (of DOE) to protect against radiological sabotage. DOE should also identify the comparable surface facilities upon which the certification is based.

1.5 PHYSICAL SECURITY PLAN

DOE should provide a description of the physical security plan for protection against radiological sabotage. Since radiation hazards associated with high-level wastes (including spent nuclear fuel) make them inherently unattractive as a target for theft or diversion, no detailed information need be submitted on protection against theft or diversion. However, a description of the proposed nuclear material control and accounting program should be provided.

1.6 SITE CHARACTERIZATION PROGRAM REVIEW

1.6.1 Site Characterization Work Conducted

DOE should summarize the site characterization work actually conducted at the repository site and reference, as appropriate, the semi-annual progress reports and the SAR portion of the LA. If the completed work differs from that described in the Site Characterization Plan, semi-annual progress reports, and study plans, DOE should identify the differences and explain why such work differed. This information should serve to place the LA in the context of the process described in the NWPA and 10 CFR Part 60. Details of data obtained during site characterization should be set out in the SAR.

1.6.2 Status of DOE Resolution of NRC Objections

Throughout the prelicense application phase, the NRC staff objects when a concern with some aspect of DOE's program is of such significance that the staff would consider the LA to be incomplete or insufficient in a particular area if submitted with the objection unresolved by DOE. While the NRC staff expects that DOE will continue to place a high priority on resolving NRC staff objections as well as other types of concerns, it is possible that reaching an agreeable resolution for some objections could be difficult. As part of the acceptance review of the LA and before a decision on docketing it, the NRC staff will evaluate the effect of any unresolved objections, both individually and in combination with others, on the NRC staff's ability to conduct a meaningful review of the LA that would enable NRC to determine whether or not compliance with 10 CFR 60 has been demonstrated. To assist the NRC staff in evaluating the effects of unresolved objections and deciding whether to docket the LA, DOE should provide the following information about unresolved objections:

1. Identify all unresolved objections.

2. Explain the differences between NRC and DOE positions that have precluded resolution of each objection.

3. Describe all attempts to achieve resolution.

4. Explain why resolution has not been achieved.

5. Describe the effects of the different positions on demonstrating compliance with 10 CFR Part 60.

SAFETY ANALYSIS REPORT

2. GENERAL INFORMATION FOR THE SAFETY ANALYSIS REPORT

2.1 IDENTIFICATION OF AGENTS AND CONTRACTORS

This section should identify the prime agents or contractors for the design, construction, and operation of the HLW repository. The principal consultants and outside service organizations (e.g., those providing audits of the quality assurance plan) should be identified. The division of technical work areas between the agents or contractors should be delineated.

2.2 MATERIAL INCORPORATED BY REFERENCE

This section should provide a list of all topical and issue-resolution reports that are incorporated by reference as part of the safety analysis report (SAR). In this context, "topical or issue-resolution reports" are defined as reports that have been prepared by DOE, its prime agents or contractors, or other organizations and filed separately with the NRC in support of this SAR. For each topical or issue-resolution report, this list should include (1) the title, (2) the report number, (3) the date submitted to the NRC, and (4) the sections of the SAR in which this report is referenced. For any topical or issue-resolution reports proposed to be withheld from public disclosure pursuant to 10 CFR 2.790(b) as proprietary documents, nonproprietary summary descriptions of the general content of such reports should also be referenced. This section should also include a list of documents submitted to the NRC in other applications that are incorporated in whole or in part in this application by reference. If any information submitted in connection with other applications is incorporated by reference in the SAR, summaries of such information should be included in the appropriate sections of the SAR. Results of tests and analyses may be submitted as separate reports. In such cases, these reports should be referenced in this section and summarized in the appropriate section of the SAR.

2.3 USE OF NRC TECHNICAL POSITIONS

The SAR should include a table indicating the extent to which DOE intends to use all applicable NRC Technical Positions, and the title, number, and revision number of those positions. For each applicable technical position, the table should identify those sections of the SAR to which the position applies and should indicate any proposed exceptions to the technical position.

2.4 REQUIREMENTS FOR FURTHER TECHNICAL INFORMATION

In accordance with 10 CFR 60.24(a), the SAR must be as complete as possible in the light of information that is reasonably available at the time of submission. This section should explain, with reference to information not supplied at the time of submission, why such information was not reasonably available.

The SAR should identify, describe, and discuss those safety features or components for which further technical information is required in support of the issuance of a license, but has not been supplied in the SAR. This section of the LA should:

2.4.1. Identify and distinguish between those technical information development programs that will be required to determine the adequacy of a new design and those that will be used to demonstrate the margin of conservatism of a proven design.

2.4.2. Describe the specific technical information that must be obtained to demonstrate acceptable resolution of the program.

2.4.3. Describe the program in sufficient detail to show how the information will be obtained, or cross-reference those sections of the LA in which the information is provided.

2.4.4. Provide a schedule of completion of the program as related to the projected startup date of repository operation.

2.4.5. Discuss the design alternatives or operational restrictions available in the event that the results of the program do not demonstrate acceptable resolution of the problem.

Reference may be made to topical program or issue-resolution summary reports filed with the NRC; however, if such references are made, the applicability of each technical information development item to the repository should be discussed.

This section should also include a resume of special technical information development programs undertaken to establish the final design and/or demonstrate the conservatism of the design and a discussion of any programs that will be conducted during operation in order to demonstrate the acceptability of contemplated future changes in design or operation.

2.5 RADIOACTIVE MATERIALS

DOE should provide a description of the kind, amount, and specifications of the radioactive material proposed to be received and possessed at the geologic repository operations area.

2.6 LICENSE SPECIFICATIONS

DOE should concisely identify those variables, conditions, or other items determined to be probable subjects of license specifications. In addition, DOE should provide, by reference or otherwise, the justification for the selection of those variables, conditions, or other items.

3. THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING

This chapter should describe the natural systems of the geologic setting of the region in which the geologic repository is to be located. It should include a description of the overall purpose and function of the repository site and how the site fulfills the requirements of 10 CFR Part 60. The focus of the descriptions and assessments should be the function of the natural systems of the geologic setting in isolating high-level radioactive waste from the accessible environment.

3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE

This section should describe the natural systems of the geologic setting of the region of the site. This description should, in all cases, include such information for the controlled area. In addition, if conditions outside the controlled area may affect isolation within the controlled area, the description should include information on conditions outside the controlled area to the extent such information is relevant and material.

3.1.1 Geologic System

This section should describe the geologic conditions of both the geologic setting and the region of the site. Demonstrate that the areas studied provide a representative description of the conditions throughout the region around the site and at the site. Detailed justification for the areal limits placed on regional studies should be provided.

The pertinent data, analyses, and level of assessment of natural geological analogs should be provided, such as those selected for tectonic (faulting, seismic, and volcanic) models, natural resource assessment, and geomorphic evaluation of the site. The basis for selecting the analog and the basis for comparing and contrasting the analog conditions with those at the site should be discussed. Similarities between the natural analog and the site, the process or features of interest, how the analog will be used, the time frame of the comparative study, and any differences in scale or features between the analog and the site should be described and discussed. Maps and cross sections should be provided to illustrate the locations and geological characteristics of the analog sites.

Sources of information and data collection methods used to obtain measurements and observations should be described and documented. Geological and geophysical descriptions should be accompanied by illustrations such as maps, cross sections, photographs, and fence diagrams. The variability and uncertainty of data and information should be discussed.

The discussions and descriptions should address the representativeness of the data, the effects of varying geologic conditions, the reliability of geological and geophysical interpretations made, and uncertainties associated with the extrapolation of data and information to repository conditions. The use of conceptual models should be discussed with respect to uncertainties in the data bases, the applicability and appropriateness of the geologic assumptions, the sensitivity of the model results to the uncertainty of the geologic input data, and model validation.

3.1.1.1 Regional Geology

Provide sufficient data and technical analyses to describe the geologic characteristics of the region of the site. The description of the geology of the region should include information and investigations on the following:

3.1.1.1.1. Geomorphology and Topographic Features in the Region of the Site Area. Describe the data, information, investigations, and analyses bearing upon the geomorphology and topographic features in the region of the site. Conditions (past, present, and future) that bear upon the reasonable assessment of geomorphic processes and topographic features such as climate and tectonism should be thoroughly investigated. Such data, information, investigations, and attendant analyses should address matters such as the identification of the geomorphic units and features within and abutting the controlled area, the geomorphic processes that are acting or could be acting within the geologic system, and the paleogeomorphic processes that have occurred, could have occurred, or could reoccur within the geologic system. Particular emphasis should be placed on erosion rates that occurred within the Quaternary Period and on those rates projected to occur during at least the next 10,000 years.

3.1.1.1.2. Stratigraphy and Lithology of the Region. Describe the stratigraphic and lithologic framework of the region surrounding the site. The description should include a discussion of the relationship (including contact relationships) between stratigraphic and lithologic units. Descriptions of stratigraphic units should also include accepted names, absolute and relative ages of stratigraphic units, and the rationale for stratigraphic boundaries based upon criteria such as mineralogical or geochemical characteristics.

The history of pertinent stratigraphic and lithologic units should include a discussion of processes of formation and alteration. Discussions of formation should consider sedimentation, provenance, environment of genesis, and deposition. Alteration history should include alteration effects resulting from processes such as tectonism, metamorphism, plutonism, and volcanism with attendant hydrothermal processes.

3.1.1.1.3. Seismology. A complete list of all historically reported earthquakes that reasonably could have affected the region surrounding the site should be provided. The list should encompass all earthquakes that have been reported to have occurred in geologic settings or on geologic structures that lie at least partially within 200 miles of the site. The regional geologic structure and tectonic activity that are significant in determining regional earthquake potential should be identified. The identification should include a description of the variation in characteristics of geologic structure, tectonic history, present and past stress regimes, and seismicity of the geologic settings and geologic structures. A correlation between epicenters or regions of highest intensity of historically reported earthquakes and the geologic setting or geologic structures within the setting should be provided. Whenever an earthquake hypocenter or concentration of earthquake hypocenters can be reasonably correlated with geologic structures, the rationale for the association should be developed. When earthquake hypocenters cannot be reasonably correlated with geologic structures, the hypocenters should be discussed in relation to the geologic setting. The largest earthquakes associated with the geologic setting or each geologic structure within that setting should be identified.

3.1.1.1.4. Structural Geology and Tectonic Information. Provide information on the structural and tectonic features in the site region, and include a discussion and analysis of regional tectonic models and their applicability to the site. Detailed discussions should be included on the tectonic history, volcanic history, faulting history, and folding history as well as a discussion of the active stress field in the region. A discussion of the relationship (if any) between known structural features and historical seismicity should also be provided.

Provide a detailed description of the orientation, distribution, spacing, and density of fractures, discontinuities, and heterogeneities, and discuss their origins and history, including information on any aperture in-filling.

3.1.1.1.5. Natural Resources. Describe the natural resources (both known and postulated) near the site that are economic, marginally economic, and sub-economic, the exploitation of which could result in inadvertent intrusion into the repository. This description should be derived from but should not be limited to sources such as literature, mapping, geochemical sampling, and comparison with working models of known mines, prospects, and exploratory drill holes. Consideration should be given to resources such as minerals (including metallic and nonmetallic ores); fuels; hydrocarbons, including gas, oil, tar sands, and asphalt; and geothermal resources. Potable, agricultural, and industrial waters, including waters in the form of brines, should also be addressed.

The description of these resources should include information on resource type, occurrence, location, extent, net worth, recoverability, and current and projected use. In addition, provide (1) a comparison of the site and environs with areas of mineral and hydrocarbon deposits with similar origins, host rocks, and structural regimes, (2) an assessment of the near-site area based on comparisons with known mineral resources and models, and (3) the location, nature, and extent of any known or suspected mineralization, hydrocarbons, or waters of elevated temperatures.

3.1.1.1.6. Geophysics. Describe the results of geophysical investigations, as needed, for issue resolution and basic understanding of the region of the site. Surface-based geophysical investigations (such as seismic reflection and refraction, gravity, magnetic, remote sensing, aeromagnetic, and low-sun-angle mapping) are critical components of site characterization. They provide necessary information using nondestructive methods. The investigations should provide adequate characterization of natural resources, faulting, fractures and voids, potential magma chambers, magma sources, and other tectonic features of importance to the design and analysis of the HLW repository. Investigation of the region should identify the major tectonics and natural resource features in the site vicinity.

3.1.1.2 Site Geology

Provide sufficient data and technical analyses to describe the geologic characteristics of the site. The description of the geology of the site should include information and investigations on the following:

3.1.1.2.1. Geomorphology and Topographic Features of the Site Area. Describe the data, information, investigations, and analyses bearing upon the geomorphology and the topographic features that are characteristic of the site. The data, information, investigations, and analyses should address such matters as whether extreme erosion is representative of the site or the area adjacent to the site such that isolation within the site may or may not be affected. Provide projections of the maximum rate of erosion in the vicinity of facilities important to safety (critical structures) and engineered features, such as the exploratory shafts and the waste handling facilities and in other areas, especially in wash areas and those areas overlying the underground facility having minimum thicknesses of overburden or greatest vulnerability to denudation.

In addition, this section should provide geomorphic and topographic maps and cross sections, as appropriate, and should assess the effects of subsidence and faulting in order to project rates of erosion and the attendant effect of such erosion on specific engineered structures and other critical areas.

3.1.1.2.2. Stratigraphy and Lithology of the Site. Describe the stratigraphic and lithologic framework of the site. The description should include a discussion of contact and genetic relationships between stratigraphic or lithologic units. Descriptions of stratigraphic units should include accepted names and relative or isotopic ages of stratigraphic units, genetic relationships of delineated units, and the rationale for stratigraphic boundaries based on mineralogical, geochemical, or paleontological characteristics.

A discussion of the history of stratigraphic and lithologic units should include a description of processes of formation and alteration affecting those units. Discussions of formation of stratigraphic or lithologic units should consider sedimentation, provenance, genetic environment, and deposition. Alteration history should include processes resulting from tectonism, metamorphism, plutonism, and volcanism with attendant hydrothermal processes.

A detailed description of stratigraphic or lithologic units surrounding or hosting (repository horizon) the waste should include identification of mineralogical and paleontological constituents and identification of physical characteristics such as texture, bedding, grain size, percent and size of cavities, degree of cementation, and schistosity, as appropriate. Descriptions of zones of alteration should accompany descriptions of stratigraphic and lithologic units. Vertical or lateral variation of compositional or physical characteristics within units should be described, and thicknesses and spatial extent of stratigraphic or lithologic units, in particular, host units or those units credited as barriers to migration of waste, should be defined. In addition, changes in lateral continuity of units from faulting, folding, uplift, and subsidence should be described.

Stratigraphic and lithologic information sources and the methods used to obtain site-specific data should be described and documented. Unit descriptions should be accompanied by geologic maps and isopach maps of subsurface stratigraphic units. Maps should be accompanied by cross sections illustrating stratigraphic or lithologic units at the site. Locations of cross sections should be delineated on appropriate maps.

3.1.1.2.3. Seismology. Ground motion at the site should be determined assuming seismic energy transmission effects are constant over the region and assuming the largest earthquake associated with each geologic structure or appropriate geologic settings occurs at the point of closest approach of that structure or setting to the site. If different potential earthquakes would produce the maximum ground motion in different frequency bands, the conditions describing all such earthquakes should be specified. The following material properties should be determined for each stratum under the site: seismic compressional and shear velocities, bulk densities, soil properties and classification, shear modulus and its variation with strain level, and water table elevation and its variation. For each set of conditions describing the occurrence of the maximum potential earthquakes, the types of seismic waves producing the maximum ground motion should be determined, and an analysis should be performed to determine the effects of transmission in the site material for the identified seismic wave types in the significant frequency bands. The acceleration, the effective frequency range, and the duration corresponding to each maximum potential earthquake should be determined both at the ground surface and at the depth of the underground facility of the geologic repository. Design response spectra corresponding to the design basis earthquake should be defined and their conservatism assessed by comparing them to the ground motion expected from the potential earthquakes.

3.1.1.2.4. Structural Geology and Tectonics. Describe and discuss the structural and tectonic features in the site area, and include a discussion and analysis of local structural and tectonic models and their applicability to the site. Detailed descriptions (including detailed maps and cross sections) of the volcanic history, faulting history, folding history, and jointing history as well as a discussion of the stress field at the site should be included. Individual tectonic features that might affect waste isolation directly or indirectly should be described and discussed in detail. In addition, the possible relationship among tectonic processes, including the possibility of coupled processes, should be described and discussed. All discussions and descriptions should include sufficient detail to demonstrate that features and conditions described are representative of structural and tectonic features of the site area and that the range of tectonic conditions has been established.

The methods (i.e., remote sensing techniques) used to determine the location, ages, and recurrence intervals of fault movements and volcanic episodes should be described and documented.

3.1.1.2.5. Natural Resources. Describe the natural resources (either known or postulated) at the site that are economic, marginally economic, or subeconomic, the exploitation of which could result in inadvertent intrusion into the controlled area. Consideration should be given to resources such as minerals (including metallic and non-metallic ores); fuels; hydrocarbons, including gas, oil, tar sands, and asphalt; and geothermal resources. Describe the association of possible hydrocarbon resources with Paleozoic stratigraphic units underlying the site and trap rocks. Potable, agricultural, and industrial waters, including waters in the form of brines, should also be addressed. The economic assessment should be derived from, but should not be limited to sources such as literature, mapping, geochemical sampling, and comparison with working models of known mines, prospects, and exploratory drill holes.

The description of these resources should include information on resource type, occurrence, location, extent, net worth, recoverability, and current and projected use.

In addition, provide (1) a comparison of the site with areas of mineral and hydrocarbon deposits with similar origins, host rocks, and structural regimes, (2) an assessment of the site area based on comparisons with known mineral resources and models, (3) the location, nature, and extent of any known or suspected mineralization, hydrocarbons, or waters of elevated temperatures.

Discuss the possible presence of mineral deposits at the site and their association with stratigraphic units of volcanic origin, veining, fault zones, alteration zones, and subsurface plutons.

3.1.1.2.6. Geophysics. Describe the results of geophysical investigations conducted for issue resolution and basic understanding of the site. Limitations of the data collected should be discussed with regard to level of detail, resolution quality, and other sources of uncertainty. Such data should consist of surface-based geophysical investigations (such as seismic reflection and refraction, gravity, magnetic, aeromagnetic, resistivity, and electromagnetic) and borehole geophysical investigations (such as downhole and crosshole seismic surveys, nuclear logs, acoustic logs, and borehole gravimetry, magnetic, and radar). The investigations should provide detailed characterization of tectonic features, physical properties of the formations, and fracture characteristics.

3.1.1.2.7. Geoengineering. Describe and discuss the geoengineering properties of the rock units present at the site. The discussions should describe the properties that have been ascertained by testing, the testing procedure, the logic for selection of rock samples, the stratigraphy framework for testing (including strategy for testing intact rock units as well as discontinuities within or between rock units), the sample size, the number of joints or fractures, and the conceptual rock mechanics models that used the collected data. For each rock unit or rock discontinuity, the geoengineering properties should include a set of mechanical properties, a set of thermal and thermomechanical properties, and the existing stress field. These properties include but are not limited to confined and unconfined compressive strength, Young's modulus, Poisson's ratio, tensile strength, thermal conductivity, and thermal expansion. Discussions on the stress field should include geologic and tectonic evidence, results of field testing, and estimates on the variability of the stress field around the site and within the GROA.

Descriptions of testing should include results of the effects of anisotropy, lithophysae, porosity, density, and water saturation on the geoengineering properties of the rock units. The discussions should also include excavation characteristics of the rock mass, the methods chosen for excavation of the shafts and ramps and the underground facility, changes in geoengineering properties resulting from excavation and the application of thermal load, estimated inflow of ground water, and estimated ground support requirements under both ambient and elevated temperature conditions.

3.1.1.3 Future Variation in Geologic Processes

From analyses and models representative of conditions in the geologic setting, provide an assessment of future changes that might be expected to occur in the geologic system. The assessments of predicted changes should be supported by the use of appropriate field and laboratory tests, monitoring data, and natural analog studies. Long-term estimates should include (1) the potential for earthquakes on any faults in the geologic system, (2) the potential for new and extended faulting and fracturing in currently unfaulted and unfractured areas, including locations and nature of rupture, and (3) the potential for volcanism, including estimates of location, extent, and proximity to the site.

Also describe features of interest, how the analog will be used, the time frame of the comparative study, and any differences in scale or features between the analog and site. Provide maps or cross sections when appropriate to illustrate the locations and geologic characteristics of the analog sites.

3.1.2 Hydrologic System

This section should describe the hydrologic conditions of the geologic setting of the region and the site. Demonstrate that the areas studied provide a representative description of the conditions throughout the region around the site and at the site. Detailed justification for the areal limits placed on regional studies should be presented.

3.1.2.1 Surface-Water Hydrology

Provide sufficient data and technical analyses to describe the surface-water hydrology characteristics of the geologic setting of the region and the site. The description of the surface-water hydrology of the site should include the following:

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3.1.2.1.1. Description of Surface-Water Bodies and Physical Characteristics of Drainage Areas. Describe all perennial and ephemeral surface-water bodies of the site, including the location, size, shape, and other hydrologic characteristics of all streams, lakes, playas, and coastal areas. Sufficient graphical and quantitative data and information should be provided to fully characterize the site drainage and surrounding watershed fluvial features. Sources of information should be described and documented.

3.1.2.1.2. Surface-Water Monitoring Network. Describe the monitoring network used to establish baseline information on the site surface-water system. Include in the description the location, installation type, and method and frequency of measurements.

3.1.2.1.3. Water Control Structures and Diversions. Provide a description of existing water control structures and diversions, both upstream and downstream, that may influence the site. Any planned man-made changes to the surface-water hydrologic system that may influence the potential for flooding at the site should be described (such changes may include construction of reservoirs, urban development, strip mining, or lumbering). The description of these changes should include the proximity of the affected area to the site, the surface-water bodies affected, and the size of the area affected. Sources of information should be described and documented.

3.1.2.1.4. Flood History. Provide data and information on the site's flood history used to determine the capability of the site to withstand floods (both water levels and velocities) and flood waves. The date, level, peak discharge, and related information for major historical flood events, including stream floods, surges, seiches, tsunamis, dam failures, ice jams, floods induced by landslides, and similar events should be included. Flow duration data that indicate minimum, maximum, and average historical observations for surface-water bodies should be included. Include geologic evidence of Quaternary flooding, with emphasis on the Holocene, in the description of the flood history. The methods used to obtain these measurements and observations should be described and documented.

In addition to measurements and observations obtained directly from the site characterization program, water resource data should be provided, including maps,

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hydrographs, and stream records from other agencies such as the U.S. Geological Survey and U.S. Army Corps of Engineers.

3.1.2.1.5. Flood Potential. Describe the predicted flooding of the site from streams, reservoirs, and adjacent watersheds. The static and dynamic consequences of all types of flooding that could occur should be described. The design basis water level at the location of surface facilities and underground openings should be provided. The elevations of all structures and systems related to the surface facilities and underground openings, including cross sections related to streams, drainage channels, or erosion protection, should be provided to allow independent flood evaluations. The methods used to predict flooding of the site and estimated consequences of predicted floods should be described and documented.

3.1.2.1.6. Chemical Composition of Identified Bodies of Surface Water. Describe the chemical composition of bodies of water that could be affected by releases from the facility. Measured baseline data derived from historical records and site characterization activities, seasonal cycles of physical and chemical limnological parameters, information that describes the bottom and shoreline configuration, sedimentation rates (suspended and bed load), sedimentation graduation analysis, and sorption should be included. The methods used to obtain this information should be described and documented.

3.1.2.1.7. Location, Quantity, and Quality of Surface Water Extracted. Provide an inventory of all existing surface-water users whose water supply could be affected by the facility. The inventory should include the water source location, owner, type of intake, population served, maximum daily and average quantities of water pumped, type of treatment given to the water before distribution, and water quality of the source. Sources of information should be described and documented.

3.1.2.1.8. Projected Surface-Water Uses. Provide a projection into the future of the quantities and potential areas of surface-water use for the region. Projections should be based on expected growth rate of the region; industries likely to develop in the future because of location, climate, or natural resources; and probable changes in the technology or economic requirements. Projections should not be based solely on extrapolations of historical data. Locate possible points of withdrawal for any potential future water users that have been identified. Describe the methods used to make the projection. Sources of information should be described and documented.

3.1.2.2 Regional Hydrogeology

Provide sufficient data and technical analyses to describe the regional hydrogeologic systems. The description of the regional hydrogeologic systems should include the following:

3.1.2.2.1. Regional Flow System Boundaries and Hydrogeologic Units. Describe the physical boundaries and hydrogeologic units of the regional hydrogeologic system or systems. Describe the basis for defining the physical boundaries of the regional hydrogeologic systems. Describe the basis for defining the hydrogeologic units, including stratigraphic relationships, lithology, thickness, lateral extent, and trends in hydraulic characteristics.

3.1.2.2.2. Potentiometric Levels and Hydraulic Gradients. Provide the time history and areal distribution of measured potentiometric levels of each hydrogeologic unit. Describe observed hydraulic gradients within and between units. The sources and methods used to obtain this information should be described and documented.

3.1.2.2.3. Characteristics of Hydrogeologic Units. Describe the hydraulic characteristics of each hydrogeologic unit. The information should include the ranges and mean values of the hydraulic characteristics such as horizontal and vertical hydraulic conductivity, storage coefficient, effective porosity, and saturated thickness. The sources and methods used to obtain this information should be described and documented.

3.1.2.2.4. Recharge and Discharge. Describe the areas with their modes and rates of recharge (accounting for evapotranspiration and infiltration potential), discharge, and basin interflow. The methods used to determine the rates of recharge, discharge, and basin interflow should be described and documented.

3.1.2.2.5. Age of Regional Ground Water. Provide an estimate of the age of regional ground waters based on the hydrochemical information. The methods used for ground-water age determination should be described and documented.

3.1.2.2.6. Ground-Water Flow Paths. Describe the ground-water flow paths of the regional hydrogeologic systems and associated fluxes. Use cross sections and maps (e.g., flow nets) to present the flow paths.

Describe the methodology used to develop the description of the regional ground-water flow paths and fluxes. At a minimum, the methodology should synthesize and interpret all available information (e.g., hydraulic characteristics, gradients, hydrochemistry, recharge, discharge). The variability and uncertainty of data and information should be discussed. Justification for neglecting any contradicting information or alternative interpretations should be clearly presented. If the methodology applied includes the use of numerical analysis techniques, the numerical model type, documentation, verification, calibration, and other associated information should be described. Sufficient detail should be provided to allow independent analysis of results. The role of expert judgment in developing the description of ground-water flow paths and fluxes should be documented.

3.1.2.2.7. Paleohydrology. Describe geologic evidence of hydrogeologic conditions (e.g., discharge locations, prehistoric water levels, hydraulic gradients) throughout the region that have occurred during the Quaternary Period, with emphasis on the Holocene. Sources and methods used to obtain this evidence should be described and documented.

3.1.2.2.8. Regional Ground-Water Use. Identify the principal regional ground-water uses, with users, locations, rates, typical well construction, and specific hydrogeologic unit source. Include irrigation, municipal, domestic livestock, and energy resource development uses. Identify areas of large ground-water pumping or injection on a regional hydrogeologic map. Describe the relationship between ground-water use, aquifer storage, and recharge to identify areas of stress on aquifers and mining of the ground-water resource. Include the extent of depression or impression cones on the potentiometric surfaces. Sources used to obtain this information should be described and documented.

3.1.2.2.9. Regional Ground-Water Management Plans. Identify regional ground-water management agencies and their water use plans. Provide an assessment, using this information, of regional ground-water use projections for the foreseeable future.

3.1.2.3 Site Hydrogeology

Provide sufficient data and technical analyses to describe the site hydrogeologic system. The description of the site hydrogeologic system should include the following:

3.1.2.3.1. Baseline Monitoring Network. Describe the monitor well network and other surface or subsurface monitoring installations (e.g., exploratory shafts and drifts, vadose zone boreholes, infiltration plots) used to establish baseline information on the site hydrogeologic system. Detailed descriptions should be included for all installations. For installations. For monitor wells, include location, construction, and completion details (e.g., wellhead elevation, total depth, casing type and depth, seals, screened intervals, monitored intervals) and hydrogeologic units being monitored.

The selection process for choosing the location and depth of data collection systems should be described in detail to demonstrate that the baseline information (e.g., potentiometric levels, matric potentials, water contents, hydrochemistry, hydraulic characteristics of hydrogeologic units in both saturated and unsaturated media, distribution of infiltration) collected during the site characterization program is representative of the site.

3.1.2.3.2. Site Flow System Boundaries and Hydrogeologic Units. Describe the physical boundaries and hydrogeologic units (within the vadose zone and aquifers and confining units within the saturated zone, as appropriate) of the site hydrogeologic system.

Describe the basis for defining the boundaries of the site hydrogeologic system. Describe the general basis for defining hydrogeologic units, including stratigraphic relationships, thickness, lateral extent, lithology, and other physical or hydraulic characteristics.

3.1.2.3.3. Potentiometric Levels, Matric Potentials, and Gradients. For saturated media, provide the time history and areal distribution of measured potentiometric levels of each hydrogeologic unit. For unsaturated media, provide the time history and areal distribution of measured matric potentials and moisture contents (including osmotic potentials, if appropriate) of each hydrogeologic unit. Details on the variability (such as the mean, variance, and covariance) or trends of parameter values within hydrogeologic units should be provided.

Describe the temporal aspects and spatial extent of any perched systems, their causes, and water flow rates and direction.

Describe observed hydraulic gradients both within and between individual hydrogeologic units. Provide information on the existing geothermal gradient or gradients and any relationship to hydraulic gradient.

Provide the measurement frequency for each monitoring point. The method of presenting the information, particularly for saturated media, can include hydrographs, potentiometric contour maps, and graphs to identify characteristic fluctuations resulting from various factors (e.g., seasonal precipitation and evaporation fluctuations, seasonal pumping variations, seasonal response to surface water bodies, barometric variations).

Methods used to obtain information (e.g., samples, measurements, observations) on potentiometric levels, matric potentials, moisture contents, hydraulic gradients, and geothermal gradients should be described and documented.

3.1.2.3.4. Characteristics of Hydrogeologic Units. Describe in detail the characteristics of each hydrogeologic unit. Conditions and interactions at the interfaces between units should also be described. Information should be grouped into separate sections for each hydrogeologic unit and should include the following characteristics, as appropriate.

For saturated media, include:

(a) General physical characteristics. This group of characteristics is to include total and effective porosity. Indicate the nature of the porosity (e.g., interstitial, fracture, or solution) and distinguish primary porosity and secondary porosities. Include fracture geometry, orientation, filling, and fracture-matrix sealing along surfaces.

(b) General hydraulic characteristics. This group of characteristics is to include intrinsic permeability, transmissivity, hydraulic conductivity (with saturated thickness), leakage coefficients for aquitards, and the storage coefficient. Include characteristics of fractures and the matrix as appropriate.

(c) General transport characteristics. This group of characteristics is to include longitudinal and transverse dispersivity and tortuosity. Describe characteristics for fractures and the matrix as appropriate.

For unsaturated media, include:

(a) General physical characteristics. This group of characteristic is to include total and effective porosity, pore size distribution, pore geometry, bulk and skeletal density, pore surface area, fracture geometry, orientation, porosity, and tortuosity.

(b) Additional fracture surface characteristics. This group of characteristics for fractured media is to include fracture-matrix sealing along surfaces, fracture surface profiles, roughness, fracture permeability, drainage suction (capillary aperture), and fracture conductance (conductivity normal to the fracture plane).

(c) General hydraulic characteristics. This group of characteristics is to include air or water intrinsic permeability and Klinkenberg coefficent, saturated hydraulic conductivity, unsaturated hydraulic conductivity as a function of both water content and matric potential (otherwise called matrix suction or capillary pressure), moisture characteristic curves (both wetting and drying), including scanning curves, moisture diffusivity as a function of both water content and matric potential, and specific water capacity as a function of both water content and matric potential.

(d) General transport characteristics. This group of characteristics is to include longitudinal and transverse dispersivity.

(e) General pneumatic and vapor transport characteristics. This group of characteristics is to include unsaturated pneumatic permeability and the relevant diffusion coefficient. Describe the variation of existing gaseous components as well as existing gaseous flow and transport conditions.

(f) Parameters for hydrologic models. Any fitting parameters used in defining constitutive relationships between hydraulic characteristics and water content or matric potential should be described.

For saturated or unsaturated media in the vicinity of the underground facility (i.e., subject to thermal loading), summarize the general thermal characteristics. In addition to the thermal characteristics provided in Section 3.1.1.2.7

on geoengineering properties, provide either or both the thermal diffusivity or thermal diffusivity as a function of water content, matric potential, and the heat capacity of dry rock.

In addition to describing in detail the characteristics of individual hydrogeologic units, this section should include a description of any zones or geologic features (e.g., faults or other mappable zones of high permeability) that could serve as potential pathways of high fluid flux. The characteristics of such features should be provided in detail as appropriate.

The spatial variability of these data and information should be assessed statistically (such as mean, variance, and covariance) in order to describe heterogeneity, anisotropy, or any trends of parameter values within individual hydrogeologic units. Uncertainty in these data and information, for example, resulting from measurement error, scale effects, or extrapolation to repository conditions, should also be discussed. The methods used to obtain these data and information (e.g., in situ measurements, laboratory measurements, field tests, pump tests, tracer tests, interpretive techniques) should be described and documented.

3.1.2.3.5. Site Ground-Water Recharge. Describe the mode and the spatial and temporal distribution of moisture infiltration at the site. Describe the local flux rates to the regional water table (deep percolation or net infiltration) accounting for evapotranspiration and other processes (e.g., vapor flux) that could affect the net recharge rate. The methods used to obtain these data and information should be described and documented.

3.1.2.3.6. Site Ground-Water Discharge. Describe the areas, modes, and rates of any local ground-water discharge (e.g., springs, seeps, stream baseflow) not described previously in the context of the regional hydrogeologic system. The methods used to determine this information should be described and documented.

3.1.2.3.7. Age of Site Ground Water. Provide an estimate of the age variation of ground waters and velocity of movement at the site based on hydrochemical information. The methods of ground-water age and velocity determination, as well as an error analysis of all results, should be described and documented.

3.1.2.3.8. Site Pathway Analysis. Describe the fluid pathways (e.g., liquid or gas) to the accessible environment. The distribution of flux should be considered critical to the pathway analysis. The transience of baseline conditions and the sensitivity of baseline conditions to perturbations should be assessed (this is in the context of the existing, or near-term time frame, not thousands of years).

Describe the methodology used to develop the description of the fluid pathways to the accessible environment. At a minimum, the methodology should be able to synthesize and interpret all available information (e.g., hydraulic characteristics, gradients, hydrochemistry, recharge, discharge). The variability and uncertainty of data and information should be accounted for in the analysis. Justification for neglecting any contradicting information or alternative interpretations should be clearly presented. If the methodology applied includes the use of numerical analysis techniques, the numerical model type, documentation, verification, calibration, and other associated information should be described. Sufficient detail should be provided to allow independent analysis of results. The role of expert judgment in developing the description of fluid pathways to the accessible environment should be documented.

3.1.2.3.9. Local Ground-Water Use. Identify all the local ground-water users and their locations, rates, typical well construction, and hydrogeologic unit source. Include irrigation, industrial, municipal, domestic, livestock, and energy resource development users. Sources used to obtain this information should be described and documented.

3.1.2.3.10. Paleohydrology. Describe those hydrogeologic conditions during the Quaternary Period, with emphasis on the Holocene, that differ significantly from present conditions at the site. Sources and methods used to obtain this information should be described and documented.

3.1.3 Geochemical System

This section of the SAR should describe the geochemical characteristics of the geologic setting and the site, including information on anomalies, properties, and conditions affecting the stability of geochemical characteristics. Demonstrate that the areas studied provide a representative description of the conditions throughout the region around the site and at the site. Detailed justification for the areal limits placed on regional studies should be provided. The differences between unsaturated zone and saturated zone geochemical characteristics, properties, and conditions should be provided.

3.1.3.1 Regional Geochemistry

Provide sufficient data and technical analyses to describe the saturated and unsaturated zone geochemical characteristics, conditions, and properties of the region. Specifically, discuss geochemical conditions and processes that exist and that have existed during the Quaternary (with emphasis on those that differ significantly from present conditions), and provide assessments of changes that might reasonably be expected to occur in the future. Sufficient detail should be provided to allow independent analysis of results. The use of natural analogs should be addressed. The role of expert judgment should be documented. The description of the regional geochemistry should include the following:

3.1.3.1.1. Information and Investigations on the Geochemistry of the Regional Rock. Describe the regional saturated and unsaturated zone mineralogy, petrology, and rock chemistry. Include mineral distributions in bulk rock; mineral distributions in fractures; bulk rock chemistry; chemistry of fracture deposits; information on rock, mineral and glass origins; alteration history; and mineral and glass stability. Differences between the geochemistry of the regional saturated and unsaturated zone rock should be evaluated and discussed.

Sources of information, the locations of sampling, and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scale between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model saturated and unsaturated zone rock, mineral, and glass geochemistry should be discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used to model regional saturated and unsaturated zone rock geochemistry, and the sensitivity of model results to the uncertainty of the geochemical input data. The variability and uncertainty of data and information and the propagation of errors should be discussed. Input and output data and interpretations should also be provided.

3.1.3.1.2. Information and Investigations on the Regional Geochemistry of the Ground Water. Describe the regional properties and chemistry of the saturated and unsaturated zone ground water. The information on water chemistry should include a detailed description and analyses of the ground-water chemistry, major and minor inorganic and organic content, trace element content, stable isotopes, dissolved and undissolved gas content, particulates, colloids, background radioactivity, temperature, and pressure. The mineralized controls on water composition should be described and discussed. In addition, a discussion and rationale for the selection of ground water used for conducting experiments should be provided. Differences between the geochemistry of the regional saturated and unsaturated zone ground-water geochemistry should be evaluated and discussed.

Sources of information, the locations of sampling, and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scale between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model regional saturated and unsaturated zone ground-water geochemistry should be discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used to model saturated and unsaturated zone ground-water geochemistry, and the sensitivity of model data. The variability and uncertainty of data and information and the propagation of errors should be discussed. Input and output data and interpretations should also be provided.

3.1.3.1.3. Information and Investigations on the Regional Geochemistry Governing Radionuclide Mobility. Describe the regional saturated and unsaturated zone geochemical properties and conditions that can affect radionuclide mobility. The information should include (1) solubility and precipitation as a function of radionuclide speciation, water chemistry, and radiation field, (2) sorption and desorption as functions of ground-water composition, mineralogy and surface structure, speciation, waste element concentration, gas composition, temperature, colloidal material, and organic complexation, (3) sorption kinetics, (4) biological sorption and desorption, (5) dispersive, diffusive, and advective processes, and (6) the transport of gaseous radionuclides. Differences between the regional saturated and unsaturated zone transport characteristics should be discussed.

Sources of information (e.g., location, hydrogeologic unit, referenced sources) and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scales between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model saturated and unsaturated zone radionuclide mobility should be evaluated with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of assumptions used to model regional radionuclide mobility in the saturated and unsaturated zone, and the sensitivity of model results to the uncertainty of the geochemical input data. The variability and uncertainty of data and information and the propagation of errors should be discussed. Input and output data and interpretations should also be provided.

3.1.3.2 Site Geochemistry

Provide sufficient data and technical analyses to describe the saturated and unsaturated zone geochemical characteristics, conditions, and properties of the site. Specifically, discuss geochemical conditions and processes that exist and that have existed during the Quaternary (with emphasis on those that differ significantly from present conditions), and provide assessments of changes that might reasonably be expected to occur in the future. Sufficient detail should be provided to allow independent analysis of results. The use of natural analogs should be addressed. The role of expert judgment should be documented. The description of the site geochemistry should include the following:

3.1.3.2.1. Information and Investigations on the Geochemistry of the Site Rock. Describe the saturated and unsaturated zone mineralogy, petrology, and rock chemistry of the site. The information should include mineral distributions in bulk rock; mineral distributions in fractures; bulk rock chemistry; chemistry of fracture deposits; information on rock, mineral, and glass origins; alteration history; mineral and glass stability; and general thermal characteristics. Differences between the geochemistry of the site's saturated and unsaturated zone rock should be evaluated and discussed.

Sources of information, the locations of sampling, and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scale between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model saturated and unsaturated zone rock, mineral, and glass geochemistry should be discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used to model site saturated and unsaturated zone rock geochemistry, and the sensitivity of model results to the uncertainty of the geochemical input data. The variability and uncertainty of data and information, as well as the propagation of errors, should be discussed. Input and output data and interpretations should also be provided.

<u>3.1.3.2.2. Information and Investigations on the Geochemistry of the Site Ground Water</u>. Describe the properties, character, and chemistry of saturated and unsaturated zone ground water at the site. The information should include detailed description and analyses of the ground-water chemistry, major and minor inorganic content, stable isotopes, trace element content, organic and inorganic content, dissolved and undissolved gas content, particulates, colloids, background radioactivity, temperature, pressure, and mineralogical controls on water composition. In addition, a discussion and rationale for the selection of ground water used for conducting experiments should be provided. Differences between the geochemistry of the saturated and unsaturated zone ground-water geochemistry at the site should be evaluated and discussed.

Sources of information (the location, hydrogeologic unit, referenced sources) and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scale between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model site saturated and unsaturated zone ground-water geochemistry should be discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used to model saturated and unsaturated zone ground-water geochemistry, and the sensitivity of model results to the uncertainty of the geochemical input data. The variability and uncertainty of data and information, as well as the propagation of errors, should be discussed. Input and output data and interpretations should also be provided.

3.1.3.2.3. Information and Investigations on the Site Geochemistry Governing Radionuclide Mobility. Describe the saturated and unsaturated zone geochemical properties and conditions of the site that characterize the geochemistry of radionuclide mobility. The information should include (1) solubility and precipitation as a function of radionuclide speciation, water chemistry, and radiation field, (2) sorption and desorption as functions of ground-water composition, mineralogy and surface structure, speciation, waste element concentration, gas composition, temperature, colloidal material, and organic complexation, (3) sorption kinetics, (4) biological sorption and desorption, (5) dispersive, diffusive, and advective processes, and (6) the transport of gaseous radionuclides. Differences between the site saturated and unsaturated zone transport characteristics should be evaluated and discussed.

Sources of information, the locations of sampling, and data collection methods used to obtain measurements and observations should be described and documented. The discussion should include evaluations of data representativeness, the effects of differences in scale between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information. Also, conceptualizations and the documentation and validation of codes used to model saturated and unsaturated zone radionuclide mobility should be discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of assumptions used to model site radionuclide mobility in the saturated and unsaturated zone, and the sensitivity of model results to the uncertainty of the geochemical input data. The variability and uncertainty of data and information, as well as the propagation of errors, should be discussed. Input and output data and interpretations should also be provided.

3.1.4 Climatological and Meteorological Systems

In this section, describe the past and present climatological and meteorological conditions of the geologic setting and the site. In addition, provide an assessment of future climatic variation of the site. Demonstrate that the areas studied provide a representative description of the conditions throughout the region around the site and at the site. Detailed justification for the areal limits placed on regional studies should be presented.

3.1.4.1 Present Climate and Meteorology

Describe the baseline climatological and meteorological conditions of the site. This description should include the following:

3.1.4.1.1. Climate. The general climate should be described with respect to types of air masses, synoptic features, frontal systems, airflow patterns, and relationships between synoptic-scale atmospheric processes and site meteorological conditions. Climatological characteristics attributable to the terrain should be identified.

Data should be provided in sufficient detail to indicate impacts on the conceptual design and operation of a geologic repository at the site. All information should be fully documented and should be based on data for the most recent 30-year record period. Sources of such information could include National Oceanic and Atmospheric Administration (NOAA) facilities such as the National Climatic Center (NCC) and the National Weather Service (NWS) stations, other government facilities (e.g., military stations), and private organizations such as universities that have maintained quality-controlled data collection programs. The validity of information provided, with respect to representation of the conditions at and near the site, should be substantiated.

3.1.4.1.2. Site Meteorological Monitoring Network. The network of meteorological monitoring instruments used to develop baseline information for the site should be described. Include the type of monitoring installation, instrument performance specifications, locations, parameters measured, method and frequency of measurements, and data analysis procedures. Refer to Regulatory Guide 1.23, "Onsite Meteorological Programs," for guidance on acceptable onsite meteorological measurements and data format.

The selection process for choosing the locations of data collection systems should be described in detail to demonstrate that baseline information collected during the site characterization program is representative of the site.

3.1.4.1.3. Site Meteorology. Describe the site meteorological conditions, including temperature, humidity, average and extreme duration and intensity of precipitation, and average and extreme wind vectors. Information should be sufficiently detailed to adequately characterize atmospheric dispersion processes (e.g., airflow trajectories, atmospheric stability conditions, depletion and deposition characteristics).

3.1.4.2 Paleoclimatology

Provide an analysis of the Quaternary climatology of the site. The analysis should include atmospheric, hydrospheric, and cryospheric aspects of the successive climatic regimes, in the context of determining the magnitude of the climatic changes and the rates at which the changes occurred. Changes in precipitation regimes, glaciated areas, and windflow patterns should be identified. Geological, biological, and ecological evidence to support the analysis should be provided. Information should also be provided on the size (areal extent and thickness) of any glaciers and on accumulation and ablation rates. The impacts of any glaciers on precipitation regimes and windflow patterns should be discussed. Relationships between air temperatures and regional precipitation, in relationship to the water balance of the area, should also be discussed.

Sources of all information should be provided. The validity and applicability of the information provided, with respect to the representation of conditions at the site, should be substantiated.

3.1.4.3 Future Climatic Variation

Provide an assessment of the magnitude and rate of climatic changes that might be reasonably expected to occur in the future. The assessment should be based on reconstruction of the paleoclimate and the recent climate, and it should consider human activities for both the present and near-term future. Long-term estimates should include:

(a) Potential maximum and minimum changes and rates of change in precipitation and air temperature from the present.

(b) Potential regional windflow and precipitation patterns that may evolve in the future as a result of climatic and geologic changes.

(c) The potential for glaciation, including estimates of times of onset of glaciation and lengths and severity of glacial regimes in the site area.

(d) Future fluctuations in sea levels and the cryosphere caused by climatic changes.

All procedures, including models, used in the climatic extrapolations should be identified, as should all assumptions and areas where insufficient data make extrapolations questionable. All assumptions and areas with insufficient data to make reasonable extrapolations should be identified.

3.1.5 Integrated Natural System Response to the Maximum Design Thermal Loading

Describe the anticipated response of the geomechanical, hydrologic, and geochemical subsystems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and ground water.

The variability and uncertainty of data and information and the propagation of errors should be assessed. The results of codes used to model the integrated system response should be discussed with respect to sensitivity to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of assumptions used to model site and regional integrated properties in the saturated and unsaturated zone, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided.

3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

This section should describe the characteristics of each anticipated process, anticipated event, unanticipated process, and unanticipated event, along with the rationale and justification for the selection of each specific process and event described. While the majority of the background information on each process and event can be presented elsewhere, it should be summarized in this section. This section should concentrate on the methods by which the projections of processes and events have been accomplished and their bases. Therefore, demonstrate that the data base is sufficient to determine which processes and events are anticipated or unanticipated. In addition, demonstrate that the models used to make the projections are applicable and that the interactions between the various natural, repository-induced, and human-induced processes and events that may affect waste isolation are understood and factored into the analysis.

3.2.1 Description of Data Base

3.2.1.1 Natural Processes and Events

The nature, rate, and effects of each natural process that may be significant to waste isolation, and which occurred within the geologic setting during the Quaternary Period, should be described. Such things as the spatial and temporal variability of the process should be described, both qualitatively and by using statistical parameters.

The interrelationship of each process with other natural processes should be described.

The characteristics of each natural event that occurred within the geologic setting during the Quaternary Period and that may be important to waste isolation should be described. This description should include the relationship of the event to the underlying process, the known times of occurrence, the recurrence rate, duration, and effect.

The nature, rate, and effects of natural processes and events that have occurred within the geologic setting during the pre-Quaternary, and which have a cycle of occurrence that could be projected to reoccur during the intended period of performance, should be described. In general, such processes and events should have a probability of occurrence greater than 1 chance in 10,000 during the period of intended performance.

3.2.1.2 Characteristics of the Emplaced Waste

The characteristics of the waste and the waste emplacement area should be described, with emphasis on those characteristics that have the potential to modify the natural system. Include such things as the expected thermal output, chemical characteristics of the waste package and engineered barrier, location and size of the emplacement panels, effects from excavation on the natural system, and the expected effects on the natural system.

3.2.1.3 Past Human Activities

Human activities that have occurred within the geologic setting or that have affected the geologic setting should be described. Emphasis should be placed on those activities that have had a direct effect on the controlled area. Include such things as drilling and excavation within or near the controlled area, effects to the atmosphere from pollution, effects from weapons testing, and effects from ground-water withdrawal or injection. This description should include the location and severity of such activities and the interrelationship of such activities with natural processes and events.

3.2.2 Anticipated Processes and Events and Unanticipated Processes and Events

3.2.2.1 Natural Processes and Events

The projected rate of each process, including the "best estimate" and "extremes," should be provided using statistical parameters to describe the uncertainty of this projection. The model or models used to provide these projections should be described and justified. Other known and generally recognized models that were rejected for making these projections should also be described along with the basis for rejection.

Events that could be projected to occur as a result of each process should be described. This description should include intensity, duration, effect, and location. In general, events that have a probability of occurrence of less than 1 chance in 10,000 during the period of intended performance need not be considered.

3.2.2.2 Repository Effects

The expected effect on each natural process or event from the emplacement of waste should be described. This should include such things as changes to the local stress field, thermal drying, convection cells, and geochemical modifications. This description should include a discussion of those expected effects that could significantly change the nature of the natural process and a discussion of those expected effects that could "trigger" an event. The expected changes through time and the models used to determine the expected changes should be described.

3.2.2.3 Human Activities

The human activities that are projected to occur during the intended period of performance and that could affect waste isolation should be described. The models used to make these projections, the direct expected effects of these projected activities, and the effects such human activities can have on the natural process should be described. Controls that will be in place should also be described, along with the expected effects that such controls will have to prevent or mitigate such human activities.

3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR PART 60

This section should provide an analysis of the natural systems of the geologic setting of the site, specifically including the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of the site. This analysis should include analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized and the extent to which it contributes to or detracts from isolation. To determine the presence of potentially adverse conditions, investigations should extend from the surface to a depth sufficient to determine critical pathways for radionuclide migration from the underground facility to the accessible environment. Potentially adverse conditions should be investigated outside of the controlled area if they affect isolation within the controlled area.

This analysis should also include an analysis of the pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment.

Finally, this section should identify those natural barriers, including barriers that may not themselves be a part of the geologic repository operations area, important to the isolation of high-level radioactive waste from the accessible environment. Include a determination of the effectiveness of those natural barriers against the release of radioactive material to the environment.

3.3.1 Geologic System

This section should describe the analyses that determine which of the favorable and potentially adverse conditions identified in 10 CFR 60.122 that are related to the geologic system are present or absent.

With respect to favorable conditions found to be present, this section should provide analyses to determine the degree to which each favorable condition has been characterized and the extent to which it contributes to isolation.

With respect to potentially adverse conditions found to be present, this section should provide analyses to determine the degree to which each potentially adverse condition has been characterized and the extent to which it detracts from isolation. In addition, provide analyses that demonstrate that:

(a) The condition has been adequately investigated, including the extent to which the condition may be undetected taking into account the degree of resolution achieved by the investigations;

(b) The effect of the condition has been adequately evaluated using analyses that are sensitive to the potentially adverse condition and assumptions that are not likely to underestimate its effects; and

(c) The condition does not significantly affect the ability of the repository to meet the performance objectives, or the condition is compensated by favorable conditions, or the condition can be remedied.

Describe the criteria used to determine that any potentially adverse condition is compensated by the presence of one or more favorable conditions or that the potentially adverse condition can be remedied.

An explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of methods such as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncerainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

3.3.1.1 Favorable Conditions

The favorable conditions to be considered in this section include:

(a) The nature and rates of tectonic and geomorphic processes operating within the geologic setting during the Quaternary Period that, when projected, would not affect or would favorably affect the ability of the repository to isolate waste,

(b) Conditions that permit emplacement of waste at a minimum depth of 300 meters below ground surface,

(c) A low population density within the geologic setting and a controlled area that is remote from population centers.

3.3.1.2 Potentially Adverse Conditions

The potentially adverse conditions to be considered in this section include:

(a) Evidence of dissolutioning such as breccia pipes, dissolution cavities, or brine pockets,

(b) Structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period,

(c) Historic earthquakes that could significantly affect the site if they were repeated,

(d) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency or magnitude of earthquakes may increase,

(e) More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area of the geologic setting,

(f) Evidence of igneous activity since the start of the Quaternary Period,

(g) Evidence of extreme erosion during the Quaternary Period,

(h) The presence of naturally occurring materials, whether identified or undiscovered, within the site, in such form that:

   (h.1) economic extraction is currently feasible or potentially feasible during the foreseeable future; or

   (h.2) such materials have greater gross or net value than the average for other areas of similar size that are representative of and located within the geologic setting.

(i) Evidence of subsurface mining for resources within the site,

(j) Evidence of drilling for any purpose within the site,

(k) Geomechanical properties that do not permit design of an underground opening that will remain stable through permanent closure.

This section should also include an identification and evaluation of the natural resources of the geologic setting, including estimates of undiscovered deposits, the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area should be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, should be conducted for the site and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets, the resources must be assessed, with estimates provided of both gross and net value. The estimate of net value must take into account current development, extraction, and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources should be described by physical factors such as tonnage or other amount, grade, and quality.

3.3.2 Hydrologic System

This section should describe the analyses that determine which of the favorable and potentially adverse conditions related to the hydrologic system and identified in 10 CFR 60.122 are present or absent.

With respect to favorable conditions found to be present, this section should provide analyses to determine the degree to which each favorable condition has been characterized and the extent to which it contributes to isolation.

With respect to potentially adverse conditions found to be present, this section should provide analyses to determine the degree to which each potentially adverse condition has been characterized and the extent to which it detracts from isolation. In addition, provide analyses that demonstrate that:

(a) The condition has been adequately investigated, including the extent to which the condition may be undetected taking into account the degree of resolution achieved by the investigations;

(b) The effect of the condition has been adequately evaluated using analyses that are sensitive to the potentially adverse condition and assumptions that are not likely to underestimate its effects; and

(c) The condition does not significantly affect the ability of the repository to meet the performance objectives, or the condition is compensated by favorable conditions, or the condition can be remedied.

Describe the criteria used to determine that any potentially adverse condition is compensated by the presence of one or more favorable conditions or that the potentially adverse condition can be remedied.

An explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of methods such as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

3.3.2.1 Favorable Conditions

The favorable conditions to be considered in this section include:

(a) The nature and rates of hydrogeologic processes operating within the geologic setting during the Quaternary Period that, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(b) For disposal in the saturated zone, hydrogeologic conditions that provide:

(b.1) A host rock with low horizontal and vertical permeability,

(b.2) Downward or dominantly horizontal hydraulic gradient in the host rock and immediately surrounding hydrogeologic units, and

(b.3) Low vertical permeability and low hydraulic gradient between the host rock and the surrounding hydrogeologic units.

(c) Pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(d) For disposal in the unsaturated zone, hydrogeologic conditions that provide:

(d.1) Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units, (d.2) A water table sufficiently below the underground facility such that fully saturated voids contiguous to the water table do not encounter the underground facility,

(d.3) A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility, and

(d.4) A host rock that provides for free drainage.

3.3.2.2 Potentially Adverse Conditions

The potentially adverse conditions to be considered in this section include:

3.3.2.2.1. Potential for flooding of the underground facility, whether resulting from the occupancy and modification of flood plains or from the failure of existing or planned man-made surface-water impoundments.

3.3.2.2.2. Potential for foreseeable human activity to adversely affect the ground-water flow system, such as ground-water withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activity, or construction of large-scale surface-water impoundments.

3.3.2.2.3. Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface-water impoundments could be created that could change the regional ground-water flow system and thereby adversely affect the performance of the geologic repository.

3.3.2.2.4. Structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional ground-water flow system.

3.3.2.2.5. Potential for changes in hydrologic conditions that would affect the migration of radionuclides to the accessible environment, such as changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

3.3.2.2.6. Rock or ground-water conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

3.3.2.2.7. Potential for the water table to rise sufficiently to cause saturation of an underground facility located in the unsaturated zone.

3.3.2.2.8. Potential for existing or future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment.

3.3.3 Geochemical System

This section should describe the analyses that determine which of the favorable and potentially adverse conditions related to the geochemical system and identified in 10 CFR 60.122 are present or absent.

With respect to favorable conditions found to be present, this section should provide analyses to determine the degree to which each favorable condition has been characterized and the extent to which it contributes to isolation.

With respect to potentially adverse conditions found to be present, this section should provide analyses to determine the degree to which each potentially adverse condition has been characterized and the extent to which it detracts from isolation. In addition, provide analyses that demonstrate that:

(a) The condition has been adequately investigated, including the extent to which the condition may be undetected taking into account the degree of resolution achieved by the investigations;

(b) The effect of the condition has been adequately evaluated using analyses that are sensitive to the potentially adverse condition and assumptions that are not likely to underestimate its effects; and

(c) The condition does not significantly affect the ability of the repository to meet the performance objectives, or the condition is compensated by favorable conditions, or the condition can be remedied.

Describe the criteria used to determine that any potentially adverse condition is compensated by the presence of one or more favorable conditions or that the potentially adverse condition can be remedied.

An explanation of measures supporting the models used to perform analyses should be provided. Analyses and models should be supported by using an appropriate combination of methods such as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpetation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

3.3.3.1 Favorable Conditions

The favorable conditions to be considered in this section include:

3.3.3.1.1. The nature and rates of geochemical processes operating within the geologic setting during the Quaternary Period that, when projected, would not affect or would favorably affect the ability of the repository to isolate waste.

3.3.3.1.2. Geochemical conditions that (a) promote precipitation or sorption of radionuclides, (b) inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides, or (c) inhibit the transport of radionuclides by particulates, colloids, and complexes.

3.3.3.1.3. Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration.

3.3.3.2 Potentially Adverse Conditions

Potentially adverse conditions to be considered in this section include:

3.3.3.2.1. Ground-water conditions in the host rock, including chemical composition, high ionic strength, or ranges of Eh-pH, that could increase the solubility or chemical reactivity of the engineered barrier system.

3.3.3.2.2. Geochemical processes that would reduce sorption of radionuclides, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system.

3.3.3.2.3. Ground-water conditions in the host rock that are not reducing.

3.3.3.2.4. Potential for the movement of radionuclides in a gaseous state through air-filled spaces of an unsaturated geologic medium to the accessible environment.

3.3.4 Climatological and Meteorological Systems

This section should describe the analyses that determine which of the favorable and potentially adverse conditions related to the climatological and meteorological systems, and identified in 10 CFR 60.122, are present or absent.

With respect to favorable conditions found to be present, this section should provide analyses to determine the degree to which each favorable condition has been characterized and the extent to which it contributes to isolation.

With respect to potentially adverse conditions found to be present, this section should provide analyses to determine the degree to which each potentially adverse condition has been characterized and the extent to which it detracts from isolation. In addition, provide analyses that demonstrate that:

(a) The condition has been adequately investigated, including the extent to which the condition may be undetected taking into account the degree of resolution achieved by the investigations;

(b) The effect of the condition has been adequately evaluated using analyses that are sensitive to the potentially adverse condition and assumptions that are not likely to underestimate its effects;

(c) The condition does not significantly affect the ability of the repository to meet the performance objectives, or the condition is compensated by favorable conditions, or the condition can be remedied.

Describe the criteria used to determine that any potentially adverse condition is compensated by the presence of one or more favorable conditions or that the potentially adverse condition can be remedied.

An explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of methods such as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modelling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpetation. Sufficient detail should be provided to allow independent analysis of results. When used, the role of expert judgment should be documented.

3.3.4.1 Favorable Conditions

The favorable condition to be considered in this section is a climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration.

3.3.4.2 Potentially Adverse Conditions

The potentially adverse condition to be considered in this section is the potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes.

3.3.5 Assessment of Compliance with Performance Objectives

This section should provide an assessment that describes how the geologic setting complies with the pre-waste-emplacement ground-water travel time requirement. This assessment should describe:

(a) Disturbed Zone. Describe the boundaries of the disturbed zone. The criteria and analytic techniques used to establish those boundaries should also be described and documented.

(b) Ground-Water Travel Time. Describe the pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment. Describe the approach taken and methodologies used to determine the fastest path of likely radionuclide travel.

Any proposal to specify some other ground-water travel time based on factors outlined in 10 CFR 60.113(b) should be presented in this section. Background hydrologic information used to assess ground-water travel time should be described in detail in Section 3.1.2 (Hydrologic System).

An explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system, such as in defining the disturbed zone, should be supported by using an appropriate combination of methods such as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpetation. Sufficient detail should be provided to allow independent analysis of results. When used, the role of expert judgment should be documented. This section should include consideration, to the extent pertinent, of the favorable and potentially adverse conditions described in 10 CFR 60.122 and show compliance with the requirements of that section.

3.3.6 Effectiveness of Natural Barriers Against the Release of Radioactive Material to the Environment

This section should identify those natural barriers, including barriers that may not themselves be a part of the geologic repository operations area, that are important in the isolation of high-level radioactive waste from the accessible environment. In addition, determine the effectiveness of those barriers against the release of radioactive material to the environment.

This section should consider all relevant background information provided in Section 3.1 (Description of the Individual Systems and Characteristics of the Site), the analysis of the favorable and potentially adverse conditions in Sections 3.3.1 through 3.3.4, and the analysis of the pre-waste-emplacement groundwater travel time presented in Section 3.3.5. Any other applicable information or analyses presented elsewhere in the LA should be considered as appropriate.

4. GEOLOGIC REPOSITORY OPERATIONS AREA: PHYSICAL FACILITIES

This chapter should present information describing the physical facilities and assessment of compliance for the geologic repository operations area (GROA). The design description; the methods of compliance for surface facilities, shafts, ramps, and the underground facility; and the interfaces between all structures, systems, and components should be addressed. Also, identification of the structures, systems, and components as important to safety, retrievability, or isolation should be included. Physical measures to provide radiation protection should be described. The discussions presented should be organized in two broad sections: Section 4.1 should provide a description of the physical facilities, and Section 4.2 should assess compliance with 10 CFR 60.

4.1 DESCRIPTION OF THE GROA STRUCTURES, SYSTEMS, AND COMPONENTS

In this section, the general overall description of the GROA should be provided, including a description of the site with a discussion of site features that could affect the GROA design and performance. In this discussion, describe the location of the GROA as it relates to the accessible environment boundary. Provide the schedules for the GROA construction, receipt of waste, and emplacement of waste. Describe the major design features important to waste isolation and provide the basis for their identification. Discuss the comparative evaluations of these design features with particular attention to alternatives that would provide for longer radionuclide containment and isolation.

For each of the GROA structures, systems, and components discussed in the preceding sections, the overall purpose and function, design description, location, and layout of features should be provided. As necessary, provide piping and instrumentation diagrams or flow diagrams. Describe and discuss the design of the structures, systems, and components, including the design bases. Include in the presentation the principal design criteria used and the resulting value of design parameters. Discuss the basis for the parameters, the uncertainties associated with each parameter, and the treatment of parameter uncertainties. For each structure, system, and component in the GROA, discuss any applicable industry standards and codes used in the design.

Discuss the basis for the GROA design, including the characteristics of the waste and its package, the characteristics of the site in which the waste is to be emplaced, and the functions that the repository must perform. Discussion of the radioactive waste design basis should include the type of waste, quantities, receipt rates, and the characteristics of the waste, including waste history, thermal output, parameters of the waste packages, any treatment or processing, and packaging.

Discussion of the site design basis should include compilation and interpretation (including any assumptions used) of all physical data that is relevant to the GROA design. This discussion should include: (1) relevant information on site geology such as stratigraphy, structural features, major and minor faults, old volcanos, history of seismic activity; (2) surface and ground-water hydrologic data, including flood history, surface drainage characteristics, drainage through strata penetrated by shafts and ramps, both above and below the underground facility, (3) soil properties and other relevant data for design of foundations, (4) weather and other relevant meteorological data, including human-induced phenomena such as nearby nuclear detonations and aircraft traffic, (5) rock data and properties that are relevant to the design and excavation of foundations for surface facilities, shafts and ramps, and the underground facility, including mechanical, thermal and thermomechanical, hydrological, and geochemical data; (6) data on engineered components that are placed within and into the underground facility host rock and shafts and ramps, such as injected grouts, backfill emplaced around the waste packages, backfill emplaced in drifts, shafts and ramps, and liners and other engineered components for shafts and ramps.

Discussion of the functions that the GROA must perform should include general descriptions of the design criteria and performance objectives of 10 CFR 60, the DOE documents that direct and control the GROA design such as the generic requirements documents, the systems and subsystems requirements documents, and the DOE mission plan. This section should also discuss how the GROA meets any other legal requirements of Federal and State agencies such as the Occupational Safety and Health Administration of the United States Department of Labor (OSHA), the Mine Safety and Health Administration of the United States Department of the Interior (MSHA), and the United States Environmental Protection Agency (EPA).

This section should also identify structures, systems, and components of the GROA that are important to safety, waste isolation, or retrievability. The SAR should discuss the activities and events, whether planned or unplanned, that could interfere with the ability of such structures, systems, and components to perform their intended functions. Such discussion should serve as the framework for identifying the structures, systems, and components for the specific systems discussed below.

Identify those structures, systems, and components requiring research and development to confirm the adequacy of design. Discuss the programs designed to confirm the adequacy of design along with a schedule for completion. If appropriate, provide justification for proceeding with construction before any necessary research work is complete. Also, describe contingency plans if the adequacy of the design is not confirmed.

4.1.1 Surface Facilities

Depict the layout and location of the surface facilities, and provide the design bases and design descriptions of all surface facilities, including the following systems and subsystems:

4.1.1.1 Hot Cell (Waste-Handling System, Buildings, and Equipment)

Provide the designs, design bases, pertinent design features, and safety and operating components of the hot cell for receiving, transporting, handling, storing, treating, or preparing waste for transfer and final disposal in the underground facility. Describe all features, systems, or special handling techniques that are important to safety under both normal and off-normal conditions. Also describe any temporary storage facilities. The design descriptions should include specific provisions for waste retrieval operations.

4.1.1.2 On-Site Radioactive Waste Management System

Provide detailed descriptions of the on-site radioactive waste management system to track, control, and dispose of all solid, liquid, and gaseous radioactive waste that is generated at the site. Describe each waste source. For each form of waste, describe collection, treatment, packaging, and disposal design bases and designs of subsystems. Describe effluent control and monitoring systems during normal operations. In this discussion, include any temporary onsite storage facilities used before either final disposal in the GROA or shipping to an alternate site.

4.1.1.3 Fire and Explosion Protection System

Provide the design bases and system descriptions of the fire and explosion protection system for the surface facilities, and describe the buildings and design features that contribute to the prevention of fires. Include a list of unusually hazardous or combustible materials used at the site.

4.1.1.4 Emergency Systems

Provide the design bases and system descriptions of the GROA emergency systems to maintain control of radioactive waste and radioactive effluents. Discuss system failures and emergency situations, including but not limited to situations caused by offsite power failures, floods, seismic events, sabotage, war, or any other disaster or emergency, whether natural or human-induced.

4.1.1.5 Communication Systems

Provide the design bases and system description of the communication systems within the GROA as well as to offsite locations. Discussions should include the various types of communications and alarm systems, including surface, surface to underground, and within the underground facility.

4.1.1.6 Utility Systems

Provide the design bases, designs, and operating features for each of the utility service systems, including electrical power, compressed air, water supply, steam supply, chilled water, fuels supply, both sanitary and chemical (nonnuclear) sewage treatment, and auxiliary or backup systems. The system descriptions should include the design features that are essential to safety under both normal and accident conditions. Redundant systems designed to maintain adequate capability for utility systems that are important to safety should be described.

4.1.1.7 Instrumentation and Control Systems

Provide the designs and operational features for computer systems at the GROA, including data acquisition systems that support meteorological monitoring, hydrological monitoring, geophysical or seismic monitoring, monitoring for surface-based testing, monitoring for in situ testing, and performance confirmation monitoring. Also include descriptions of instrumentation and control systems that monitor and control the behavior of equipment or systems important to safety, retrievability, and isolation.

4.1.1.8 Onsite Transportation System

Provide the design bases as well as overall and detailed engineering drawings for the onsite surface transportation systems, including railroads, paved roads, hoist buildings, and ramp buildings.

4.1.1.9 Ventilation Systems

Describe the surface facilities' ventilation systems and the surface portion of the ventilation systems that support the underground facility, including emplacement ventilation system, development ventilation system, HEPA filters, ventilation monitoring systems, and refrigeration plant system. Descriptions should include safety measures for operations under normal and accident conditions.

4.1.1.10 Operations Support Systems

Describe the designs and operating features of the systems that support the GROA, including the maintenance shops, supplies warehouse and storage yard, workers' lockers and showers, visitors center, and office buildings.

4.1.1.11 Decommissioning System

Identify and describe all the equipment, systems, or facilities requiring decontamination and decommissioning, as well as the methods and procedures used for decontamination, reclamation of the land, and installations of fences and markers. Provide specific descriptions of the various procedures and operations required for decommissioning surface facilities, including the waste-handling building, waste treatment building, performance confirmation building, ventilation exhaust building for the underground facility emplacement areas, and decontamination building designed for use during operations of the GROA. Also discuss any decommissioning operations, such as dismantling of surface facilities by blasting the foundations, which may adversely impact the long-term isolation capability of the site.

4.1.1.12 Other Surface Systems

Describe the design and provide the design bases for any other surface systems such as muck piles and surface lagoons.

4.1.2 Shafts and Ramps

Provide the layout, design bases, and design descriptions of all shafts and ramps connecting the surface facilities with the underground facility (include both the underground facility development area and the waste emplacement area). Every structure, system, or component of the shafts and ramps should be identified, and note whether each is important to safety, retrievability, or isolation. Also include schedules for inspections, testing, and maintenance of all structures, systems, and components.

4.1.2.1 Waste Shaft or Ramp

Depending on which is chosen, provide design bases and the detailed design as well as the layout and general arrangement for the waste ramp or shaft. For ramps, provide details of the portals, liners (if any), and general hauling arrangements (include descriptions of the trucks or rail system and other hauling equipment). For shafts, include details of the shaft collar and shaft liner. In either case, provide cross sections at various rock types penetrated by the ramps or shafts. Describe waste types, volumes, and weights. Discuss safety measures to be used to prevent accidents. Include in this section detailed information about ventilation, operational and post-closure seals (if any), linings, and drainage. Also describe instrumentation and control systems for ramp or shaft design validation and performance monitoring. Include schedules for operations and maintenance.

4.1.2.2 Muck Shaft or Ramp

Depending on which is chosen, provide design bases and the detailed design as well as the layout and general arrangement for the muck ramp or shaft. For ramps, provide details of the portals, liners (if any), and general hauling arrangements (include descriptions of the trucks or rail system and other hauling equipment). For shafts, include details of the shaft collar and shaft liner. In either case, provide cross sections at various rock types penetrated by the ramps or shafts. Describe waste types, volumes, and weights. For shafts, describe trucks and equipment to be used for hauling. Discuss safety measures to be used to prevent accidents. Include in this section detailed information about ventilation, operational and post-closure seals (if any), linings, and drainage. Also describe instrumentation and control systems for ramp or shaft design validation and performance monitoring. Include schedules for operations and maintenance.

4.1.2.3 Ventilation Intake Shafts

Provide the layout and general arrangement for the ventilation intake shafts. Discuss the design bases and detailed design of the intake shafts. Include details of the shaft collar, shaft liner, cross sections at various rock types penetrated by the shafts, and average and maximum quantities of air. Describe operational and post-closure seals (if any), linings, and drainage. Discuss instrumentation for systems and components used for shaft design validation and performance monitoring. Include the maintenance schedule.

4.1.2.4 Ventilation Exhaust Shafts

Provide the layout and general arrangement for the ventilation exhaust shafts. Provide discussions of the design bases and detailed design of the intake shafts, including details of the shaft collar, liner, and cross sections at various rock types penetrated by the shafts. Describe average and maximum quantities of air and HEPA and exhaust filters. Describe operational and post-closure seals (if any), linings, and drainage. Discuss safety measures to be used to prevent accidents. Discuss instrumentation for systems and components used for shaft design validation and performance monitoring. Include the maintenance schedule.

4.1.2.5 Personnel and Materials Shafts

Provide the layout and general hauling arrangement for the shafts for personnel and materials. Describe the design bases and detailed design, including details of the shaft collars and cross sections at various rock types penetrated by the shaft. Also describe hoisting equipment (including cage capacity), safety measures to prevent accidents and free falls, ventilation, operational and post-closure seals (if any), linings, and drainage. Discuss instrumentation for systems or components for shaft design validation and performance monitoring. Include schedules for operations and maintenance.

4.1.2.6 Decommissioning System

Describe the backfilling and sealing system that will be used to permanently close the shafts or ramps. Include the proposed materials for backfilling and sealing, the bases for selection of these materials, methods and equipment for emplacement, and the installation of plugs and bulkheads. Specifically, discuss operational seals and whether or not they will be left in place as part of the post-closure seals.

4.1.2.7 Other Shaft or Ramp Systems

Describe any other shaft or ramp systems at a level of detail similar to the previous paragraphs.

4.1.3 Underground Facility

Provide overall and detailed layouts, design bases, and design descriptions of the underground facility, including development and emplacement areas and any other underground areas such as maintenance, shops, personnel showers, and decontamination areas. Identify structures, systems, and components in the underground facility, and indicate whether or not they have been classified as important to safety, retrievability, or isolation. Include schedules for inspections, testing, and maintenance of these structures, systems, and components. Also discuss sealing and drainage of the underground facility.

4.1.3.1 Excavation and Ground Support Systems

Provide the design bases, designs, and operating features of each excavation and support system to be used in excavation and construction of the underground facility. Discuss the extent of the damaged zone around openings (mechanical, thermomechanical, hydrological, and chemical effects of each excavation method on the rock mass). Drill and blast methods, mechanical methods (including tunnel boring machines and continuous miners), and ground support systems used for short- and long-term stability of excavated openings should be considered. Discuss the response of these support systems under thermal loading and retrieval conditions. Include discussion of tonnages of excavated rock, rates of advance, and configuration of the excavation machinery.

4.1.3.2 Muck Handling System

Provide the design bases, general layouts, and designs of the systems for handling the excavated tuff. Describe the units or systems used, such as LHD (load-haul-dump) units and belt conveyors. The description should also include the disposition of tuff rock from development areas as well as emplacement areas.

4.1.3.3 Ventilation System

Provide the design bases, general facility layouts (mains and submains), and panel layouts for fresh and return air flows for both the development and emplacement areas. Discuss the system capacity of both the development and emplacement areas relative to the maximum ventilation requirements during the operational lifetime of the repository. Also consider fan characteristics, the ventilation control system (bulkheads, regulators, stoppings), and ventilation system monitoring (for pressure drops, air velocities, system leakage, etc.). Discuss the requirements for air cooling for test, maintenance, or retrieval operations. Include the number of days needed to cool the emplacement drifts and a determination of whether the system, as constructed, will be able to support these operations. Also discuss instrumentation for the control and maintenance system. Include schedules for operations and maintenance.

4.1.3.4 Waste Emplacement System

Provide the design bases, types and thermal decay characteristics of wastes, dimensions and weights of the waste packages, general arrangement of emplacement panels and drifts, modes of waste emplacement (vertical boreholes, horizontal boreholes, or other modes of emplacement, and whether a hole liner is used), power output per canister, and the area thermal load for each emplacement configuration. Discuss methods of construction used for the waste emplacement system (refer to excavation systems), long-term stability of emplacement drifts under repository conditions, and methods and systems for ground support, including backfill materials used around the waste packages. Also discuss the machinery for transporting the waste from the bottom of the waste ramp or shaft to the emplacement areas, including the casks used, the equipment and machinery for emplacement operations, and the shielding provided.

4.1.3.5 Waste Retrieval System

Provide the design bases and details of retrieval plans to locate, access, retrieve, and transport waste packages through the underground facility and up the shaft or ramp to the appropriate surface facilities. Include discussions on the drift roof and wall support systems and the ventilation system requirements, including the drift wall temperature, drift air temperatures before cooling, capacity of refrigeration plant, quantity of air needed, and number of cooling days needed before personnel and retrieval machinery can enter. Descriptions of the retrieval system should include shielding and the sequence of retrieval operations under normal and off-normal conditions.

4.1.3.6 Emergency Systems

Describe the emergency systems within the underground facility, including alarm systems, emergency power systems, and systems to prevent the spread of floods or fires.

4.1.3.7 Communication System

Provide the design bases and describe the communication system used within the underground facility and with the surface.

4.1.3.8 Operations Support System

Describe the designs and operating features of support systems for the underground facility, mine waste-water drainage system, lighting system, power systems; electrical, compressed air, fuels supply, steam supply, and water supply auxiliary or backup systems; maintenance shops; supply rooms; and offices. The system descriptions should note the design features that are essential to safety under both normal and accident conditions.

4.1.3.9 Decommissioning System

Describe the backfilling and sealing systems that will be used to permanently close the waste emplacement areas and the remaining portions of the underground facility. Discuss the materials proposed for the systems, the bases for selection of these materials, methods and equipment with which placement of these materials will be accomplished, and provisions for dealing with sealing of fracture zones, perched water zones, and fault areas. Discuss in detail sealing waste emplacement areas, including consideration of boreholes, drifts and panels, removal of underground equipment, removal of operational underground systems and structures (such as belt conveyor systems, ventilation doors, regulators, and bulkheads), ways of dealing with any operational seals, injection of grouts, and construction of plugs or bulkheads. This section should include discussions on long-term repository drainage.

4.1.3.10 Other Underground Systems

If there are other underground systems that are part of the underground facility, provide descriptions for those with a level of detail similar to those provided in the previous paragraphs.

4.1.4 Radiation Protection

In this section, describe how the radiological designs of the surface and underground physical facilities in the GROA will permit safe handling and storage of radioactive wastes during operations and retrieval. The description should include the layouts of the facilities for radiation protection in the GROA (including the locations of radiological monitoring instruments) and the radiological design features for each system described in Section 4.1 that are to be employed by the applicant in meeting the standards of 10 CFR Part 20, the guidance given in any appropriate NRC regulatory guides, and any generally applicable environmental standards for radioactivity that have been established by the EPA.

4.1.4.1 Layout Drawings of Radiological Areas and Facilities

These layout drawings should show shield wall thicknesses, controlled-access areas, personnel and equipment decontamination areas, contamination-control areas with type of controls, traffic patterns, location of the health physics facilities, locations of monitors for airborne radioactive materials and area radiation, locations of control panels for radiological waste equipment and components, location of the onsite laboratory for analysis of chemical and radioactive samples, and location of the counting room. Describe the facilities and equipment involved, including any special equipment rovided specifically for radiation protection.

4.1.4.2 ALARA Design Considerations

Describe layout and equipment that are designed for ensuring that occupational and radiation exposures are as low as reasonably achievable (ALARA) for the GROA systems in Section 4.1. Describe how relevant experience from any past designs was (and will be) used to develop improved designs for ensuring that occupational radiation exposures will be ALARA and that contamination incidents will be minimized. The description should also include a discussion of the radiological safety features in the designs for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste.

Describe how the designs are directed toward (1) reducing the need for maintenance of equipment, (2) reducing radiation levels and time spent where maintenance is required, and (3) controlling contamination in handling, transfer, and storage of all radioactive materials. These descriptions should also indicate how the applicable design consideration guidance provided in Regulatory Position 2, "Facility and Equipment Design Features," of Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," was followed. If it was not followed, indicate the specific alternative approaches that were used.

Identify each ventilation and offgas treatment system on the appropriate equipment and process flow drawings, and include in the description how:

- Releases of radioactivity will be maintained ALARA during normal operations;
- Capacity is sufficient to confine radioactive material during projected operating conditions;
- Provisions are incorporated to adequately monitor performance;
- Design features are incorporated to interface with other effluent and ventilation systems; and
- The spread of radioactive materials between operating areas and within the ventilation systems will be controlled (include a description of the various radiation zones to be used to limit exposures and contamination).

Discuss the program for measuring the efficiency of filters and other gaseous effluent treatment devices over the lifetime of the installation. Provide criteria for changing filters. Discuss how the ventilation system design will allow filter changes to be compatible with the ALARA principle.

4.1.4.3 Characterization of Shielding

Describe the sources of radiation that were used as the bases for the radiological designs for any shielding used in each facility listed in Section 4.1. The description should include a tabulation of all radioactive sources by isotopic composition. For x-ray and gamma ray sources, the description should include the energy groupings considered (from zero to the maximum photon energies), photon yields, and the source geometries. Similar information should be included for neutron sources used for shielding calculations. In addition to the spent fuel and vitrified high-level waste sources, describe those radioactive materials contained in storage containers, tanks, or equipment that are expected to be present in the GROA and that are expected to require shielding. Show the location of each source on scaled layout and arrangement drawings for the GROA. The layout drawings should include the designations of each restricted area, including the boundary of the area and the type of interface with adjacent areas (e.g., partitions, locked doors, or barriers).

Provide information on the shielding for each of the radiation sources identified above. Show the design of penetrations, the material, the method by which the shield parameters (e.g., attenuation coefficients, buildup factors) were determined, and the assumptions, codes, and techniques used in the calculations. Describe special protective features that use shielding, geometric arrangement (including equipment separation), or remote handling to ensure that occupational exposures to radiation will be ALARA in normally occupied areas. Describe the use of portable shielding, if applicable.

4.1.4.4 Radiological Monitoring Instrumentation

Describe the fixed-area radiation monitors and the continuous airborne-monitoring instrumentation and the placement of each. Describe the criteria and methods used for determining setpoints for alarms from the radiological monitoring system. For each monitoring instrument, provide information on auxiliary and emergency power supplies, range, sensitivity, accuracy, energy-dependence, calibration methods and frequency, alarm setpoints, recording devices, and the location of detectors, readouts, and alarms. Also provide the location of the continuous airborne-monitoring sample collectors, and give details of sampling-line pump location. Provide details of how representative samples from effluent monitors will be obtained.

4.1.5 Interface of Structures, Systems, and Components

Identify and describe the structures, systems, and components that provide interface between the surface facilities, shafts or ramps, and the underground facility. Discussions should include systems that interface such as the ventilation system, the hoisting system, the communication system, instrumentation and control system, utility system, operations support system, and emergency system. Describe how non-safety-related systems are designed to ensure that, in the event of the failure of a non-safety-related system, its interfacing safety-related systems can still perform. If descriptions have already been provided in other chapters or sections of Chapter 4, references should be provided.

4.2 SURFACE FACILITIES

For each structure, system, and component discussed in each subsection of Section 4.1, provide an analysis demonstrating compliance with those applicable 10 CFR Part 60 requirements. This demonstration is based on meeting a set of general requirements applicable to all the GROA systems discussed in the preceding sections, as well as individual design requirements that apply to specific GROA systems. For each analysis, discuss the appropriate design parameters and describe how these parameters result in compliance with the appropriate 10 CFR Part 60 requirements. Also, justify how any applicable industry codes and standards used in the design result in compliance with the requirements of 10 CFR Part 60. Provide a discussion of the accidents the structures, systems, and components are designed to withstand. Discuss the accident analyses that were performed, and describe how the system is intended to perform during the accident. Demonstrate that the structures, systems, and components are designed to withstand the effects of the accident. Describe the steps taken in the design of the structures, systems, and components to provide for the prevention of accidents, including those caused by natural phenomena. Provide the basis for, and analysis of, the approaches used to identify structures, systems, and components important to safety, waste isolation and retrievability.

With respect to those structures, systems, and components important to safety, provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin. For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and the uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in the modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

4.2.1. For each surface subsystem described in Section 4.2, demonstrate compliance with the following requirements and criteria as applicable. NOTE that each requirement may not apply to each subsystem or component listed in Sections 4.2, 4.3, and 4.4. Compliance should be demonstrated only with applicable require ments and criteria.

4.2.1.1. Demonstrate that the concentrations of airborne radioactive materials in restricted areas (in combination with the concentrations discharged from the other GROA systems) will be consistent with the inhalation quantity limits (intakes) as required by 10 CFR 20.103, "Exposure of Individuals to Concentrations of Radioactive Materials in Air in Restricted Areas." For each source term that was used to estimate these concentrations, identify the quantity of radioactivity discharged per unit time, particle sizes (AMAD), chemical and physical forms, and the lung-solubility classes.

For those areas that will contain potentially airborne radioactive materials and that will be accessible to (or normally occupied by) operating personnel, provide estimates of the maximum individual and total person-hours of occupancy and the anticipated concentrations of each airborne radioactive material expected during such occupancy. Tabulate the projected concentrations and the estimated intakes of radionuclides in restricted areas until permanent closure expected as a result of (1) handling, storage, retrieval, emplacement, or isolation of radioactive waste by any of these systems and (2) damage to any items intended to control or monitor radiological exposure as a result of accident conditions. Provide the models and the model parameters used to calculate these quantities. Compare the projected intakes to the intake limits in 10 CFR Part 20.

Indicate the provisions to be made for personnel protective measures (such as respiratory equipment or exhaust hoods) and how the guidance provided by ANSI N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities," or alternative methods, will be followed.

4.2.1.2. Demonstrate that the means (such as equipment designed for ease of repair and replacement and adequate space for ease of operation) to limit the occupancy time required to perform work in the vicinity of radioactive materials contained within each system will be adequate to ensure compliance with 10 CFR Part 20.

4.2.1.3. Demonstrate that each system will be provided with suitable shielding. Include any cost/benefit analyses used to demonstrate that each shield complies with the ALARA conditions of 10 CFR Part 20 and the dose limitation requirements of 10 CFR 20.101.

4.2.1.4. Demonstrate that the means employed to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas will ensure compliance with the ALARA requirements of 10 CFR 20.1(c), the dose limitation requirements of 10 CFR 20.101, and the limits on concentrations in air required by 10 CFR 20.103.

4.2.1.5. Demonstrate that the means to control access to high-radiation areas or to airborne radioactivity areas will permit occupancy and appropriate actions to be taken for safe operation of the facility. Describe the redundancy that allows the facility to be put in a safe condition if any such area is removed from service and how this condition will be monitored.

4.2.1.6. Demonstrate that the radiation alarm systems are designed to warn operating personnel of significant increases in radiation levels and concentrations of radioactive materials in air, to warn of increased radioactivity released in effluents, and with provisions for calibration and for testing their operability. Refer to the National Council on Radiation Protection and Measurement (NCRP) report No. 88, "Radiation Alarms and Access Control Systems," issued December 30, 1986, as partial guidance for the assessment of radiation alarm systems.

4.2.1.7. Demonstrate that the levels of radiation in restricted areas (in combination with levels of radiation from the other GROA systems) will be in compliance with the dose standards in 10 CFR 20.101. Provide the objectives and criteria for design dose rates in various areas. Provide an estimate of the annual collective person-rem doses associated with major functions such as spent fuel or high-level radioactive waste transfer and storage operations, ancillary activities (e.g., offgas handling, waste treatment), maintenance, radwaste handling, decontamination, retrieval, and proposed inservice inspections. Provide the estimated annual occupancy times, including the maximum expected total hours per year for any individual and total person-hours per year for all personnel for each restricted area during such occupancy. Supply the bases, models, and assumptions for the above values.

Calculations of dose should identify the dose-conversion factors and illustrate how they are used to calculate exposures. The biological and dosimetry models used to calculate dose to occupational radiation workers should be technically acceptable to the NRC staff, consistent with 10 CFR Part 20.

4.2.1.8. Demonstrate that for each system every reasonable effort will be made to maintain radiation exposures, and releases of radioactive material in effluents to restricted areas, ALARA as required by 10 CFR 20.1(c). Describe the management policy that will be employed to ensure that occupational exposures to radiation and radiation-producing sources from the system under consideration are ALARA. Describe the policy with respect to designing and operating the installation to achieve ALARA objectives. Indicate how the guidance given in Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," and, where appropriate, Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable," will be followed for each individual system. If this guidance will not be followed, indicate the specific alternative approaches to be used.

4.2.1.9. Demonstrate that the structures, systems, and components important to safety are designed so that natural phenomena and environmental conditions anticipated at the GROA will not interfere with necessary safety functions.

4.2.1.10. Demonstrate that the structures, systems, and components important to safety are designed to withstand dynamic effects, such as missile impacts, that could result from equipment failure and similar events and conditions that could lead to loss of their safety functions.

4.2.1.11. Demonstrate that the structures, systems, and components important to safety are designed to perform their safety functions during and after credible fires or explosions in the GROA.

4.2.1.12. Demonstrate that the GROA has been designed, to the extent practicable, to incorporate the use of noncombustible and heat-resistant materials.

4.2.1.13. Demonstrate that the GROA has been designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

4.2.1.14. Demonstrate that the GROA has been designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

4.2.1.15. Demonstrate that the structures, systems, and components important to safety are designed to maintain control of radioactive waste and radioactive effluents and to permit prompt termination of operations and evacuation of personnel during an emergency.

4.2.1.16. Demonstrate that the GROA has been designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical, and ambulance service) that may aid in recovery from emergencies.

4.2.1.17. Demonstrate that each utility service system that is important to safety is designed so that essential safety functions can be performed under both normal and accident conditions.

4.2.1.18. Demonstrate that the utility service systems important to safety include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

4.2.1.19. Demonstrate that provision has been made so that, if there is a loss of the primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, operating systems, and alarm systems important to safety.

4.2.1.20. Demonstrate that the structures, systems, and components important to safety have been designed to permit periodic inspection, testing, and maintenance as necessary to ensure their continued functioning and readiness.

4.2.1.21. Demonstrate that all systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste have been designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Demonstrate that each system has been designed for criticality safety under normal and accident conditions, and that the calculated effective multiplication factor (K_{eff}) is sufficiently below unity to show at least 5% margin, after allowance for the bias in the method of calculation and uncertainty in the experiments used to validate the method of calculation.

4.2.1.22. Demonstrate that the designs of the surface facilities include provisions for instrumentation and control systems to monitor and control the behavior of systems important to safety over anticipated ranges of normal operation and for accident conditions.

4.2.1.23. Demonstrate that the design includes provisions for worker protection to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. (DOE is not subject to the Federal Mine Safety and Health Act of 1977 during the construction and operation of the GROA.) Note that any deviation for relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N, will give rise to a rebuttable presumption that this requirement has not been met.

4.2.1.24. Demonstrate that hoists important to safety are designed:

(a) to preclude cage freefall;
(b) to have a reliable cage location system;
(c) to have a reliable system of interlocks that will fail safely upon malfunction; and
(d) to include two independent indicators to indicate when waste packages are in place and ready for transfer.

4.2.1.25. Demonstrate that the GROA surface facilities have been designed to allow safe handling and storage of wastes at the GROA, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility.

4.2.1.26. Demonstrate that surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging are designed to protect against radiation exposures and offsite releases as provided in 10 CFR 60.111(a).

4.2.1.27. Demonstrate that the surface facilities are designed to control the release of radioactive materials in effluents during normal operations so as to meet the performance objectives of 10 CFR 60.111(a).

4.2.1.28. Demonstrate that the effluent monitoring systems are designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform to the design requirements for effluent control. Demonstrate that the monitoring systems are designed to include alarms that can be periodically tested.

4.2.1.29. Demonstrate that the radioactive waste treatment facilities are designed to process any radioactive wastes generated at the GROA into a form suitable for safe disposal at the GROA or suitable for safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

4.2.2. Compliance with the above listed applicable requirements and criteria (4.2.1.1 through 4.2.1.29) should be demonstrated specifically for the following systems:

4.2.2.1 Hot Cell (Waste Handling Systems, Buildings, and Equipment)
4.2.2.2 Onsite Radioactive Waste Management Systems
4.2.2.3 Fire and Explosion Protection Systems
4.2.2.4 Emergency Systems
4.2.2.5 Communication Systems
4.2.2.6 Utility Systems

4.2.2.7 Instrumentation and Control Systems

4.2.2.8 Onsite Transportation System

4.2.2.9 Ventilation Systems

4.2.2.10 Operations Support Systems

4.2.2.11 Decommissioning System

4.2.2.12 Other Surface Systems

4.3 SHAFTS OR RAMPS

For each shaft or ramp structure, system, and component discussed in each subsection in Section 4.1, provide an analysis demonstrating compliance with the applicable 10 CFR Part 60 requirements. This demonstration is based on meeting a set of general requirements applicable to all the GROA systems discussed in the preceding sections, as well as individual design requirements that apply to specific GROA systems. For each analysis, discuss the appropriate design parameters and describe how these parameters result in compliance with the appropriate 10 CFR Part 60 requirements. Also, justify how any applicable industry codes and standards used in the design result in compliance with the requirements of 10 CFR Part 60. Discuss the accidents the structures, systems, and components are designed to withstand. Discuss the accident analyses that were performed, and describe how the system is intended to perform during the accident. Demonstrate that the structures, systems, and components are designed to withstand the effects of the accident. Describe the steps taken in designing the structures, systems, and components for preventing accidents, including those caused by natural phenomena.

With respect to those structures, systems, and components important to safety, provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including occurrences of natural origin. For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and the uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided, along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

4.3.1. For each shaft or ramp subsystem described in Section 4.1.2, demonstrate compliance with the following as applicable. NOTE that each requirement may not apply to each subsystem or component listed. Compliance should be demonstrated only with applicable requirements.

4.3.1.1. Demonstrate that the concentrations of airborne radioactive materials in restricted areas (in combination with the concentrations discharged from the other GROA systems) will be consistent with the inhalation quantity limits (intakes) as required by 10 CFR 20.103, "Exposure of Individuals to Concentrations of Radioactive Materials in Air in Restricted Areas." For each source term that was used to estimate these concentrations, identify the quantity of radioactivity discharged per unit time, particle sizes (AMAD), chemical and physical forms, and the lung-solubility classes.

For those areas that will contain potentially airborne radioactive materials and that will be accessible to (or normally occupied by) operating personnel, provide estimates of the maximum individual and total person-hours of occupancy and the anticipated concentrations of each airborne radioactive material expected during such occupancy. Tabulate the projected concentrations and the estimated intakes of radionuclides in restricted areas until permanent closure expected as a result of (1) handling, storage, retrieval, emplacement, or isolation of radioactive waste by any of these systems and (2) damage to any items intended to control or monitor radiological exposure as a result of accident conditions. Provide the models and the model parameters used to calculate these quantities. Compare the projected intakes to the intake limits in 10 CFR Part 20.

Indicate the provisions to be made for personnel protective measures (such as respiratory equipment or exhaust hoods) and how the guidance provided by

ANSI N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities" (or alternative methods) will be followed.

4.3.1.2. Demonstrate that the means employed to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas will ensure compliance with the ALARA requirements of 10 CFR 20.1(c), the dose limitation requirements of 10 CFR 20.101, and the limits on concentrations in air required by 20.103.

4.3.1.3. Demonstrate that the levels of radiation in restricted areas (in combination with levels of radiation from the other GROA systems) will be in compliance with the dose standards in 10 CFR 20.101. Provide the objectives and criteria for design dose rates in various areas. Provide an estimate of the annual collective person-rem doses associated with major functions such as spent fuel or high-level radioactive waste transfer and storage operations, ancillary activities (e.g., offgas handling, waste treatment), maintenance, radwaste handling, decontamination, retrieval, and proposed inservice inspections. Provide the estimated annual occupancy times, including the maximum expected total hours per year for any individual and total person-hours per year for all personnel for each restricted area during such occupancy. Supply the bases, models, and assumptions for the above values.

Calculations of dose should identify the dose-conversion factors and illustrate how they are used to calculate exposures. The biological and dosimetry models used to calculate occupational dose to radiation workers should be technically acceptable to the NRC staff, consistent with 10 CFR Part 20.

4.3.1.4. Demonstrate that the structures, systems, and components important to safety are designed so that natural phenomena and environmental conditions anticipated at the GROA will not interfere with necessary safety functions.

4.3.1.5. Demonstrate that the structures, systems, and components important to safety are designed to withstand dynamic effects, such as missile impacts, that could result from equipment failure and similar events and conditions that could lead to loss of their safety functions.

4.3.1.6. Demonstrate that the structures, systems, and components important to safety are designed to perform their safety functions during and after credible fires or explosions in the GROA.

4.3.1.7. Demonstrate that the GROA has been designed, to the extent practicable, to incorporate the use of noncombustible and heat-resistant materials.

4.3.1.8. Demonstrate that the GROA has been designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

4.3.1.9. Demonstrate that the GROA has been designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

4.3.1.10. Demonstrate that the structures, systems, and components important to safety are designed to maintain control of radioactive waste and radioactive effluents and to permit prompt termination of operations and evacuation of personnel during an emergency.

4.3.1.11. Demonstrate that each utility service system that is important to safety is designed so that essential safety functions can be performed under both normal and accident conditions.

4.3.1.12. Demonstrate that the utility services important to safety include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

4.3.1.13. Demonstrate that provision has been made so that, if there is a loss of primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, operating systems, and alarm systems important to safety.

4.3.1.14. Demonstrate that the structures, systems, and components important to safety have been designed to permit periodic inspection, testing, and maintenance as necessary to ensure their continued functioning and readiness.

4.3.1.15. Demonstrate that all systems for transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste have been designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Demonstrate that each system has been designed for criticality safety under normal and accident conditions, and that the calculated effective multiplication factor (K_{eff}) is sufficiently below unity to show at least 5% margin, after allowance for the bias in the method of calculation and uncertainty in the experiments used to validate the method of calculation.

4.3.1.16. Demonstrate that the design of the shafts and ramps includes provisions for instrumentation and control systems to monitor and control the behavior of systems important to safety over anticipated ranges of normal operation and for accident conditions.

4.3.1.17. Demonstrate that the design includes provisions for worker protection to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. (DOE is not subject to the Federal Mine Safety and Health Act of 1977 during the construction and operation of the GROA.) Note that any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N, will give rise to a rebuttable presumption that this requirement has not been met.

4.3.1.18. Demonstrate that seals for shafts and boreholes are designed so that following permanent closure they do not become pathways that compromise the GROA's ability to meet the performance objectives for the period following permanent closure.

4.3.1.19. Demonstrate that the materials and placement methods for seals have been selected to reduce, to the extent practicable, the potential for (a) creating a preferential pathway for ground water to contact the waste packages or (b) radionuclide migration through existing pathways.

4.3.2. Compliance with the above listed applicable requirements should be demonstrated specifically for the following systems.

4.3.2.1 Waste Shaft or Ramp

4.3.2.2 Muck Shaft or Ramp

4.3.2.3 Ventilation Intake Shafts

4.3.2.4 Ventilation Exhaust Shafts

4.3.2.5 Personnel and Materials Shafts

4.3.2.6 Decommissioning System

4.3.2.7 Other Shaft or Ramp Systems

4.4 UNDERGROUND FACILITY

For each underground facility structure, system, and component discussed in each subsection in Section 4.1, provide an analysis demonstrating compliance with applicable 10 CFR Part 60 requirements. This demonstration is based on meeting a set of general requirements applicable to all the GROA systems discussed in the preceding sections, as well as individual design requirements that apply to specific GROA systems. For each analysis, discuss the appropriate design parameters and describe how these parameters result in compliance with the appropriate 10 CFR Part 60 requirements. Also, justify how any applicable industry codes and standards used in the design result in compliance with the requirements of 10 CFR Part 60. Provide a discussion of the accidents that the structures, systems, and components are designed to withstand. Discuss the accident analyses that were performed, and describe how the system is intended to perform during the accident. Demonstrate that the structures, systems, and components are designed to withstand the effects of the accident. Describe the steps taken in the design of the structures, systems, and components to provide for the prevention of accidents, including those caused by natural phenomena.

With respect to those structures, systems, and components important to safety, provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin. For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and the uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

4.4.1. For each underground facility subsystem described Section 4.1, demonstrate compliance with the following requirements as applicable. NOTE that each requirement may not apply to each subsystem or component listed. Compliance should be demonstrated only with applicable requirements.

4.4.1.1. Demonstrate that the concentrations of airborne radioactive materials in restricted areas (in combination with the concentrations discharged from the other GROA systems) will be consistent with the inhalation quantity limits (intakes) as required by 10 CFR 20.103, "Exposure of Individuals to Concentrations of Radioactive Materials in Air in Restricted Areas." For each source term that was used to estimate these concentrations, identify the quantity of radioactivity discharged per unit time, particle sizes (AMAD), chemical and physical forms, and the lung-solubility classes.

For those areas that will contain potentially airborne radioactive materials and that will be accessible to (or normally occupied by) operating personnel, provide estimates of the maximum individual and total person-hours of occupancy and the anticipated concentrations of each airborne radioactive material expected during such occupancy. Tabulate the projected concentrations and the estimated intakes of radionuclides in restricted areas until permanent closure expected as a result of (1) handling, storage, retrieval, emplacement, or isolation of radioactive waste by any of these systems and (2) damage to any items intended to control or monitor radiological exposure as a result of accident conditions. Provide the models and the model parameters used to calculate these quantities. Compare the projected intakes to the intake limits in 10 CFR Part 20.

Indicate the provisions to be made for personnel protective measures (such as respiratory equipment or exhaust hoods) and how the guidance provided by ANSI N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities" (or alternative methods) will be followed.

4.4.1.2. Demonstrate that the means (such as equipment designed for ease of repair and replacement and adequate space for ease of operation) to limit the occupancy time required to perform work in the vicinity of radioactive materials contained within each system will be adequate to ensure compliance with 10 CFR Part 20.

4.4.1.3. Demonstrate that each system will be provided with suitable shielding. Include any cost/benefit analyses used to demonstrate that each shield complies with the ALARA conditions of 10 CFR Part 20 and the dose limitation requirements of 10 CFR 20.101.

4.4.1.4. Demonstrate that the means employed to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas will ensure compliance with the ALARA requirements of 10 CFR 20.1(c), the dose limitation requirements of 10 CFR 20.101, and the limits on concentrations in air required by 20.103.

4.4.1.5. Demonstrate that the means to control access to high-radiation areas or to airborne radioactivity areas will permit occupancy and appropriate actions to be taken for safe operation of the facility. Describe the redundancy that allows the facility to be put in a safe condition if any such area is removed from service and how this condition will be monitored.

4.4.1.6. Demonstrate that the radiation alarm systems are designed to warn operating personnel of significant increases in radiation levels and concentrations of radioactive materials in air, to warn of increased radioactivity released in effluents, and with provisions for calibration and for testing their operability. Refer to the National Council on Radiation Protection and Measurement (NCRP) report No. 88, "Radiation Alarms and Access Control Systems," issued December 30, 1986, by the National Council on Radiation Protection and Measurements as partial guidance for the assessment of radiation alarm systems.

4.4.1.7. Demonstrate that the levels of radiation in restricted areas (in combination with levels of radiation from the other GROA systems) will be in compliance with the dose standards in 10 CFR 20.101. Provide the objectives and criteria for design dose rates in various areas. Provide an estimate of the annual collective person-rem doses associated with major functions such as spent fuel or high-level radioactive waste transfer and storage operations, ancillary activities (e.g., offgas handling, waste treatment), maintenance, radwaste handling, decontamination, retrieval, and proposed inservice inspections. Provide the estimated annual occupancy times, including the maximum expected total hours per year for any individual and total person-hours per year for all personnel for each restricted area during such occupancy. Supply the bases, models, and assumptions for the above values.

Calculations of dose should identify the dose-conversion factors and illustrate how they are used to calculate exposures. The biological and dosimetry models used to calculate dose to occupational radiation workers should be technically acceptable to the NRC staff, consistent with 10 CFR Part 20.

4.4.1.8. Demonstrate that for each system every reasonable effort will be made to maintain radiation exposures, and releases of radioactive material in effluents to restricted areas, ALARA as required by 10 CFR 20.1(c). Describe the management policy that will be employed to ensure that occupational exposures to radiation and radiation-producing sources from the system under consideration are ALARA. Describe the policy with respect to designing and operating the installation to achieve ALARA objectives. Indicate how the guidance given in Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable," and, where appropriate, Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable," will be followed for each individual system. If this guidance will not be followed, indicate the specific alternative approaches to be used.

4.4.1.9. Demonstrate that the structures, systems, and components important to safety are designed so that natural phenomena and environmental conditions anticipated at the GROA will not interfere with necessary safety functions.

4.4.1.10. Demonstrate that the structures, systems, and components important to safety are designed to withstand dynamic effects such as missile impacts, which could result from equipment failure, and similar events and conditions that could lead to loss of their safety functions.

4.4.1.11. Demonstrate that the structures, systems, and components important to safety are designed to perform their safety functions during and after credible fires or explosions in the GROA.

4.4.1.12. Demonstrate that the GROA has been designed, to the extent practicable, to incorporate the use of noncombustible and heat-resistant materials.

4.4.1.13. Demonstrate that the GROA has been designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

4.4.1.14. Demonstrate that the GROA has been designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

4.4.1.15. Demonstrate that the structures, systems, and components important to safety are designed to maintain control of radioactive waste and radioactive effluents and to permit prompt termination of operations and evacuation of personnel during an emergency.

4.4.1.16. Demonstate that the GROA has been designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical, and ambulance service) that may aid in recovery from emergencies.

4.4.1.17. Demonstrate that each utility service system that is important to safety is designed so that essential safety functions can be performed under both normal and accident conditions.

4.4.1.18. Demonstrate that the utility service systems important to safety include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

4.4.1.19. Demonstrate that provision has been made so that, if there is a loss of the primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, operating systems, and alarm systems important to safety.

4.4.1.20. Demonstrate that the structures, systems, and components important to safety have been designed to permit periodic inspection, testing, and maintenance as necessary to ensure their continued functioning and readiness.

4.4.1.21. Demonstrate that all systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste have been designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Demonstrate that each system has been designed for criticality safety under normal and accident conditions, and that the calculated effective multiplication factor (K_{eff}) is sufficiently below unity to show at least 5% margin, after allowance for the bias in the method of calculation and uncertainty in the experiments used to validate the method of calculation.

4.4.1.22. Demonstrate that the designs of the surface facilities include provisions for instrumentation and control systems to monitor and control the behavior of systems important to safety over anticipated ranges of normal operation and for accident conditions.

4.4.1.23. Demonstrate that the design includes provisions for worker protection to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. (DOE is not subject to the Federal Mine Safety and Health Act of 1977 during the construction and operation of the GROA.) Note that any deviation from relevant design requirement in 30 CFR, Chapter I, Subchapters D, E, and N, will give rise to a rebuttable presumption that this requirement has not been met.

4.4.1.24. Demonstrate that the orientation, geometry, layout, and depth of the underground facility and the design of any engineered barriers that are part of the underground facility contribute to the containment and isolation of radionuclides.

4.4.1.25. Demonstrate that the underground facility has been designed so that the effects of credible disruptive events during the period of operations, such as flooding, fires, and explosions, will not spread through the facility.

4.4.1.26. Demonstrate that the underground facility has been designed with sufficient flexibility to allow adjustments where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

4.4.1.27. Demonstrate that the underground facility has been designed to permit retrieval of waste in accordance with the performance objectives of 10 CFR 60.111.

4.4.1.28. Demonstrate that the design of the underground facility provides for control of water or gas intrusion.

4.4.1.29. Demonstrate that openings in the underground facility have been designed so that operations can be carried out safely and the waste will be retrievable.

4.4.1.30. Demonstrate that openings in the underground facility have been designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.

4.4.1.31. Demonstrate that the design of the underground facility incorporates excavation methods that limit the potential for creating a preferential pathway for ground water to contact the waste packages and that prevent radionuclide migration to the accessible environment.

4.4.1.32. Demonstrate that the ventilation system has been designed to (a) control the transport of radioactive particulates and gases within and control release from the underground facility in accordance with the performance objectives of 10 CFR 60.111(a), (b) assure continued functions during normal operations and under accident conditions, and (c) separate the ventilation of excavation and waste emplacement areas.

4.4.1.33. Demonstrate that the engineered barriers have been designed to assist the geologic setting in meeting the performance for the period following permanent closure.

4.4.1.34. Demonstrate that the underground facility has been designed to meet the performance objectives, taking into account the predicted thermal and thermomechanical response of the host rock, the surrounding strata, and the ground-water system.

4.4.2. The above listed compliance assessments should be provided as applicable for the following systems:

4.4.2.1 Excavation and Ground Support Systems
4.4.2.2 Muck Handling System
4.4.2.3 Ventilation System
4.4.2.4 Waste Emplacement System
4.4.2.5 Waste Retrieval System
4.4.2.6 Emergency Systems
4.4.2.7 Communication System
4.4.2.8 Operations Support System
4.4.2.9 Decommissioning System
4.4.2.10 Other Underground Systems

4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

In this section, compliance of the GROA as a system with regard to the radiation protection for members of the public and waste retrievability performance objectives of 10 CFR Part 60 should be demonstrated. This demonstration is based on meeting a set of general requirements applicable to all the GROA systems discussed in the preceding sections, as well as individual design requirements that apply to specific GROA systems. Include, as appropriate, those engineered barrier subsystems described in Chapter 5 that interact with, or otherwise affect, the ability of the GROA to meet these performance objectives. Provide an analysis demonstrating compliance with the appropriate performance objectives. For each analysis, discuss the appropriate design parameters and describe how these parameters result in compliance with the appropriate performance objectives. Also, justify how any applicable industry codes and standards used in the design result in compliance with the performance objectives. Discuss the accidents the structures, systems, and components are designed to withstand. Discuss the accident analyses that were performed and describe how the system is intended to perform during the accident. Demonstrate that the structures, systems, and components are designed to withstand the effects of the accident. Describe the steps taken in the design of the structures, systems, and components to provide for the prevention of accidents, including those caused by natural phenomena.

With respect to those structures, systems, and components important to safety, provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin. For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness and the uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

4.5.1 Protection Against Radiation Exposures and Releases of Radioactive Material to Unrestricted Areas

Demonstrate that the design for the GROA will comply with the requirements in 10 CFR Part 60 for the radiological safety of the public. The projected levels of radiation and the concentrations of radionuclides expected should be reported (1) for discharges of radioactive materials to, and radiation fields found in, unrestricted areas and in the general environment until permanent closure as a result of handling, storage, retrieval, emplacement, and isolation of radioactive waste during normal operations and anticipated operational occurrences and (2) after damage to any items intended to control or monitor radiological exposure as a result of accident conditions during any of these operations. As required by 10 CFR 60.111(a), the GROA must be designed to maintain radiation exposures, radiation levels, and concentrations of radioactive materials released to unrestricted areas within the concentration and exposure limits specified in 10 CFR 20.105 and 106, and within such generally applicable standards for radioactivity as may have been established by EPA.

The information provided in Section 4.1.4, Radiation Protection, and any necessary computer codes and models should be used to estimate these concentrations and exposures. Relate the calculations to the meteorological data presented in Chapter 3 and the radioactive material release rates (source terms). The estimated values should be compared to the appropriate numerical limits to demonstrate compliance. However, to show that the ALARA requirements of 10 CFR 20.1(c) have been satisfied, a qualitative discussion may be acceptable. Any mathematical or physical models required to perform analyses of the radiological consequences of the activities associated with the GROA (including any simplifications or approximations needed to make the calculations) should be described or summarized in sufficient detail to provide a basis for determination that the conditions for radiological safety required by 10 CFR Part 60 are met. Reference to computer models already available to the NRC may be made by summary only. Uncertainties in the calculational methods and equipment performance should be discussed. Conservatism existing in assumptions should also be described. Published data associated with the analysis should also be referenced. Any digital computer programs or analog simulation used in the analysis should also be identified. Adequate figures should be included on the analytical model, computer listing, and input data.

4.5.1.1. Demonstrate that airborne gaseous and particulate effluents, liquid effluents, and solid wastes discharged from the GROA comply with 10 CFR 20.106, "Radioactivity in Effluents to Unrestricted Areas." The consequence analyses for effluents should be supported by the following information and any other assumptions or data required for an independent assessment of the performance by the NRC staff:

(a) A summary that identifies each effluent and the type of waste. Effluents from the following waste types should be included: treated process effluent (from waste treatment area), sewage, drinking water, rain runoff, laundry waste, and items requiring further development;

(b) The amount of effluent generated per metric ton (or other unit) of waste handled and stored per unit of time;

(c) The source terms for each radionuclide discharged as airborne or liquid effluent, including, as appropriate, particle sizes (AMAD), chemical and physical forms, lung-solubility classes, and the total quantity and concentration of each radionuclide discharged per unit time in each unit stream;

(d) The locations beyond the restricted areas that are potentially impacted by radioactive materials in effluents;

(e) The anticipated concentrations of each radionuclide at the boundary of the restricted areas and the contribution of each radionuclide to the radiation dose to human occupants as a result of potential discharges from the GROA. For each radioisotope that contributes more than 10 percent of total dose, include the characteristics of the radionuclide pertinent to its release and eventual biological impact;

(f) Sample calculations and an explanation of the measures used to support the biological and transport models used to perform the assessments with emphasis on critical pathways to humans;

(g) For each effluent, describe the constraints imposed on process systems and equipment to ensure meeting the performance objectives in 10 CFR 60.111(a).

4.5.1.2. Demonstrate that levels of radiation in unrestricted areas comply with the dose limits in 10 CFR 20.105, "Permissible Levels of Radiation in Unrestricted Areas." Provide anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved.

For each radionuclide that contributes more than 10 percent of total dose, include a description of the characteristics of the radionuclide pertinent to its release and eventual biological impact. Provide details of assumptions, and give sample calculations with emphasis on critical pathways to humans.

4.5.1.3. Demonstrate that the GROA complies with Section 191.03 in Subpart A of 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes." Estimate the largest value of the annual dose equivalent to any member of the public in the general environment that results from (1) discharges of radioactive material and direct radiation from management and storage of spent nuclear fuel or high-level transuranic radioactive wastes at the GROA and (2) all operations covered by 40 CFR 190. In addition, present the annual whole-body collective doses (person-rem) estimated to be attributable to effluents and direct radiation from the GROA for each of the 16 compass sectors about the GROA between each of the arcs having radii of 1.5, 3, 5, 6.5, 8, 16, 32, 48, 64, and 80 kilometers (approximately 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles).
In addition to the whole-body determinations, details on doses to all affected organs should also be provided.

4.5.1.4. Demonstrate that for the GROA a reasonable effort has been made to maintain radiation exposures, and releases of radioactive material in effluents to unrestricted areas, ALARA as required by 10 CFR 20.1(C). Describe the management policy and organizational structure related to ensuring that exposures of members of the public to radiation and radiation-producing sources are ALARA. Describe the applicable activities to be conducted by the individuals having responsibility for radiation protection. Describe policy with respect to designing and operating the installation to achieve ALARA objectives.

4.5.2 Retrievability of Waste

Demonstrate that the GROA has been designed to preserve the option of waste retrieval throughout the emplacement period and, thereafter, until the completion of a performance confirmation program and NRC review of the information obtained from such a program. To satisfy this performance objective, the GROA should be designed so that any or all the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste operations are initiated, unless a different time period is approved or specified by the NRC. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program. A reasonable schedule for retrieval is one that would permit retrieval in about the same time that is devoted to construction of the GROA and the emplacement of wastes.

5. ENGINEERED BARRIER SYSTEMS

The description and evaluation of the engineered barrier systems (EBS) should include a discussion of the overall purpose and function of the EBS and how the EBS fulfill the requirements of 10 CFR Part 60.

5.1 DESCRIPTION OF ENGINEERED SYSTEMS AND COMPONENTS THAT PROVIDE A BARRIER BETWEEN THE HIGH-LEVEL WASTE AND THE GEOLOGIC SETTING

The EBS is composed of the waste packages, including the waste form, and the underground facility. This section should provide a description of the EBS and components as well as their intended functions and relations in the overall repository design. Identify structures, systems, and components of the EBS, and indicate whether or not they have been classified as important to safety, retrievability, or isolation.

5.1.1 Waste Package (Design Description, Purpose and Function, Materials, Alternative Materials, and Designs Considered)

This section should provide a description of the waste package design and alternative designs. The description should include all waste package components, including the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. The description should also include a discussion of any coatings, liners, or fillers that may be incorporated in the container design. Identify the materials specifications and general manufacturing methods used. Describe the intended functions, including any assigned performance allocation, of each component of the waste package. Describe the comparative evaluation of the alternative waste package designs with particular emphasis on those features that would provide longer radionuclide containment and isolation.

5.1.2 Waste Form

In this section, provide the following information about the waste form to be emplaced in the repository:

(1) Kinds and sources of waste;

(2) Total volume of waste and kinds of waste to be emplaced in the repository and the emplacement schedules;

(3) Physical, chemical, thermal, and radiological characteristics of waste and waste forms;

(4) Waste form handling, treatment (e.g., spent fuel rod consolidation and vitrification of HLW), and acceptance processes and activities. In this section, describe treatments, manufacturing processes, and acceptance procedures used to ensure the high quality of the packaged waste form. This information is typically provided in waste acceptance specifications, waste form compliance plans, waste qualification reports, and waste process control program plans.

5.1.3 Underground Facility

Provide a general description of the design of the underground facility, including descriptions of the waste emplacement areas, panels, emplacement drifts, and boreholes. The discussions should include design descriptions of the portions of the underground facility (e.g., the openings and backfill materials) that are considered part of the engineered barrier system; include the provisions provided for retrieval. Backfill materials used in the emplacement drifts and boreholes and other drifts (mains, submains, etc.) should be described, discussing backfill particle size distributions; physical and chemical characteristics; density after emplacement; changes in density and physical and chemical characteristics with time; mechanical, thermal, and thermomechanical properties; emplacement machinery; and capability for retrieval or removal.

5.1.4 Engineered Barrier System/Waste Package Emplacement Environment

This section should describe the environment that will be experienced by the EBS and the waste package. A description of pre-emplacement site conditions should be provided, including ambient temperature; mechanical, physical, and chemical properties of the host rock; the geology of the site (e.g., faultic and seismic information); and the "average" water chemistry and water flow rate.

Also discuss how the construction of the repository and the emplacement of wastes surrounded by backfill will change the emplacement environment. This section should also describe the expected post-closure temperature profile with time of the backfill or packing around the waste packages and the characteristics of the ground water at the outermost boundary of the waste package compared with that at the interface of the backfill or packing and the next package component.

5.1.5 Radiation Protection

This section should describe the measures to be taken to maintain the radiological safety of workers in the underground facility (including the measures to be taken to minimize potential levels of radioactive contamination) during the handling, storage, retrieval, emplacement, and isolation of radioactive waste packages for normal operations, anticipated operational occurrences, and accident conditions.

Identify the physical and chemical properties of any radioactive effluents expected to be discharged into the underground facility as a result of any operational occurrences and accident conditions. Any effluents that could be released from the underground facility, that pass through the surface facilities to the general environment, and that result in a projected radiation exposure to members of the public or to workers in surface facility should also be characterized. This description should include, for each effluent, an estimate of the quantity that could be released, the rate of release, and the points of origin in the EBS.

5.2 ASSESSMENT OF COMPLIANCE WITH 10 CFR PART 60

The assessment of compliance with 10 CFR Part 60 should be in two parts: the assessment of compliance with particular barriers in regard to design requirements and the assessment of compliance with performance objectives.

5.2.1 Assessment of Compliance for Particular Barriers

This section should assess (1) how the waste package, including the waste form and the underground facility, complies with the design requirements of 10 CFR 60.135 and (2) how the EBS and the waste package comply with the performance objectives.

5.2.1.1 Waste Package Design Requirements

Discuss design criteria for HLW packages and the following:

(1) Consider how the HLW package designs will not compromise the function of the waste packages, the performance of the underground facility, or the geologic setting;

(2) Consider solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions; and

(3) Consider (a) explosive, pyrophoric, and chemically reactive materials, (b) free liquids, (c) handling, and (d) unique identification.

Discuss any applicable industry codes and standards that were used in the design. Identify the value of design parameters used to meet the design criteria, including the parameters. Describe any uncertainties associated with the parameters and the treatment of those uncertainties. Justify how these parameters result in compliance with the applicable requirements of 10 CFR Part 60.

Describe the modeling methods used to demonstrate that the design parameters are met. Provide an explanation of the measures supporting the models used to perform the analyses. Analyses and models used to predict future conditions and changes in the waste package or its environment should be supported.

For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness, as well as uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

For design criteria for other than HLW packages, provide the information for those packages as discussed above.

5.2.1.2 Waste Form

Discuss how waste form criteria for HLW are met with regard to (1) solidification, (2) consolidation, and (3) combustibles.

In general, describe the design parameters that have been established to comply with the waste form criteria and the basis for those parameters. Identify any uncertainties associated with the design parameters and the treatment of those uncertainties. Discuss the modeling method used to demonstrate that the design parameters are met. Provide an explanation of measures supporting the models used to perform analyses. Analyses and models used to predict future conditions and changes in the waste form should be supported.

For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness, as well as uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

5.2.1.3 Underground Facility

Discuss design criteria for the portion of the underground facility that is considered part of the EBS. The discussions should show how the underground facility design acts in tandem with the waste package design to form engineered barriers that assist the geologic setting in meeting the performance objectives for the post-closure period (see 10 CFR 60.133(h)).

Discuss any applicable industry codes and standards that were used in the design. Identify the value of design parameters used to meet the design criteria, including the parameters. Describe any uncertainties associated with the parameters and the treatment of those uncertainties. Justify how these parameters result in compliance with the applicable requirements of 10 CFR Part 60.

Describe the modeling methods used to demonstrate that the design parameters are met. Provide an explanation of the measures supporting the models used to perform the analyses. Analyses and models used to predict future conditions and changes in the waste package or its environment should be supported.

For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness, as well as uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

5.2.2 Assessment of Compliance with Performance Objectives

Provide an assessment that describes how the waste package and EBS comply with containment and release rate requirements, respectively. As a minimum, the assessment should discuss in detail the following:

(1) EBS and waste package performance assessment codes, including supporting research, testing, and model development;

(2) Assumed anticipated processes and events as well as degradation scenarios;

(3) Extrapolation of short-term measurements to long-term predictions of EBS and waste package performance;

(4) Uncertainties in the data, models, codes, and results related to the performance assessments;

(5) Allocation of performance to each of the EBS or waste package components;

(6) Comparative evaluation of the alternative waste package designs, with particular emphasis on those features that would provide longer radionuclide containment and isolation.

If a radionuclide release rate or designed containment period other than those nominally specified in 10 CFR 60.113(a) is proposed, the assessment should identify it and provide a rationale, taking into account the factors set out in 10 CFR 60.113(b).

5.2.2.1 Containment

In this section, evaluate whether containment of the HLW within the waste package will be substantially complete during the period when radiation and thermal conditions in the EBS are dominated by fission product decay. The duration of this period will be determined by the NRC, taking into account the factors specified in 10 CFR 60.113(b), provided that such period will not be less than 300 years nor more than 1,000 years after permanent closure. Address sources of uncertainties and discuss how the concept of "substantially complete containment" is satisfied. This section should include consideration, to the extent pertinent, of the favorable and potentially adverse conditions described in 10 CFR 60.122 and should show compliance with the requirements of that section.

5.2.2.2 Release Rate

Provide the projected release rate of any radionuclide from the EBS following the containment period defined in the previous section, and evaluate such release rate in accordance with the requirements of 10 CFR 60.113(a)(ii)(B). This section should include consideration, to the extent pertinent, of the favorable and potentially adverse conditions described in 10 CFR 60.122 and should show compliance with the requirements of that section.

5.2.3 Radiation Protection

In this section, provide reasonable assurance that until permanent closure the radiological designs for the engineered barrier systems described in Section 5.1 will comply with requirements in 10 CFR Part 60 for the radiological safety of workers and members of the public.

To the extent that this information was not provided in Chapter 4, this section should describe those measures to be taken to maintain the radiological safety of workers in the underground facility (including the measures to be taken to minimize potential levels of radioactive contamination) during the handling, storage, retrieval, emplacement, and isolation of radioactive waste packages for normal operations, anticipated operational occurrences, and accident conditions.

Tabulate the projected radiation exposures to workers and to members of the public from handling, storage, retrieval, emplacement, and isolation of radioactive waste packages in the underground facility during normal operations, anticipated operational occurrences, and accident conditions that are expected to prevail until permanent closure. The guidelines for reporting information on radiation protection outlined in Section 4.2 should also be used in this section to report information for the engineered barrier systems.

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6. OVERALL SYSTEM PERFORMANCE ASSESSMENT

This chapter should describe the quantitative analyses of overall system performance that demonstrate compliance with the regulatory requirements of 10 CFR 60.112. This should include (by reference where appropriate) such additional nonquantitative information as may be necessary to support the quantitative analyses described here.

6.1 BASIC APPROACH

This section should describe the conceptual and mathematical background for the assessments of overall system performance presented in this chapter.

6.2 SYSTEM DESCRIPTION

This section should describe the conceptual models, processes, and events that are used to assess overall repository system performance. In general, the supporting bases for the conceptual models, processes, and events are presented in other chapters. In this section, they should be summarized in sufficient detail to provide a basis for the performance assessments of this chapter. To the extent that processes and events have previously been identified and described in Sections 3.2.1 and 3.2.2, only a listing of these processes and events need be presented in this section. If the identification of processes and events presented here is more (or less) extensive than that of Sections 3.2.1 and 3.2.2, the reasons for the differences should be presented.

6.2.1 Conceptual Models

Describe the conceptual models (and reasonable alternatives) applicable to the assessment of overall system performance. Provide estimates of performance for each alternative conceptual model, including the preferred model, or provide the basis for excluding an alternative concept from the performance assessment.

6.2.2 Potentially Disruptive Processes and Events

Identify all credible potentially disruptive processes and events that could significantly and adversely affect the post-closure performance of the overall repository system. Each process or event should be described in terms of its cause (if known), its expected location or locations of occurrence, and, in general terms, its effects on the post-closure performance of the overall repository system.

6.2.3 Undisturbed Performance Processes and Events

Identify all processes and events expected to affect the predicted post-closure behavior of the overall repository system in its undisturbed state. Each process or event should be described in terms of its cause (if known), its expected location or locations of occurrence, and, in general terms, its effects on the post-closure performance of the overall repository system.

6.3 ASSESSMENT OF COMPLIANCE: CUMULATIVE RELEASE OF RADIOACTIVE MATERIALS

The performance of the overall repository system should be evaluated in terms of cumulative releases of radioactive materials to the accessible environment for 10,000 years after repository closure. The description should characterize the predicted release resulting from each scenario that can materially affect repository performance and the combined release caused by all scenarios. This description should also include the results of sensitivity analyses identifying the features of the overall system that most significantly affect performance for each of the most significant scenarios.

6.3.1 Screening of Processes and Events

The processes and events identified in Sections 6.2.2 and 6.2.3 above should be screened to eliminate those that are physically or logically unrealistic, or are expected to have trivial consequences. This section should provide the specific criteria that were used for screening processes and events. A listing of those processes and events that are retained after completion of the screening should also be provided. The screening must not exclude any processes or events that may materially affect the performance assessment. The elimination of any process or event must be justified by data and a reasoned explanation that demonstrate the absence of any such material effect.

6.3.2 Scenario Development and Screening

The processes and events retained after the screening of Section 6.3.1 above should be used to formulate scenarios consisting of credible combinations and sequences of processes and events. One or more scenarios should consist of the behavior of the overall system not disrupted by human intrusion or by the occurrence of unlikely natural events ("undisturbed performance"). The full set of scenarios should then be screened to eliminate those that are physically or logically unrealistic, are not sufficiently credible to warrant further consideration, or are expected to have trivial consequences.

Describe (1) the method used for forming scenarios, (2) the criteria used for scenario screening, and (3) the scenarios retained in the analysis after completion of screening.

6.3.3 Consequence Analyses: Estimates of Cumulative Releases

This section should describe the results of analyses projecting the performance of the overall repository system as influenced by the scenarios described in Section 6.3.2 above. The results of the analyses should be expressed in terms of the cumulative releases of radioactive materials to the accessible environment. This section should also describe the analytical methods (e.g., computer codes) used for these analyses.

6.3.4 Probability Estimates

This section should provide the probability of occurrence of each individual process or event in Section 6.3.1 that might lead to a significant release of radionuclides from the overall system. Probabilities or frequencies of occurrence must also be estimated for each of the scenarios described in Section 6.3.2. Describe all techniques used to estimate these probabilities (e.g., predictive modeling or estimates from site characterization activities) and the criteria required for the use of each technique. As appropriate, explain how time-dependent probabilities have been assessed for scenarios that involve transient phenomena. The sources of uncertainty in the data and techniques used to develop the probabilities, as well as the uncertainties in the probabilities themselves, should be identified and addressed.

Include a discussion of any alternative approaches used for estimating probabilities when little or no theoretical, experimental, or historical data are available. For all cases, the discussion should identify the factual bases and rationale for the values adopted.

6.3.5 Compliance Assessment for Cumulative Releases

This section should demonstrate that the overall system performance objective for cumulative releases in 10 CFR 60.112 is met. The scenario probabilities described in Section 6.3.4 and the estimates of overall repository system performance described in Section 6.3.3 must be combined into a single "complementary cumulative distribution function" (CCDF) displaying the likelihood that cumulative releases of radioactive material to the accessible environment over 10,000 years will not exceed the release limits of the EPA standards (40 CFR Part 191). This section should describe the means used to produce the required CCDF, should present that CCDF, and should show that the performance of the overall repository system satisfies this requirement of the EPA standard. Additional guidance will be provided (if necessary) when the final EPA standards are issued.

6.3.6 Model and Code Verification and Validation

Describe the models and any computer codes used to assess the cumulative releases to the accessible environment and the program(s) used to verify and validate them.

6.4 ASSESSMENT OF COMPLIANCE: UNDISTURBED PERFORMANCE

As required by the EPA standards, this section should provide an assessment of the predicted behaviors of the overall repository system (including a consideration of the uncertaintites in these behaviors) when the system is not disrupted by human intrusion or the occurrence of unlikely natural events. Those assessments should cover the period addressed by the EPA standards. If appropriate, the assessment should identify the dose conversion factors used to calculate the dose rates and their sources. Additional guidance will be provided (if necessary) when the final EPA standards are issued.

6.4.1 Individual Protection Requirements

For each scenario of "undisturbed performance" identified in Section 6.3.2, the assessment should describe all potential pathways involved in the transport of radionuclides from the repository to members of the public residing in the accessible environment and the radiation dose rates projected to be received by those persons. The pathways analysis should also identify the concentrations of radionuclides in potential sources of drinking water (outside the controlled area) that might be obtained from a "significant source" of ground water that has been contaminated by a release of radionuclides from the repository, and it should identify the individual exposures that could result from ingestion of this water.

6.4.2 Ground-Water Protection Requirements

For each scenario of "undisturbed performance" identified in Section 6.3.2, this assessment should identify the concentrations of radionuclides in potential sources of drinking water that might be obtained from a "special source" of ground water that has been contaminated by a release of radionuclides from the repository, and it should identify the individual exposures that could result from ingestion of this water.

6.4.3 Model and Code Verification and Validation

Describe the models and any computer codes used to assess the concentrations and dose rates in Sections 6.4.1 and 6.4.2 and the programs used to verify and validate them.

6.5 10 CFR PART 60 CRITERIA

This section should provide an assessment to demonstrate that site conditions present at the proposed repository are consistent with the performance objectives in 10 CFR 60.112 relating to isolation of waste.

6.5.1 Favorable Conditions

Summarize the favorable conditions that are present at the proposed repository site. If favorable conditions are present at the proposed repository site, demonstrate that those conditions are sufficient to provide reasonable assurance that the performance objectives in 10 CFR 60.112 relating to isolation of waste will be met. This would ordinarily be accomplished by incorporating the favorable conditions into the conceptual models and descriptions of processes and events that could affect the repository (Sections 6.2.2 and 6.2.3). Confirm that this has been done by describing how each condition that is analyzed in this way has been incorporated into a scenario of Section 6.3.2 or a conceptual model.

6.5.2 Potentially Adverse Conditions

Summarize the potentially adverse conditions that are present at the proposed repository site. If any potentially adverse condition present could significantly affect the ability of the repository to meet the performance objectives of 10 CFR 60.112 and it cannot be demonstrated that the condition is compensated by favorable conditions and cannot be remedied, the condition should be incorporated into the conceptual design models and descriptions of processes and events that could affect the repository (Section 6.3.1). Confirm that this has been done by describing how each conditon that is analyzed in this way has been incorporated into a scenario of Section 6.3.2 or a conceptual model.

7. CONDUCT OF REPOSITORY OPERATIONS

This chapter should present information describing the conduct of repository operations and the associated procedures, including planned activities and processes, security and safeguards, maintenance, radiation protection, plant organizational plan, personnel, procedure generation package, inspection and testing, and records and reports.

7.1 MAINTENANCE

This section should identify and describe the operational procedures for maintenance of structures, systems, and components important to safety and retrievability at the GROA, both surface and underground. Discussion should include consideration of the the following factors to ensure operation of structures, systems, and components important to safety and retrievability:

(1) Maintenance plans and schedules for all surface facilities described in Section 4.1.1, including plans and schedules for maintenance of the identified structures, systems, and components important to safety and to retrievability;

(2) Maintenance plans and schedules for shafts and ramps described in Section 4.1.2, including plans and schedules for maintenance of the identified structures, systems, and components important to safety, to retrievability, and to isolation;

(3) Maintenance plans and schedules for the underground facility described in Section 4.1.3, including plans and schedules for maintenance of the identified structures, systems, and components important to safety, to retrievability, and to isolation.

7.2 RADIATION PROTECTION

Describe the health physics program at the geologic repository, and describe the specialized facilities, equipment, and instrumentation that will be used to monitor and control internal and external radiological exposure to workers and to members of the public during normal operations as required by 10

CFR Part 20, and during anticipated operational occurrences and radiological emergencies as required by 10 CFR Part 60.

7.2.1 Organization

Describe the administrative organization of the health physics program, including the authority and responsibility of each position identified. Indicate how the applicable guidance in Regulatory Position 2 of Regulatory Guide 8.8 and in Regulatory Guide 8.10 has been followed. If it was not followed, describe the specific alternative approaches used. Describe the experience and qualification of the personnel responsible for the health physics program.

7.2.2 Equipment, Instrumentation, and Facilities

Describe portable and laboratory equipment and instrumentation for (1) performing radiation and contamination surveys, (2) sampling airborne radioactive material, (3) monitoring area radiation, and (4) monitoring personnel during normal operation, anticipated operational occurrences, and accident conditions. Describe the instrument storage, calibration, and maintenance facilities. Describe the health physics facilities, laboratory facilities for radioactive material analyses, protective clothing, respiratory protective equipment, decontamination facilities (for equipment and personnel), and other contamination control equipment and areas that will be available. Indicate how the health physics program follows the guidance provided by Regulatory Guide 8.4, "Direct-Reading and Indirect-Reading Pocket Dosimeters"; Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program"; and Regulatory Position 4, "Radiation Protection Facilities, Instrumentation, and Equipment," of Regulatory Guide 8.8. Some information on testing and calibration of radiation protection instruments can be found in Draft Regulatory Guide OP 032-5, "Test and Calibration of Radiation Protection Instrumentation." If they are not to be followed, describe the specific alternative methods to be used.

Describe the types of the respiratory protective equipment, protective clothing, and portable and laboratory equipment and instrumentation to be used. Describe the types of detectors and monitors and the quantity, sensitivity, range, and frequency and methods of calibration for all the equipment and instrumentation mentioned above.

7.2.3 Procedures

Describe how the following procedures in this program are intended to maintain radiation exposures and contamination levels as low as reasonably achievable (include cost-benefit analyses as necessary to justify these procedures).

7.2.3.1 Radiation Surveys

Describe the methods, frequencies, and plans for conducting radiation surveys. Describe the health physics plans that have been developed for ensuring that occupational radiation exposures will be ALARA during these surveys. Describe the physical and administrative measures for controlling access and stay time for designated radiation areas. Describe the bases and methods for monitoring and controlling personnel, equipment, and surface contamination. Describe radiation protection training programs. Indicate how the guidance on ALARA given in Regulatory Guides 8.9, 8.10, and Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," will be followed. If it will not be followed, describe the specific alternative approaches to be used.

7.2.3.2 Personnel Dosimetry

Describe the methods and plans for personnel dosimetry, including methods for recording and reporting results. Describe how dosimetric results are used as a guide to operational planning. The criteria for performing routine and nonroutine whole body and lung counting and bioassays should be provided. Describe the methods and procedures for evaluating and controlling potential airborne radioactive material concentrations, including any requirements for special air sampling. Discuss the use of respiratory protective devices, including the respiratory protective equipment fitting programs and training of personnel.

7.2.3.3 Decontamination of Surface Facilities

Describe the radiological safety procedures to be used for decontamination of the GROA and the repository site. Include sufficient detail to support the assessment of the individual and collective exposures for repository workers and for members of the public. Describe the operating features and limitations of the systems used for decontamination of personnel. Describe plans for the safe disposal of residual radioactive material after decontamination efforts are completed.

7.2.3.4 ALARA Procedures

Identify and describe procedures and methods of operation that are used to ensure that (a) occupational radiation exposures are ALARA (such as those pertinent procedures in Regulatory Position 4 of Regulatory Guide 8.8 and in Regulatory Guide 8.10) and (b) residual contamination levels are ALARA for all systems that contain, collect, store, or transport radioactive solids and liquids, including those from the radioactive waste treatment, handling, and storage systems.

7.2.4 Effluent Monitoring Programs

Describe the program and the analytical approaches to be taken to monitor the radioactive material content of the effluent streams of the GROA facilities. Relate the monitoring program to process flow diagrams and the discussions.

7.2.4.1 Effluent Monitoring--Gases and Particulates

Describe the features of the monitoring systems to be used, their locations, and the release paths to be monitored. For each system, show the expected reliability and sensitivity. The selection of each system and instrument should be justified. The frequency of sampling, the limits for action, and the plans to be used to maintain continued integrity of analyses should also be discussed.

7.2.4.2 Effluent Monitoring--Liquids

Describe the features of the liquid monitoring systems to be used, their locations, and the items to be monitored. For each system, show the expected reliability and sensitivity. The selection of each system and instrument should be justified. Whenever sampling is used, the frequency of sampling, the limits for action, and the plans to be used to maintain continued integrity of analyses should also be discussed.

7.2.4.3 Solid Waste Monitoring

Describe the procedures, equipment, and instrumentation used to monitor all solid radioactive waste.

7.2.5 Environmental Monitoring Program

The program for monitoring and estimating the contribution of radioactive materials to the environment should be described. Present the details of the approach, the results obtained for determining the background levels, and estimates of subsequent contributions of the GROA. Describe those aspects of the radiological environmental monitoring program (by reference if appropriate) that will be used in conjunction with mathematical models (1) to show compliance of the GROA with the performance objectives in 10 CFR 60.111 until permanent closure, and (2) to provide reasonable assurance that the engineered systems, structures, and components in the GROA are functioning as intended and anticipated.

Describe in detail the environmental monitoring program for those pathways that lead to the highest potential external and internal radiation exposures of individuals resulting from operations. Provide a table showing the type of sample (e.g., water, soil, vegetable), number of samples, sample location, collection frequency, and sample analysis to be performed and its frequency. Identify the sampling locations on a map of suitable scale to show distance and direction of monitoring stations, with the site boundary also indicated on this map. This section should include the program for continuing meteorological data collection and evaluation to supplement the estimates previously developed.

7.3 ORGANIZATIONAL STRUCTURE, MANAGEMENT, AND ADMINISTRATIVE CONTROLS

This section should identify and describe the structure, functions, and responsibilities of the operating organization.

7.3.1 Organization

Provide a comprehensive description of the organizational arrangement of the facility showing the title of each position and the flow of responsibility as depicted by an organizational chart.

7.3.2 Personnel Functions, Responsibilities, and Authorities

Provide a description of delegations of authority (including specific succession to responsibility for overall operation of the repository in the event of absences, incapacitation, or other emergencies) and assignments of responsibility, whether by regulations, administrative directives, contract provisions, or otherwise.

7.3.3 Personnel Qualifications Requirements

Describe the proposed minimum qualifications requirements for personnel. The identification and qualifications of personnel finally selected should be presented to the NRC as these occur, as well as any changes in required qualifications. The minimum qualification requirements should be stated for major operating, technical, health physics, and maintenance supervisory personnel. The qualifications of the individuals assigned to the managerial and technical positions described should be presented in resume form. The resumes should identify individuals by position title and, as a minimum, should describe the formal education, training, and pertinent experience of the individuals.

7.4 PROCEDURE DEVELOPMENT

This section should identify and describe various procedures needed for the GROA operations, as well as the program for generating procedures needed at later times in GROA operations. The program may include procedures such as (1) GROA general operating procedure, (2) general emergency procedure, (3) specific procedures for emergencies, such as fires, explosions, and earthquakes, (4) transportation procedure for workers, waste, equipment, and supplies, (5) procedure for traffic control, (6) plans and procedures for startup activities and startup testing, (7) a description of plans for retrieval and alternative storage for the radioactive wastes should the geologic repository prove to be unsuitable for disposal of radioactive wastes, (8) plans and procedures for any uses of the GROA for purposes other than disposal of radioactive waste, and (9) plans and procedures for areas in the GROA that have been set aside for performance confirmation purposes. Also include a description of the review, change, and approval practice for all operating, maintenance, and testing procedures.

7.5 RECORDS AND REPORTS

In this section, identify and describe the program for keeping records of activities at the GROA, including maintaining records of the licensed activity with a complete history of receipt, handling, storage, and disposition of radioactive waste; construction records; reports of deficiencies of the site; records of permanent closure; records of tests using radioactive waste that are conducted during construction or emplacement; and records of inspections.

7.6 TRAINING PROGRAMS

Describe proposed training programs, including the scope of training in:

(1) Installation operations and design, instrumentation and control, methods of dealing with operating malfunctions, decontamination procedures, and emergency procedures;

(2) Health physics subjects such as the nature and sources of radiation, methods of controlling contamination, interactions of radiation with matter, biological effects of radiation, use of monitoring equipment, and principles of criticality hazards control (identify personnel classification with the level of instruction);

(3) Mining;

(4) General training for personnel.

Describe the program for continued training that provides additional material and refresher training.

Provide a means for evaluating the effectiveness of the training program for all employees.

7.7 SCHEDULES

The schedule for inspections, testing, and maintenance to ensure continued operation, as well as proposed schedules for the GROA construction, receipt of waste, and emplacement of wastes should be provided.

7.8 IDENTIFICATION OF OPERATING CONTROLS AND LIMITS

The operating controls and limits for a repository are derived from the compliance assessments and include all aspects of operation that are important to safety, retrievability, and isolation.

The analyses should support the conclusion that the health and safety of the public and operating personnel will be protected during operations if all operations are performed within certain prescribed limits. These limits are defined and established in the operating controls and limits.

7.8.1 Proposed Operating Controls and Limits

Identify and justify the selection of those variable conditions or other items based on the design criteria or determined, as a result of safety assessment and evaluation, to be probable subjects of operating controls and limits. The operating controls and limits should be complete, i.e., to the fullest extent possible, numerical values and other pertinent data should be provided, including the technical and operating conditions supporting the selection. For each control or limit, the applicable sections of the SAR that develop, through analysis and evaluation, the details and bases for the control or limit should be referenced. A license issued under 10 CFR Part 60 will contain technical operating limits, conditions, and requirements imposed upon the conduct of operations in the interest of the health and safety of the public. The operating controls and limits are to be proposed in the SAR. A statement of the bases or reasons for proposed controls or limits should be included in the SAR. After review by the NRC, they are modified as necessary before becoming part of the license.

Therefore, the physical format for operating controls and limits assumes importance since the collection of controls or limits and their written bases forms a document that delineates those features and actions important to the safety of the operation, the reasons for their importance, and their relationship to each other.

7.8.2 Suggested Format for Operating Controls and Limits

1. Title.

2. Specification (limits).

3. Applicability: Systems or operations to which the control or limit applies should be clearly defined.

4. Objective: The reasons for the control or limit and the specific unsafe conditions it is intended to prevent.

5. Action: What is to be done if the control or limit is exceeded; clearly define specific actions.

6. Surveillance Requirements: What maintenance and tests are to be performed and when.

7. Bases: The SAR should contain all pertinent information and an explicit detailed analysis and assessment supporting the choice of the item and its specific value or characteristics. The bases for each control or limit should contain a summary of the information in sufficient depth to indicate the completeness and validity of the supporting information and to provide justification for the control or limit. The following subjects may be appropriate for discussion in the bases section:

   a. Technical Basis. The technical basis is derived from technical knowledge of the process and its characteristics and should support the choice of the particular variable as well as the value of the variable. The results of computations, experiments, or judgments should be stated, and analysis and evaluation should be summarized.

   b. Equipment. A safety limit often is protected by or closely related to certain equipment. Such a relationship should be noted, and the means by which the variable is monitored and controlled should be stated. The function of the equipment and how and why the requirement is selected should be noted here. In addition, the means by which surveillance is accomplished should be noted. If periodic surveillance is required, the basis for frequency of required action should be given.

c. Operation. The margins and the bases that relate to the safety limits and the normal operating zones should be stated. The roles of operating procedures and of protective systems in guarding against exceeding a limit or condition should be stated. Include a brief discussion of such factors as system responses, process or operational transients, malfunctions, and procedural errors. Reference to related controls or limits should be made.

7.9 PRESERVATION OF RECORDS

This section should provide discussions on the system or procedure that the DOE will use for the permanent preservation of site records, including site data prior to the SCP, data from the SCP experiments and in situ tests, construction records, and performance confirmation records. This section should include discussions on compliance with 10 CFR 60.51(a)(2)(ii).

7.10 SITE MARKERS

This section should provide discussions on the design and construction of site markers or monuments for the period following permanent closure. Discussions should also include identification of the controlled area and the GROA and the locations for placing the monuments. Compliance with 10 CFR 21(c)(8) and 60.51(a)(2)(i) requirements should also be discussed in this section.

8. PERFORMANCE CONFIRMATION PROGRAM

In this chapter, to the extent practicable, DOE should describe its performance confirmation program, which was started during site characterization and will continue until permanent closure. This program should provide data that indicate whether actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review. Through the performance confirmation program, DOE should demonstrate that the natural and engineered systems and components required for repository operation, or those which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated. To accomplish these objectives, the performance confirmation program should include in situ monitoring, laboratory and field tests, and in situ experiments.

The performance confirmation program must not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives. It should provide baseline information and analysis of the information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities. The program is to provide for monitoring and analysis of changes from the baseline condition of parameters that could affect the performance of a geologic repository. It should include an established plan for feedback, analysis of data, and implementation of appropriate action (see Section 8.5).

For each of the systems discussed below, DOE should identify any additional performance confirmation activities that need to be carried out as a result of the sensitivity analyses and code and model validation in Chapter 6. As applicable, these results should be used as part of the performance confirmation for each of the systems.

8.1 PERFORMANCE CONFIRMATION FOR THE NATURAL SYSTEMS OF THE GEOLOGIC SETTING

This section should describe the performance confirmation program for the natural systems of the geologic setting that began during site characterization and that will be continued through construction and operation until permanent closure.

For each natural system of the geologic setting, demonstrate that the performance confirmation program will (1) not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives, (2) monitor and analyze changes from the baseline condition of parameters that could affect the performance of the geologic repository by evaluating measurements and observations against design assumptions and design bases, and (3) confirm design assumptions and parameters.

8.1.1 Geologic System

This section should describe the performance confirmation program related to the geologic system and should include sufficient background information to allow an evaluation of the adequacy of the program.

In particular, this section should summarize information on the assumed limits of subsurface conditions, geotechnical and design parameters, and original design bases and assumptions that are relevant to the geologic system and that have been presented in detail elsewhere in the SAR. Those parameters and natural processes pertaining to the geologic system of the geologic setting that may be changed by site characterization, construction, and operational activities should be identified. In addition, parameters that could affect the performance of a geologic repository should be highlighted.

This section also should include details of any in situ monitoring, geologic mapping, laboratory and field testing, and in situ experiments planned to confirm design assumptions and parameters and to monitor and evaluate changes from the baseline condition of parameters that could affect the performance of the geologic repository. In general, subsurface geologic conditions should be mapped, monitored, and evaluated against design assumptions. Geologic mapping, observations, and measurements should be done as appropriate to record rock deformations and displacements as well as changes in rock stress and strain.

Detailed information on the baseline condition of parameters and natural processes pertaining to the geologic system, including results of site characterization, analytical techniques, experimental data, and any other supporting data, should be described in Section 3.1.1 (Geologic System).

8.1.2 Hydrologic System

This section should describe the performance confirmation program related to the hydrologic system and should include sufficient background information to allow an evaluation of the adequacy of the program.

In particular, this section should summarize information on the assumed limits of subsurface conditions, geotechnical and design parameters, and original design bases and assumptions that are relevant to the hydrologic system and that have been presented in detail elsewhere in the SAR. Those parameters and natural processes pertaining to the hydrologic system of the geologic setting that may be changed by site characterization, construction, and operational activities should be identified. In addition, parameters that could affect the performance of the geologic repository should be highlighted.

This section also should include details of any in situ monitoring, laboratory and field testing, and in situ experiments planned to confirm design assumptions and parameters and to monitor and evaluate changes from the baseline condition of parameters that could affect the performance of the geologic repository. In general, the rate and location of water inflow into subsurface areas, changes in ground-water conditions, and changes in rock pore water pressures, including those along fractures and joints, should be monitored and evaluated against design assumptions.

Detailed information on the baseline condition of parameters and natural processes pertaining to the hydrologic system, including results of site characterization, analytical techniques, experimental data, and any other supporting data, should be described in Section 3.1.2 (Hydrologic System).

8.1.3 Geochemical System

This section should describe the performance confirmation program related to the geochemical system and should include sufficient background information to allow an evaluation of the adequacy of the program.

In particular, this section should summarize information on the assumed limits of subsurface conditions, geotechnical and design parameters, and original design bases and assumptions that are relevant to the geochemical system and that have been presented in detail elsewhere in the SAR. Those parameters and natural processes pertaining to the geochemical system of the geologic setting that may be changed by site characterization, construction, and operational activities should be identified. In addition, parameters that could affect the performance of the geologic repository should be highlighted.

This section should also include details of any in situ monitoring, laboratory and field testing, and in situ experiments planned to confirm design assumptions and parameters and to monitor and evaluate changes from the baseline condition of parameters that could affect the performance of the geologic repository. In general, subsurface geochemical conditions should be monitored and evaluated against design assumptions.

Detailed information on the baseline condition of parameters and natural processes pertaining to the geochemical system, including results of site characterization, analytical techniques, experimental data, and any other supporting data should be described in Section 3.1.3 (Geochemical System).

8.1.4 Climatological and Meteorological Systems

This section should describe the performance confirmation program related to the climatological and meteorological systems and should include sufficient background information to allow an evaluation of the adequacy of the program.

In particular, this section should summarize information on climatological, meteorological, and design parameters, as well as original design bases and assumptions that are relevant to the climatological and meteorological systems and that have been presented elsewhere in the SAR. Parameters that could affect the performance of the geologic repository should be highlighted.

This section also should include details of any monitoring, testing, or experiments planned to confirm design assumptions and parameters and to monitor and evaluate changes from the baseline condition of parameters that could affect the performance of the geologic repository.

Detailed information on the baseline condition of parameters and natural processes pertaining to the climatological and meteorological systems, including results of site characterization, analytic techniques, experimental data, and any other supporting data, should be described in Section 3.1.4 (Climatological and Meteorological Systems).

8.2 PERFORMANCE CONFIRMATION FOR THE STRUCTURES, SYSTEMS, AND COMPONENTS OF THE GROA

This section should describe the performance confirmation program to be conducted on the GROA post-closure natural and engineered systems and components. The program should be planned and implemented to satisfy the requirements of 10 CFR 60.140, 141, and 142 for the structures, systems, and components of the GROA that have been classified as important to isolation.

8.2.1 Surface Facilities

A specific performance confirmation program for surface facilities is not necessary. However, DOE should describe how the performance confirmation programs for other parts of the program could affect design of the surface facilities.

8.2.2 Shafts and Ramps

Provide a description of all performance confirmation testing that will be conducted for the shafts and ramps. The description should include all phases of planning and implementing the performance confirmation program for the shafts and ramps, which will span the period from site characterization to just prior to permanent closure. These phases should include (1) collection of baseline data for the penetrated strata and the shaft and ramp engineered components, (2) initial performance assessments for the shaft/ramp, (3) revising performance confirmation plans based on data collected during construction and subsequent operations, (4) full-scale testing to evaluate the effectiveness of seals, grouts, plugs, and backfill and to evaluate the effectiveness of drainage, and (5) performance assessments supporting permanent closure. Discussions should also include (1) development of computer codes that will be used for performance confirmation, especially to assess interaction effects of the thermal load on the liners, seals, and backfill, (2) the facilities where the performance confirmation testing will be conducted, (3) the component in which the testing is conducted and parameters measured, (4) duration of the tests, and (5) whether testing is conducted using nuclear materials.

8.2.3 Underground Facility

Provide a description of all performance confirmation testing that will be conducted for the underground facility. The description should include the phases of planning and implementing the performance confirmation program for the underground facility, which will span the period from site characterization to just prior to permanent closure. These phases should include (1) collection of baseline data for the host rock and the engineered components, (2) initial performance assessments for the underground facility, (3) revising performance confirmation plans based on data collected during construction and subsequent operations, (4) continued performance confirmation to assess thermal and thermomechanical response of the natural and engineered components to construction and emplacement of waste, (5) full-scale testing to evaluate the effectiveness of emplacement area seals, grouts, plugs, and backfill, and (6) performance assessments supporting permanent closure. Discussions should also include (1) development of computer codes that will be used for performance confirmation, especially to assess interaction effects of the thermal load on the liners, seals, and backfill, (2) the facilities where the performance confirmation testing will be conducted, (3) the component in which the testing is conducted and parameters measured, (4) duration and sequencing of the tests, (5) validation of codes and models, and (6) whether testing is conducted using nuclear materials.

8.3 PERFORMANCE CONFIRMATION FOR THE ENGINEERED BARRIER SYSTEM

Confirmation of performance for the EBS is required in general for anticipated processes and events. However, the applicant must also identify those unanticipated processes and events that may lead to EBS failures and that could cause the repository to fail to meet its overall performance requirements. A performance confirmation program cannot by itself demonstrate actual EBS performance because only relatively short-term data will be available to project long-term performance. However, through such a program, confidence in the EBS design can be increased.

8.3.1 Waste Package Monitoring

This section should discuss the program established at the GROA for monitoring the condition of the waste packages.

8.3.1.1 Waste Form

A specific performance confirmation program for the waste form is not necessary. However, DOE should describe how the performance confirmation programs for other parts of the program could affect design of the waste form.

8.3.1.2 In Situ Waste Package Monitoring

Describe the monitoring tests to be performed in situ to observe the performance of the waste packages in their actual repository environment and demonstrate that they conform to design and regulatory requirements. The monitoring tests must address any change in the environment caused by emplacement of the waste packages. The characteristics monitored must be adequate to fully describe the components of the waste package for confirming how well the components perform up to the time of repository closure and for validating the methods of extrapolation proposed by DOE to evaluate post-closure performance. For these reasons, the packages selected must be representative of the total waste package population.

The parameters that should be monitored in situ and their objectives include the following:

(1) Radiation: To monitor the intensity of the gamma radiation field surrounding the waste packages, to detect the escape of any radioactive materials (alpha, beta, and gamma), and to confirm that the radiation and its effects on the environs are within design specifications.

(2) Temperature: To monitor the intensity of the thermal field surrounding the waste packages and to confirm that the thermal field and its effects on the environs are within design specifications.

(3) Repository water: To monitor the flow rate of repository water to and from the waste packages, to determine the chemistry of the water under high thermal and high radiation conditions, and to confirm that the water and its effects on the waste package and its immediate environs are within design specifications.

(4) Mechanical properties: To monitor the internal and external pressures exerted on the waste packages and their components, to monitor the effects of these pressures on waste package integrity, and to confirm that the pressures and their effects on the waste packages and their environs are within design specifications.

8.3.1.3 External Waste Package Monitoring Environment

This section should describe the methods for monitoring the external environment of the waste packages. The monitoring data must accurately reflect performance under normal repository conditions, and the duplication of these conditions must not endanger the integrity of the repository or personnel engaged in that testing.

8.3.1.4 Laboratory Waste Package Monitoring

This section should provide a summary of the waste package monitoring program intended to satisfy 10 CFR 60.143(c), which states: "The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the underground facility during the waste package monitoring program shall be duplicated in the laboratory experiments." The intent of such laboratory experiments is to make it possible to examine and monitor conditions within the waste package, using appropriate experimental methods and instrumentation, which generally could not be accomplished within the repository. The "laboratory" may include a hot cell facility within a subsurface facility in candidate host rock. The environmental conditions to be monitored should include temperature, pressure, and representative ground water. Conditions within the waste package that should be monitored include temperature, pressure, and gas generation within both the waste container and the packing or backfill material.

8.3.1.5 Duration of Post-Emplacement Waste Package Monitoring

Monitoring of the emplaced waste packages should begin immediately after emplacement is initiated and should extend to the end of the retrieval period (i.e., permanent closure, see 10 CFR 60.143(d)).

8.3.1.6 Demonstration of Compliance

This section should discuss DOE's program for demonstration of compliance with waste package monitoring requirements. The objective of the demonstration is to show that prior to waste package emplacement, existing geologic, hydrologic, and environmental conditions within the repository will have been characterized. The waste package and its components will have been evaluated and the expected conditions near and around the emplaced waste package will have been estimated. Bounding conditions for waste package/repository behavior will have been set as guidelines for acceptable system behavior. Postemplacement monitoring will help to ensure that repository operating conditions (those to be expected) do not exceed repository design conditions (the range of conditions which will guarantee acceptable behavior). Parameters that exceed these predetermined conditions during the monitoring period may indicate the existence of a potential problem that could ultimately lead to the development of hazard conditions.

DOE's discussions should include environmental parameters to be monitored, waste package condition, types of monitors used, location of monitors, monitor polling frequency, water samples, accuracy of measurement, quality control, calibration, and reliability of maintenance and monitoring systems.

8.3.2 Engineered Barrier and Waste Package Performance Objectives

8.3.2.1 Failure Mode and Effects Analysis

Discuss the screening of repository scenarios and anticipated and unanticipated processes and events leading to EBS component failures. The EBSs are required to be designed not to fail under anticipated processes and events with a sufficient margin of safety. The confirmation program will serve to validate such designs. In addition, for those unanticipated processes and events that may cause EBS failures, the consequences and effects of such failures must be analyzed. The effects from unanticipated EBS failures must not by themselves or with the occurrence of other events constitute sufficient cause for failure of the repository as a whole to meet its performance requirements.

8.3.2.2 Environmental Conditions for Confirmatory Tests and Analyses

Document test conditions and repository environmental conditions for which the EBS are analyzed for performance confirmation. Relate the conditions to repository scenarios. If the conditions are not the same as those found in the scenarios, provide justification and rationales for using them.

8.3.2.3 Confirmatory Tests and Analysis

Describe the overall confirmatory methodology. Document tests and analyses, including any computer codes and methods of extrapolation used. The tests may be any combination of laboratory tests, field tests, and in situ tests, and the analyses may be an interpretation of test results or analogies.

In situ tests and other on-site tests must not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

8.3.2.4 EBS Performance Allocation

This section should discuss design performance allocated to the different components of the EBS and how the allocation contributes to satisfaction of the overall EBS performance requirements. An objective of the performance confirmation program is to validate that the EBS can function as intended.

8.3.2.5 Results of EBS Performance Confirmation

Present and discuss results of confirmatory tests and analyses.

8.4 RADIATION PROTECTION

Describe the plans (include a description of the fixed and portable facilities, equipment, and instrumentation) to monitor and control internal and external radiological exposure to workers and to members of the public that might result from tests and experiments conducted during the performance confirmation period. Provide the analyses required to show how these plans comply with 10 CFR Part 20 and such generally applicable environmental standards for radioactivity as may have been established by the EPA. The description should follow the format given in Section 4.1.4 for the GROA. The description should also include a discussion of the health physics program on those aspects that are unique to the performance confirmation program, referencing Section 7.2 as necessary. The assessment should follow the formats given in Section 4.2 for restricted areas and in Section 4.5.1 for unrestricted areas.

8.5 ANALYSIS OF CHANGES FROM PERFORMANCE CONFIRMATION BASELINE

Describe the plan for monitoring and analyzing changes from the baseline condition of parameters that could affect the performance of a geologic repository. Specifically discuss the process for feedback, analysis of data, and implementation of appropriate action.

8.6 UNRESOLVED SAFETY QUESTIONS

Taking into account the assessments done in the previous sections of this chapter, identify all unresolved safety questions and provide a schedule indicating when they will be resolved.

9. LAND OWNERSHIP AND CONTROL

This chapter should describe the interests in real property that have been, or will be, obtained by the applicant to demonstrate compliance with the regulatory requirements of 10 CFR Part 60.

9.1 PLANS FOR RESTRICTING CONTROLLED AREA ACCESS

9.1.1 Identification of Controlled Area

This section should provide a legal description of the lands proposed to be designated the "controlled area" as defined in 10 CFR Part 60. The description should be by metes and bounds and should be supplemented by maps that display relevant features within the controlled area and outside the controlled area. The section should display the limits of the underground facility and state the maximum horizontal distance between the underground facility and the boundary of the controlled area. The area of the controlled area should be stated both in terms of acres and square kilometers.

9.1.2 Identification of Existing Legal Interests

This section should provide a complete legal description of all existing present or future interests of record in any of the lands within the controlled area. The information should be provided for both surface and subsurface estates. The section should identify specifically any acquired lands within the controlled area that are under the jurisdiction and control of DOE and any lands within the controlled area that have been permanently withdrawn and reserved for its use. Among the interests that must be described are encumbrances such as (1) rights arising under the general mining laws, (2) easements for right-of-way, and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise. Copies of the relevant records themselves need not be included, so long as information precisely identifying such records and their location is provided.

9.1.3 Identification of Legal Interests To Be Obtained

This section should identify all legal interests within the controlled area that DOE has not obtained, but which it proposes to have obtained before it receives and possesses any source, special nuclear, or byproduct material at the GROA. There should be a discussion of the legal authority, including statutes and judicial decisions as appropriate, relied upon by DOE. If there are any encumbrances that DOE proposes not to acquire, the section should clearly identify them and should demonstrate that they are not significant with respect to achievement of the purposes of 10 CFR Part 60.

9.1.4 Water Rights

This section must evaluate quantitatively and qualitatively any waters needed to accomplish the purpose of the GROA. It must also refer to those legal interests specified in Sections 9.1.2 and 9.1.3 that will provide DOE with rights to such waters.

9.2 PLANS FOR REGULATING LAND USE OUTSIDE THE CONTROLLED AREA

9.2.1 Identification of Adjacent Areas of Concern

This section should detail the bounds of the area (outside the controlled area) within which DOE must exercise jurisdiction and control of surface and subsurface estates so as to prevent adverse human actions that could significantly reduce the geologic repository's capability for isolation. The section should describe the human actions that are considered to have the potential to affect the geologic repository. Maps should be included as necessary to show relevant features.

9.2.2 Identification of Existing Legal Interests

This section should provide a complete legal description of all existing present or future interests of record held by DOE in any of the lands identified in Section 9.2.1. There should also be an evaluation of the extent to which, in the absence of unanticipated processes and events, DOE's jurisdiction and control of such interests would serve to prevent adverse human actions that could significantly reduce the geologic repository's capability for isolation. The geographical extent of the interests so identified should be indicated on maps. Copies of the relevant records themselves need not be included, so long as information precisely identifying such records and their location is provided. Water rights are among the interests to be addressed in this section.

9.2.3 Identification of Legal Interests To Be Obtained

This section should identify all legal interests outside the controlled area that DOE has not obtained, but which it proposes to have obtained before it receives and possesses any source, special nuclear, or byproduct material at the GROA. All such legal interests should be described in sufficient detail to demonstrate that DOE's jurisdiction and control would, in the absence of unanticipated processes and events, prevent adverse human actions that could significantly reduce the geologic repository's capability for isolation. The geographical extent of such interests should be indicated on maps. There should be a discussion of the legal authority, including statutes and judicial decisions as appropriate, relied upon by DOE. Water rights are among the interests to be addressed in this section.

9.3 PLANS FOR REGULATING LAND USE AT THE GROA

This section should describe the interests in land that DOE has obtained or will obtain with respect to any "restricted area" as defined in 10 CFR Part 60. The description should be provided in sufficient detail to demonstrate that DOE can control access as necessary to protect individuals from exposure to radiation and radioactive materials. In addition, DOE should identify those lands constituting the geologic repository and areas adjacent thereto, to which it has rights of access and that are accordingly available to the Commission to carry out its inspection activities. Cross-references to other parts of this chapter may be used so long as they are specific and clear.

10. QUALITY ASSURANCE

This chapter should describe the quality assurance (QA) programs to be established and executed for various activities associated with the geologic repository to meet the requirements of Subpart G to 10 CFR Part 60.

The structures, systems, and components important to safety for which the QA programs apply should be identified, and the analyses used for this identification should be described or referenced from Section 4.2 of the SAR. The barriers important to waste isolation falling under the QA programs should be identified, and the evaluations used to identify these barriers should be described or referenced. The above items and descriptions should be incorporated into the 10 CFR Part 60, Subpart G, QA programs for site characterization, design and construction, and operations.

The quality activities list, or Q-List, which lists major site characterization, design and construction, operation, and performance confirmation activities under the respective QA program, should be provided. The list developed for the GROA in Chapter 4 may be referenced with any additional information provided here.

This chapter should also describe the QA program to assure compliance with those aspects of 10 CFR 60.131(a) that apply to items (e.g., protection of worker health and safety) other than those important to safety or waste isolation as defined in 10 CFR Part 60.

Assessment of activities during site characterization and their compliance with QA program requirements should also be described.

10.1 DESCRIPTION OF THE QUALITY ASSURANCE (QA) PROGRAMS

10.1.1 QA Program for Site Characterization

This section should describe the QA program that has been applied to activities affecting quality during site characterization of the geologic repository. The description of the QA program should, at a minimum, address each of the applicable criteria of Appendix B to 10 CFR Part 50 in sufficient detail to satisfy the criteria contained in the USNRC "Review Plan for

High-Level Waste Repository Quality Assurance Program Descriptions," Revision 2, dated March 1989.*

A general listing by activity of existing data that has not been gathered under a 10 CFR Part 60, Subpart G, QA program and requires qualification for use in licensing should also be provided in this section.

10.1.2 QA Program for Design and Construction

This section should describe the QA program that will be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation during the design and construction of the geologic repository. Particular areas (e.g., IV-Procurement Document Control) in the QA program for site characterization may be referenced in the QA program for design and construction when specific requirements in these areas are identical to both QA programs. For those activities applicable only to the design and construction phase, a level of detail similar to the description contained in Section 10.1.1 should be used to enable the NRC staff to determine whether and how all the applicable requirements of Appendix B to 10 CFR Part 50 will be satisfied.

10.1.3 QA Program for Performance Confirmation

This section should describe a QA program that will be established and implemented for quality affecting activities associated with the performance confirmation program of the geologic repository.

Particular areas (e.g., XI-Test Control) in the QA programs for site characterization or design and construction may be referenced in the QA program for performance confirmation when specific requirements in these areas are identical in the respective QA programs. For those activities applicable only to the performance confirmation program, a level of detail similar to the description contained in Section 10.1.1 should be used to enable the NRC staff to determine whether and how all the applicable requirements of Appendix B to 10 CFR Part Part 50 will be satisfied.

*This document is available for inspection or copying for a fee from the NRC Public Document Room, 2120 L Street NW., Washington, DC, under Accession Number 8903240188.

10.1.4 QA Program for Operations, Permanent Closure, Decontamination, and Decommissioning

This section should describe a QA program that will be established and implemented for quality affecting activities associated with the operations, permanent closure, decontamination, and decommissioning phases of a geologic repository.

Particular areas (e.g., X-Inspection) in the QA programs for site characterization or design and construction may be referenced in the QA program for operations, permanent closure, decontamination, and decommissioning when specific requirements in these areas are identical in the respective programs. For those activities applicable only to the operations, permanent closure, decontamination, and decommissioning phases, a level of detail similar to the description contained in Section 10.1.1 should be used to enable the NRC staff to determine whether and how all the applicable requirements of Appendix B to 10 CFR Part 50 will be satisfied.

10.2 IMPLEMENTATION OF THE QA PROGRAM FOR SITE CHARACTERIZATION

This section should describe how the completed and ongoing quality-affecting activities at the time of the license application were determined (e.g., by audits and surveillances) to comply with the QA program requirements for site characterization described in Section 10.1.1 in sufficient detail to enable the NRC staff to determine whether and how all the applicable requirements of Appendix B to 10 CFR Part 50 were satisfied.

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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The regulatory analysis prepared for amendments to 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," June 26, 1984, provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW., Washington, DC, as Enclosure E to Secy 84-263.