APPENDIX A

GLOSSARY

APPENDIX A

GLOSSARY

Abstraction (of a model)–means a simplification of a mathematically complex numerical model of a physical or chemical process for use in TSPAs. These simplifications generally result in response functions or surfaces representing the relationships between input and output parameters in place of complex partial differential equations. Response functions and surfaces mean algebraic functions relating the output variables to the input variables of a mathematical model. They are derived from results of multiple runs of the detailed process-level computer codes for a range of values of the input variables. They are usually represented by multi-dimensional tables, which require interpolation to calculate the value of the output variables for specific values of the input variables.

Accessible environment–means the atmosphere, the land surface, surface water, oceans, and the portion of the lithosphere that is outside the postclosure controlled area.

Backfill–means (1) the general fill that is placed in the excavated areas of the underground facility, in particular within emplacement drifts; or (2) the material or process used to refill an excavation. Backfill materials may be either excavated tuff or other earthen materials.

Barrier–means any material or structure that prevents or substantially delays the movement of water or radionuclides.

Blending (of waste)–refers to the systematic, deliberate selection of spent nuclear fuel assemblies to be placed within a particular waste package (as compared with a random or "as-received" order of filling) to reduce the heat output or the reactivity of the waste package.

Borehole–means a hole drilled from the surface or from within an underground excavation (1) to collect information about the geology or hydrology of the sampled rock or soil, and/or (2) to install instrumentation into the rock or soil. A borehole is sometimes also referred to as a boring, drill hole, core hole or well bore.

Capillary barrier–is an optional component of the engineered barrier system used in conjunction with backfilling of the emplacement drifts. The barrier is composed of two (or more) earthen material layers, placed over the waste package. By design, the upper layer has a substantially greater hydraulic conductivity than the lower layer when the two layers are at the same moisture potential. For low seepage fluxes, the difference in conductivity diverts flows in the upper layer along the sloped interface between the two layers and away from the underlying waste package.

Cladding–means the metallic outer sheath of a fuel element generally made of stainless steel or a zirconium alloy. It is intended to isolate the fuel element from the external environment.

Colloid–means a large molecule or small particle that has at least one dimension within the size range of 10^{-9} to 10^{-6} m, and is suspended in a liquid such as groundwater. Some radionuclides can bind with colloids (either reversibly or irreversibly) depending on the type of colloid) and travel great distances in groundwater. Colloids may form directly from insoluble radioactive

material (intrinsic colloids), may result from degraded spent nuclear fuel or glass waste forms (waste form colloids), or may result from other natural or man-made materials with which radionuclides can bind (pseudocolloids).

Constraint–means a limitation or implied requirement that constrains the design solution or implementation of the systems engineering process, is not changeable by the performing activity, and is generally nonallocable.

Containment–means the confinement of radioactive waste within a designated boundary.

Controlled area–means a surface location, to be marked by suitable monuments, which area has been committed to use as a geologic repository and from which incompatible activities would be prohibited before and after permanent closure. (Also understood as synonymous with postclosure controlled area.)

Design Basis Event–is a an event or occurrence identified for repository design, and includes:

1. Those natural and human-induced events that are reasonably likely to occur regularly, moderately frequently, or one or more times before permanent closure of the GROA.

2. Other natural and man-induced events that are considered unlikely, but sufficiently credible to warrant consideration, taking into account the potential for significant radiological impacts on public health and safety.

Disturbed zone–means that portion of the postclosure controlled area, the physical or chemical properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive wastes, such that the resultant change of properties may have a significant effect on the performance of the geologic repository.

Downgradient–means the direction that water will tend to flow as the result of a difference in pressure, as indicated by the elevation change in the potentiometric surface. Based on current understanding of the hydraulic gradient below Yucca Mountain, downgradient is toward the south to southeast of the potential repository location.

Drift–means (in mining terminology) a horizontal underground passage. The term is defined herein to mean the near-horizontal underground passageways from the shaft(s) to the other excavations such as alcoves and rooms. The term includes excavations for emplacement (emplacement drifts) and access (access mains).

Drip shield–is a component of the engineered barrier system. The drip shield is above the waste package and designed to prevent seepage from dripping directly onto the surface of the waste package.

Dummy waste package–means a waste package with the same dimensions, configuration, and materials as a real waste package, but containing heating elements instead of real waste to simulate the heat output of actual waste packages.

Emplacement–means the placement and positioning of canisters of SNF or high-level radioactive fuel (i.e., waste packages) in prepared locations within excavations of a geologic repository.

Emplacement drift–is a drift in which canisters of SNF or high-level radioactive fuel (i.e., waste packages) have been placed.

Engineered barrier system–means the waste packages and the underground facility. The term includes the designed (or engineered) components of the disposal system, including the drip shield and backfill (if employed).

Fault (Geologic)–means a fracture in rock along which the movement of one side relative to the other side has occurred.

Geologic repository–means a system, requiring licensing by the NRC, that is intended to be used, or may be used, for the permanent disposal of radioactive waste (including SNF) in excavated geologic media. A geologic repository includes (1) the GROA and (2) the portion of the geologic setting that provides isolation of the radioactive waste and is located within the controlled area.

Geologic repository operations area (GROA)–means a high-level radioactive waste facility that is part of a geologic repository, including both surface and sub-surface areas, where waste handling activities are conducted.

Geologic setting–means the geologic, hydrologic, and geochemical systems of the region in which a geologic repository is or may be located.

Hydraulic conductivity–means in general terms, the capacity of a medium like rock, sediment, or soil to transmit liquid or gas. Hydraulic conductivity depends on the substance transmitted (oil, air, water, etc.) and on the size and shape of the pores, joints, and fractures in the medium and the manner in which they are interconnected.

In situ–means "in its natural position or place." The phrase distinguishes between tests or experiments conducted in the field (e.g., in an underground excavation, in-place) from tests and experiments conducted in a laboratory.

Key performance confirmation factor–means a factor or process, which is to be considered in the MGR design under performance confirmation.

License Application (LA)–means an application by the DOE for a license from the NRC to construct a repository.

Natural barrier–means the physical, mechanical, chemical, and hydrologic characteristics of the geologic environment that individually and collectively act to minimize or preclude radionuclide transport.

Natural barrier system–means the geologic setting suitable for repository construction and waste emplacement. It includes natural barriers that provide containment and isolation to

minimize or preclude radionuclide transport and provide conditions that will minimize the potential for human interference in the future.

Near-field–means the region where the natural geohydrologic system has been significantly perturbed by the excavation of the repository and the emplacement of the waste.

Observation drift–means a drift near an emplacement drift, from which conditions in the emplacement drifts can be observed without adverse effects from radiation or temperature.

Off-normal events or conditions–are abnormal or unplanned events or conditions that adversely affect, potentially affect, or are indicative of degradation in, the safety, security, environmental or health protection performance or operation of a facility. Included in this definition are design basis events.

Off site–means a location outside of the site.

On site–means a location within the site.

Performance assessment–(in general discussion) means any analysis that predicts the behavior of a system or system component under a given set of constant and/or transient conditions. Performance assessments will include estimates of the effects of uncertainties in data and modeling. In strict regulatory terms, performance assessment is defined as a probabilistic analysis that: (1) Identifies the features, events and processes that might affect the performance of the geologic repository; and (2) Examines the effects of such features, events and processes on the performance of the geologic repository; and (3) Estimates the expected annual dose to the average member of the critical group as a result of releases from the geologic repository.

Performance confirmation–means the program of tests, experiments, and analyses conducted to evaluate the accuracy and adequacy of the information used to determine, with reasonable assurance, that the performance objectives for the period after permanent closure will be met.

Performance measure–means a physical quantity that describes the performance of a system, system element, structure, component, or process in meeting licensing strategy for an issue.

Performance requirement–means the measurable criterion that identifies a quality attribute of a function or how well a functional requirement must be accomplished.

Permanent closure–is the completion of the closure operations of the geologic repository. Closure operations will include closing and sealing the subsurface facilities, placement of drip shields and backfilling of the underground facility (if backfill is employed), sealing of shafts and boreholes, decontaminating, decommissioning, removing the surface facilities, constructing monuments, creating institutional barriers, and returning the site to natural conditions as required by the NRC.

Permeability–(see hydraulic conductivity).

Postclosure controlled area–means a surface area marked by suitable monuments, that encompasses no more than 300 square kilometers and has been committed to use as a geologic

repository and from which incompatible activities would be restricted following permanent closure. It shall not extend farther south than 36° 40' 13.6661" North latitude, in the predominant direction of groundwater flow and shall extend no more than five kilometers from the repository footprint in any other direction. It also includes the subsurface underlying the surface area.

Preclosure controlled area–means that surface area surrounding the GROA for which the licensee exercises authority over its use, until permanent closure has been completed.

Process Model–is a depiction, representation, or computer model of a process along with any hypotheses required to describe or to explain the process.

Project–is synonymous with Yucca Mountain Project.

Program–is synonymous with performance confirmation program.

Q-List–is a Yucca Mountain Site Characterization Project (YMP) controlled document that lists engineered structures, systems, and components, and natural barriers within the Monitored Geologic Repository, that the DOE has identified for application of the Office of Civilian Radioactive Waste Management QA program.

Radiologically Controlled Area–is an area of the surface repository which includes the facilities and transportation systems required to receive and ship rail and truck waste shipments, prepare shipping casks for handling, and load waste forms into disposal containers for underground emplacement. It also includes the facility and systems required to treat and package site-generated, low-level radioactive waste for offsite disposal. The entire area is to be enclosed by security fences, control gates, lighting, and access detection systems.

Repository–is synonymous with geologic repository.

Requirement–means a statement identifying a capability, physical characteristic, or quality factor that bounds a product or process need for which a solution will be pursued.

Seepage–is the inflow of the groundwater moving in fractures and the pore spaces of rock into an underground opening, such as an emplacement drift. Technically, seepage is defined as the amount of percolation flux that enters a drift in a given time period. (The percolation flux is the rate of groundwater moving through the rock mass.)

Saturated zone (SZ)–means that part of the earth's crust beneath the regional water table in which all voids, large and small, are filled with water under pressure greater than atmospheric.

Seismic–means pertaining to, characteristic of, or produced by earthquakes or earth vibrations.

Seismic event–is an earthquake or a somewhat similar transient earth motion caused by an explosion.

Site–means the location of the preclosure controlled area, or of the postclosure controlled area, or both. The term is also used as a synonym for natural barrier system, as in, "Site Monitoring and Testing."

Site Characterization–means activities, whether in the laboratory or in the field, undertaken to establish the geologic conditions and the ranges of the parameters of a candidate site relevant to the location of a repository, including borings, surface excavations, excavations of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing needed to evaluate the suitability of a candidate site for the location of a repository, but not including preliminary borings and geophysical testing needed to assess whether site characterization should be undertaken.

Total system performance assessment (TSPA)–is a risk assessment that quantitatively estimates how the proposed Yucca Mountain repository system will perform in the future under the influence of specific features, events, and processes, incorporating uncertainty in the models and data. Its purposes are: (1) provide the basis for predicting system behavior and testing that behavior against safety measures in the form of regulatory standards, (2) provide the results of TSPA analyses and sensitivity studies, (3) provide guidance to site characterization and repository design activities, and (4) help prioritize testing and selection of the most effective design options.

Tuff–means igneous rock formed from compacted volcanic fragments from pyroclastic (explosively ejected) flows with particles generally smaller than 4 mm in diameter. The most abundant type of rock at the Yucca Mountain site.

Underground facility–means the underground structure, backfill materials (if any), and openings that penetrate the underground structure (e.g., ramps, shafts, and boreholes, including their seals).

Unsaturated zone (UZ)–means the zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the fluid pressure locally may be greater than atmospheric. The UZ is also termed the vadose zone.

Variances–are defined in this context to describe the occurrence when performance confirmation data values exceed specified tolerances described in the performance confirmation baseline for these data.

Waste form–is a generic term that refers to radioactive materials and any encapsulating or stabilizing matrix. There are five general categories of waste forms that will be emplaced in the proposed repository: (1) spent fuel from commercial nuclear reactors, (2) high-level radioactive waste, (3) SNF from DOE programs, (4) SNF from the U.S. Naval Nuclear Propulsion program, and (5) immobilized plutonium.

Waste package–means the waste form and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

Zircaloy–is a trade name for zirconium alloys containing low percentages of chromium, nickel, iron and tin, and developed specifically for nuclear applications. Two common forms of the alloy are Zircaloy-2 (UNS R60802) and Zircaloy-4 (UNS R60804).

APPENDIX B

U.S. DEPARTMENT OF ENERGY REVISED INTERIM GUIDANCE SUBPART F

APPENDIX B

U.S. DEPARTMENT OF ENERGY REVISED INTERIM GUIDANCE SUBPART F

Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)

Subpart F

Reference:

Subpart F text from:

Dyer, J.R. 1999. "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." Letter from Dr. J.R. Dyer (DOE/Yucca Mountain Site Characterization Office [YMSCO]) to Dr. D.R. Wilkins (CRWMS M&O), September 3, 1999, OL&RC:SB-1714, with enclosure, "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)." ACC: MOL.19990910.0079.

Subpart F -- Performance Confirmation Program

Section 131 General requirements.

(a) The performance confirmation program shall provide data important to parameters and conceptual models used in the performance assessment prepared pursuant to Section 114 that indicate, where practicable, whether:

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Geologic and engineered systems and components required for repository operation, and that are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program shall include in-situ monitoring, laboratory and field testing, and in-situ experiments, as may be appropriate to provide the data required by paragraph (a) of this section.

(d) The program shall be implemented so that:

(1) It does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

Section 132 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters used in the performance assessment are confirmed and to ensure that appropriate action is taken to inform the NRC of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) DOE shall determine the parameters, measurements, and observations appropriate for inclusion in the program based on their importance to confirming repository performance and shall describe monitoring plans in the license application.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences, their significance to repository performance, and the recommended changes reported to the NRC.

(e) In-situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure, to ensure that the performance of the geologic and engineering features is within design limits.

Section 133 Design testing.

(a) During the early or developmental stages of construction, a program for testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as practicable.

(c) If backfilling the emplacement drifts is planned, a backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole, shaft, and ramp seals before full-scale operation proceeds to seal boreholes, shafts, and ramps.

Section 134 Monitoring and testing waste packages.

(a) A program shall be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste packages chosen for the program shall be representative of those to be emplaced in the underground facility.

(b) Consistent with safe operation at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program shall be representative of the environment in which the wastes are to be emplaced.

(c) The waste package monitoring program shall include laboratory experiments that 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.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

APPENDIX C

COMPARISON OF REVISED INTERIM GUIDANCE AND 10 CFR 60

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COMPARISON OF REVISED INTERIM GUIDANCE AND 10 CFR 60

Comparison of Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01) Subpart F, "Performance Confirmation Program"[1]

to

10 CFR 60 Subpart F, "Performance Confirmation Program"[2]

Note:

The Revised Interim Guidance is shown as changed from 10 CFR 60. Deletions of 10 CFR 60 text are noted by strikeout of text; additions to 10 CFR 60 text are indicated by text in bold.

References:

1. Subpart F taken and reformatted from:

Dyer, J.R. 1999. "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." Letter from Dr. J.R. Dyer (DOE/Yucca Mountain Site Characterization Office [YMSCO]) to Dr. D.R. Wilkins (CRWMS M&O), September 3, 1999, OL&RC:SB-1714, with enclosure, "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)." ACC: MOL.19990910.0079.

2. Subpart F taken from 10 CFR 60

Subpart F -- Performance Confirmation Program

~~§ 60.140~~ **Section 131** General requirements.

(a) The performance confirmation program shall provide data ~~which indicates~~ **important to parameters and conceptual models used in the performance assessment prepared pursuant to** Section **114** that indicate, where practicable, whether:

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) ~~Natural~~ **Geologic** and engineered systems and components required for repository operation, ~~or which~~ **and that** are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program shall include in-situ monitoring, laboratory and field testing, and in-situ experiments, as may be appropriate to ~~accomplish the objectives as stated above~~ **provide the data required by paragraph (a) of this section.**

(d) The program shall be implemented so that:

(1) It does not adversely affect the ability of the geologic and engineered elements of the ~~natural~~ **geologic** repository to meet the performance objectives.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters

that could affect the performance of a geologic repository.

~~(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.~~

~~§ 60.141~~ Section 132 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters **used in the performance assessment** are confirmed and to ensure that appropriate action is taken to inform the ~~Commission~~**NRC** of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) ~~As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures, including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.~~**DOE shall determine the parameters, measurements, and observations appropriate for inclusion in the program based on their importance to confirming repository performance and shall describe monitoring plans in the license application.**

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences, their significance to repository performance, and the recommended changes reported to the ~~Commission.~~**NRC**.

(e) In-situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure, to ensure that the performance of the ~~natural~~**geologic** and engineering features ~~are~~**is** within design limits.

~~§ 60.142~~ Section 133 Design testing.

(a) During the early or developmental stages of construction, a program for testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as practicable.

(c) ~~A~~**If backfilling the emplacement drifts is planned, a** backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of ~~boreholes and shafts~~ **borehole, shaft, and ramp** seals before full-scale operation proceeds to seal ~~boreholes and shafts.~~ **boreholes, shafts, and ramps**.

~~§ 60.143~~ Section 134 Monitoring and testing waste packages.

(a) A program shall be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste packages chosen for the program shall be representative of those to be emplaced in the underground facility.

(b) Consistent with safe operation at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program shall be representative of the environment in which the wastes are to be emplaced.

(c) The waste package monitoring program shall include laboratory experiments ~~which~~**that** 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.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

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APPENDIX D

REPOSITORY CONCEPTUAL DESIGN, HIGHER-TEMPERATURE OPERATING MODE

APPENDIX D

REPOSITORY CONCEPTUAL DESIGN, HIGHER-TEMPERATURE OPERATING MODE

DESIGN CHARACTERISTICS

Characteristics of a conceptual repository design for a higher-temperature operating mode are presented in Table D-1 and illustrated in Figure D-1. This design is considered as the nominal scenario for the Site Recommendation (e.g., BSC 2001a) and was utilized in the development of the testing and monitoring program described in this version of the *Performance Confirmation Plan*. The design is conceptual and not for construction, and is only one mode under the flexible design concept. A discussion of performance confirmation for other, lower-temperature operating modes is presented in Appendix H.

Table D-1. Conceptual Repository Design, Higher-Temperature Operating Mode

Design Characteristics	Repository Design Value [1,2]
Areal mass loading	13.8 kgHM/m^2 (56 MTHM/acre)[3]
Repository capacity & contingency	70,000 MTHM, composed of 63,000 MTHM or equivalent of CSNF and 7,000 MTHM or equivalent DOE SNF and HLW. The MGR shall not preclude the capability of accommodating 105,000 MTHM of CSNF; 2,500 MTHM of DOE SNF; and 11,140 MTHM of DHLW.
Drift-to-drift spacing	81 m, centerline to centerline
Repository emplacement area	4.55 km^2 (1,125 acres) for 70,000 MTHM case[3]
Emplacement drift diameter/profile	5.5 m diameter, circular
Total length of emplacement drifts	63,090 m (including contingency drifts) for 70,000 MTHM case[3]
Number of emplacement drifts	58 (including contingency drifts) for 70,000 MTHM case[3]
Access drift diameter/profile	7.62 m diameter, circular
Total access drift length	19,530 m for 70,000 MTHM case[3]
Number of waste packages	11,184 for 70,000 MTHM case[3]
Waste package spacing	Minimum 10 cm between packages (termed "line loading")
Waste package materials	Exterior of package to consist of two layers: outer layer: 20-mm nickel-chromium-molybdenum alloy (UNS N06022)[4,5] inner layer: 50-mm stainless steel SS-316 NG (UNS S31603)[4]
Average PWR[6] waste package output	11.3 kW[7]
Peak waste package heat output	11.8 kW at emplacement
Aging of waste at surface	Yes
Blending of waste	Yes
Ground support	Carbon steel: steel sets with steel lagging; and/or rock bolts and mesh, as required for initial support. Rock bolts grouted-in with cementitious material.
Invert configuration	Carbon steel frame with granular ballast
Emplacement Pallet[8]	Frame is nickel-chromium-molybdenum alloy[5] with stainless steel lifting components
Drip shield	Titanium Grade 7 (UNS R52400) emplaced at closure, "U" Shape, self-supporting 15 mm minimum thickness and structural members of Titanium Grade 24 (UNS R56405)

Table D-1. Conceptual Repository Design, Higher-Temperature Operating Mode (Continued)

Design Characteristics	Repository Design Value [1,2]
Backfill	No Backfill[9]
Minimum duration of preclosure period	Closure as early as 26 years after emplacement of the last waste package.[7] Closure as early as 30 years after emplacement of the last waste package.
Maximum duration of preclosure period	A maximum of 300 years after emplacement of last waste package.
Preclosure ventilation rate	15 m^3/sec

NOTES:
1 This is a preliminary conceptual design and is not for construction.

2 Except where noted, parameter values taken from *Monitored Geologic Repository Project Description Document* (Curry 2001, pp. 1-6 to 1-12, 2-12, 2-18 to 2-21, and 5-3 to 5-4).

3 Value is from BSC (2001a, pp. 77 to 89).

4 Material designations (i.e., the UNS numbers) under "waste package materials" and "drip shield" are from *License Application Design Selection Feature Report: Waste Package Corrosion Resistant Materials (Metal and Ceramic) (Design Feature #14)* (CRWMS M&O 1999h, p. 4) and *Design Analysis for the Ex-Container Components* (CRWMS M&O 2000a, pp. 17 to 18).

5 Also identified in source references by the term, Alloy 22.

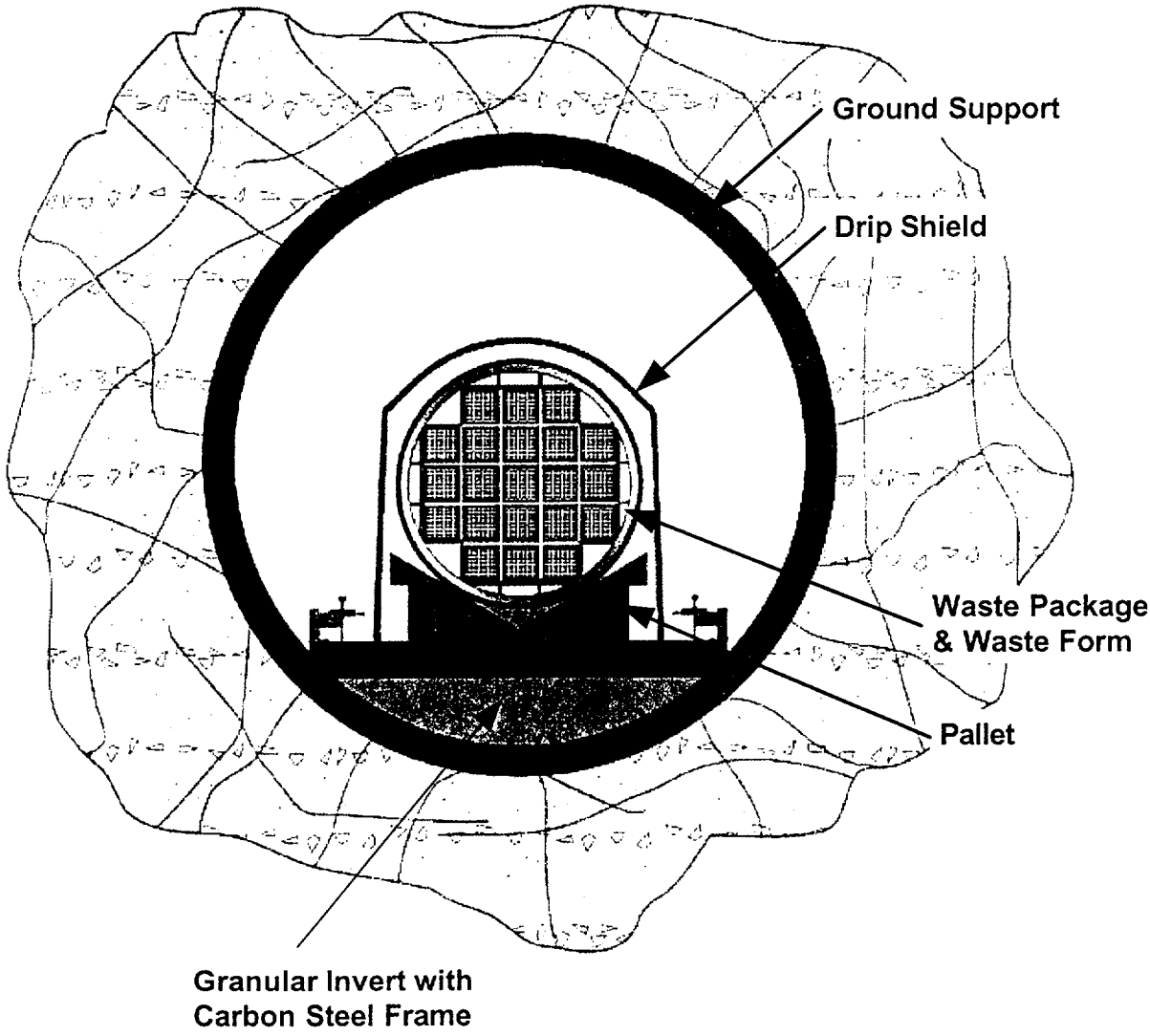
6 PWR (pressurized-water reactor).

7 Value is from Stroupe (2000).

8 Term replaces pedestal.

9 Backfill was removed from the reference design, but not precluded as a design option, as directed by Dyer (2000).

Typical Emplacement Drift



Conceptual: Not To Scale

Figure D-1. Configuration of Typical Emplacement Drift

APPENDIX E

PERFORMANCE CONFIRMATION REQUIREMENTS

APPENDIX E

PERFORMANCE CONFIRMATION REQUIREMENTS

APPLICABLE REQUIREMENTS

General

As part of the project's technical baseline, the *Civilian Radioactive Waste Management System Requirements Document* (DOE 2001) controls the YMP-RD (YMP 2001a). The YMP-RD provides a summary of requirements as they are interpreted from the high-level project documents and provides guidance for the development of various repository systems. Extracted from the YMP-RD and discussed in the following sections are those requirements that pertain to the performance confirmation program. Also provided are the other performance confirmation program-related requirements with explanation as to how they apply to the performance confirmation program. In general, the majority of requirements originate in Subpart F of the "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada" (Dyer 1999) which is hereafter referred to as "Interim Guidance."

Additional documents were also reviewed as to their impact on performance confirmation. Requirements are identified based on the final EPA rule, 40 CFR 197 (Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada), and the *Monitored Geologic Repository Project Description Document* (Curry 2001), and are described in this appendix.

Overall, the cited requirements are addressed based on the current status of the project and the repository design for the higher-temperature operating mode, as presented in Appendix D. The dynamic nature of the project may cause the current list of performance confirmation-related requirements to change, resulting in future updates or modifications. Any such changes will be incorporated into future revisions of the *Performance Confirmation Plan*.

MGR Requirements for Performance Confirmation

MGR requirements applicable to the performance confirmation program are identified in the YMP-RD and are based on several source documents. Specifically, there are 42 requirements relating to performance confirmation in Section 2.3.2.04 of the YMP-RD (YMP 2001a, pp. 2.3-19 to 2.3-55). A number of these requirements incorporate text directly from the Interim Guidance, in particular, Subpart F (see YMP-RD requirements 2.3.2.04.01 to 2.3.2.04.28, and 2.3.2.04.33). Others are based on the proposed 40 CFR 197 (64 FR 46976) (requirements 2.3.2.04.30 to 2.3.2.04.32), on system level requirements from Section 1.3.2 of the YMP-RD (requirements 2.3.2.04.34 to 2.3.2.04.40), and on prior commitments (requirements 2.3.2.04.29, 2.3.2.04.41 to 2.3.2.04.42). The system level requirements in Section 1.3.2 of the YMP-RD are based on the *Civilian Radioactive Waste Management System Requirements Document* (DOE 2001).

As shown in Table E-1, each of these requirements has been analyzed to identify the implications of the directive for performance confirmation. In addition, the approach to comply with each requirement (as documented in the *Performance Confirmation Plan)* is also described in this table.

EPA Regulations Related to Performance Confirmation (40 CFR 197)

The EPA has recently promulgated a final rule on environmental radiation protection standards applicable to the potential Yucca Mountain nuclear geologic repository. The rule is 40 CFR 197 (Protection of Environment: Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada). While this rule does not directly apply to the Yucca Mountain Project (as the NRC is the licensing body), the NRC is required to address the final version of this rule in their regulations (i.e., in 10 CFR 63) as required by law (Energy Policy Act 1992).

This final rule supplants the draft rule (64 FR 46976) that was cited in the YMP-RD requirements, and discussed in the previous section. For the present analyses, the final rule is assumed as stated, superseding the applicability of the draft rule and the related YMP-RD requirements. Table E-2 presents the relevant requirements from the final rule, together with an assessment of applicability of each requirement to the *Performance Confirmation Plan*. As such, this table will require updating upon expected revision of the YMP-RD requirements (so as to address the final rule and the final 10 CFR 63).

Project Requirements Related to Performance Confirmation

The *Monitored Geologic Repository Project Description Document* (MGR-PDD) (Curry 2001) allocates functions, requirements, criteria, and assumptions to project systems and is a flow-down document from the YMP-RD (see Curry 2001, p. 1-13). As such, it replaces and supersedes the earlier *Controlled Design Assumptions Document* (CRWMS M&O 1998c), and presents project design criteria and controlled project assumptions.

Identified in the present version of the MGR-PDD (Curry 2001) are performance criteria that, although not directly attributed to performance confirmation, represent the current design approach that affect performance confirmation activities. Specific performance requirements, which affect the performance confirmation program, are listed in Table E-3. The table presents a brief discussion of applicability of each of the items to the *Performance Confirmation Plan*.

Final 10 CFR 63 Impacts to Current Performance Confirmation Program

Concurrent with the preparation of this version of the *Performance Confirmation Plan*, the NRC has recently revised the draft rule for 10 CFR 63 and published the final rule, issued on November 2, 2001 (66 FR 55732). This version supersedes the Interim Guidance used in this plan, and this final 10 CFR 63 will become a major governing regulation for the repository in licensing. To assess the impact of this change in regulatory requirements, the final regulation has been evaluated vis-a-vie the current performance confirmation program. Each applicable section of the rule has been evaluated and requirements for performance confirmation have been identified as shown in Table E-4 under the "compliance approach" section. In addition, areas where the current program must be changed/expanded to address this final rule are identified with each requirement, also under the "compliance approach" section. These areas will be

addressed by the subsequent revision of the *Performance Confirmation Plan* in preparation for the LA.

Other Requirements

As the regulatory process proceeds, it can be expected that additional requirements will be identified that could affect the performance confirmation program. These requirements may be identified in response to directives made by DOE, or in requirements stipulated by the NRC during the license review. As such requirements are identified, they will be evaluated as to their applicability, and as appropriate, incorporated into the *Performance Confirmation Plan.*

Table E-1. Performance Confirmation Requirements Based on YMP-RD

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.01 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the scope of the performance confirmation activities as prescribed in the definition of Section 2 of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079][2]:* *"Performance confirmation means the program of tests, experiments, and analyses that is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objective at Section 113(b) will be met."* **Assessment:** This section defines performance confirmation and identifies the objectives of the program to be described in the *Performance Confirmation Plan*. **Compliance:** The scope of the performance confirmation program shall encompass this definition, as documented on page 1-1 of the *Performance Confirmation Plan.*

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.02 Design of the Performance Confirmation Testing Program	**Requirement:** *The Performance Confirmation Testing Program will be designed to comply with the provisions of Section 44(a) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[License Issuance and Amendment]] *"General Provisions: Changes, tests, and experiments: Definitions.* *(5) Tests or experiments not described in the Safety Analysis Report (as updated) means any condition where the geologic repository operations area or any of its systems, structures, and components important to safety, or barriers important to waste isolation, are utilized, controlled, or altered in a manner which either:* *(i) Is outside the controlling range of parameters of the design bases as described in the Safety Analysis Report (as updated); or* *(ii) Invalidates the analyses in the Safety Analysis Report (as updated)."* **Assessment:** This section defines the "tests-not-described" with respect to the Safety Analysis Report[3]. The term is used in Section 44(b)(1): *"(b)(1) DOE may make changes in the geologic repository operations area as described in the Safety Analysis Report (as updated), make changes in the procedures as described in the Safety Analysis Report (as updated), and conduct tests or experiments not described in the Safety Analysis Report (as updated), without obtaining either an amendment of construction authorization pursuant to Sec. 63.33 or a license amendment pursuant to Sec. 45, if a change in the conditions 'incorporated in the construction authorization or license is not required, and the change, test, or experiment does not meet any of the criteria in paragraph (b)(2) of this section."* The Safety Analysis Report is directed by the Interim Guidance[2], Sec. 21, "Content of Application", Item 19, to provide a description of the performance confirmation program. Hence, by inference, all performance confirmation tests are required to be described in the Safety Analysis Report. Further, this implies that the term, "tests-not-described," must exclude performance confirmation testing. **Compliance:** The term, "tests or experiments not described in the SAR", shall not apply to performance confirmation program. A description of all performance confirmation tests shall be included in the License Application (LA) (i.e., in the Safety Analysis Report), and conducted as described.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.03 Design of the Postclosure Monitoring Program	**Requirement:** *The Performance Confirmation Testing Program will be designed to exclude the activities prescribed in Section 51(a)(2) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* *"(a) DOE shall submit an application to amend the license before permanent closure of a geologic repository at the Yucca Mountain site. The submission shall consist of an update of the license application submitted under Secs. 21 and 22, including: ...* *(2) A description of the program for post-permanent closure monitoring of the geologic repository."* **Assessment:** This section defines the requirement for a description of a post-permanent closure-monitoring program. This program is not to include performance confirmation activities as it starts after closure and the termination of performance confirmation (see requirement 2.3.2.04.11). Hence, the post-permanent closure monitoring program is not defined under the *Performance Confirmation Plan*, but will be described in a separate plan (or other document) to be prepared in support of the submittal for the license for closure, in accordance with the regulations. **Compliance:** The scope of the performance confirmation program shall exclude post-permanent closure monitoring. This separation of programs is illustrated in Figure 1-2 of the *Performance Confirmation Plan* and included in the discussion of MGR testing on pages 1-8 to 1-10.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.04 Scope of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be developed to address the scope of testing prescribed in Section 74(a) and 74(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Sec. 74Tests.]] *"(a) DOE shall perform, or permit the NRC to perform, such tests as the NRC deems appropriate or necessary for the administration of the regulations in this part. These may include tests of:* *(1) Radioactive waste,* *(2) The geologic repository, including portions of the geologic setting and the structures, systems, and components constructed or placed therein,* *(3) Radiation detection and monitoring instruments, and* *(4) Other equipment and devices used in connection with the receipt, handling, or storage of radioactive waste.* *(b) The tests required under this section shall include a performance confirmation program carried out in accordance with Subpart F of this document."* **Assessment:** This requirement is allocated to the geologic repository to have the capability to support various tests and test activities. The requirement includes performance confirmation tests per item (b). Some tests may be conducted by the NRC, to be specified in the LA. Note that the testing examples listed under item (a) represent the range of possible repository testing and not solely performance confirmation testing. Therefore, the overall repository test program, as well as performance confirmation testing and monitoring, will comply with this requirement. **Compliance:** The geologic repository shall have the capability to support tests and test activities, including performance confirmation tests. Some performance confirmation tests may be conducted by the NRC and performance confirmation activities shall support such tests. Facilities to support performance confirmation testing is described in Section 5.4 and prescribed testing is briefly discussed in Section 3.4.4 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.05 Design Requirements of the Performance Confirmation Program	**Requirement:** *Design requirements for the performance confirmation program will be developed and integrated into the design of the MGR such that the provisions of Section 111(d) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079] can be met:* [[Sec. 111 Performance objectives for the geologic repository operations area through permanent closure.]] *"(d) Performance confirmation. The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this document."* **Assessment:** This section is a requirement for the repository design to accommodate and include performance confirmation facilities and activities. In addition, the requirement implies that the design requirements of the repository will be based on *Performance Confirmation Plan* (as incorporated in appropriate system description documents). The requirement also indicates performance confirmation will address the regulations described in Subpart F. **Compliance:** The geologic repository shall be designed to have the capability to support performance confirmation tests and test activities. Design requirements shall be identified based on the performance confirmation program, as documented in the *Performance Confirmation Plan*. The performance confirmation program shall meet the requirements of regulations in Subpart F, as documented in Appendix E of the *Performance Confirmation Plan*.
2.3.2.04.06 Scope of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the stages of licensing as specified in Section 102(c) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Sec. 102 Concepts.]] *"(c) Stages in the licensing process. There are several stages in the licensing process. The site characterization stage, when the performance confirmation program is started, begins before the submission of the license application. Permanent closure represents the end of the performance confirmation program; final backfilling of the underground facility, if appropriate; and the sealing of shafts, ramps, and boreholes."* **Assessment:** This section describes the repository phases and defines the start of the performance confirmation program (i.e., during site characterization) and the end (i.e., at closure). This description is consistent with Subpart F requirements in regard to the extent of performance confirmation. **Compliance:** The performance confirmation program shall start during the site characterization stage and end at the start of closure operations, as documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.07 Scope of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be developed to address the scope of testing as defined in Section 102(m) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Sec. 102 Concepts.]] [[m]] *"Performance confirmation. A performance confirmation program will be conducted to verify the assumptions, data, and analyses that support the performance assessment, and any findings, based thereon, that permitted construction of the repository. Key geologic, hydrologic, geomechanical, and other physical parameters will be monitored throughout site characterization, construction, emplacement, and operation to detect any significant changes in the conditions assumed in the performance assessment that may affect compliance with the performance objective at Section 113(b)."* **Assessment:** This section defines the requirement for the MGR to perform performance confirmation activities. This section also defines the term, performance confirmation, and indicates such activities are to be concerned with postclosure safety, as described in the performance objective (see YMP-RD requirement 2.3.2.04.09). In addition, the text indicates that the confirmation program should support performance assessment, and therefore focus on the items important to the postclosure performance as indicated by TSPA analyses. **Compliance:** This definition shall be utilized in defining the performance confirmation program, and is included in the program objectives on page 2-1 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.08 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 131(a)(1) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(a) The performance confirmation program shall provide data important to parameters and conceptual models used in the performance assessment prepared pursuant to Sec. 114 that indicate, where practicable, whether:* *(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review;"* **Assessment:** This section specifies that performance confirmation activities shall provide data on important subsurface (geologic) conditions encountered during construction, in order to confirm that these conditions are similar (i.e., within the limits assumed) to those conditions in the licensing review[4]. This requires that performance confirmation include observations of the encountered subsurface (geologic) conditions of the repository horizon. The guidance also requires that performance confirmation provide data on the changes in these conditions which occur during construction and waste emplacement operations and verify that the changed values are also within the limits assumed in the licensing review. Such changes in conditions can occur due to the thermal loading induced by emplaced waste packages, or due to construction-related activities such as construction materials left in-place (as to provide for support) or lubricant spills. This requires that observations are performed and attendant records are maintained by the performance confirmation program during construction and waste emplacement operations of the repository in order to observe such changes. **Compliance:** Observations of the encountered subsurface (geologic) conditions of the repository horizon shall be included in the performance confirmation program. To address this requirement, geologic observation of mining and mapping of excavations shall be performed together with index laboratory testing of representative samples from these excavations. This requirement is included in test planning as documented in Table 3-6 the current *Performance Confirmation Plan*. Monitoring of changes in subsurface conditions shall be included in the performance confirmation program. Rock mass monitoring (temperature and displacement) near emplacement drifts shall be performed to monitor changes and address this requirement. This requirement is included in test planning as documented in Table 3-6 the *Performance Confirmation Plan*. The performance confirmation program shall maintain records of observations during construction and waste emplacement operations of the repository in order to observe the extent and magnitude of such changes. This is documented in Section 6.1.2 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.09 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed with the objective of demonstrating that the overall performance objective as defined in Section 113(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079] can be met:* [[113 Performance objective for the geologic repository after permanent closure.]] *"(b) The engineered barrier system shall be designed so that, working in combination with natural barriers, the expected annual dose to the average member of the critical group shall not exceed 0.25 mSv (25 mrem) TEDE [5,6] at any time during the first 10,000 years after permanent closure, as a result of radioactive materials released from the geologic repository."* **Assessment:** This section defines the performance objective for the repository system and for performance confirmation as referenced in YMP-RD requirements 2.3.2.04.01 and 2.3.2.04.07. The achievement of this objective will be based on performance assessment analyses of the total repository system as documented in the LA. Performance confirmation testing and monitoring will be performed to confirm these analyses to the extent feasible, during the preclosure period. Therefore, as part of performance confirmation, predictions of testing and monitoring will be performed, and the actual response be monitored and compared to the predictions to provide such confirmation, and thereby confirm the long-term objective. **Compliance:** The performance confirmation program shall be designed to predict expected response and then measure and compare observed response to the predictions to confirm these analyses as described in the current *Performance Confirmation Plan* in Section 4.3.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.10 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 131(a)(2) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(a) The performance confirmation program shall provide data important to parameters and conceptual models used in the performance assessment prepared pursuant to Sec. 114 that indicate, where practicable, whether: ...* *(2) Geologic and engineered systems and components required for repository operation, and that are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated."* **Assessment:** Similar to YMP-RD requirement 2.3.2.04.08, this item specifies that the performance confirmation program shall conduct analyses and monitoring (as appropriate) of the elements of the repository barrier in order to confirm that these elements are functioning as intended and anticipated. In this context, elements are systems, subsystems, or components of the repository that are intended to function as geologic and engineered barriers after closure. At a minimum, this requirement stipulates that the performance confirmation program monitor the engineered and natural barrier system after waste emplacement. In addition, to demonstrate that that these systems are functioning as intended and anticipated will require a performance confirmation baseline to define the expected response of the systems/components as it varies with time and repository construction and operation. Further, Section 114 includes consideration of probable disruptive processes and events. To provide a basis for assessment, some monitoring of potential indicators of disruptive processes and events are implied by the regulation. Indicators of potential disruptive processes and events may include subsurface seismicity, surface uplift above the facility and changes in water level and temperature of monitoring wells. **Compliance:** The performance confirmation program shall monitor the geologic and engineered barrier systems (after waste emplacement) that are important to postclosure performance. This objective shall be included within the scope and design of the performance confirmation program and is documented in the current *Performance Confirmation Plan* in Section 2.1.1. Some disruptive event monitoring shall be performed as part of performance confirmation. The current performance confirmation program (as documented in *Performance Confirmation Plan)* includes subsurface seismicity, surface uplift above the facility and changes in water level and temperature of monitoring wells (see Test Descriptions DE-01 to DE-03) and the requirement is included in Table 3-6.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.11 Scope of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to meet the scope of testing prescribed in Section 131(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(b) The program shall have been started during site characterization and it will continue until permanent closure."* **Assessment:** As in YMP-RD requirement 2.3.2.04.06, this item specifies the duration of the performance confirmation program. It stipulates that a portion of the program should be started in the initial stage of the MGR (i.e., prior to completion of site characterization), and that the program extends to the start of closure. This requirement will therefore have an impact on duration and cost associated with the performance confirmation program. **Compliance:** The performance confirmation program shall start during site characterization and end at the start of closure operations as documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*.
2.3.2.04.12 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing prescribed in Section 131(c) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(c) The program shall include in-situ monitoring, laboratory and field testing, and in-situ experiments, as may be appropriate to provide the data required by paragraph (a) of this section."* **Assessment:** This requirement identifies the range of techniques that can be used in the performance confirmation program. These techniques will be used as appropriate in meeting the objectives of the program and requirements (a) of the section (see YMP-RD requirement 2.3.2.04.10). **Compliance:** In situ monitoring, laboratory and field testing, and in situ experiments shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 5.3.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.13 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed and conducted to meet the constraint defined in Section 131(d)(1) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(d) The program shall be implemented so that:* *(1) It does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives."* **Assessment:** This requirement constrains the performance confirmation program to not adversely affect the ability of the repository (in particular, the natural elements) to isolate waste as a result of installing or performing field testing and in situ experiments for performance confirmation. This consideration has been incorporated into the planning of each test documented in the *Performance Confirmation Plan.* In addition, this requirement is to be formally addressed by conducting Determination of Importance Evaluation (DIE) analyses for each field test; these DIE's are currently being performed for all field and in situ activities. The DIE analyses assess the impact on the geologic and engineered systems of a specific activity to assure that the activity does not impact repository performance. **Compliance:** Considerations for not impacting the geologic and engineered elements of the geologic repository shall be included in all field design efforts. Conceptual test plans as documented in the current *Performance Confirmation Plan* in Appendix G will provide a basis of initial review by NRC for this consideration. Determination of Importance Evaluation analyses shall be performed for each performance confirmation field test during the detailed test planning to demonstrate that the activity does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.14 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing prescribed in Section 131(d)(2) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(d) The program shall be implemented so that: ...* *(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities."* **Assessment:** This regulation requires that a baseline be established for processes and parameters that will be measured as part of performance confirmation. This baseline shall identify the expected data values before actual testing begins. The form of this baseline will typically consist of parameter values obtained during the Site Characterization Program, together with an expected-value prediction for the parameter along with tolerances or bounds to address expected variation in the prediction of the parameter. **Compliance:** The baseline concept shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 4.2.
2.3.2.04.15 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 131(d)(3) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 131 General requirements.]] *"(d) The program shall be implemented so that: ...* *(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository."* **Assessment:** This regulation requires that performance confirmation data be compared to the baseline predictions during testing and monitoring to observe any data outside the tolerances established as part of the baseline condition. This requires (by inference) that performance confirmation data be accumulated, stored, and evaluated periodically to detect out-of-tolerance data. Observed data significantly outside the baseline tolerances (termed a "variance") shall, by inference, be reported to the NRC (see Section 132 (a)). **Compliance:** Data shall be accumulated, stored, and evaluated periodically to detect variances as part of the performance confirmation program; the process is documented in the *Performance Confirmation Plan* as part of the concept of operations in Sections 2.1.2 and 2.1.7.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.16 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 132(a) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 132 Confirmation of geotechnical and design parameters.]] *"(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters used in the performance assessment are confirmed and to ensure that appropriate action is taken to inform the NRC of changes needed in design to accommodate actual field conditions encountered."* **Assessment:** Along with YMP-RD requirements 2.3.2.04.06 and 2.3.2.04.11, this requirement specifies the time period for the performance confirmation (i.e., during repository construction and operation stages of the MGR). This section also stipulates that geotechnical (i.e., the mechanical properties of the rock) and design parameters that are of importance to postclosure safety (and thereby are employed in performance assessment analyses) shall be confirmed by a continuing program as appropriate to the parameter and expected changes in the parameter. In addition, this section also requires that the performance confirmation program identify a process that will ensure that appropriate action will be taken to notify the NRC in the event that a variance in the data necessitate a change in design. **Compliance:** The performance confirmation program shall be conducted during repository construction and operation (as documented in *Performance Confirmation Plan).* This is documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*. The performance confirmation program shall conduct surveillance, measurement, and testing of geotechnical and design parameters as documented in the *Performance Confirmation Plan.* To address this requirement, geologic observation of mining and mapping of excavations shall be performed together with index laboratory testing of representative samples from these excavations (also specified in YMP-RD requirement 2.3.2.04.08). This requirement is included in Table 3-6 of the current *Performance Confirmation Plan* and geologic mapping, observations and index testing is part of the test program in Appendix G. The general process of notifying the NRC when variances occur shall be included in the operations of the performance confirmation program. The concept of operations for the performance confirmation program is included in Section 2.1.2 and 2.1.7 of the current *Performance Confirmation Plan* and reporting of results to the NRC is documented in Section 6.2.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.17 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 132(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 132 Confirmation of geotechnical and design parameters.]] *"(b) Subsurface conditions shall be monitored and evaluated against design assumptions."* **Assessment:** Along with YMP-RD requirement 2.3.2.04.08, this requirement specifies that subsurface conditions are monitored but this requirement extends the evaluation process by stipulating a comparison of obtained subsurface (geologic) data against design assumptions important to postclosure safety. **Compliance:** As for YMP-RD requirement 2.3.2.04.08, monitoring of changes in subsurface conditions shall be included in the performance confirmation program, as documented in the *Performance Confirmation Plan.* Rock mass monitoring (temperature and displacement) near emplacement drifts shall be performed to monitor changes and address this requirement. This requirement is included in test planning as documented in Table 3-6 the *Performance Confirmation Plan* and in test plans in Appendix G.
2.3.2.04.18 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 132(c) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 132 Confirmation of geotechnical and design parameters.]] *"(c) DOE shall determine the parameters, measurements, and observations appropriate for inclusion in the program based on their importance to confirming repository performance and shall describe monitoring plans in the license application."* **Assessment:** This requirement implies that prior to the LA, DOE is to determine what parameters, measurements, and tests are to be included to confirm repository performance and describe the associated program in the LA. Activities are to be included in the program based on their importance to repository performance. **Compliance:** Parameters to be measured and monitored by performance confirmation program shall be identified in the LA and activities shall be included in the program based on their importance to repository performance. The process to identify key performance confirmation parameters is described in Section 3.4.5 and specific parameters for each process are described in Appendix G of the current *Performance Confirmation Plan*. Activities important to performance are discussed in Section 3.4.2.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.19 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to meet the provision of Section 132(d) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079][9]:* [[Subpart F-Performance Confirmation Program Sec. 132 Confirmation of geotechnical and design parameters.]] *"(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences, their significance to repository performance, and the recommended changes reported to the NRC."* **Assessment:** This requirement, as in YMP-RD requirement 2.3.2.04.14, stipulates the process of comparing obtained data to a performance confirmation baseline. Again, if variances (i.e., data outside baseline tolerances) are indicated, the variances shall be evaluated, and the impact to design or construction shall be assessed. Recommendations as a result of these variance assessments shall be reported to the NRC. **Compliance:** The baseline concept shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 4.2. Comparisons of data to predictions and recommendations to address variances shall be provided to the NRC as part of the performance confirmation program. This is documented in Sections 6.1.3, 6.1.4 and 6.1.8 of the current *Performance Confirmation Plan.*
2.3.2.04.20 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 132(e) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 132 Confirmation of geotechnical and design parameters.]] *"(e) In-situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure, to ensure that the performance of the geologic and engineering features is within design limits."* **Assessment:** Along with YMP-RD requirements 2.3.2.04.07 and 2.3.2.04.11, this requirement specifies the duration of the performance confirmation program by directing that performance confirmation monitoring (specifically of the thermomechanical response of the underground facility) be conducted until the start of permanent closure. Such monitoring is also required to start during construction as per YMP-RD requirement 2.3.2.04.16, defining a period of surveillance for geotechnical monitoring. **Compliance:** Thermomechanical response of the underground facility shall be conducted as part of the performance confirmation until the start of permanent closure. Rock mass monitoring (including thermomechanical response) is included as part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see Test PM-05 in Appendix G). Measurement of rock mass response is also identified as a prescribed test activity in Table 3-6.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.21 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to address the purpose and scope of testing as defined in Section 133(a) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 133 Design testing.]] *"(a) During the early or developmental stages of construction, a program for testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted."* **Assessment:** This directive requires that testing of design features be conducted. It is understood that the list of features would be limited to those important to postclosure performance. As defined, these design features may include seals, backfill, and the interaction of engineered and natural components within the engineered barrier system area. This list of features includes (by inference) other barriers to be employed within the engineered barrier system, such the drip shield, the invert and capillary barriers (if employed), as included in the LA design. Presently, backfill is not included in the repository design, and therefore backfill testing will not be performed. It also places a constraint on the timing of this testing, requiring that this testing be conducted during the early stages of construction. **Compliance:** Performance and constructablitity testing of borehole, ramp and shaft seals shall be conducted as part of performance confirmation. Seal testing is included as part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see Test EB-01 and EB-02 in Appendix G). Seal testing is also identified as a prescribed test activity in Table 3-6. Engineered barrier system interaction response of waste packages, rock, and groundwater shall be conducted. This testing of coupled processes is included as part of the postclosure simulation test as documented in the current Performance Confirmation Program (see Test PS-01 in Appendix G). This testing is also identified as a prescribed test activity in Table 3-6.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.22 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include testing of the nuclear safety-related design features of the MGR in accordance with Section 133(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 133 Design testing.]] "Design testing. *(b) The testing shall be initiated as early as practicable."* **Assessment:** Together with YMP-RD requirement 2.3.2.04.21, this section indicates that performance confirmation program-related design testing shall be initiated as soon as practicable. **Compliance:** The design of the performance confirmation shall initiate performance confirmation program-related seal testing as soon as practicable. The requirement was included in the design considerations in the performance confirmation program, and the schedule for seal testing is documented in the current *Performance Confirmation Plan* (see Figures 2-3 and 2-4).
2.3.2.04.23 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include testing of the nuclear safety-related design features of the MGR in accordance with Section 133(c) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 133 Design testing.]] "Design testing. *(c) If backfilling the emplacement drifts is planned, a backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun."* **Assessment:** This regulation requires that if backfilling of the emplacement drifts is part of the repository license design, that a backfill test section be constructed and tested. The section is to test the effectiveness of backfill construction process. At present, backfill will not be employed in the license design (Dyer 2000) and therefore this requirement does not apply at present to performance confirmation. If backfill were employed, a surface demonstration emplacement drift facility to conduct such a constructability test could be developed to address this requirement. The "effectiveness" of the construction process in this context is understood to be the ability to construct the backfill according to design specifications. **Compliance:** The requirement is not applicable to the present repository design (e.g., see Appendix D) and no performance confirmation activity is identified.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD Requirement[1]	Requirement Statement and Assessment
2.3.2.04.24 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include testing of the nuclear safety-related design features of the MGR in accordance with Section 133(d) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 133 Design testing.]] "Design testing. ... *"(d) Test sections shall be established to test the effectiveness of borehole, shaft, and ramp seals before full-scale operation proceeds to seal boreholes, shafts, and ramps."* **Assessment:** The requirement directs that test sections shall be established to test various seals (testing directed by YMP-RD requirement 2.3.2.04.21). By inference, this requirement also requires that repository design allow space for these test sections and to accommodate the objective and timing of such testing. **Compliance:** For performance confirmation, the testing of seals shall include test sections, and is included in the program as documented in the current *Performance Confirmation Plan* (see Appendix G, descriptions for tests EB-01 and EB-02). The design of the repository shall accommodate performance confirmation seal testing.
2.3.2.04.25 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include monitoring of the condition of the waste packages in accordance with Section 134(a) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 134 Monitoring and testing waste packages.]] *"Monitoring and testing waste packages.* *(a) A program shall be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste packages chosen for the program shall be representative of those to be emplaced in the underground facility."* **Assessment:** This regulation requires that a program be planned and conducted to monitor the condition of in situ waste packages. As indicated in YMP-RD requirement 2.3.2.04.27, the phrase "monitoring the condition of the waste packages" in this context is used broadly, and includes laboratory testing as well as inspection of emplaced packages. The waste packages and materials selected for this monitoring shall be representative of packages emplaced within the repository. **Compliance:** In situ waste package monitoring (and associated laboratory testing) shall be conducted. In drift waste package monitoring is included as part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see test description PM-06 in Appendix G). In situ waste package monitoring is also identified as a prescribed test activity in Table 3-6.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.26 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include monitoring of the condition of the waste packages in accordance with Section 134(b) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 134 Monitoring and testing waste packages.]] *"Monitoring and testing waste packages.* *(b) Consistent with safe operation at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program shall be representative of the environment in which the wastes are to be emplaced."* **Assessment:** This section requires that for the monitoring program established earlier under YMP-RD requirement 2.3.2.04.25, the monitoring environment shall be representative of the in situ emplacement drifts and reflect the real emplacement conditions. The present operations approach for performance confirmation is to periodically monitor all packages within emplacement drifts, thereby addressing the requirement. **Compliance:** The monitoring environment for in situ waste package monitoring shall be representative of the in situ emplacement drifts. In situ waste package monitoring is planned for all waste packages as part of the performance confirmation program and documented in the current *Performance Confirmation Plan* (see PM-06 in Appendix G). The in situ monitoring of waste packages at a representative environment is prescribed in Table 3-6.
2.3.2.04.27 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include monitoring of the condition of the waste packages in accordance with Section 134(c) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 134 Monitoring and testing waste packages.]] *"Monitoring and testing waste packages.* *(c) The waste package monitoring program shall include laboratory experiments that 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."* **Assessment:** This section stipulates that laboratory tests be performed on the internal materials of the waste package and on the waste form, as part of the program established under YMP-RD requirement 2.3.2.04.25. It requires that the test environment for this lab testing shall be representative of the conditions within the emplacement drifts during the monitoring program (i.e., during the preclosure period). **Compliance:** Laboratory investigations of internal waste package material testing shall be performed at representative conditions as part of the performance confirmation program. Waste package lab testing is included in the current *Performance Confirmation Plan* (see PM-03 in Appendix G) and is also prescribed in Table 3-6.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.28 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include monitoring of the condition of the waste packages in accordance with Section 134(d) of the "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)" [MOL.19990910.0079]:* [[Subpart F-Performance Confirmation Program Sec. 134 Monitoring and testing waste packages.]] *"Monitoring and testing waste packages.* *(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure."* **Assessment:** This requirement is to monitor and test waste packages and materials as long as practicable up to the time of permanent closure as part of performance confirmation, consistent with YMP-RD requirements 2.3.2.04.06 and 2.3.2.04.11. **Compliance:** The monitoring and testing waste packages and materials shall be performed as part of the performance confirmation program as long as practicable, until the end of the performance confirmation program (i.e., to the start of closure). This requirement was included in the design of the performance confirmation program, and the schedule for waste package monitoring and testing is documented in the current *Performance Confirmation Plan* (see Figures 2-3 to 2-5 as included under process monitoring).
2.3.2.04.29 Design of the Performance Confirmation Program	**Requirement:** *"As the needs for performance confirmation testing are identified, the details requested by the NRC will be provided in progress reports and technical documents. The performance confirmation program for the confirmation period following submittal of the license application will be described in the license application for construction authorization or in updates to the license application to receive and possess."* **Assessment:** This requirement duplicates YMP-RD requirement 2.3.2.04.02 as The *Safety Analysis Report* (i.e., the LA) is directed to provide a description of the performance confirmation program by the Interim Guidance, Sec. 21, "Content of Application", Item 19. It is also expected that response to requests by the NRC are mandatory and will be provided in progress reports and technical documents as part of the licensing process. **Compliance:** The LA (i.e., the *Safety Analysis Report*) shall provide a description of all performance confirmation testing and monitoring. Progress reports and technical documents shall be provided to the NRC and the public as part of the licensing process to describe the program and its progress; this process is described in Section 6.2 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.30 Objectives for Performance Confirmation Program	**Requirement:** *The performance confirmation program will include a testing program that demonstrates MGR system compliance with radioactive storage requirements specified in Section 4 of 64 FR 46987 (Proposed 40 CFR 197) [readily available]*[7]*:* [[§ 197.4]] "*What is DOE required to do relative to stored radioactive material?* *(a) The DOE must ensure that no member of the public in the general environment receives more than an annual committed effective dose equivalent of 150 microsieverts (15 millirems)* [5,6] *from the combination of:* *(1) Management and storage (as defined in 40 CFR 191.02) of radioactive material which:* *(i) Is subject to 40 CFR 191.03(a); and* *(ii) Occurs outside of the Yucca Mountain repository but within the Yucca Mountain site; and* *(2) Storage (as defined in § 197.02) of radioactive material inside the Yucca Mountain repository."* **Assessment:** The basis of this requirement has been superseded by the issuance of the final rule. Final 40 CFR Part 197, which replaces 64 FR 46976 (Proposed 40 CFR 197). See Table E-2. **Compliance:** No activity is identified for the performance confirmation program.[8]
2.3.2.04.31 Objectives for the Performance Confirmation Program	**Requirement:** *The performance confirmation program will include a testing program that demonstrates MGR system compliance with radioactive storage requirements specified in Section 20 of 64 FR 46987 (Proposed 40 CFR 197) [readily available]*[7]*:* [[§ 197.20]] "*What standard must DOE meet?* *The DOE must demonstrate, using performance assessment, that there is a reasonable expectation that for 10,000 years following disposal the reasonably maximally exposed individual receives no more than an annual committed effective dose equivalent*[5] *of 150 microsieverts) (15 mrem* [6] *from releases from the undisturbed Yucca Mountain disposal system. The DOE's analysis must include all potential pathways of radionuclide transport and exposure."* **Assessment:** The basis of this requirement has been superseded by the issuance of the final rule. Final 40 CFR Part 197, which replaces 64 FR 46976 (Proposed 40 CFR 197). See Table E-2. **Compliance:** No activity is identified for the performance confirmation program.[8]

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

<table>
<tr><th>YMP-RD[1] Requirement</th><th>Requirement Statement and Assessment</th></tr>
<tr><td>2.3.2.04.32
Objectives for Performance Confirmation Program</td><td>
Requirement:
The performance confirmation program will include a testing program that demonstrates MGR system compliance with radioactive storage requirements specified in Section 35 of 64 FR 46987 (Proposed 40 CFR 197) [readily available][7]:
[[§ 197.35]] "What standards must DOE meet?
In its license application to NRC, DOE must provide a reasonable expectation that, for 10,000 years of undisturbed performance after disposal, releases of radionuclides from radioactive material in the Yucca Mountain disposal system will not cause the level of radioactivity in the representative volume of ground water at the point of compliance to exceed the limits in Table 1 as follows:
<table>
<tr><th colspan="3">Table 1.—Limits on Radionuclides in the Representative Volume.</th></tr>
<tr><th>Radionuclide or type of radiation emitted</th><th>Limit</th><th>Is natural background Included?</th></tr>
<tr><td>Combined radium-226 and radium-228</td><td>5 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Gross alpha activity (including radium-226 but excluding radon and uranium)</td><td>15 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Combined beta and photon emitting radionuclides</td><td>40 microSieverts (4 millirem) per year to the whole body or any organ.</td><td>No</td></tr>
</table>
Assessment:
The basis of this requirement has been superseded by the issuance of the final rule. Final 40 CFR Part 197, which replaces 64 FR 46976 (Proposed 40 CFR 197). See Table E-2.
Compliance:
No activity is identified for the performance confirmation program.[8]
</td></tr>
<tr><td>2.3.2.04.33
Scope of the Performance Confirmation Program</td><td>
Requirement:
The performance confirmation program will be designed to address the scope of requirements specified in the YMP-RD 1.3.1.C:
"The MGR shall comply with the interim guidance entitled, "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999) for Yucca Mountain, Nevada" (Dyer 1999), developed to reflect the proposed NRC and U.S. Environmental Protection Agency (EPA) regulatory requirements.
Assessment:
This Interim Guidance makes direct reference to performance confirmation, and forms the basis for many YMP-RD requirements. Subpart F of the Interim Guidance specifies performance confirmation activities, together with the definition of performance confirmation under Subpart A, and specifies performance confirmation design requirements under Subpart E.
YMP-RD-requirements 2.3.2.04.01 to 2.3.2.04.28 are taken directly from the Interim Guidance.
Compliance:
The performance confirmation program shall comply with the Interim Guidance. The Performance Confirmation Plan documents the compliance with the current regulations and addresses the Interim Guidance in the response to YMP-RD-requirements 2.3.2.04.01 to 2.3.2.04.28, which are based directly on the Interim Guidance.
</td></tr>
</table>

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.34 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to test, monitor and provide resulting analyses of the accepted 70,000 MTHM or equivalent of SNF/HLW, listed in YMP-RD requirement 1.3.2.A, for disposal in the primary area of the first repository.* **Assessment:** This requirement is derived from a system-level requirement on the MGR and it specifies the amount of waste that the minimum performance confirmation program shall be designed to test and monitor. This has indirect implications on performance confirmation program by influencing the extent of monitoring as proposed in implementing the program. **Compliance:** The performance confirmation program shall be designed to accommodate a repository of 70,000 MTHM and be flexible to accommodate a larger inventory as documented in the current *Performance Confirmation Plan* (e.g., pg. 5-4 on flexibility in design and Figure 5-4 for performance confirmation program for the expanded repository area).
2.3.2.04.35 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to test and monitor the inventory of nuclear materials specified in YMP-RD 1.3.2.B.2:* *"Inventory of nuclear materials:* *The MGR shall be designed to be capable of accommodating the following inventory of DOE SNF and HLW for SR:* *a. 2,500 MTHM DOE SNF (which includes 65 MTHM naval SNF)* *b. 22,147 HLW canisters composed of 300 canisters of commercial HLW (CHLW) and 21,847 canisters of defense (DHLW) with IPWF[10], 6,712 additional short DHLW canister, and 14,500 long (4.5-meter) DHLW canisters."* **Assessment:** As for YMP-RD requirement 2.3.2.04.34, this constraint is derived from a system-level requirement on the MGR, and implies that the performance confirmation program is to be designed so that it is capable (flexible with appropriate modifications) of accommodating a varying and perhaps expanded inventory. Also, the requirement has indirect implications on performance confirmation by influencing the extent of monitoring as proposed in implementing the program. **Compliance:** The performance confirmation program shall be designed to accommodate the inventory specified in YMP-RD requirement 1.3.2.B.2 and be flexible to accommodate a larger inventory as documented in the current *Performance Confirmation Plan* (see Figure 5-4 for performance confirmation program for the expanded repository area).

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.36 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to evaluate and demonstrate the constraints on repository performance as prescribed in the requirement YMP-RD 1.3.2.F:* *"The MGR shall limit the change in temperature, at 45 cm below the soil surface, to 2°C above what the established naturally occurring pre-emplacement average annual ground surface temperature is within the footprint(see footnote a) of the MGR. [TBV 12]"* *"Footnote (a): The MGR footprint is defined as that area directly above emplaced waste packages and extending 500 m horizontally beyond the scope of emplaced packages."* **Assessment:** This requirement is related to the postclosure performance of the repository, as a significant temperature rise will influence near-surface evapotranspiration. The requirement stipulates a not-to-exceed temperature limit for the soil or rock at a depth of 45 cm below the existing grade to be addressed. In review, no performance confirmation test activity is identified to address this requirement, as near-surface temperatures will only rise significantly at times long after closure. This requirement, therefore, will be addressed by performance assessment analyses and associated process model analyses. The analyses will be supplemented by performance confirmation temperature measurements around emplacement drifts (as directed by other requirements) to confirm the predicted temperature ranges in the rock near the emplacement drifts during preclosure. **Compliance:** This requirement shall be addressed by performance assessment analyses and associated process model analyses, and no additional activity is identified for the performance confirmation program.
2.3.2.04.37 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to meet the requirements of YMP-RD 1.3.2.H:* *"The proposed monitored geologic concept shall be capable of operating over a range of thermal conditions. For the high-temperature end of the range, the MGR design shall allow closure as early as 30 years after the last waste package is emplaced. For the full range of operating conditions, the MGR design shall allow the repository to remain open for up to 300 years after final waste emplacement, with appropriate monitoring and maintenance."* **Assessment:** This constraint is derived from a system-level requirement on the MGR. This requirement indirectly controls the duration of the performance confirmation program (which must be terminated by the start of closure). In addition, the performance confirmation program is directed to be flexible so as to support closure as early as 30 years after last emplacement This requirement also provides an upper bound on the duration of the program, as the design of the performance confirmation program shall allow (with appropriate modifications) for a closure deferral up to 300 years after the end of emplacement. **Compliance:** The performance confirmation program shall be designed to accommodate a schedule for closure 30 years after last emplacement and accommodate (with modification) a duration of up to 300 years after last emplacement. The schedule for performance confirmation is documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.38 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to evaluate compliance with the provisions of requirement YMP-RD 1.3.2.L:* *"All commercial spent fuel waste forms containing zirconium-based cladding shall be maintained during preclosure and postclosure periods at temperatures that will not accelerate the degradation of cladding to the point that it affects the performance of the system."* **Assessment:** This specification stipulates a temperature range shall be maintained for any CSNF waste form with zirconium-based (e.g., zircaloy) cladding. In review of this requirement, performance confirmation will comply with this requirement through a combination of measurements and analyses. The monitoring will measure temperatures at the waste package's exterior surface and calculate the interior temperature of the zircaloy-clad fuel. This avoids the penetration of the waste package canister in order to conduct such measurements directly of the cladding, and thereby degrading the long-term safety of the package. **Compliance:** The surface temperature of waste packages shall be measured as part of the performance confirmation program to assure that the maximum surface temperature does not exceed the defined limit to maintain the cladding (as based on thermal analyses). Temperature measurement of the waste package surface is included in the *Performance Confirmation Plan* as part of Test PM-06 in Appendix G and indicated as a specified measurement in Table 3-6.
2.3.2.04.39 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to evaluate compliance with the provisions of requirement YMP-RD 1.3.2.N:* *"Following repository closure, rock temperatures shall allow free draining conditions to exist that are sufficient to preclude development of a perched water zone above the repository block."* **Assessment:** This specification stipulates that temperatures in the rock (mass) shall not preclude free drainage after closure of the repository. Such a condition would occur if the temperature of entire rock mass between two emplacement drifts (i.e., the rock pillar) exceeds boiling, thereby impeding free draining between drifts. In review of this constraint, no direct performance confirmation test activity is identified to address this requirement, as above-boiling temperatures will occur only after active ventilation is terminated at closure (and then, only for a high-temperature operating mode). This requirement therefore will be addressed by performance assessment analyses and associated process computations, supplemented by testing of simulated postclosure conditions, including coupled processes (when performed). **Compliance:** No specific testing is identified as part of performance confirmation. If postclosure simulation testing is performed, the rock temperatures during simulated postclosure conditions shall be measured to support analyses of repository temperature conditions in the rock mass. Temperature measurement of simulated postclosure conditions is included in the *Performance Confirmation Plan* as part of Test PS-01 in Appendix G.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.40 Objective of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to evaluate and demonstrate compliance with the postclosure performance objectives specified in YMP-RD 1.3.2.P:* *"The expected annual dose to the average member of the critical group shall not exceed 0.25 mSv (25 mrem)[5,6] Total Effective Dose Equivalent at any time during the first 10,000 years after permanent closure, as a result of radioactive materials released from the MGR."* **Assessment:** This section defines the performance objective for the repository system and for performance confirmation as referenced in the Interim Guidance (see YMP-RD requirements 2.3.2.04.09). The achievement of this objective will be based on performance assessment analyses of the total repository system as documented in the LA. Performance confirmation testing and monitoring will be performed to confirm these analyses (to the extent feasible) during the preclosure period. Briefly, as part of performance confirmation, predictions of testing and monitoring will be performed, and the actual response be monitored and compared to the predictions to provide such confirmation, and thereby confirming the long-term objective. **Compliance:** The performance confirmation program shall be designed to predict expected response and then measure and compare observed response to the predictions to confirm the data in the LA as described in the current *Performance Confirmation Plan* in Section 4.3.
2.3.2.04.41 Design of the Performance Confirmation Program	**Requirement:** *The performance confirmation program will be designed to meet the following constraint:* *The NRC will be contacted before a decision is made on penetrating the Calico Hills Unit.* **Assessment:** This constraint is based on a historical commitment of the DOE to the NRC and is listed in the Commitments Management System as Commitment No. 01567[11]. This commitment is indicated as having been superseded by Commitment 00143[12], but the database also indicates that the original commitment has been fulfilled. Historically, the commitment 01567 was addressed in Section 8.4.2.1.6.1 (Characterization of Calico Hills) of the Site Characterization Plan[13]. Currently, the present version of the *Performance Confirmation Plan* does not excavate or impact the Calico Hills unit below the repository. Any intention to excavate this geologic unit by performance confirmation activities will first be described in a future revision of the *Performance Confirmation Plan*. After any such revision, the plan will be provided to the NRC and detailed plans will in turn be prepared and again provided to the NRC. Thus, the intent of the requirement (for providing prior notification of penetrating the Calico Hills unit) will be fulfilled in the future. Commitment 00143 involves the acceptability of DOE Quality Assurance Program. This commitment is indicated as closed in the Commitments Management System[12]. Therefore, no additional action is indicated. **Compliance:** The commitment is considered to be met and closed. To comply with the spirit of the requirement, revisions to the *Performance Confirmation Plan* shall be provided to the NRC in a timely fashion.

Table E-1. Performance Confirmation Requirements Based on YMP-RD (Continued)

YMP-RD[1] Requirement	Requirement Statement and Assessment
2.3.2.04.42 Design of the Performance Confirmation Program	**Requirement:** *The DOE anticipates that the performance confirmation program will evolve as site characterization proceeds. Changes in the program during site characterization phase will be presented in the Annual Progress Reports to NRC.* **Assessment:** This constraint is based on a historical commitment of the DOE to the NRC and is listed in the Commitments Management System as Commitment No. 01603[14]. This commitment is indicated as having been superseded by Commitment 00362[15]. The original commitment is considered fulfilled by issuance of the first *Performance Confirmation Plan*[16] and by reporting subsequent changes to the program in the annual progress reports to the NRC. Commitment 00362 states that the information to NRC presented is insufficient to determine if the confirmation program meets the requirements of 10 CFR 60. However, the current revision of the *Performance Confirmation Plan* documents this compliance, and the issue is considered as having been addressed. **Compliance:** The commitment is considered to have been addressed and fulfilled. To comply with the spirit of the requirement, revisions to the *Performance Confirmation Plan* shall be provided to the NRC in a timely fashion.

NOTES:
1 *Yucca Mountain Site Characterization Project Requirements Document* (YMP 2001a).
2 Included in reference list (Dyer 1999). Text in double square brackets, i.e., [[ ]], has been added for clarity.
3 The *Safety Analysis Report* is defined in Section 21 of the Interim Guidance (Dyer 1999).
4 In this context, licensing review assumptions are understood to be documented in the LA document, the associated TSPA computation report(s), and other appropriate documents submitted to the NRC as part of the license review process.
5 Note that the NRC regulations are stated in terms of the "total effective dose equivalent" (TEDE) while the EPA regulation are stated in terms of "committed effective dose equivalent" (CEDE).
6 The Interim Guidance refers to an annual dose limit 25 mrem, while the EPA rule uses a limit of 15 mrem. This will be resolved in the final version of 10 CFR 63.
7 Cite to 64 FR 46987 should be to 64 FR 46976, which is included in the reference list.
8 See Table E-2, which evaluates the related requirement from 40 CFR 197.
9 Error in citation; text shown is taken directly from Interim Guidance (Dyer 1999).
10 IPWF (immobilized plutonium waste form).
11 Included in reference list (Lindner 2001c).
12 Included in reference list (Lindner 2001a).
13 Included in reference list (DOE 1988, pp. 8.4.2-32 to 8.4.2-35).
14 Included in reference list (Lindner 2001d).
15 Included in reference list (Lindner 2001b).
16 Included in reference list (CRWMS M&O 1997a).

Table E-2. Performance Confirmation Requirements Based on Final EPA Rule

Final EPA Rule 40 CFR 197[1]	Requirement Statement and Assessment
Subpart A Part 197.4	**Requirement:** ***Subpart A–Public Health and Environmental Standards for Storage*** ***§ 197.4 What standard must DOE meet?*** *"The DOE must ensure that no member of the public in the general environment receives more than an annual committed effective dose equivalent of 150 microsieverts (15 millirems) from the combination of:* *(a) Management and storage (as defined in 40 CFR 191.2) of radioactive material that:* *(1) Is subject to 40 CFR 191.3(a); and* *(2) Occurs outside of the Yucca Mountain repository but within the Yucca Mountain site; and* *(b) Storage (as defined in § 197.2) of radioactive material inside the Yucca Mountain repository."* **Assessment:** The dose level specified in this part differs from the Interim Guidance (Dyer 1999), which specifies 0.25 mSv[2] (25 mrem) TEDE[3,4]. If the text is incorporated by the NRC in its final rule as stated (irregardless of dose level), this directive indicates that handling and temporary storage of nuclear waste at the Yucca Mountain site, either above ground or below ground, shall not provide a specified annual TEDE to the public requiring environmental monitoring of the general environment (i.e., both within the controlled area and at the boundary of the controlled area). The directive encompasses two activities at the facility: (a) the management and storage, and (b) storage. For the first activity, storage is temporary process; as defined in 40 CFR 191.2, storage means the "*...retention of spent nuclear fuel or radioactive wastes with the intent and capability to readily retrieve such fuel or waste for subsequent use, processing, or disposal.*" (40 CFR 191.2). The management and storage activity clearly applies to the waste handling and the storage required for the processes in the surface facility during preclosure. This temporary storage will require both air and near-surface water monitoring within the controlled area to evaluate the impact to the environment. However, given the preclosure motivation of these efforts, this monitoring is not considered to be part of the performance confirmation program. For the second activity, (b) storage is designated as "*... retention (and any associated activity, operation, or process necessary to carry out successful retention) of radioactive material with the intent or capability to readily access or retrieve such material.*" (40 CFR 197.02). This second activity is focused on subsurface waste storage, but during the preclosure phase of the repository, as after permanent closure, the waste will not be either readily accessible or retrievable. Given the focus on storage (and therefore long-term performance) this regulation will be included as a performance confirmation directive, notwithstanding the preclosure consideration. Environmental monitoring in this case will be focused on water quality at the edge of the accessible environment (i.e., at the controlled boundary of the facility). **Compliance:** Air and near-surface water monitoring of the environment shall be conducted within the controlled area. (This monitoring is not considered to be part of performance confirmation.) Water quality monitoring shall be conducted at the boundary of the controlled area as part of performance confirmation program. This requirement is documented as a required test in Table 3-6, and included as a test activity (EM-01) in Appendix G of the *Performance Confirmation Plan*.

Table E-2. Performance Confirmation Requirements Based on Final EPA Rule (Continued)

Final EPA Rule 40 CFR 197[1]	Requirement Statement and Assessment
Subpart B Part 197.20 Individual-Protection Standard	**Requirement:** ***Subpart B–Public Health and Environmental Standards for Disposal*** ***Individual-Protection Standard*** ***§ 197.20 What standard must DOE meet?*** *"The DOE must demonstrate, using performance assessment, that there is a reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual committed effective dose equivalent of 150 microsieverts (15 millirems) from releases from the undisturbed Yucca Mountain. ..."* **Assessment:** The dose level specified in this part differs from the Interim Guidance (Dyer 1999), which specifies 0.25 mSv (25 mrem) TEDE[3]. If the text is incorporated by the NRC in its final rule as stated (except that the higher dose level in the guidance is employed), this specification requires that performance assessment analyses demonstrate the performance of the total system does not exceed the stated performance objective (i.e., the dose exposure). For performance confirmation, this directive does not require a specific activity, as the requirement will be addressed by performance assessment analyses. However, the part defines a postclosure performance objective and thereby indirectly applies to all performance confirmation activities. **Compliance:** No activity is required of the performance confirmation by this directive. If the 150 mSv limit is incorporated by the NRC in its rule, the new limit would modify the definition of the postclosure performance goal, and therefore indirectly affect performance confirmation requirements.

Table E-2. Performance Confirmation Requirements Based on Final EPA Rule (Continued)

Final EPA Rule 40 CFR 197[1]	Requirement Statement and Assessment
Subpart B Part 197.25 Human-Intrusion Standard	**Requirement:** ***Subpart B–Public Health and Environmental Standards for Disposal*** ***Human-Intrusion Standard*** ***§ 197.25 What standard must DOE meet?*** *"The DOE must determine the earliest time after disposal that the waste package would degrade sufficiently that a human intrusion (see § 197.26) could occur without recognition by the drillers. The DOE must:* *(a) If complete waste package penetration is projected to occur at or before 10,000 years after disposal:* *(1) Demonstrate that there is a reasonable expectation that the reasonably maximally exposed individual receives no more than an annual committed effective dose equivalent of 150 microsieverts (15 millirems) as a result of a human intrusion, at or before 10,000 years after disposal. The analysis must include all potential environmental pathways of radionuclide transport and exposure; and* *(2) If exposures to the reasonably maximally exposed individual occur more than 10,000 years after disposal, include the results of the analysis and its bases in the environmental impact statement for Yucca Mountain as an indicator of long-term disposal system performance; and* *(b) Include the results of the analysis and its bases in the environmental impact statement for Yucca Mountain as an indicator of long-term disposal system performance, if the intrusion is not projected to occur before 10,000 years after disposal."* **Assessment:** In review, no performance confirmation test activity is identified to address this requirement (and provide a "demonstration"), as the penetration of the waste package (under this human intrusion case) can occur only after closure of the facility. The demonstration and analyses described in this directive will be addressed by performance assessment analyses and incorporated into the environmental impact statement for Yucca Mountain as directed (assuming the text is incorporated by the NRC in its rule as stated above). It is also noted that the directive also employs a lower dose (as defined in Part 197.20, described earlier) than in the Interim Guidance (Dyer, 1999). **Compliance:** No activity is required of the performance confirmation by this directive. If the 150 mSv limit is incorporated by the NRC in its rule, the new limit would modify the definition of the postclosure performance goal, and therefore indirectly affect some performance confirmation requirements.

Table E-2. Performance Confirmation Requirements Based on Final EPA Rule (Continued)

<table>
<tr><th>Final EPA Rule 40 CFR 197[1]</th><th>Requirement Statement and Assessment</th></tr>
<tr><td>Subpart B
Part 197.30
Ground Water Protection Standards</td><td>
Requirement:
Subpart B–Public Health and Environmental Standards for Disposal
Ground Water Protection Standards
§ 197.30 What standards must DOE meet?
"The DOE must demonstrate that there is a reasonable expectation that, for 10,000 years of undisturbed performance after disposal, releases of radionuclides from waste in the Yucca Mountain disposal system into the accessible environment will not cause the level of radioactivity in the representative volume of ground water to exceed the limits in the following Table 1:
Table 1. Limits on radionuclides in the representative volume.
<table>
<tr><th>Radionuclide or type of radiation emitted</th><th>Limit</th><th>Is natural background included?</th></tr>
<tr><td>Combined radium-226 and radium-228</td><td>5 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Gross alpha activity (including radium-226 but excluding radon and uranium)</td><td>15 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Combined beta and photon emitting radionuclides</td><td>40 microsieverts (4 mrem) per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume</td><td>No</td></tr>
</table>
Assessment:
This part specifies (as a generalization) that, due to any releases from the repository, the gross activity or annual dose to the accessible environment shall not exceed the limits in Table 1 of the rule. Assuming the text is incorporated by the NRC in its rule as stated, these limits apply to a specified volume of groundwater at a specified distance from the repository for 10,000 years. The directive encompasses both the preclosure and the postclosure performance of the repository.
However, this directive does not require monitoring, as it is focused on future use and monitoring is considered to be addressed by other parts of the regulation (specifically, the individual-protection standard under Part 197.20 discussed earlier). As described under background information of the regulation addressing the technical approach for protecting ground water, the regulation states (66 FR 32074, p. 32109):
"... Because the purpose of the engineered and natural barriers of the geologic repository at Yucca Mountain is to contain radionuclides and minimize their movement into the general environment, we anticipate that radionuclide releases from the repository will not occur for a long period of time. With this assumption in mind, we believe that ground water protection for the Yucca Mountain site should focus upon the protection of the ground water as a resource for future human use. It is the general premise of this rule that the individual-protection standard will adequately protect those few current residents closest to the repository..."
From this discussion, it is concluded that the directive is to be addressed by TSPA analyses, conducted as part of system evaluation, and that monitoring is not stipulated by this section, but rather is included under Section 197.4 of the regulation.
Compliance:
TSPA analyses will be conducted to address this requirement, and no performance confirmation activity is required of the by this directive. Monitoring requirements are addressed under Section 197.4 of the regulation (see above).
</td></tr>
</table>

Table E-2. Performance Confirmation Requirements Based on Final EPA Rule (Continued)

Final EPA Rule 40 CFR 197[1]	Requirement Statement and Assessment
Subpart B Public Health and Environmental Standards for Disposal Additional Provisions Part 197.35	**Requirement:** *Subpart B–Public Health and Environmental Standards for Disposal* *Additional Provisions* *§ 197.35 What other projections must DOE make?* *"To complement the results of § 197.20, DOE must calculate the peak dose of the reasonably maximally exposed individual that would occur after 10,000 years following disposal but within the period of geologic stability. No regulatory standard applies to the results of this analysis; however, DOE must include the results and their bases in the environmental impact statement for Yucca Mountain as an indicator of long-term disposal system performance."* **Assessment:** All calculations and analyses described in this directive will be addressed by performance assessment analyses and incorporated into the environmental impact statement for Yucca Mountain as directed (assuming the text is incorporated by the NRC in its rule as stated above). This directive indicates no performance confirmation test and monitoring activities. **Compliance:** Performance assessment analyses will be conducted to address this requirement. No test or monitoring activity is required for the performance confirmation to address this requirement.

NOTES:
1 As provided in final EPA Rule 40 CFR 197.

2 Caution: the EPA rule uses μSv or microSieverts (10^{-6} Sv) while the Interim Guidance (Dyer 1999) refers to mSv, or milliSieverts (10^{-3} Sv).

3 TEDE (total effective dose equivalent).

4 Note that the dose in the Interim Guidance is stated in terms of the "total effective dose equivalent" (TEDE) while dose in the EPA regulations are stated in terms of "committed effective dose equivalent" (CEDE).

Table E-3. Performance Confirmation Requirements Based on MGR-PDD

MGR-PDD[1] Reference	Requirement Statement and Assessment
Section 5.1.1 Performance Requirements Item 5.1.1.1 (see Note 2)	**Requirement:** *"The MGR design shall allow the repository to remain open for up to 300 years following final waste emplacement, with appropriate monitoring and maintenance (YMP 2001a[3], 1.3.2.H[4]), and could allow closure of the repository 30 years following final waste emplacement, with variations in thermal management via operational flexibility."* **Assessment:** This requirement essentially duplicates YMP-RD requirement 2.3.2.04.37 (see Table E-1). As defined, this constraint is derived from a system-level requirement on the MGR and it indirectly controls the duration of the performance confirmation program (which must be terminated by the start of closure). In addition, the performance confirmation program must be flexible so as to permit the start of closure: 30 years after last emplacement. Note that this time period will also include the NRC review and approval of the information obtained from the performance confirmation program prior to closure, so in effect, the duration of the performance confirmation program would be somewhat shorter than the specified years. This requirement also provides an upper bound on the duration of the program, and, the design of the performance confirmation program shall allow (with appropriate modifications) for a closure deferral up to 300 years after the start of emplacement. **Compliance:** The performance confirmation program shall be designed to accommodate a schedule for closure 30 years after last emplacement, and also accommodate (with some modifications to the program) a duration of up to 300 years after emplacement start. The expected program schedule is documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*.
Item 5.1.1.2	**Requirement:** *"The MGR design under preclosure and postclosure normal operating conditions shall maintain the zirconium-alloy cladding of the CSNF at temperatures that will preserve and not accelerate the degradation of the performance of the cladding as received at the repository (DOE 2001b[5], 3.4F)."* **Assessment:** This requirement essentially duplicates YMP-RD requirement 2.3.2.04.38 for performance confirmation (see Table E-1). This specification stipulates a temperature range shall be maintained for any CSNF waste form with zirconium-based (e.g., zircaloy) cladding. In review of this requirement, performance confirmation will evaluate compliance with this requirement through a combination of measurements and analyses. The monitoring will measure temperatures at the waste package's exterior surface and calculate the surface temperature of the zircaloy-clad fuel. This is to avoid a direct penetration of the waste package canister in order to conduct such measurements, and thereby degrading the long-term safety of the package. **Compliance:** The surface temperature of waste packages shall be measured as part of the performance confirmation program to assure that the maximum surface temperature does not exceed the defined limit to maintain the cladding (as based on thermal analyses). Temperature measurement of the waste package surface is included in the *Performance Confirmation Plan* as part of Test PM-06 in Appendix G.

Table E-3. Performance Confirmation Requirements Based on MGR-PDD (Continued)

MGR-PDD[1] Reference	Requirement Statement and Assessment
Item 5.1.1.3	**Requirement:** *"The MGR shall be designed to allow flexibility of operations within a range of thermal modes during preclosure and postclosure. The end points of the thermal range are:* *Maintaining WP[6] surface temperature below 85°C (low end of range)* *Avoiding long-term accumulation of water in the rock above the emplacement drifts by controlling rock temperatures so that there is free drainage between the emplacement drifts (high end of range) (YMP 2001a, 1.3.2.M, 1.3.2.N; DOE 2001b, 3.4.E)"* **Assessment:** The first part of this specification stipulates that the waste package surface temperature is maintained below 85°C during both pre- and postclosure periods, establishing a long-term performance goal. The requirement applies therefore to performance confirmation, requiring the program to actively measure the waste package surface temperature to confirm that this limit is maintained during the early (and hottest) portion of the waste package life, i.e., during preclosure. The second part of the specification requires that induced temperatures in the rock shall be such to allow free draining conditions to exist that are sufficient to preclude development of a perched water zone above the repository block. In general intent, this duplicates YMP-RD requirement 2.3.2.04.39 for performance confirmation. This requirement is addressed by limiting the temperatures in the rock between adjacent emplacement drifts. In review of this requirement, no direct performance confirmation test activity is identified to address this requirement, as the temperature condition can not occur during preclosure. In more detail, if the first condition of this specification is achieved during preclosure (i.e., the waste package surface is less than 85°C) the rock mass will by definition not be above 85°C (and well below boiling) as the waste package supplies the heat that will enter the rock mass and drives the rock temperatures. This requirement therefore will be addressed by performance assessment analyses and associated process computations, supplemented by testing of simulated postclosure conditions, including coupled processes. **Compliance:** For the first part of the specification, the surface temperature of waste packages shall be measured as part of the performance confirmation program to assure that the maximum surface temperature does not exceed 85°C. Temperature measurement of the waste package surface is included in the *Performance Confirmation Plan* as part of Test PM-06 in Appendix G. For the second part of the specification, no specific testing is identified as part of performance confirmation. If postclosure simulation testing is performed, the rock temperatures during simulated postclosure conditions shall be measured to support analyses of repository temperature conditions in the rock mass. Temperature measurement of simulated postclosure conditions is included in the *Performance Confirmation Plan* as part of Test PS-01 in Appendix G.

Table E-3. Performance Confirmation Requirements Based on MGR-PDD (Continued)

MGR-PDD[1] Reference	Requirement Statement and Assessment
Item 5.1.1.4	**Requirement:** *"The MGR shall limit the change in temperature of the soil near the surface above the repository in accordance with the YMP RD (YMP 2001a, 1.3.2.F)."* **Assessment:** This requirement duplicates YMP-RD requirement 2.3.2.04.36 for performance confirmation (see Table E-1). This requirement is related to the postclosure performance of the repository, as a significant temperature rise will influence near-surface evapotranspiration. The requirement stipulates a not-to-exceed temperature limit for the soil or rock at a depth of 45 cm below the existing grade to be addressed. In review, no performance confirmation test activity is identified to address this requirement, as near-surface temperatures will only rise significantly at times long after closure. This requirement therefore will be addressed by performance assessment analyses and associated process model analyses, supplemented by temperature measurements around emplacement drifts to confirm predicted temperature ranges in the rock near the emplacement drifts. **Compliance:** This requirement shall be addressed by performance assessment analyses and associated process model analyses, and no activity is identified for the performance confirmation program.
Section 5.1.2 Regulatory Requirements (see Note 2)	**Requirement:** *"The "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada" (Dyer 1999)[7] is the controlling regulatory requirement for the MGR. The MGR shall comply with this guidance in accordance with the YMP RD (YMP 2001a, 1.3.1.C). An allocation of the regulatory requirements contained within this guidance is correlated to the MGR Level 5 systems that support SR as shown in Table 5-8. A comprehensive allocation of this guidance and additional regulatory requirements will be provided in a later revision of this document."* **Assessment:** To summarize, under this requirement, the performance confirmation program is directed to comply with both the YMP-RD (YMP 2001a) and Interim Guidance (Dyer 1999). The YMP-RD also directs performance confirmation to comply with the Interim Guidance under YMP-RD requirement 2.3.2.04.33 and incorporates each section of this guidance under YMP-RD requirements 2.3.2.04.01 to 2.3.2.04.32. As to Table 5-8 (Curry 2001), the current table does not indicate performance confirmation systems. **Compliance:** This performance confirmation program shall comply with the applicable requirements identified in the YMP-RD. The requirements allocated to performance confirmation are evaluated in Table E-1 in the current *Performance Confirmation Plan.*

Table E-3. Performance Confirmation Requirements Based on MGR-PDD (Continued)

MGR-PDD[1] Reference	Requirement Statement and Assessment
Item 5.1.2.2 (see Note 2)	**Requirement:** *"The MGR shall comply with the applicable provisions of 10 CFR 20, "Standards for Protection Against Radiation," in accordance with the CRD[8] (DOE 2001b, 3.1.1.B)."* **Assessment:** This is a system requirement for the MGR and by allocation, for performance confirmation. This requirement directs that the performance confirmation program activities be conducted in a safe manner, specifically with respect to potential radiation hazards (considered in 10 CFR 20). To properly assess the hazard to personnel, a detailed layout of equipment and instrumentation is required as well specification of routine operations and maintenance. This information and associated protective measures and dose calculations shall be included in the detailed planning documents for each test to demonstrate compliance with 10 CFR 20. Given the nature of the *Performance Confirmation Plan* as an upper-level planning document, the plan will not demonstrate compliance to this requirement. **Compliance:** Detailed planning documents for each performance confirmation activity shall provide sufficient data to demonstrate that all activities are to be conducted in a safe manner and in compliance with 10 CFR 20.
Item 5.1.2.4 (see Note 2)	**Requirement:** *"The MGR shall comply with the applicable provisions of 29 CFR 1910, "Occupational Safety and Health Standards," in accordance with the CRD (DOE 2001b, 3.1.1.I)."* **Assessment:** This is a system requirement for the MGR and by allocation, for performance confirmation. This requirement directs that the performance confirmation program activities be conducted in a safe manner, specifically with respect to potential occupational and health hazards (considered in 29 CFR 1910). To properly assess the hazard to personnel, a detailed specification of routine operations and maintenance is required for each test. This information and associated protective measures shall be included in the detailed planning documents for each test to demonstrate compliance with 29 CFR 1910. In addition, all performance confirmation activities will be conducted per defined and documented procedures for the repository, which also must comply with 29 CFR 1910. Given the nature of the *Performance Confirmation Plan* as an upper-level planning document, the plan will not demonstrate compliance to this requirement, rather, compliance shall be documented in detailed test plans. **Compliance:** Detailed planning documents for each performance confirmation activity shall provide sufficient data to demonstrate that all activities are to be conducted in a safe manner and in compliance with 29 CFR 1910.

Table E-3. Performance Confirmation Requirements Based on MGR-PDD (Continued)

MGR-PDD[1] Reference	Requirement Statement and Assessment
Item 5.1.2.5 (see Note 2)	**Requirement:** *"The MGR shall comply with the applicable provisions of 29 CFR 1926, "Safety and Health Regulations for Construction," in accordance with the YMP RD (YMP 2001a, 1.3.1.F)."* **Assessment:** This is a system requirement for the MGR and by allocation, for performance confirmation. This requirement directs that construction of performance confirmation facilities be conducted in a safe manner, specifically with respect to construction hazards (considered in 29 CFR 1926). It is understood that all construction activities will be conducted per defined and documented procedures for the repository, which must comply with 29 CFR 1926. Where applicable to performance confirmation activities, information and associated protective measures shall be included in the detailed planning documents for each test that requires construction as part of the activity to demonstrate compliance with 29 CFR 1926. To properly assess the hazard to personnel, a detailed specification of operations and activities is required for each test. Therefore, given the nature of the *Performance Confirmation Plan* as an upper-level planning document, the plan will not demonstrate compliance to this requirement; rather, compliance shall be documented in detailed test plans for performance confirmation. **Compliance:** Detailed planning documents for each performance confirmation activity shall provide (as appropriate) sufficient data to demonstrate that all included construction-related tasks for the specific activity are to be constructed in a safe manner and complying with 29 CFR 1926 in accordance with the YMP RD.
Item 5.1.2.6 (see Note 2)	**Requirement:** *"The MGR shall comply with laws, statutes, U.S. Code, treaties, Codes of Federal Regulations, Executive Orders, NUREGs, state and local codes and regulations, DOE Orders, and other directives identified through analysis, as identified in the YMP RD (YMP 2001a, 1.3.1.G)."* **Assessment:** This is a system requirement for the MGR and by allocation, for performance confirmation. Briefly, the stipulation requires that the performance confirmation program comply with all other requirements as analyzed and defined in the YMP-RD (YMP 2001a). At present, no requirements identified by the YMP-RD for performance confirmation include U.S. Code, treaties, Codes of Federal Regulations, Executive Orders, NUREGs, state and local codes and regulations. Most requirements for performance confirmation are based on the proposed 10 CFR 63 as currently implemented for the program under the Interim Guidance (Dyer 1999). **Compliance:** The performance confirmation program shall comply with all requirements assigned by the YMP-RD to performance confirmation, as documented in Table E-1 of the *Performance Confirmation Plan.*

Table E-3. Performance Confirmation Requirements Based on MGR-PDD (Continued)

MGR-PDD[1] Reference	Requirement Statement and Assessment
Item 5.1.6 (see Note 2)	**Requirement:** *"All MGR SSCs shall be designed and fabricated in accordance with the CRD (DOE 2001b, 3.2.3)."* **Assessment:** This is a system requirement for structures, systems, and components (SSCs) of the MGR and by allocation, for performance confirmation. Briefly, the stipulation requires that SSCs of the performance confirmation program shall be designed and fabricated in accordance with appropriate industry codes, standards, engineering principles and practices with particular attention to those which incorporate system safety, human factors, reliability, availability, maintainability, habitability standards, and environmental protection. Given the nature of the *Performance Confirmation Plan* as an upper-level planning document, the plan will not demonstrate compliance to this requirement; rather, compliance shall be documented in detailed test plans. **Compliance:** Detailed test plans for performance confirmation program shall comply with all applicable requirements for SSCs as indicated in the CRD.

NOTES: [1] As identified in the *Monitored Geologic Repository Project Description Document* (Curry 2001).

[2] Allocated to performance confirmation systems (Curry 2001, Table 5-7).

[3] Included in reference list (YMP 2001a).

[4] The designation refers to a requirement number in the cited reference.

[5] Included in reference list (DOE 2001).

[6] WP (waste package).

[7] Included in reference list (Dyer 1999).

[8] CRD (*Civilian Radioactive Waste Management Requirements Document*).

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart A - General Provisions § 63.2	**Requirement:** *"§ 63.2 Definitions.* *... Performance confirmation means the program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives in Subpart E. ..."* **Assessment:** This section defines performance confirmation and identifies the objectives of the program. The objectives include preclosure and postclosure performance objectives described in §§ 63.111 and 63.113 (respectively) of the regulation (i.e., Subpart E). Upon review of these sections, the objectives at §§ 63.111(a), 63.111(e), 63.113(b), 63.113(c), and 63.113(d) are identified as directly applicable to performance confirmation. The inclusion of preclosure objectives represents an expanded scope from the Interim Guidance. The preclosure objectives will be addressed in a subsequent revision of the *Performance Confirmation Plan*. **Compliance Approach:** The scope of the performance confirmation program shall focus on both postclosure and preclosure performance. The current program has been focused on postclosure performance, as documented on page 1-1 of the current *Performance Confirmation Plan.* Subsequent revision of the *Performance Confirmation Plan* shall expand the focus of the program to include preclosure performance.
Subpart B – Licenses License Application § 63.21(c)(17)	**Requirement:** *"§ 63.21 Content of application.* *(c) The Safety Analysis Report must include:* *(17) A description of the performance confirmation program that meets the requirements of Subpart F."* **Assessment:** This requirement is directed at the content of the initial License Application, specifically, the Safety Analysis Report. The requirement implies that a description of the performance confirmation program will be prepared based on the *Performance Confirmation Plan*, which in turn will meet the requirements of Subpart F of the regulations. **Compliance Approach:** The *Performance Confirmation Plan* shall meet the requirements of Subpart F of the regulations. Subpart F is part of the regulatory basis for performance confirmation as documented in Section 1.2.2 of the *Performance Confirmation Plan* and evaluated in Appendix E.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart B – Licenses License Issuance and Amendment § 63.44(a)(6)	**Requirement:** *"§ 63.44 Changes, tests, and experiments.* *(a) Definitions for the purposes of this section: ...* *(6) Tests or experiments not described in the SAR (as updated) means any condition where the geologic repository operations area or any of its structures, systems, and components important to safety, or important to waste isolation, are utilized, controlled, or altered in a manner which is either: (i) Outside the reference bounds of the design bases as described in the SAR (as updated); or (ii) Inconsistent with the analyses or descriptions in the SAR (as updated)."* **Assessment:** This section defines the "tests-not-described" with respect to the Safety Analysis Report (SAR). The definition is used (exclusively) in § 63.44(b)(1): *"(b)(1) DOE may make changes in the geologic repository operations area as described in the SAR (as updated), make changes in the procedures as described in the SAR (as updated), and conduct tests or experiments not described in the SAR (as updated), without obtaining either an amendment of construction authorization under § 63.33 or a license amendment under § 63.45, ..."* The Safety Analysis Report is directed in § 63.21(c)(17), "Content of application", to provide a description of the performance confirmation program. Hence, by inference, all performance confirmation tests are required to be described in the Safety Analysis Report. Further, this implies that the term, "tests-not-described," must exclude performance confirmation testing. **Compliance Approach:** The term, "tests or experiments not described in the SAR", shall not apply to performance confirmation program. A description of all performance confirmation tests shall be included in the LA (i.e., in the Safety Analysis Report), and be conducted as described.
Subpart B – Licenses License Issuance and Amendment § 63.44(c)(2)	**Requirement:** *"§ 63.44 Changes, tests, and experiments.* *(c)(2) No less frequently than every 24 months, DOE shall prepare a report containing a brief description of such changes, tests, and experiments, including a summary of the evaluation of each. DOE shall furnish the report to the appropriate NRC Regional Office shown in Appendix D of Part 20 of this chapter, with a copy to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Any report submitted under this paragraph must be made a part of the public record of the licensing proceedings."* **Assessment:** This section defines a requirement for all testing to provide a report of ongoing testing at least once every two years. Hence, all ongoing performance confirmation testing and monitoring are required to be described periodically, at a frequency of at least once every two years. **Compliance Approach:** A report on all on-going performance confirmation testing shall be prepared periodically, at least once every two years. Periodic reporting is indicated in Section 6.2 of the current *Performance Confirmation Plan*; the 24-month period will be explicitly indicated in the subsequent revision of the plan.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart B – Licenses Permanent Closure § 63.51(a)(1)	**Requirement:** *"§ 63.51 License amendment for permanent closure.* *(a) DOE shall submit an application to amend the license before permanent closure of a geologic repository at the Yucca Mountain site. The submission shall must consist of an update of the license application submitted under §§ 63.21 and 63.22, including:* *(1) An update of the assessment of the performance of the geologic repository for the period after permanent closure. The updated assessment must include any performance confirmation data collected under the program required by Subpart F, and pertinent to compliance with § 63.113."* **Assessment:** This requirement is directed at the application to amend the license to close the repository, and requires that all performance confirmation data relevant to postclosure performance (see § 63.113) will be included in the performance assessment for the application. This, in turn, implies that a report on performance confirmation data (relevant to postclosure performance) is required for the application, to provide a basis for the assessment. **Compliance Approach:** The performance assessment shall be updated for the application to amend the license to close the repository, and shall include all relevant performance confirmation data. The performance confirmation program shall issue a data report in support of this performance assessment for closure. The report shall be as indicated in Section 6.2.5 of the current *Performance Confirmation Plan.* The specific issuance of a report for the closure time-period will be included in the subsequent revision of the plan.
Subpart B – Licenses Permanent Closure § 63.51(a)(2)	**Requirement:** *"§ 63.51 License amendment for permanent closure.* *(a) DOE shall submit an application to amend the license before permanent closure of a geologic repository at the Yucca Mountain site. The submission must consist of an update of the license application submitted under §§ 63.21 and 63.22, including:* *(2) A description of the program for post-permanent closure monitoring of the geologic repository."* **Assessment:** This part defines the requirement for a description of a post-permanent closure monitoring program. This program does <u>not</u> include performance confirmation activities as it starts after closure and the termination of performance confirmation (see discussion of §§ 63.102(c) and 63.102(m) of the regulations, which define the performance confirmation period). However, the requirement does not preclude that the post-permanent closure monitoring program may extend some monitoring activities from the performance confirmation program into the postclosure time period. Therefore, the post-permanent closure monitoring program is not defined under the *Performance Confirmation Plan* but will be described in a separate plan to be prepared in support of the submittal for the license for closure, in accordance with the regulations. **Compliance Approach:** The scope of the performance confirmation program shall exclude the description of post-permanent closure monitoring. This separation of programs is illustrated in Figure 1-2 of the current *Performance Confirmation Plan* and included in the discussion of MGR testing on pages 1-8 to 1-10.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart D - Records, Reports, Tests, and Inspections § 63.74	**Requirement:** *"§ 63.74 Tests.* *(a) DOE shall perform, or permit the Commission to perform, those tests the Commission considers appropriate or necessary for the administration of the regulations in this part. This may include tests of --* *(1) Radioactive waste,* *(2) The geologic repository, including portions of the geologic setting and the structures, systems, and components constructed or placed therein,* *(3) Radiation detection and monitoring instruments, and* *(4) Other equipment and devices used in connection with the receipt, handling, or storage of radioactive waste.* *(b) The tests required under this section must include a performance confirmation program carried out in accordance with Subpart F."* **Assessment:** This is a system-level requirement for the MGR that the geologic repository will perform (and have the capability to support) various tests and test activities. The requirement includes performance confirmation tests per item (b), and some of these tests may be conducted by the NRC (the Commission), to be specified in the LA. It also specifies that the performance confirmation shall be conducted in accordance with Subpart F of the regulation. Note that the intent of the testing is not defined by this specific requirement, but is defined by other parts of the regulation. Also, the testing examples listed under item (a) represent the range of possible repository testing and are not directed to be performance confirmation tests. **Compliance Approach:** The geologic repository shall perform tests and have the capability to support tests and test activities, including performance confirmation tests. If the NRC indicates in the LA that it will conduct performance confirmation testing, performance confirmation activities shall support such testing. The performance confirmation program shall be carried out in accordance with Subpart F. Facilities to support performance confirmation testing are described in Section 5.4 and prescribed testing is briefly discussed in Section 3.4.4 of the current *Performance Confirmation Plan*. Subpart F of the regulation is part of the regulatory basis for performance confirmation as documented in Section 1.2.2 of the *Performance Confirmation Plan* and evaluated in Appendix E.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria § 63.102(c)	**Requirement:** *"§ 63.102 Concepts.* *This section provides a functional overview of this Subpart E. In the event of any inconsistency, the definitions in § 63.2 prevail.* *(c) Stages in the licensing process. There are several stages in the licensing process. The site characterization stage, when the performance confirmation program is started, ... Permanent closure represents the end of the performance confirmation program; ..."* **Assessment:** This section describes the repository phases and indicates the start of performance confirmation program (i.e., during site characterization) and the end (i.e., at closure). This description is consistent with Subpart F requirements in regard to the extent of performance confirmation. **Compliance Approach:** The performance confirmation program shall start during the site characterization stage and end at the start of closure operations, as documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan.*
Subpart E - Technical Criteria § 63.102(m)	**Requirement:** *"§ 63.102 Concepts.* *This section provides a functional overview of this Subpart E. In the event of any inconsistency, the definitions in § 63.2 prevail. ...* *(m) Performance confirmation. A performance confirmation program will be conducted to evaluate the adequacy of assumptions, data, and analyses that led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Key geotechnical and design parameters, including any interactions between natural and engineered systems and components, will be monitored throughout site characterization, construction, emplacement, and operation to identify any significant changes in the conditions assumed in the license application that may affect compliance with the performance objectives specified at §§ 63.113(b) and (c)."* **Assessment:** This section defines the requirement for the MGR to perform performance confirmation activities. This section also defines the term, performance confirmation, and indicates such activities are to be concerned with postclosure safety, as described in the performance objective at §§ 63.113(b) and 63.113(c). In addition, the text indicates that the confirmation program should support performance assessment, and therefore, focus on the items important to the postclosure performance as indicated by TSPA analyses. **Compliance Approach:** This definition shall be utilized in defining the performance confirmation program, indicating a primary focus on postclosure objectives. The definition is included in the program objectives on page 2-1 of the current *Performance Confirmation Plan* as directed to objective 113(b). Revision of the Plan shall incorporate the second objective, 113(c), and preclosure objectives as well, in accordance with § 63.2.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria Preclosure Performance Objectives § 63.111(a)(1)	**Requirement:** *"§ 63.111 Performance objectives for the geologic repository operations area through permanent closure. ...* *a) Protection against radiation exposures and releases of radioactive material.* *(1) The geologic repository operations area must meet the requirements of part 20 of this chapter."* **Assessment:** This is a system-level requirement for the MGR and applies to performance confirmation as well. This requirement directs that the performance confirmation program activities be conducted in a safe manner, specifically with respect to potential radiation hazards (considered in 10 CFR 20). To properly assess the hazard to personnel, a detailed layout of equipment and instrumentation is required as well specification of routine operations and maintenance. This information and associated protective measures and dose calculations will be included in the detailed planning documents for each test to demonstrate compliance with 10 CFR 20. Given the nature of the *Performance Confirmation Plan* as an upper-level planning document, the plan will not demonstrate compliance to this requirement. **Compliance Approach:** Detailed planning documents for each performance confirmation activity shall provide sufficient data to demonstrate that all tasks are to be conducted in a safe manner and in compliance with 10 CFR 20.
Subpart E - Technical Criteria Preclosure Performance Objectives § 63.111(a)(2)	**Requirement:** *"§ 63.111 Performance objectives for the geologic repository operations area through permanent closure. ...* *a) Protection against radiation exposures and releases of radioactive material.* *2) During normal operations, and for Category 1 event sequences, the annual TEDE (hereafter referred to as dose) to any real member of the public located beyond the boundary of the site may not exceed the preclosure standard specified at § 63.204."*[2] **Assessment:** This section identifies a preclosure performance objective to protect the public beyond the boundary of the site during both normal and abnormal (i.e., Category 1 events) conditions. § 204 prescribes the annual dose to the public shall not exceed 0.15 mSv at the bounds of the general environment (or conservatively, within the access-controlled government lands). To address this objective directly by performance confirmation activities (as directed by § 63.2), the air, surface waters and subsurface waters will be monitored at the boundary of the general environment (see § 63.202), as these are main means of radioactive release. **Compliance Approach:** Performance confirmation shall monitor air quality, surface water, and conduct well monitoring at the boundary of the general environment. Well monitoring around the repository is identified in Table 3-6 of the current *Performance Confirmation Plan*. Subsequent revision of the Plan shall incorporate air and surface water quality monitoring for radioactive materials from the repository.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria Preclosure Performance Objectives § 63.111(d)	**Requirement:** *"§ 63.111 Performance objectives for the geologic repository operations area through permanent closure. ...* *d) Performance confirmation. The geologic repository operations area must be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F."* **Assessment:** This section is a requirement for repository design to accommodate and include performance confirmation facilities and activities. In addition, the requirement implies that the design requirements of the repository will be based on *Performance Confirmation Plan* (as incorporated in appropriate system description documents). The requirement also indicates performance confirmation will address the regulations described in Subpart F. **Compliance Approach:** The geologic repository shall be designed to have the capability to support performance confirmation tests and test activities. Design requirements shall be based on the performance confirmation program, as documented in the *Performance Confirmation Plan.* The performance confirmation program shall meet the requirements of regulations in Subpart F, as documented in Appendix E of the current *Performance Confirmation Plan*.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria Preclosure Performance Objectives § 63.111(e)(1)	**Requirement:** *"§ 63.111 Performance objectives for the geologic repository operations area through permanent closure. ...* *(e) Retrievability of waste.* *1) The geologic repository operations area must be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area must be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program."* **Assessment:** This part identifies a preclosure performance objective to preserve the option of waste retrieval up to the time period approved by the NRC (with a default period of 50 years). It also indicates that performance confirmation will be completed prior to retrieval and implies that a report on performance confirmation data will be prepared at the completion of the performance confirmation program to be submitted to the NRC for review. To address this objective explicitly by performance confirmation activities (as indicated by § 63.2; see also 66 FR 55732 [Response to Comments, Section 2.3, Issue 1]), two key assumptions for retrieval will be confirmed: accessibility and equipment operability. This will involve (1) monitoring the stability of accessways to the emplacement drifts and drifts themselves, and (2) verifying that the equipment identified for retrieval can perform the operations as required. To confirm accessibility, the main accessways (i.e., the tunnels from the surface to emplacement drifts) and emplacement drifts will be periodically monitored and inspected for stability (especially at junctions of two or more tunnels) prior to closure. To confirm that equipment will work as required for both normal and off-normal conditions, a prototype facility will be constructed on the surface to test prototype equipment under repository-like conditions using remote controls. **Compliance Approach:** The performance confirmation program shall periodically monitor and inspect the stability of main accessways (especially at junctions of two or more tunnels) and emplacement drifts. The program shall also incorporate the testing of the prototype equipment for retrieval under repository-like conditions using remote controls. Subsequent revision of the *Performance Confirmation Plan* shall include this monitoring and prototype testing.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria Postclosure Performance Objectives §63.113(b)	**Requirement:** *"§ 63.113 Performance objectives for the geologic repository after permanent closure.* *(b) The engineered barrier system must be designed so that, working in combination with natural barriers, radiological exposures to the reasonably maximally exposed individual are within the limits specified at § 63.311 of Subpart L. Compliance with this paragraph must be demonstrated through a performance assessment that meets the requirements specified at § 63.114 of this subpart, and §§ 63.303, 63.305, 63.312 and 63.342 of Subpart L."* **Assessment:** This section defines a postclosure performance objective for the repository. The achievement of this objective will be based on performance assessment analyses of the total repository system as documented in the LA. § 63.311 stipulates that for 10,000 years following disposal, the reasonably maximally exposed individual (outside the controlled area, defined in §3.302) should not receive more than an annual dose of 0.15 mSv from releases from the undisturbed Yucca Mountain disposal system. To explicitly address this objective by performance confirmation (as indicated by §§ 63.2 and 63.102(m) of the regulation), testing and monitoring will be performed to confirm these analyses to the extent feasible during the preclosure period. Monitoring of releases will involve monitoring the waste packages in situ to verify containment at the source and the monitoring of the water quality of the uppermost aquifer at the boundary downgradient of the controlled area to provide additional assurance to the public. **Compliance Approach:** Total system performance assessment analyses shall document compliance with this performance measure, as document in the LA. To provide additional assurance during preclosure, performance confirmation shall monitor the in situ condition of waste packages (i.e., within emplacement drifts) and the quality of the aquifer at the boundary of the controlled area. Well monitoring around the repository is identified as a requirement in Table 3-6 and included as Test EM-01 in appendix G of the current *Performance Confirmation Plan*. In situ monitoring of the waste package condition is also identified in Table 3-6 as a requirement, and is included under Test PM-2 in appendix G.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart E - Technical Criteria Postclosure Performance Objectives § 63.113(c)	**Requirement:** *"§ 63.113 Performance objectives for the geologic repository after permanent closure.* *(c) The engineered barrier system must be designed so that, working in combination with natural barriers, releases of radionuclides into the accessible environment are within the limits specified at § 63.331 of Subpart L. Compliance with this paragraph must be demonstrated through a performance assessment that meets the requirements specified at § 63.114 of this subpart and §§ 63.303, 63.332 and 63.342 of Subpart L."* **Assessment:** This section defines a postclosure performance objective for the repository. The achievement of this objective will be based on performance assessment analyses of the total repository system as documented in the LA. § 63.331 stipulates that that there is a reasonable expectation that, for 10,000 years after disposal, releases of radionuclides into the accessible environment will not cause the level of radioactivity in the representative volume of ground water to exceed the limits defined in Table 1 (see § 63.331). To explicitly address this objective by performance confirmation (as indicated by §§ 63.2 and 63.102(m) of the regulation), monitoring will be conducted to monitor releases from the repository similar to the monitoring to comply with § 63.113(b). **Compliance Approach:** Total system performance assessment analyses shall document compliance with this performance measure, as document in the LA. To provide additional assurance during preclosure, performance confirmation shall monitor the in situ condition of waste packages and the quality of the aquifer at the boundary of the controlled area. Well monitoring around the repository is identified as a requirement in Table 3-6 and included as Test EM-01 in appendix G of the current *Performance Confirmation Plan*. In situ monitoring of the waste package condition is also identified in Table 3-6 as a requirement, and is included under Test PM-2 in appendix G.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.131(a)(1)	**Requirement:** *"§ 63.131 General requirements.* *(a) The performance confirmation program must provide data that indicate, where practicable, whether:* *(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and"* **Assessment:** This section specifies that performance confirmation activities must provide data on subsurface (geologic) conditions encountered during construction and operations, in order to confirm that these conditions are similar (i.e., within the limits assumed) to those in the licensing review[3]. This requires that performance confirmation include observations of the encountered subsurface (geologic) conditions of the repository horizon. This guidance also requires that performance confirmation provide data on the changes in these conditions which occur during construction and waste emplacement operations and verify that the changed values are also within the limits assumed in the licensing review. Such changes in conditions can occur due to the thermal loading induced by emplaced waste packages, due to construction-related activities (such as excavation and support installation) or lubricant spills. This requires that monitoring and observations are performed and that attendant records are maintained by the performance confirmation program during construction and waste emplacement operations of the repository in order to observe such changes. **Compliance Approach:** Observations of the encountered subsurface (geologic) conditions of the repository horizon shall be included in the performance confirmation program. To address this requirement, geologic observation of mining and mapping of excavations shall be performed during construction together with index laboratory testing of representative samples from these excavations. This requirement is included in test planning as documented in Table 3-6 the current *Performance Confirmation Plan*, and the mapping and testing of the subsurface is in included under Test Descriptions BD-01 and BD-02. Monitoring of changes in subsurface conditions shall be included in the performance confirmation program. Rock mass monitoring (temperature and displacement) near emplacement drifts shall be performed to monitor changes and address this requirement. This requirement is included in test planning as documented in Table 3-6 the *Performance Confirmation Plan* and the rock mass monitoring is in included under Test Description PM-05. The performance confirmation program shall maintain records of observations during construction and waste emplacement operations of the repository in order to observe the extent and magnitude of such changes. This is documented in Section 6.1.2 of the current *Performance Confirmation Plan*.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program §63.131(a)(2)	**Requirement:** *"§ 63.131 General requirements.* *(a) The performance confirmation program must provide data that indicate, where practicable, whether: ...* *(2) Natural and engineered systems and components required for repository operation, and that are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated."* **Assessment:** This requirement specifies that the performance confirmation program shall conduct analyses and monitoring (as appropriate) of the elements of the repository barrier in order to confirm that these elements are functioning as intended and anticipated. In this context, elements are systems, subsystems, or components of the repository that are intended to function as geologic and engineered barriers after closure. At a minimum, this requirement stipulates that the performance confirmation program monitor the engineered and natural barrier systems after waste emplacement. To demonstrate that that these systems are functioning as intended and anticipated will require a performance confirmation baseline to define the expected response of the systems/components as it varies with time and repository construction and operation. As part of this monitoring, consideration of probable disruptive processes and events must also be considered. To provide a basis for assessment, monitoring of potential indicators of disruptive processes and events are implied by the regulation. Indicators of potential disruptive processes and events may include subsurface seismicity, surface uplift above the facility and changes in water level and temperature of monitoring wells. **Compliance Approach:** The performance confirmation program shall monitor (after waste emplacement) the geologic and engineered systems that are important to postclosure performance. This objective shall be included within the scope and design of the performance confirmation program and is documented in the current *Performance Confirmation Plan* in Section 2.1.1. Some disruptive event monitoring shall be performed as part of performance confirmation. The current performance confirmation program (as documented in *Performance Confirmation Plan)* includes monitoring of subsurface seismicity, surface uplift above the facility and changes in water level and temperature of monitoring wells (see Test Descriptions DE-01 to DE-03).
Subpart F-Performance Confirmation Program § 63.131(b)	**Requirement:** *"§ 63.131 General requirements.* *(b) The program must have been started during site characterization, and it will continue until permanent closure."* **Assessment:** As stated in § 63.102(c), this requirement specifies the duration of the performance confirmation program. It stipulates that a portion of the program should be started in the initial stage of the MGR (i.e., prior to completion of site characterization), and extends up to the start of closure. This requirement will therefore have an impact on duration and cost associated with the performance confirmation program. **Compliance Approach:** The performance confirmation program shall start during the site characterization and end at the start of closure operations as documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.131(c)	**Requirement:** *"§ 63.131 General requirements.* *(c) The program must include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to provide the data required by paragraph (a) of this section."* **Assessment:** This requirement identifies the range of techniques to be used in the performance confirmation program. These techniques will be used as appropriate in meeting the objectives of the program and requirements (a) of this section. **Compliance Approach:** In situ monitoring, laboratory and field testing, and in situ experiments shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 5.3.
Subpart F-Performance Confirmation Program § 63.131(d)(1)	**Requirement:** *"§ 63.131 General requirements.* *(d) The program must be implemented so that:* *(1) It does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives."* **Assessment:** This requirement constrains the performance confirmation program to not adversely affect the ability of the repository (in particular, the natural or geologic elements) to isolate waste as a result of installing or performing field testing and in situ experiments for performance confirmation. This consideration has been incorporated into the planning of each test documented in the *Performance Confirmation Plan.* In addition, this requirement is to be formally addressed by conducting determination of importance evaluation analyses for each field test; such analyses are currently being performed for all field and in situ activities (see NLP-2-0). These analyses assess the impact on the geologic and engineered systems of a specific activity to assure that an activity does not impact repository performance. **Compliance Approach:** Considerations for not impacting the geologic and engineered elements of the geologic repository shall be included in all design efforts for performance confirmation. Consideration has been incorporated into the planning of each test documented in the *Performance Confirmation Plan.* In addition, conceptual test plans (as documented in the current *Performance Confirmation Plan* in Appendix G) will provide a basis of initial review by NRC for consideration of impact. Determination of importance evaluation analyses shall be performed for each performance confirmation field test during the detailed test planning to demonstrate that the activity does not adversely affect the ability of the geologic and engineered elements of the geologic repository to meet the performance objectives.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.131(d)(2)	**Requirement:** *"§ 63.131 General requirements.* *(d) The program must be implemented so that: ...* *(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities."* **Assessment:** This regulation requires that a baseline be established for processes and parameters that are expected to change and that will be measured as part of performance confirmation. This baseline shall identify the expected data values before confirmatory testing/monitoring begins. The form of this baseline will typically consist of parameter values and limits obtained during Site Characterization, together with an expected value predictions for the parameter along with tolerances (bounds) to address expected variation in the prediction of the parameter. **Compliance Approach:** The baseline concept shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 4.2.
Subpart F-Performance Confirmation Program § 63.131(d)(3)	**Requirement:** *"§ 63.131 General requirements.* *(d) The program must be implemented so that: ...* *(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository."* **Assessment:** This regulation requires that performance confirmation data be compared to the baseline predictions during testing and monitoring to observe any data outside the tolerances established as part of the baseline condition. This requires (by inference) that performance confirmation data be accumulated, stored, and evaluated periodically to detect out-of-tolerance data. Observed data significantly outside the baseline tolerances (termed a "variance") shall, by inference, be reported to the NRC (see § 63.132 (a)). **Compliance Approach:** Data shall be accumulated, stored, and evaluated periodically to detect variances as part of the performance confirmation program; the process is documented in the *Performance Confirmation Plan* as part of the concept of operations in Sections 2.1.2 and 2.1.7.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.132(a)	**Requirement:** *"§ 63.132 Confirmation of geotechnical and design parameters.* *(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping must be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of design changes needed to accommodate actual field conditions encountered."* **Assessment:** Along with §§ 63.102(c) and 63.131(b), this requirement specifies the time phasing of the performance confirmation program. It states that a portion of the program should be included in the construction and operational stages of the MGR. The text also stipulates that geotechnical (i.e., the mechanical properties of the rock) and design parameters that are of importance to performance (and thereby are employed in performance assessment analyses) shall be confirmed by a continuing program as appropriate to the parameter and expected changes in the parameter. In addition, this section also requires that the performance confirmation program identify a process to notify the NRC in the event that a data variance necessitates a change in design. **Compliance Approach:** The performance confirmation program shall be conducted during repository construction and operation (as documented in *Performance Confirmation Plan).* This is documented in Figure 1-1 and in Figures 2-4 and 2-5 of the current *Performance Confirmation Plan*. The performance confirmation program shall conduct surveillance, measurement, and testing of geotechnical and design parameters as documented in the *Performance Confirmation Plan.* To address this requirement, geologic observation of mining and mapping of excavations shall be performed together with index laboratory testing of representative samples from these excavations (also specified in § 63.131(a)(1)). This requirement is included in Table 3-6 of the current *Performance Confirmation Plan* and geologic mapping, observations and index testing is part of the test program in Appendix G (e.g., see test descriptions BD-01, BD-02, PM-05). The general process of notifying the NRC when variances occur shall be included in the operations of the performance confirmation program. The concept of operations for the performance confirmation program is included in Section 2.1.2 and 2.1.7 of the current *Performance Confirmation Plan* and reporting of results to the NRC is documented in Section 6.2.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.132(b)	**Requirement:** *"§ 63.132 Confirmation of geotechnical and design parameters.* *(b) Subsurface conditions must be monitored and evaluated against design assumptions."* **Assessment:** As per § 63.131(a), this requirement specifies that subsurface conditions are monitored but also requires that obtained subsurface (geologic) data be compared against design assumptions important to performance, implying the use of a baseline as indicated by § 63.131(d)(3)). **Compliance Approach:** Monitoring of changes in subsurface conditions shall be included in the performance confirmation program, as documented in the *Performance Confirmation Plan.* Data will be evaluated against design assumptions, which shall be included in the relevant parameter performance confirmation baseline. To address this requirement, rock mass monitoring (temperature and displacement) near emplacement drifts is included in test descriptions in Appendix G (test description PM-05) of the *Performance Confirmation Plan,* and the requirement is included in Table 3-6.
Subpart F-Performance Confirmation Program § 63.132(c)	**Requirement:** *"§ 63.132 Confirmation of geotechnical and design parameters.* *(c) Specific geotechnical and design parameters to be measured or observed, including any interactions between natural and engineered systems and components, must be identified in the performance confirmation plan."* **Assessment:** This requirement specifies that all geotechnical or design parameters (including parameter interactions) measured for performance confirmation be identified in the performance confirmation plan. This requirement implies that prior to the LA, the parameters and tests to confirm repository performance will be identified and the associated program will be described in the performance confirmation plan and in the LA (see § 63.21(c)(17)). To correctly focus this process, activities are to be selected based on their importance to repository performance. **Compliance Approach:** Parameters to be measured and monitored by performance confirmation program shall be identified in the performance confirmation plan, and activities shall be included in the program based on their importance to repository performance. The process to identify key performance confirmation parameters is described in Section 3.4.5 and specific parameters for each process are described in Appendix G of the current *Performance Confirmation Plan*. Activities important to performance are discussed in Section 3.4.2.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final[1] 10 CFR 63	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.132(d)	**Requirement:** *"§ 63.132 Confirmation of geotechnical and design parameters.* *(d) These measurements and observations must be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods must be determined and these differences, their significance to repository performance, and the recommended changes reported to the Commission."* **Assessment:** This requirement, as that in § 63.131(d), stipulates the process of comparing obtained data to a performance confirmation baseline described earlier. Again, if variances (i.e., data outside baseline tolerances) are indicated, the variances shall be evaluated, and the impact to design or construction shall be assessed. The occurrence of the variation and recommendations as a result of these variance assessments will be reported to the NRC. **Compliance Approach:** The baseline concept shall be utilized (as appropriate) in the design of the performance confirmation program. This is documented in the current *Performance Confirmation Plan* in Section 4.2. Comparisons of data to predictions and recommendations to address variances shall be provided to the NRC as part of the performance confirmation program. This is documented in Sections 6.1.3, 6.1.4 and 6.1.8 of the current *Performance Confirmation Plan*.
Subpart F-Performance Confirmation Program § 63.132(e)	**Requirement:** *"§ 63.132 Confirmation of geotechnical and design parameters.* *(e) In situ monitoring of the thermomechanical response of the underground facility must be conducted until permanent closure, to ensure that the performance of the geologic and engineering features is within design limits."* **Assessment:** Along with §§ 63.102(c) and 63.131(b), this requirement specifies the duration and possibly the extent of the performance confirmation program by directing that performance confirmation monitoring of the thermomechanical response of the underground facility be conducted until the start of permanent closure. Such monitoring is also required to start during construction as per 132(a), defining a period of surveillance for geotechnical monitoring. **Compliance Approach:** Thermomechanical response of the underground facility shall be conducted as part of the performance confirmation until the start of permanent closure. Rock mass monitoring (including thermomechanical response) is included as part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see Test PM-05 in Appendix G). Measurement of rock mass response is also identified as a prescribed test activity in Table 3-6.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.133(a)	**Requirement:** *"§ 63.133 Design testing.* *(a) During the early or developmental stages of construction, a program for testing of engineered systems and components used in the design, such as, for example, borehole and shaft seals, backfill, and drip shields, as well as the thermal interaction effects of the waste packages, backfill, drip shields, rock, and unsaturated zone and saturated zone water, must be conducted."* **Assessment:** This directive requires that testing of engineering systems be conducted. As defined, these design features may include seals, backfill, drip shields and the interaction of engineered and natural components (rock and water) within the engineered barrier system area. It also places a constraint on the timing of this testing, requiring that this testing be conducted during the "early stages" of construction. This list of features includes (by inference) other barriers to be employed within the engineered barrier system, such as the invert and capillary barriers (if employed), as included in the LA design. Presently, backfill is not included in the repository design, and therefore backfill testing, while suggested, will not be performed. **Compliance Approach:** Performance and constructability testing of borehole, ramp and shaft seals shall be conducted as part of performance confirmation as well as the corrosion testing of drip shield materials. Seal testing is part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see Test EB-01 and EB-02 in Appendix G). Seal testing is also identified as a prescribed test activity in Table 3-6. Engineered barrier system interaction response of waste packages, rock, and water shall be conducted. This testing of coupled processes is included as part of the postclosure simulation test as documented in the current *Performance Confirmation Plan* (see Test PS-01 in Appendix G). This testing is also identified as a prescribed test activity in Table 3-6. Test of drip shield and waste package materials is included in the current *Performance Confirmation Plan* (in Appendix G under test description PM-03, Long-Term Materials Testing). The placement of drip shields shall be included as part of the postclosure simulation testing (Test PS-01 in Appendix G).
Subpart F-Performance Confirmation Program § 63.133(b)	**Requirement:** *"§ 63.133 Design testing.* *(b) The testing must be initiated as early as practicable."* **Assessment:** Together with § 63.133(a), which states that requires testing in the early (developmental) stages of construction, this section directs that performance confirmation program-related design testing be initiated as soon as practicable. **Compliance Approach:** The performance confirmation program shall initiate design testing as soon as practicable. The requirement is included in the design considerations in the performance confirmation program, and the schedule for seal and postclosure simulation testing is documented in the current *Performance Confirmation Plan* (see Figures 2-3 and 2-4).

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.133(c)	**Requirement:** *"§ 63.133 Design testing.* *(c) If backfill is included in the repository design, a test must be conducted to evaluate the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun."* **Assessment:** This regulation requires that if backfilling of the emplacement drifts is part of the repository license design, that a backfill test section be constructed and tested. The section is to test the effectiveness of backfill construction process. At present, backfill will not be employed in the license design (Dyer 2000) and therefore this requirement does not apply at present to performance confirmation. If backfill were employed, a surface demonstration emplacement drift facility to conduct such a constructability test could be developed to address this requirement. The "effectiveness" of the construction process in this context is understood to be the ability to construct the backfill according to design specifications. **Compliance Approach:** The requirement is not applicable to the present repository design (e.g., see Appendix D) and no performance confirmation activity is identified.
Subpart F-Performance Confirmation Program § 63.133(d)	**Requirement:** *"§ 63.133 Design testing.* *(d) Tests must be conducted to evaluate the effectiveness of borehole, shaft, and ramp seals before full-scale operation proceeds to seal boreholes, shafts, and ramps."* **Assessment:** The requirement directs that tests be conducted to evaluate various seals (testing which is part of § 63.133(a)) prior to actual sealing operations (i.e., prior to closure for shafts and ramps). By inference, this requirement also requires that repository design allow space for these tests and accommodate the objective and timing of such testing. **Compliance Approach:** The design of the repository shall accommodate testing of various seals for performance confirmation. Performance confirmation program shall include the testing of borehole, shaft, and ramp seals to evaluate effectiveness, prior to actual sealing operations. For performance confirmation, in situ testing of various seals is included in the current *Performance Confirmation Plan* (see Appendix G, descriptions for tests EB-01 and EB-02) and is identified as a prescribed test activity in Table 3-6.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.134(a)	**Requirement:** *"§ 63.134 Monitoring and testing waste packages.* *(a) A program must be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste packages chosen for the program must be representative of those to be emplaced in the underground facility."* **Assessment:** This regulation requires that a program be planned and conducted to monitor the condition of waste packages. As indicated in § 63.134(c), the phrase "monitoring the condition of the waste packages" in this context is used broadly, and includes laboratory testing as well as inspection of emplaced packages. The waste packages and materials are required to be representative of the waste packages emplaced within the repository. **Compliance Approach:** In situ waste package monitoring (and associated laboratory testing) shall be conducted of representative waste packages and materials. In-drift waste package monitoring is included as part of the performance confirmation program as documented in the current *Performance Confirmation Plan* (see test description PM-06 in Appendix G). In situ waste package monitoring is also identified as a prescribed test activity in Table 3-6.
Subpart F-Performance Confirmation Program § 63.134(b)	**Requirement:** *"§ 63.134 Monitoring and testing waste packages.* *(b) Consistent with safe operation at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program must be representative of the environment in which the wastes are to be emplaced."* **Assessment:** This section requires that for the monitoring program established under § 63.134(a), the monitoring environment shall be representative of the in situ emplacement drifts and reflect the real emplacement conditions. The present operations approach for performance confirmation is to periodically monitor all packages within emplacement drifts, thereby addressing the requirement. **Compliance Approach:** The monitoring environment for in situ waste package monitoring shall be representative of the in situ emplacement drifts. In situ waste package monitoring is planned for all waste packages as part of the performance confirmation program and documented in the current *Performance Confirmation Plan* (see PM-06 in Appendix G). The in situ monitoring of waste packages at a representative environment is prescribed in Table 3-6.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart F-Performance Confirmation Program § 63.134(c)	**Requirement:** *"§ 63.134 Monitoring and testing waste packages.* *(c) The waste package monitoring program must include laboratory experiments that 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 must be duplicated in the laboratory experiments."* **Assessment:** This section stipulates that laboratory tests be performed on the internal materials of the waste package, and on the waste form, as part of the program established under § 63.134(a). It requires that the test environment for this lab testing shall be representative of the conditions within the emplacement drifts during the monitoring program (i.e., during the preclosure period). **Compliance Approach:** Laboratory investigations of internal waste package material testing shall be performed at representative conditions as part of the performance confirmation program. Waste package lab testing is included in the current *Performance Confirmation Plan* (see PM-03 in Appendix G) and is also prescribed in Table 3-6.
Subpart F-Performance Confirmation Program § 63.134(d)	**Requirement:** *"§ 63.134 Monitoring and testing waste packages.* *(d) The waste package monitoring program must continue as long as practical up to the time of permanent closure."* **Assessment:** This requirement is to monitor and test waste packages and materials as long as practicable up to the time of permanent closure as part of performance confirmation, consistent with §§ 63.102(c) and 63.131(b). **Compliance Approach:** The monitoring and testing waste packages and materials shall be performed as part of the performance confirmation program as long as practicable, until the end of the performance confirmation program (i.e., to the start of closure). This requirement is included in the design of the performance confirmation program, and the schedule for waste package monitoring and testing is documented in the current *Performance Confirmation Plan* (see Figures 2-3 to 2-5 as included under process monitoring).

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart G - Quality Assurance § 63.142(a)	**Requirement:** *"§ 63.142 Quality assurance criteria.* *(a) Introduction and Applicability. DOE is required by § 63.21(c)(20) to include a description of the quality assurance program to be applied to all structures, systems, and components important to safety, to design and characterization of barriers important to waste isolation, and to related activities in its safety analysis report. These activities include: ... performance confirmation ... "* **Assessment:** This requirement dictates that the LA (specifically, the Safety Analysis Report addressed by § 63.21) must include a description of the quality assurance program as applicable to performance confirmation. By inference, performance confirmation activities will be conducted in accordance with quality assurance requirements applicable to the program. **Compliance Approach:** Quality assurance shall be applied to performance confirmation. Performance confirmation activities will be conducted in accordance with applicable quality assurance requirements as documented in Sections 1.1.6 and 2.3 of the *Performance Confirmation Plan* and indicated under step 6 of the performance confirmation process (page2-3).
Subpart K – Preclosure Public Health and Environmental Standards § 63.204	**Requirement:** *"§ 63.204 Preclosure standard.* *DOE must ensure that no member of the public in the general environment receives more than an annual dose of 0.15 mSv (15 mrem) from the combination of:* *(a) Management and storage (as defined in 40 CFR 191.2) of radioactive material that:* *(1) Is subject to 40 CFR 191.3(a); and* *(2) Occurs outside of the Yucca Mountain repository but within the Yucca Mountain site; and* *(b) Storage (as defined in § 63.202) of radioactive material inside the Yucca Mountain repository.* - from § 63.202: *General environment means everywhere outside the Yucca Mountain site, the Nellis Air Force Range, and the Nevada Test Site.* *Storage means retention (and any associated activity, operation, or process necessary to carry out successful retention) of radioactive material with the intent or capability to readily access or retrieve such material."* **Assessment:** This standard is referenced by § 63.111(a)(2), which is a preclosure objective to be addressed by performance confirmation. It prescribes that the annual dose to the public shall not exceed 0.15 mSv at the bounds of the "general environment" (defined in § 63.202) from subsurface and surface operations at the site. As applicable to performance confirmation, the requirement prescribes a bound of performance that will be included in the baseline and addressed by measurement specifics of the program. Detail test plans for performance confirmation (which will include measurement specifics) will document compliance to this regulation; compliance to this requirement is not provided in the *Performance Confirmation Plan.* **Compliance Approach:** This standard shall be used in addressing § 63.111(a)(2) for performance confirmation, and shall be included in detailed test plans as a bounding condition.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

Final 10 CFR 63[1]	Requirement Statement and Assessment
Subpart L – Postclosure Public Health and Environmental Standards Postclosure Individual Protection Standard § 63.311	**Requirement:** *"§ 63.311 Individual protection standard after permanent closure.* *DOE must demonstrate, using performance assessment, that there is a reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) from releases from the undisturbed Yucca Mountain disposal system. DOE's analysis must include all potential pathways of radionuclide transport and exposure."* - from § 63.312 (Required characteristics of the reasonably maximally exposed individual): *The reasonably maximally exposed individual is a hypothetical person who meets the following criteria:* *(a) Lives in the accessible environment above the highest concentration of radionuclides in the plume of contamination …* - from § 63.302 (Definitions for Subpart L): *Accessible environment means any point outside of the controlled area, …* *Controlled area means* *(1) The surface area, identified by passive institutional controls, that encompasses no more than 300 square kilometers. It must not extend farther:* *(i) South than 36° 40' 13.6661" north latitude, in the predominant direction of ground-water flow; and* *(ii) Than five kilometers from the repository footprint in any other direction; and* *(2) The subsurface underlying the surface area."* **Assessment:** This standard is referenced by § 63.113(b), which is a postclosure objective to be addressed by performance confirmation. The requirement prescribes that the annual dose to the public (i.e., a reasonably maximally exposed individual) from releases from the subsurface storage shall not exceed 0.15 mSv at the boundary of the controlled area (i.e., in the accessible environment) for 10,000 years. The controlled area is defined under § 63.302. For performance confirmation, the requirement provides a bound of performance that will be included in the baseline and addressed by measurement specifics. Detail test plans for performance confirmation (which will include measurement specifics) will document compliance to this regulation; compliance to this requirement is not provided in the *Performance Confirmation Plan*. **Compliance Approach:** This standard shall be used in addressing § 63.113(b) for performance confirmation, and shall be included in detailed test plans as a bounding condition at the boundary of the controlled area.

Table E-4. Performance Confirmation Requirements Based on Final 10 CFR 63 (Continued)

<table>
<tr><th>Final 10 CFR 63[1]</th><th>Requirement Statement and Assessment</th></tr>
<tr><td>Subpart L – Postclosure Public Health and Environmental Standards

Ground-Water Protection Standards

§ 63.331</td><td>
Requirement:

"§ 63.331 Separate standards for protection of ground water.

DOE must demonstrate that there is a reasonable expectation that, for 10,000 years of undisturbed performance after disposal, releases of radionuclides from waste in the Yucca Mountain disposal system into the accessible environment will not cause the level of radioactivity in the representative volume of ground water to exceed the limits in the following Table 1:

Table 1. Limits on radionuclides in the representative volume.
<table>
<tr><th>Radionuclide or type of radiation emitted</th><th>Limit</th><th>Is natural background included?</th></tr>
<tr><td>Combined radium-226 and radium-228</td><td>5 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Gross alpha activity (including radium-226 but excluding radon and uranium)</td><td>15 picocuries per liter</td><td>Yes</td></tr>
<tr><td>Combined beta and photon emitting radionuclides</td><td>0.04 mSv (4 mrem) per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume</td><td>No</td></tr>
</table>
Assessment:

This standard is referenced by § 63.113(c), which is a postclosure objective to be addressed by performance confirmation. It provides specific limits of radioactivity as described in Table 1.

For performance confirmation, the requirement provides a bound of performance that will be included in the baseline and addressed by measurement specifics. Detail test plans (which will include measurement specifics) will document compliance to this regulation; compliance to this requirement is not provided in the Performance Confirmation Plan.

Compliance Approach:

This standard shall be used in addressing § 63.113(c) for performance confirmation, and shall be included in detailed test plans as a bounding condition.
</td></tr>
</table>

NOTES: [1] As provided in 10 CFR 63 (66 FR 55732).

[2] For this table, total effective dose equivalent (TEDE) is defined, for purposes of assessing doses to workers, as the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). For purposes of assessing doses to members of the public (including the reasonably maximally exposed individual, or RMEI), TEDE is defined as the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

[3] In this context, licensing review assumptions are understood to be documented in the LA document, the associated TSPA computation report(s), and other appropriate documents submitted to the NRC as part of the license review process.

APPENDIX F

DESCRIPTION OF MONITORED GEOLOGIC REPOSITORY TEST AND EVALUATION PROGRAM PHASES

APPENDIX F

DESCRIPTION OF MONITORED GEOLOGIC REPOSITORY TEST AND EVALUATION PROGRAM PHASES

The *Monitored Geologic Repository Test and Evaluation Plan* (Skorska 2001) can conceptually be subdivided into major functional test categories. The test categories are described briefly as follows:

- **Site Characterization Testing**–means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of the site and the surrounding region to the extent necessary to determine the suitability of the site for a geologic repository. Site characterization activities can include borings, surface excavations, excavation of exploratory shafts and/or ramps, limited subsurface lateral excavations and borings, and in situ testing at depth.

- **Development Testing**–is to support design development and integration. Development testing includes design evaluation, proof of concept, and baseline performance confirmation activities. Design evaluation assists the design efforts in evaluating alternative design concepts or technologies and to obtain information needed to establish predictive models for the engineered systems. Proof of concept prototype testing follows the design evaluation test activities and precedes the release of final design packages. This testing is performed to examine (a) new technologies or design solutions that have little history of use, (b) technologies or design solutions that have not been subjected to a test program qualified by the NRC, and (c) complex systems that may introduce schedule risk during installation and integration activities. Baseline performance confirmation activities include the predictive and bounding analyses (as well as associated testing and monitoring data) to establish a baseline for performance confirmation activities.

- **Component Testing**–verifies that an engineered component is designed, manufactured, installed as specified, and is operational. This activity includes planning, conducting and documenting qualification testing, acceptance testing, and installation and checkout testing.

- **Pre-Operational & Startup Testing**–evaluates MGR compliance with design and its impact on the environment during operations. This test phase will begin during repository construction and includes test activities for system, integration, mockup, and operational startup testing.

  System testing is conducted during repository construction to ensure that facilities and SSCs needed for startup activities are complete and component test results are acceptable. These system tests verify safety requirements and system operations for both surface and subsurface facilities.

Integration testing of facilities will begin after the successful completion of system testing of the major facilities. Integration testing will (a) operate new equipment to detect and correct any design, manufacturing, or installation defects before startup activities, and (b) provide baseline test and operating data on SSCs for future reference. Integration test activities include instrumentation and control, Design Basis Event recovery, and integrated cold startup testing.

Mockup testing involves simulation or demonstration activities with operational realism. This testing activity will serve to maximize test program effectiveness and minimize cost and schedule impacts by providing alternative test bed support to pre-operational and operational activities, such as: training, procedure/plan development, schedule integration, SSCs verification, and anomaly resolution.

Operational ("hot") startup testing begins after a license to receive and possess waste is obtained, and will verify that operation and maintenance systems work properly and will confirm that personnel radiation exposure and radiation levels fall within acceptable regulatory limits during actual repository operations.

- **Periodic Performance Testing and Monitoring**–During operation and monitoring phases of the repository (and starting with the receipt of waste), periodic performance testing and repository operational area monitoring will be conducted to ensure continued license operations and to ensure safe working conditions. Performance and surveillance testing will verify that system performance continues to comply with preclosure requirements and ensures continued proper functioning of SSCs important to radiological safety, waste isolation, fire protection, non-nuclear safety, and repository operations. In addition, environmental monitoring will be conducted to monitor the surface and subsurface environments to ensure safe working conditions and to document the continuing compliance with existing regulatory standards for air, water, and radiological conditions at the site.

Also included in this category is the post-emplacement studies and development testing conducted to provide an opportunity to further evaluate the potential for additional defense-in-depth performance, and to continue evaluation of natural analogues to increase certainty and confidence in licensing models and very long-term postclosure predictions.

- **Core Performance Confirmation Testing**–is a category of testing, monitoring, and analyses conducted for the sole purpose of performance confirmation. It focuses on post-emplacement monitoring of processes and conditions important to postclosure safety, and is divided into two general areas: process confirmation and postclosure simulation. Process confirmation is the set of monitoring and test activities to directly assess the preclosure response of systems and processes that are important to postclosure safety. Postclosure simulation testing focuses on the critical interfaces between the natural and engineered system by simulating the in-pillar and in-drift postclosure conditions as a means to evaluate conditions, processes, and environments important to postclosure safety.

- **Post Permanent Closure Monitoring**–includes those monitoring activities conducted after repository closure. The specific aspects of the post-permanent closure monitoring program are to be defined in the future, and would be described in detail in the license amendment submitted to obtain authorization to close a repository facility. Deferring the detailed definition of this program to just prior to the closure period would allow for the use of data from the PC program. It would also allow the identification of the appropriate sensing technology for the program, including technology that may not be currently available. By regulatory definition, this monitoring effort is not within the scope of the performance confirmation program.

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APPENDIX G

PRELIMINARY TEST DESCRIPTIONS

APPENDIX G

PRELIMINARY TEST DESCRIPTIONS

PRELIMINARY TEST IDENTIFICATION

This section provides preliminary test descriptions for the factors identified in Section 3, consistent with the test concepts discussed in Section 4. The descriptions are organized per test category as discussed earlier, and each has been assigned a "test number," as shown in Table G-1. The test numbers are generated using a 2-letter identifier based on the performance confirmation test element, together with a 2-digit sequential number. For example, testing for process monitoring is identified as PM-01, PM-02, etc.

The test and monitoring activities are also illustrated in Figures G-1 and G-2 by test category. Conceptually, each listing represents a set of activities to conduct the test description. For each listing, the following activities are to be performed as appropriate:

- Planning
- Baseline development
- Procurement of instruments and equipment
- Construction of facilities
- Installation of instrumentation and data acquisition systems
- Initial checkout
- Baselining of ambient response
- Monitoring and testing
- Data acquisition
- Data reporting and data evaluation.

Support facilities will be needed to conduct the performance confirmation program, and are tentatively identified in Figure G-3.

The testing identified in this section is for performance confirmation purposes only, and other test activities are described in the *Monitored Geologic Repository Test and Evaluation Plan* (Skorska 2001). These test activities are expected to be modified to some degree as the governing regulations are finalized and repository design is developed further. Therefore, tests identified in the present version of the *Performance Confirmation Plan* are considered to be preliminary.

Table G-1. Identified Performance Confirmation Testing and Monitoring Activities

Test Category	Test Element	Test Number	Performance Confirmation Description
Core Performance Confirmation	Process Monitoring	PM-01	Seepage Monitoring
		PM-02	In Situ Waste Package Monitoring
		PM-03	Long-Term Materials Testing
		PM-04	Ventilation Monitoring
		PM-05	Rock Mass Monitoring
		PM-06	In-Drift Monitoring
		PM-07	Introduced Materials Monitoring
		PM-08	Recovered Material Coupon Testing
		PM-09	Dummy Waste Package Testing
		PM-10	Recovered Waste Package Testing
	Postclosure Simulation	PS-01	Postclosure Simulation Testing
Development Testing	Baseline Development	BD-01	Geologic Observations and Mapping
		BD-02	Subsurface Sampling and Index Testing
		BD-03	Baseline Analyses and Evaluations [1]
	Pre-Emplacement Testing	PE-01	UZ Testing
		PE-02	Near-Field Environment Testing
		PE-03	Waste Form Testing
		PE-04	Waste Package Testing
Prototype Testing	EBS[2] Testing and Verification	EB-01	Borehole Seal Testing
		EB-02	Ramp and Shaft Seal Testing
Technical Specifications and Monitoring	Environmental Monitoring	EM-01	Groundwater Quality Monitoring
	Disruptive Event Monitoring	DE-01	Groundwater Level and Temperature Monitoring
		DE-02	Surface Uplift Monitoring
		DE-03	Subsurface Seismic Monitoring

NOTES: [1] This activity supports all other performance confirmation activities and is included for completeness.

[2] EBS (engineered barrier system).

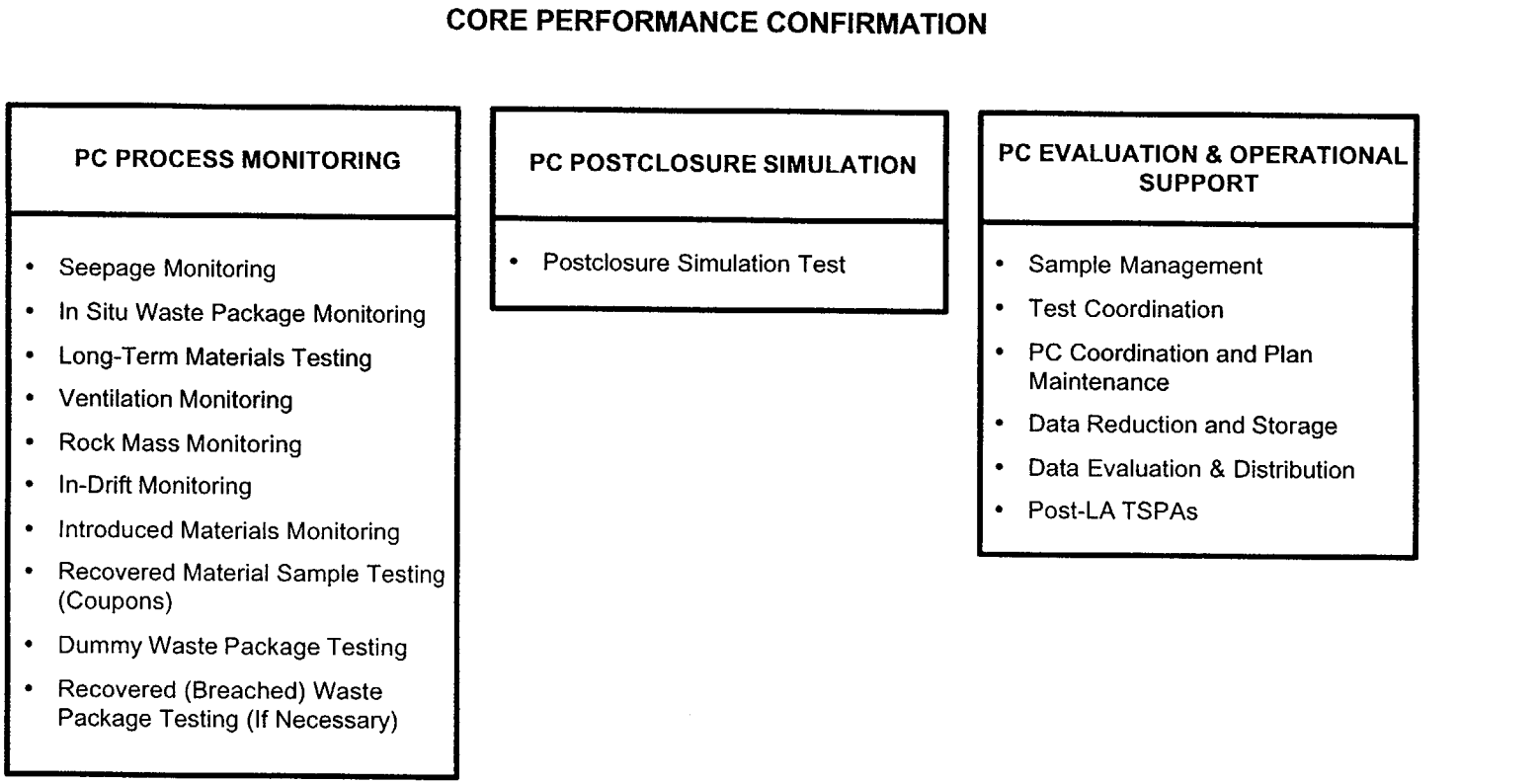

Figure G-1. Testing Activities Under Core Performance Confirmation

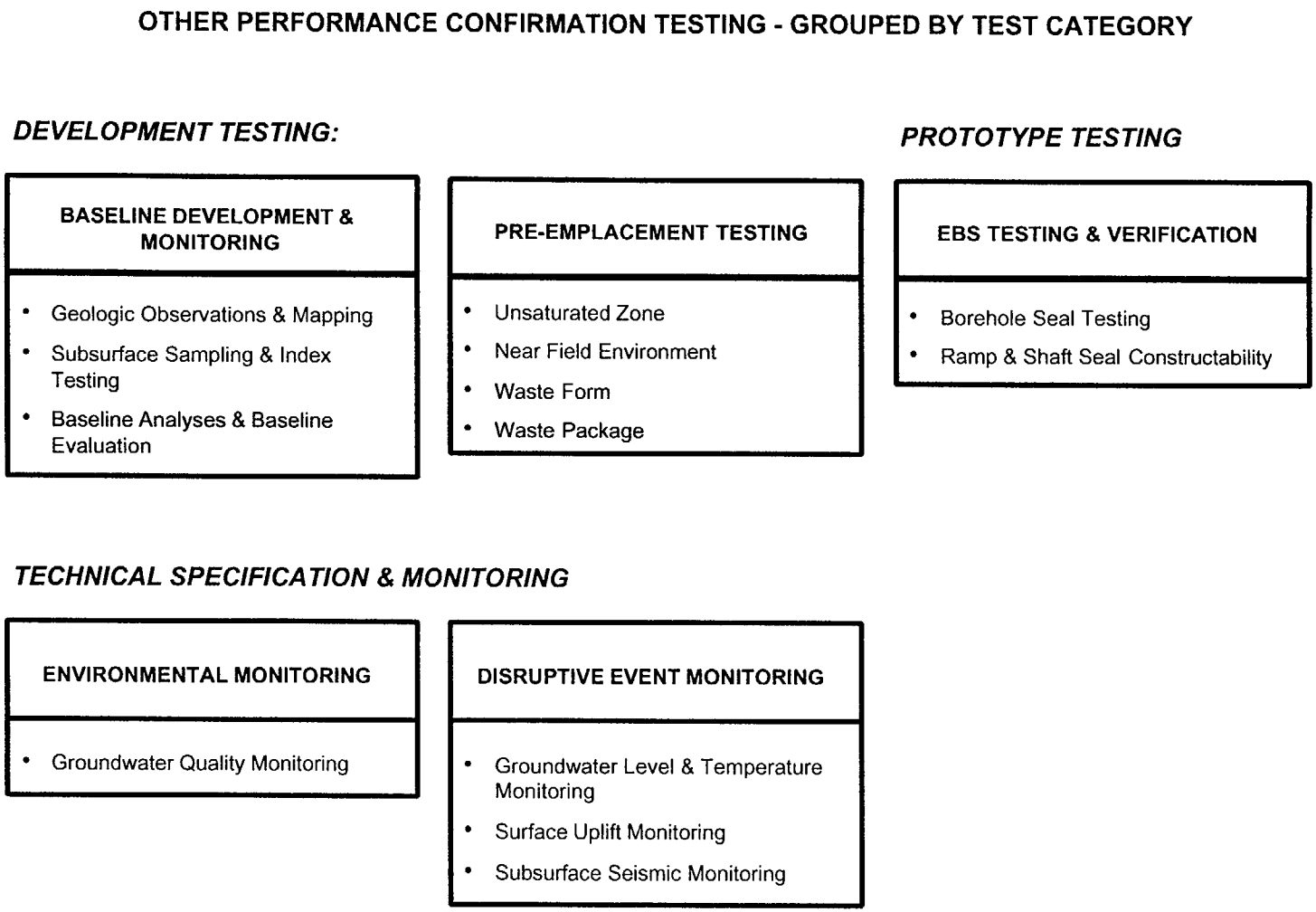

Figure G-2. Performance Confirmation Test Activities Under Other Test Categories

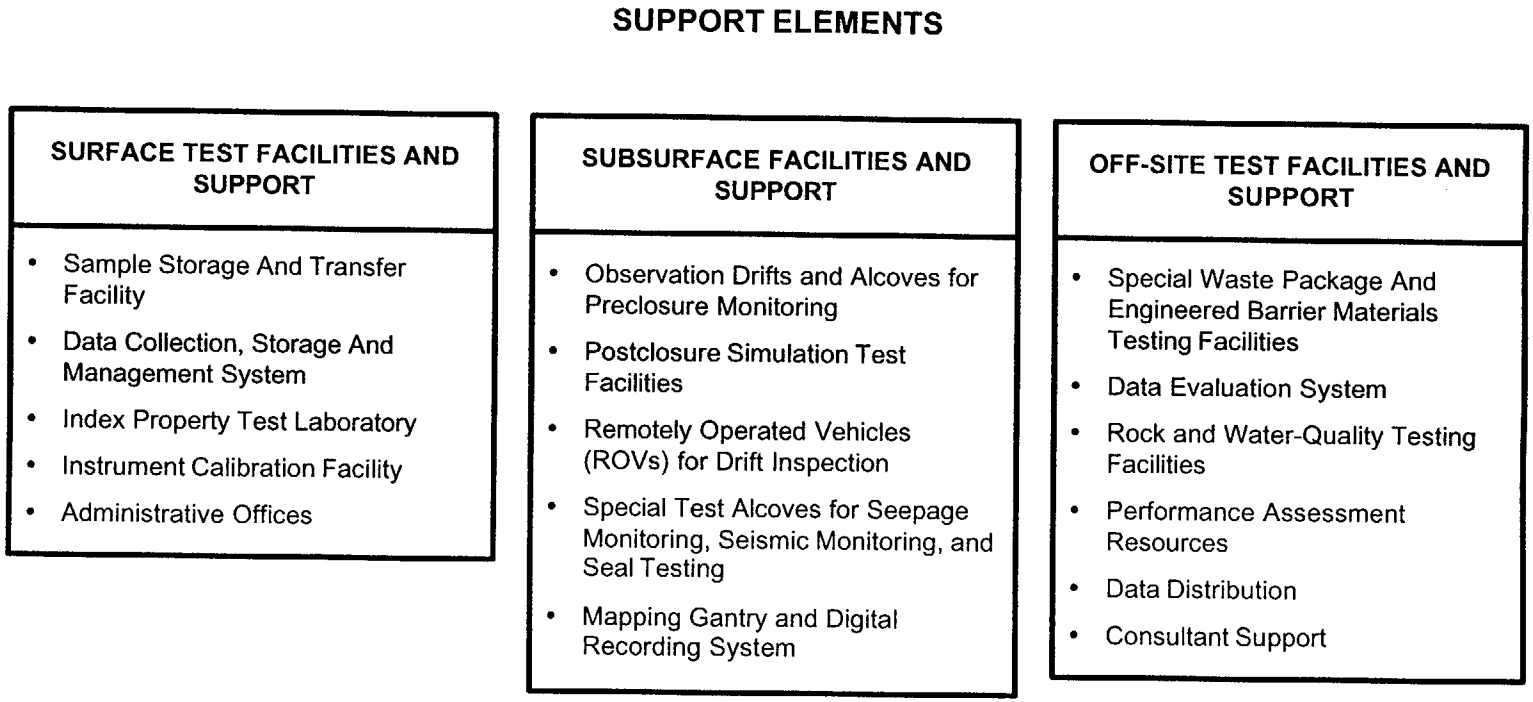

Figure G-3. Performance Confirmation Support Elements

DESCRIPTION PM-01
SEEPAGE MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The purpose of seepage testing is to obtain a reasonable bound to the seepage threshold. The seepage threshold bound can be described as the range of seepage flux that the repository lithostratigraphic units can withstand before the groundwater enters the emplacement drift.

2. Description

The seepage threshold concept will be pursued through field testing, supported by appropriate laboratory testing and process modeling.

Seepage field testing will be performed within specially constructed monitoring alcoves outside the emplacement area. The alcoves will be installed along access ways (e.g., perimeter drifts) in the repository horizon. Testing will focus on lithostratigraphic units that have not been investigated during site characterization such as the TSw lower lithophysal and nonlithophysal units, and in niches 5 and 6 in the Enhanced Characterization Repository Block drift to determine the seepage threshold bound. Since seepage is laterally variable, data will be obtained at several locations to determine whether the range of values is within the reasonable seepage bound.

Monitoring of the seepage alcove deformation will also be performed as rock movement may alter the existing fracture patterns or introduce new fractures that may effect the seepage threshold bound in the test alcove. Acceptable ranges for variation in opening geometry will be established and the changes monitored. Measuring movement of the rock mass surrounding an emplacement drift can be accomplished with borehole instruments installed from the observation drifts, from empty emplacement drifts, or from within emplacement drifts. It may also be feasible to monitor convergence or deformation from the exhaust mains or perimeter main access drifts. Laboratory testing will be performed to evaluate geohydraulic parameters to establish the effects of changing drift geometries and the magnitude of the seepage thresholds. Analyses will be conducted if a bounding seepage threshold value is determined and also to determine the range of percolation flux for comparison with the bounding seepage thresholds.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Ambient groundwater flow through the repository horizon: water potential, water content, seepage, and measurements of the hydraulic properties of fractures will be performed
- Deformation/convergence of alcoves.

4. Test Interfaces and Constraints

The seepage test program will interface with other performance confirmation test programs that evaluate the UZ and the thermally perturbed UZ performance confirmation parameters. These parameters provide an estimate of the repository boundary conditions that would affect the seepage threshold bound test program.

Excavation of the test alcoves will require interface with construction of perimeter access ways, which provide entry to different portions of the rock mass. Laboratory testing (together with shipping and the long-term sample storage of rock samples) will be provided by the performance confirmation support facilities. Laboratory testing will be performed by an offsite subcontractor.

5. Period of Performance/Schedule

The seepage test program will commence during site characterization and continue throughout the repository preclosure period. The geometry of the waste emplacement drifts will be monitored periodically. The testing with additional alcoves will be performed after the excavation of required alcoves and installation of instrumentation, subsequent to the construction of perimeter access ways.

DESCRIPTION PM-02
IN SITU WASTE PACKAGE MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The purpose of this testing activity is to make real time measurements of the condition of the waste package and the environment within the emplacement drifts. This testing will be performed periodically for all emplacement drifts.

2. Description

Remote inspection of the emplacement drifts (and the emplaced waste packages) will be periodically performed by the use of a ROV. The ROV will mount an array of remote sensors, instruments, power packs, and controls to be used within the emplacement drift. The conditions within the drift will be measured along the length of the drift by the ROV as it proceeds from one end to the other end of the emplacement drift. Laser guidance will measure position and speed of the vehicle. Cameras and closed circuit television will monitor waste package container surfaces for evidence of corrosion or other penetrating attack.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Waste package surface temperature
- Air temperature and humidity
- Rock wall temperature
- Visual condition of waste package: detection of the presence of corrosion, microbial activity, joint conditions
- Position along the drift (relative to reference position).

4. Test Interfaces and Constraints

This activity shall interface with other performance confirmation programs evaluating and monitoring the conditions within the emplacement drifts, such as in-drift and ventilation monitoring. In addition, the ROV will also be used to support the collection of material coupons in the emplacement drifts. This activity will also interface with other preclosure activities such as subsurface activities directed toward evaluating the condition of the ground support system within emplacement drifts, which use remote inspection and testing.

A major constraint is the technological state-of-the-art limitations on what parameters are measurable. The instrumentation, and in some instances, cabling or transmitters, will have to function in the thermal/radiation/geochemical environment within the emplacement drift.

5. Period of Performance/Schedule

Remote monitoring will be started with the emplacement of the first nuclear waste package in the subsurface facility, and will be conducted during both the operation and the monitoring phases of the MGR, ending with permanent closure.

DESCRIPTION PM-03
LONG-TERM MATERIALS TESTING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Surface**

1. Purpose

The main purpose of offsite laboratory testing is to obtain long-term data that could reduce the performance uncertainty and therefore lead to greater confidence in confirming performance predictions. For example, some degradation phenomena require a long incubation time before they are discernible. Laboratory testing can be conducted over a much wider range of conditions than the conditions available for repository testing in the near-term when the repository is in the thermal pulse time period shortly after waste emplacement. Much of the laboratory testing is aimed at simulating repository conditions when the waste has cooled and more moist conditions are possible.

2. Description

The following two tasks will be performed:

Task 1: Corrosion testing of drip shield and waste package materials–The key parameters affecting drip shield and waste package container performance that will be measured in laboratory testing include all of those associated with aqueous corrosion. This testing will be performed under immersed conditions and in humid atmospheres in corrosion tanks and relative humidity chambers, respectively, as well as other specialized equipment. Specimens with a variety of configurations will be exposed which will be characterized after removing them from the test apparatus following the prescribed exposure period. Also, parameters associated with phase stability in the metal and weld integrity will be measured in laboratory investigations.

With time, it is expected that the current laboratory testing will narrow the broad range of environmental parameters now being considered and identify those key parameters needing further evaluation for confirming the performance predictions for the drip shield and waste package materials. It is further expected that the current testing for evaluating several candidate materials will become more focused once the materials are selected for the LA design.

Task 2: Waste form testing–Testing will likely be performed under humid air and unsaturated drip conditions using atmosphere control at elevated temperatures. Specimens will be characterized after removing them from the test apparatus following the prescribed exposure period.

It is expected that the current laboratory testing on the SNF and HLW glass waste form performance, mostly in hot cells, will become more narrowly focused on the key parameters affecting performance. In the case of waste form testing, no equivalent in situ kind of testing in the potential repository environment is feasible, thereby increasing the importance of this testing.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Aqueous corrosion parameters: such as pitting corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement
- Waste form performance parameters: such as alteration and dissolution of both the SNF and HLW glass waste forms.

4. Test Interfaces and Constraints

This test shall interface with other performance confirmation programs and other activities to obtain further definition of the corrosion process. The major constraint on this testing is that the environments are simulated, and there is always some uncertainty in selecting the appropriate environments for these long-term tests.

5. Period of Performance/Schedule

Depending on the finalization of the LA, waste package design, and the results of the material testing work, laboratory tests are planned to continue for perhaps 10 to 20 more years to provide greater confidence in the selected design, the selected container materials, and the performance models. This period will extend into the operation phase of the MGR and may continue until closure.

TEST PM-04
VENTILATION MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The monitoring of ventilation air (exhaust and inflow) of emplacement drifts to indirectly monitor and assess in-drift conditions (including the waste package).

2. Description

Air exhausting from the drifts will be monitored to detect the presence of gaseous radionuclides, which would indicate that an early waste package leak has occurred. The leak would likely be due to a scenario in which a partially cracked weld extends and breaches the waste package. This would expose very warm spent fuel to oxygen that might lead to fuel disintegration. Air samplers will be used to detect krypton-85, tritium, possibly carbon-14 (as CO_2), and perhaps other radionuclides in the exit ventilation air. Specific tracer gases may be used so that the location of the leaking container could be determined.

Monitoring will also include temperature and moisture measurements to assure the maintenance of thermal goals for the waste package and to assess the impact of the thermal conditions on adjacent rock mass. These measurements will be performed at both the ventilation entry points as well as ventilation exit points into the exhaust main.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Dry-bulb temperature (at entry and exit)
- Wet-bulb temperature (at entry and exit)
- Air pressure (at entry and exit)
- Relative humidity (at entry and exit)
- Radioactive gas content: tritium, krypton-85, and radon (at exit)
- Oxygen and CO_2 content (at exit).

4. Test Interfaces and Constraints

Monitoring of the ventilation air will be coordinated with other emplacement drift ventilation monitoring activities for preclosure considerations and safety. It will also be coordinated with environmental emissions testing within the overall subsurface ventilation system.

5. Period of Performance/Schedule

Monitoring will be started as soon as possible for each emplacement drift, starting (if possible) during drift construction. Ventilation monitoring will continue throughout the operation and monitoring phase of the MGR (i.e., as long as ventilation is employed for emplacement drifts).

TEST PM-05
ROCK MASS MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The purpose of this activity is to monitor the rock mass TMH response around emplacement drifts due to construction and waste emplacement.

2. Description

Monitoring the rock mass response adjacent to emplacement drifts will be performed to discern construction and thermally induced response (i.e., due to waste emplacement). Observation drifts will be constructed to provide access to a limited number of monitoring "areas"; monitoring alcoves will be constructed to allow the installation of monitoring facilities and borehole-based instruments in the rock mass adjacent to the representative emplacement drifts. Monitoring will be focused on the disturbed zone around the opening expected during the preclosure period, based on appropriate analyses.

Hydrologic response to waste package heating will be evaluated by monitoring temperature, moisture potential, and moisture content in the rock mass through the use of electrical resistivity tomography, neutron logging, and cross-borehole radar techniques. Temperature measurements, which will locate the boundary between "dry" and partially saturated rock, will be obtained by deploying temperature gages at varying distances from emplacement drifts. To ascertain coupled TMH effects, temperature, fracture displacements, and transmissivities will be measured in a series of boreholes placed near the emplacement drifts. Rock mass mechanical response will be monitored using multi-point borehole extensometers, stress gages, and acoustic tomography techniques.

The monitoring using instruments emplaced within boreholes and monitored with a data acquisition system (i.e., integrated instruments) will be supplemented by periodically conducted borehole surveys (e.g., air permeability) and measurements from other nonintegrated instrumentation.

Rock cores will be collected from the boreholes for the laboratory testing of mechanical and thermal properties. These properties include unconfined compressive strength, tensile strength, direct shear strength of fractures, thermal conductivity, and the coefficient of thermal expansion.

3. Parameters Addressed

Parameters (and changes in these parameters) to be addressed by this test program include:

- Geohydraulic response: including groundwater flow, moisture content, hydraulic conductivity, water retention, and effective porosity
- Thermal response: temperature of intact rock, temperature of fluids, effective thermal conductivity, thermal expansion coefficient, and specific heat capacity of the rock mass
- Mechanical response: displacement, fracture and intact-rock strength, in situ stress, movement along fracture(s), and fracture generation (if any)
- Geochemical response: near-field groundwater chemistry, precipitation products (if observed), and groundwater pH and Eh.

4. Test Interfaces and Constraints

This test will interface with other performance confirmation programs and other repository activities. Specifically, this test will interface with construction activities regarding the excavation of the observation drifts and alcoves and providing the required access for monitoring. The test will also be coordinated with in-drift monitoring (PM-06), ventilation monitoring (PM-04), and in situ waste package monitoring (PM-02) to provide a comprehensive understanding of the coupling between engineered barrier system heating and the near-field rock mass response.

As part of the rock mass monitoring program, the monitoring of construction response will be integrated with the construction schedule to allow sufficient time after construction of observation drifts and alcoves to install baseline instruments prior to the excavation of the emplacement drifts to be monitored.

Long-term sample storage will be required and will be provided by the performance confirmation support facilities. Laboratory testing will be conducted at performance confirmation support facilities and supplemented by specialized testing conducted by an offsite subcontractor.

5. Period of Performance/Schedule

Initial test facility construction will be started during the construction phase of the MGR, and installation of the first monitoring area will be completed and baselined before the start of the first repository waste emplacement. Other monitoring facilities will be constructed to allow monitoring of construction response of the emplacement drift, as well as thermal response to waste package heating. Monitoring will continue through the operation and monitoring phases of the MGR and end with permanent closure, as required by DOE Interim Guidance (see Appendix B).

DESCRIPTION PM-06
IN-DRIFT MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The purpose of this testing activity is to conduct real-time monitoring of waste package conditions and the in-drift environment over a continuous period.

2. Description

Instruments will be remotely positioned within a limited number of representative emplacement drifts using appropriate technology. This technology may include the use of long boreholes from adjacent excavations and/or by using the access from the drift entry and an overhead rail and/or using the emplacement handling system to install a stationary gantry. Measurements will be taken on a continuous basis at several locations (stations) along the axis of the drift to measure the variation in parameters with the increased travel distance down the drift axis. Instruments will be periodically retrieved and calibrated (or replaced entirely) to ensure accurate measurements.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Waste package surface temperature
- Air temperature and humidity
- Rock wall temperature
- Visual condition of waste package: detection of the presence of corrosion, microbial activity, and joint conditions.

4. Test Interfaces and Constraints

In-drift monitoring will be coordinated with other indirect and monitoring of in-drift conditions and performed, if possible, in concert with rock mass monitoring. Access from cross-block drifts may be limited, however, and would be periodically restricted by the operational use of the cross-block drifts for other activities.

The installed instrumentation, and in some instances, cabling or transmitters, will have to function in the thermal/radiation/geochemical environment within the emplacement drifts. An effective means for replacing broken or damaged equipment or instruments will need to be available, and this may impose major constraints on instruments within the emplacement drifts.

5. Period of Performance/Schedule

In-drift monitoring will be conducted for as long as the sensing devices can be readily installed, serviced, and maintained. The instrument installation system and attendant boreholes shall be installed into emplacement drifts and baselined prior to waste emplacement in these drifts. Monitoring will be coordinated with ventilation monitoring (PM-04) and in situ waste package monitoring (PM-02) to provide a definition of spatial and temporal variations of parameters within an emplacement drift. This monitoring will also be coordinated with rock mass monitoring (PM-05) to allow assessment of the coupling between the engineered barrier system heating and the near-field rock mass response.

DESCRIPTION PM-07
INTRODUCED MATERIALS MONITORING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface**

1. Purpose

The purpose of this test program is to evaluate the impact that introduced materials such as water, hydrocarbons, concrete, steel, ground support, and rails remaining in the repository after closure would have on the postclosure performance of the repository. A system will be established to monitor the fluids and materials used for repository construction and operation (left in the underground facility) and to evaluate potentially adverse effects.

2. Description

The amount of water that will remain after repository closure in the drifts or in the rock immediately surrounding the openings, which is introduced by construction activities, fire suppression, or accidental spill, will be quantified. The chemical composition, the pH, and the Eh, of this water will be determined. The hydrocarbons that will remain in the repository after closure, such as those resulting from accidental spills, will be also be quantified. The chemical composition, the pH and Eh, of these hydrocarbons will be determined. The chemical composition/alteration of the concrete, steel, and ground support that will remain after repository closure will be evaluated by lab testing.

To determine the pH and the Eh of the water and hydrocarbons introduced into the repository that will remain after closure, data will be collected at several locations within the repository lithostratigraphic units. The tests will be conducted, when possible, in alcoves driven off the emplacement drifts and the mains. To determine the chemical composition of the water, hydrocarbons, and the other materials that will be left behind after closure, field samples will be collected and tested in the laboratory for chemical composition analysis.

A comprehensive database and 3-dimensional graphical display engine will be required to track and display introduced materials in the underground facility similar to the tracers, fluids, and materials monitoring program currently in place.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Characteristics of the hydrocarbons left within the underground facility including chemical name, composition, solubility, and degradation/alteration products
- Location, quantity, time of occurrence, and composition of fluid loss or spills

- The pH and Eh of fluids as introduced into the underground
- The chemical composition/alteration products of the various materials (solids) to be introduced into the repository and to be left within the GROA upon closure.

4. Test Interfaces and Constraints

Monitoring will be performed on both the construction and the operational areas of the repository, requiring coordination of entry to maintain equipment and data acquisition system. Little impact on other performance confirmation activities is anticipated.

5. Period of Performance/Schedule

The test program will commence during construction and will continue throughout the operation and monitoring phases of the MGR.

DESCRIPTION PM-08
RECOVERED MATERIAL COUPON TESTING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface and Surface**

1. Purpose

The purpose of coupon testing is to obtain long-term data on drip shield and waste package materials that have experienced actual emplacement drift conditions. Some degradation phenomena require a long incubation time before they are discernible, and the use of coupons subjected to actual conditions for varying periods may better define such degradation phenomena.

2. Description

The following two tasks will be performed:

Task 1: Placement and retrieval of coupons–This work involves placement of test coupons (specimens) at various locations in the repository subsurface facilities. Some specimens will act as "witness specimens" to be placed near the drip shields and waste packages and thus experience (or witness) the same temperatures and environmental conditions as the drip shield and waste package container surfaces. (This same scheme of emplacing witness specimens is often used along buried pipelines and on offshore drilling platforms.) The specimens are then retrieved at various planned intervals and analyzed for evidence of corrosion and other degradation. Some specimens will be emplaced at other locations, such as in test alcoves, so that the array of specimens will experience a wide range of different temperatures and humidities. It is even desirable to place some specimens in highly fractured areas, where waste packages would not be intentionally emplaced, in order to obtain results from a location that may be subject to water intrusion. Specimen sizes will range from laboratory coupon size to much larger panel sizes that approach some of the dimensions of the actual drip shields and waste packages. Some specimens will contain welds utilizing the same welding process used for the drip shields and waste packages.

Task 2: Examination of specimens–The examination of the retrieved specimens would likely occur at the same facility used for the ongoing laboratory testing program. The key parameters affecting drip shield and waste package container performance that will be measured in laboratory testing include all of those associated with aqueous corrosion such as pitting corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement. Specimens with a variety of configurations will be characterized following the exposure period. Parameters associated with phase stability in the metal and weld integrity will also be measured.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Aqueous corrosion parameters: such as pitting corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement
- Other possible factors affecting corrosion: including microbial population(s) type and extent
- Chemical and physical properties: including the extent and condition of surface films.

4. Test Interfaces and Constraints

This monitoring program interfaces with the in situ waste package monitoring (PM-02) to permit the ROV (identified for waste package monitoring) to also place and recover sample coupons. The present testing also interfaces with the set of testing programs involving the monitoring of environmental conditions within the emplacement drift; these other programs measure parameters such as temperature, relative humidity, and the chemistry of dripping water (if any). These parameters will be correlated with the test results of the coupons to evaluate the more important environmental considerations.

From an operational point of view, retrieval of the specimens from the emplacement drifts is constrained by the use of remote equipment. Actual locations for placing the specimens in the emplacement drifts may be limited or restricted (such as near the ends of the drift) so that the specimens are more readily retrievable. Specimens placed in the more accessible parts of the repository should not present any particular problems in retrieval. Another significant constraint is that the range of environmental exposure conditions is limited during the early stages of emplacement when the repository is undergoing the thermal pulse, and these conditions do not represent long-term conditions. The schedule for placement of specimens must also be integrated with the repository construction and waste emplacement schedules.

5. Period of Performance/Schedule

Specimens will be placed within emplacement drifts after the start of waste emplacement activities. A series of specimens will be placed and then retrieved at varying times to assess any observed effects with time. It is expected that this monitoring will extend through the MGR operation and monitoring phases and will be terminated on the approval of the LA for repository closure.

DESCRIPTION PM-09
DUMMY WASTE PACKAGE TESTING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface and Surface**

1. Purpose

The purpose of this test is to obtain information on the performance of the drip shield and waste package materials, but without the radioactive component, within the actual repository environment.

2. Description

Full-scale dummy (i.e., prototype) waste package and drip shields will be constructed and placed in situ in the repository under simulated postclosure conditions for varying periods of time to assess the affects of these conditions on performance.

The following three tasks will be performed:

Task 1: Placement of the drip shield and dummy waste package–Subsurface emplacement equipment will be utilized to place the drip shield and dummy waste package within test drifts in concert with other field tests (such as the postclosure simulation test, PS-01) or in a special test alcove dedicated to this program. Several drip shields and waste packages will be placed and heaters employed to simulate postclosure conditions in closed drifts. Backfill may be employed (if under consideration as a design option) to evaluate the impact of backfill placement upon the surface condition of the package and the subsequent response.

Task 2: Retrieval of the drip shield and dummy waste package–Subsurface emplacement equipment will be utilized to retrieve the drip shield and dummy waste package. This may require the movement of several drip shields and waste packages in order to be able to retrieve the selected drip shield and dummy waste package. Alternately, it may require the retrieval of the drip shield and dummy waste package from a special alcove devoted to this purpose. In either case, the retrieved drip shield and dummy waste package will then be placed onto the transporter and moved back to the surface facilities.

Task 3: Examination of the drip shield and dummy waste package–The drip shield and dummy waste package will be carefully examined at the surface facility designed for this purpose. The drip shield and waste package will be decontaminated (if necessary) and moved into a clean area for further examination. Equipment for opening of the waste package will need to be tested for operability. Special equipment may need to be designed and installed. Alternately, the drip shield and dummy waste package can be moved off site to another facility for sectioning and examination. The examination would focus on any surface corrosion and the metallurgical state of the materials.

Due to the expense and limited information obtained by this testing, only a limited number of waste packages and drip shields will be employed.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Aqueous corrosion parameters: such as pitting corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement
- Other possible factors affecting corrosion: including type and extent of microbial population(s)
- Chemical and physical properties: including the extent and condition of surface films and the strength and condition of welds.

4. Test Interfaces and Constraints

This test will interface with other performance confirmation testing if the full-scale prototypes are placed within another performance confirmation test under actual field conditions, as in the postclosure simulation testing. If this approach is not adopted, the test facility construction will then interface with other repository construction activities to allow for establishment of the special alcove facility. In either case, this test will also interface with the performance assessment activities with respect to the predicted performance of the drip shield and dummy waste package.

This test is also constrained by the availability of full-scale prototypes, which are to be taken from the manufacturing line (or specially manufactured), and the required additional construction (i.e., as required to seal the waste package with internal heaters and other filler materials instead of actual nuclear waste).

5. Period of Performance/Schedule

Testing is envisioned to start after the initiation of waste package construction. Placement of the drip shield and dummy waste package will depend on the repository construction and waste emplacement schedules.

DESCRIPTION PM-10
RECOVERED WASTE PACKAGE TESTING

Test Category: **Core Performance Confirmation**

Test Element: **Process Monitoring**

Location: **Subsurface and Surface**

1. Purpose

The objective of this testing is to determine the cause of the malfunction (if not obvious) and to assess the damage to the various waste package components when a malfunction or failure occurs.

2. Description

Upon the occurrence of waste package malfunction or failure, the waste package will be retrieved from the emplacement drift and examined. The nature of the failure/malfunction is undefined.

In more detail, the following two tasks will be performed:

Task 1: Retrieval of the failed waste package–Subsurface emplacement retrieval equipment will be utilized to retrieve the failed waste package. This may require the movement of several waste packages in order to be able to retrieve the package that has failed. The failed waste package will then be placed onto the transporter and moved back to the surface facilities.

Task 2: Examination of the failed waste package–The waste package will be carefully examined in the surface facility or off site. Equipment for opening the waste package will need to be tested for operability. Special equipment may need to be designed and installed. Nondestructive means would first be implemented to determine the location of the failure. Once the failure location has been determined, a detailed plan would be developed on how best to open and/or section the waste package. The sectioning would then move forward and the contents examined for condition prior to removal of any waste. The waste would then be removed, and the extent of the failure would be evaluated. Appropriate sections of the failure area and the waste would be taken for either onsite or offsite examination.

3. Parameters Addressed

Parameters for this testing are dependent on the nature and circumstances of the waste package failure when it occurs. The parameters for this testing are (at this point) undefined but will be identified upon the unlikely occurrence of a failure.

4. Test Interfaces and Constraints

The exact definition of this testing and any associated constraints must remain undefined until the occurrence of a malfunction, as the nature of the malfunction would determine the extent of

testing and related analyses required. This testing can not be scheduled or estimated, as these activities will occur only in the event of a waste package failure (which is not a planned event). Further, if a malfunction event did occur, the needed facilities and equipment appropriate for the test would need to be identified and procured, significantly delaying the start of the test process.

5. Period of Performance/Schedule

This activity is not a scheduled test or analysis. However, a schedule for the subsurface and surface facility operations for this testing will be developed at the time a malfunction is observed.

DESCRIPTION PS-01
POSTCLOSURE SIMULATION TESTING

Test Category: **Core Performance Confirmation**

Test Element: **Postclosure Simulation**

Location: **Subsurface**

1. Purpose

The purpose of this test is to confirm that measured conditions within a full-scale simulated postclosure configuration are representative of the LA.

2. Description

A full-scale simulation of the postclosure configuration (including drip shield) will be constructed and tested within a special test drift. The test drift will be essentially a typical emplacement drift. This test drift will be located within the repository emplacement horizon, will have the same drift diameter, and will be excavated in the same manner as other emplacement drifts.

Detailed geologic mapping of the facility will be performed immediately after construction of the drift. Instrumentation will then be placed in the adjacent rock mass (in boreholes from adjacent test alcoves), and operations facilities (rail, power, etc.) will be installed. Thereafter, dummy waste packages (i.e., actual waste containers containing heaters) or actual waste packages will be emplaced within a limited section of the test drift. This emplacement operation will use actual waste package operations equipment. If heaters are employed, they will be turned on. The section of the drift will then be temporarily sealed, and the rock mass will be allowed to heat for a short period of time (for 1 to 2 years) or until parameters have stabilized consistent with the expected conditions prior to closure. The drift will be ventilated similar to a normal emplacement drift. This will allow for the initial dry-out of the rock mass close to the excavation surface.

After the section has been heated for a period of time, the remaining engineered components will be installed (e.g., drip shields) together with in-drift instrumentation, and the section of the drift sealed as if for permanent closure. The test drift will be separated into test sections allowing for the simulation of several different test cases within the one overall test drift. A buffer section will isolate each section with the described installation process repeated along the drift to study various heating conditions. Monitoring of each section will include temperature, humidity, and other variables to compare those with pretest predictions. The test sections will be monitored for long periods of time (about 20 to 40 years), and then carefully disassembled to evaluate the conditions of the engineered materials.

Instrumentation will be emplaced within the drift and from adjacent test alcoves. The monitoring alcoves (and attendant observation drift) will be constructed below the test section to minimize any potential impact on the water flow around the opening (i.e., the near-field geohydrology), as well as to permit monitoring of the rock mass response below the drift, where greater temperature and response may be expected. Instruments will be periodically replaced

during the test program as required to obtain sufficient and accurate data of the response of the engineered and natural barriers.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Geohydraulic properties of the intact rock and fracture zones: hydraulic conductivity, effective porosity, moisture content, and dispersivity
- Geochemical characteristics of groundwater: chemical composition, Eh, pH, and apparent age of related mineral deposition
- Thermal properties of rock: thermal conductivity, specific heat, and thermal expansion
- Mechanical properties of the rock: tensile strength and compressive strength
- Characteristic of the engineered materials, including the condition of the passive films and corrosion parameters (if any corrosion is observed).
- Seepage entering the sealed drift, if any.
- Temperature of the rock mass.

4. Test Interfaces and Constraints

This testing will be coordinated with dummy waste package testing [PM-09] and other performance confirmation testing as appropriate. Geologic observation and mapping [BD-01] will be performed in the test drift as well as all other test excavations. Prototype equipment for closure operations may be evaluated and used in the set-up of this test.

This testing will also interface with repository construction which will provide the facility, install ground support systems, and construct the attendant observation drift and test alcoves. The test will also interface with waste package operations, which will construct the dummy (or real) waste packages (and the other engineered barriers) within the test drift.

Laboratory testing of index material properties will be measured at the onsite performance confirmation support facilities and will be supplemented by testing at an offsite laboratory. Long-term sample storage will be provided by the performance confirmation support facilities.

5. Period of Performance/Schedule

The testing will be started as operations permit and as soon as possible after the emplacement of the first nuclear waste in the subsurface facility. Monitoring will be conducted during both the operational and the monitoring phases of the MGR, but with testing in specific sections being periodically terminated to obtain more detailed data.

DESCRIPTION BD-01
GEOLOGIC OBSERVATIONS AND MAPPING

Test Category: **Development Testing**

Test Element: **Baseline Development**

Location: **Subsurface**

1. Purpose

The purpose of this test program is to confirm that geologic conditions are as expected in accordance with the LA review basis.

2. Description

Observations of geologic conditions together with digital mapping of repository underground openings and limited detailed geologic (full-peripheral) mapping will be conducted during repository construction. This mapping will be conducted in accordance with applicable procedures and standards (e.g., ASTM D 4879-89). Geologic observations and mapping data will assure identification and documentation of the presence and extent of any anomalous conditions. These anomalous conditions may include unexpected faults and shears, significant and unexpected variations in lithostratigraphy, the presence of unusual fracture characteristics or sets, and zones where the designed ground support may not be adequate.

Complete digital geologic mapping of emplacement drifts will ensure that the conditions encountered in each emplacement drift are fully documented. The photographic imaging will serve as a baseline for future analysis of each drift after emplacement and initial start-up. In addition, maintenance and service problems can be analyzed in light of the visual geologic records of any given drift. Further, the consistent and continuous recording of the encountered geologic conditions will greatly assist in remote interpretations of the drift behavior during repository operation.

As a supplement to digital mapping, detailed (manual) geologic mapping will be performed in complex geologic areas to provide additional small-scale data. In addition, limited, local mapping will be conducted to provide statistical discontinuity data to support the verification of rock mass classification for engineering purposes in accordance with ASTM D 5878-95, *Standard Guide for Using Rock Mass Classification Systems for Engineering Purposes.*

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Characteristics of unit stratigraphy: rock type, lateral extent, depth, thickness, and mineralogy
- Characteristics of fracture zones and faults: location, width, length, orientation, displacement, fracture aperture, and fracture density

- Groundwater inflow (if observed): location, magnitude, and related stratigraphy
- Characteristics of mineral resources (if any): type, location, and extent.

4. Test Interfaces and Constraints

This test will interface with other performance confirmation programs and other repository activities. Specifically, this test will interface with construction activities, as geologic observations will be performed concurrent with excavation activities, and mapping during repository construction will be coordinated with the installation of construction support and ground support systems. Digital imaging will follow immediately behind the tunnel boring machine to provide timely data for other activities. The excavation process will clean the excavation walls as necessary for digital imaging.

The progress of digital imaging and other mapping is dependent on the tunnel boring machine advance rate and geologic conditions. If unanticipated geologic conditions are encountered, it may become necessary to adjust sampling and laboratory testing requirements.

5. Period of Performance/Schedule

Field work associated with this activity will be performed concurrent with all subsurface excavation activities and will be finished with the completion of construction. Prototype testing of the digital mapping system (and the development of associated procedures) is to be performed prior to the full-scale implementation of the technique, which requires that field mapping activities precede actual repository construction by approximately one year.

DESCRIPTION BD-02
SUBSURFACE SAMPLING AND TESTING

Test Category: **Development Testing**

Test Element: **Baseline Development**

Location: **Subsurface**

1. Purpose

The purpose of subsurface sampling and testing is to obtain representative samples of the geologic units of the repository emplacement horizon and conduct index testing. The testing will be used to assess the variability of the TMH properties, and confirm that the observed variance is in accordance with the LA. The testing program will also provide data for the seepage testing and thermal testing and monitoring.

2. Description

A sampling and laboratory testing program will be undertaken to support confirmation of subsurface conditions. Rock samples will be collected by the use of short core drilling or from instrumentation holes at locations corresponding to seepage testing or rock mass monitoring, including test alcoves and observation drifts. Rock cores will also be collected from the instrumentation boreholes at the thermal test locations to be analyzed.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Geohydraulic properties of intact rock and fracture zones: hydraulic conductivity, effective porosity, moisture content, and dispersivity
- Geochemical characteristics of groundwater: chemical composition, Eh, pH, and apparent age of related mineral deposition
- Thermal properties of rock: thermal conductivity, specific heat, and thermal expansion
- Mechanical properties: tensile strength and compressive strength.

Considerations of these parameters include spatial variability.

4. Test Interfaces and Constraints

This test will interface with other performance confirmation programs and other repository activities. Specifically, this test will interface with geologic observations and mapping (BD-01), as the amount and location of samples taken is dependent on geologic conditions. If unanticipated geologic conditions are encountered, it may become necessary to adjust sampling and laboratory testing requirements.

Laboratory testing of index material properties will be measured at the onsite performance confirmation support facilities and supplemented by testing at an offsite laboratory. Long-term sample storage will be provided by the performance confirmation support facilities.

5. Period of Performance/Schedule

This activity will be performed during the construction and the operation phases of the MGR to establish the existing ambient (pre-emplacement) conditions across the emplacement horizon. Additional sampling and testing will be performed principally as a supplement to rock mass monitoring (PM-05) to evaluate changes in rock mass properties with time.

DESCRIPTION BD-03
BASELINE ANALYSES AND EVALUATIONS

Test Category: **Development Testing**

Test Element: **Baseline Development**

Location: **Surface (Off Site)**

1. Purpose

To develop estimates of expected response and tolerance limits as part of the development of the performance confirmation baseline.

2. Description

Baseline development will be required for all performance confirmation activities, including core performance confirmation activities (process monitoring and postclosure simulation). The activities required for baseline development include the following tasks:

Task 1: Establish the performance confirmation database and predict performance–This task will use the data from site characterization efforts to conduct required performance confirmation analyses. Where appropriate, AMRs will be utilized as a basis to identify expected performance. Where relevant analyses are not available, additional analyses will be performed. The first step in such analyses is to identify the analytical process models or other relevant models to be used to predict and evaluate performance. Using the site characterization data and these models, predictions of expected preclosure values and variations of these values would then be made. All predictions made will be provided as part of the LA.

Task 2: Establish tolerance and bounds–After expected performance has been evaluated, it is necessary to establish tolerances or acceptable limits (screening levels) of deviations from the expected performance, including acceptable ranges of key parameter values, regulatory limits, and model validity or credibility limits. Analyses are also to address expected changes as a result of construction, operations, and waste emplacement.

Task 3: Establish completion criteria and guidelines for corrective actions–After establishing these tolerances, it is necessary to establish the criteria and guidelines for evaluating conditions outside of tolerance and identify the recommended corrective actions to be taken when variances are observed, including parties to be notified. The extent of corrective actions will also consider performance evaluation of the variance and the implications of actions to performance confirmation and other portions of the MGR program.

3. Parameters Addressed

All key performance confirmation parameters are to be addressed by this activity.

4. Test Interfaces and Constraints

This activity will interface with all other performance confirmation testing.

5. Period of Performance/Schedule

Baseline data is in the process of compilation; baseline analyses will be started and performed during detailed test planning. These analyses will also be conducted, as needed, during operational and monitoring phases of the MGR as test programs are modified.

DESCRIPTION PE-01
UNSATURATED ZONE TESTING

Test Category: **Development Testing**

Test Element: **Pre-Emplacement Testing**

Location: **Subsurface and Surface**

1. Purpose

The purpose of UZ testing is to address data and model validation needs as identified in the UZ Flow and Transport PMR.

2. Description

The present definition of UZ testing is based on a preliminary assessment of data needs to be identified in the PMR for the UZ flow and transport model. As this PMR is in draft form, the identified testing program will be adjusted to address the final data needs when the PMR and TSPA sensitivity studies are completed.

The following three tasks pertaining to performance confirmation will be performed:

Task 1: Effects of construction on ambient moisture and seepage–This task will obtain data on the effects of construction on the ambient moisture and seepage conditions (including drainage characteristics) of the repository horizon. To obtain this data, seepage monitoring and the monitoring of moisture content in excavation walls will be performed and continued in existing ESF facilities during the initial phases of construction.

Task 2: Sorptive properties of the Calico Hills nonwelded hydrogeologic unit–This task will obtain data on the sorptive properties of the unit to better define the radionuclide transport through this unit. Emphasis will be placed on the vitric and zeolitically-altered portions of this formation. Collection of representative samples will be performed during the construction of the excavations below the repository horizon (e.g., exhaust mains and at shaft bases) and transported to offsite laboratories for further analysis of sorptive properties of both intact rock and rock fractures.

Task 3: Unsaturated flow and transport in the Calico Hills nonwelded hydrogeologic unit–This task will obtain in situ flow and transport data in the units of and near the repository horizon, including the Calico Hills summit. Geohydraulic field tests (e.g., injection/tracer tests) will be performed between different excavation levels within the existing ESF, repository excavations, and other excavations below the emplacement horizon (e.g., exhaust mains). Testing will include (if possible) the use of surrogate radionuclides and environmental tracers.

3. Parameters Addressed

A preliminary list of parameters to be addressed by this test program include:

- Geohydraulic characteristics of the CHn, including effective hydraulic conductivity, porosity, and storage capacity
- Sorptive characteristics of the CHn with respect to radionuclides.

4. Test Interfaces and Constraints

This testing will interface with construction activities and will be conducted in concert with other performance confirmation testing (i.e., subsurface sampling and testing [BD-02] and seepage monitoring [PM-01]). Laboratory testing of index material properties will be measured at the onsite performance confirmation support facilities and will be supplemented by testing at an offsite laboratory. Long-term sample storage will be provided by the performance confirmation support facilities.

5. Period of Performance/Schedule

This testing will be performed during the early portion of the construction phase of the MGR, prior to waste emplacement, and will continue until sufficient data has been obtained.

DESCRIPTION PE-02
NEAR-FIELD ENVIRONMENT TESTING

Test Category: **Development Testing**

Test Element: **Pre-Emplacement Testing**

Location: **Subsurface**

1. Purpose

The purpose of near-field environment testing is to address data and model validation needs identified in the Near-Field Environment PMR.

2. Description

The present definition of near-field environment testing is based on a preliminary assessment of data needs to be identified in the PMR for the near-field environment model. As this PMR is in draft form, the identified testing program will be adjusted to address the final data needs when the PMR and relevant TSPA sensitivity studies are completed.

The following tasks will be performed:

Task 1: Rock mass cooling response–This testing is to obtain data on the coupled, thermal-mechanical-hydrological-chemical response of the rock mass due to cooling. Borehole-based data will be obtained during the cool-down portion of the ongoing drift scale test to assess differences in response from the initial data observed during the heating cycle of the test.

Task 2: Coupled process testing–This task involves additional field and laboratory testing in concert with the ongoing drift scale test to investigate coupled processes, necessary to confirm the near-field environment.

3. Parameters Addressed

A preliminary list of parameters to be addressed by this test program include thermal-mechanical-hydrological-chemical characteristics of the rock mass.

4. Test Interfaces and Constraints

This testing will interface with construction activities and will be conducted in concert with other performance confirmation testing (e.g., UZ testing [PE-01]).

Laboratory testing of index material properties will be measured at the onsite performance confirmation support facilities and supplemented by testing at an offsite laboratory. Long-term sample storage will be provided by the performance confirmation support facilities.

5. Period of Performance/Schedule

This testing will be performed during the early construction phase of the MGR (i.e., pre-emplacement) and will continue until sufficient data has been obtained.

DESCRIPTION PE-03
WASTE FORM TESTING

Test Category: **Development Testing**

Test Element: **Pre-Emplacement Testing**

Location: **Surface**

1. Purpose

The purpose of waste form testing is to address data and model validation needs identified in the Waste Form Degradation PMR.

2. Description

The present definition of waste form testing is based on a preliminary assessment of data needs to be identified in the PMR for the waste form degradation model. As this PMR is in draft form, the identified testing program will be adjusted to address the final data needs when the PMR and relevant TSPA sensitivity studies are completed.

The following tasks will be performed:

Task 1: Dissolved radionuclide concentration testing–This task involves laboratory testing to obtain additional data on dissolved radionuclide concentration limits of waste form materials.

Task 2: Colloidal concentration and transport testing–This task involves laboratory testing to obtain additional data on colloidal concentration and transportation limits of waste form materials.

Task 3: Cladding performance testing–This task involves laboratory testing to obtain additional data on cladding performance over the range of expected in situ conditions.

Task 4: In-package chemical processes testing–This task involves laboratory testing to obtain additional data on in-package chemistry, its effects on cladding performance, and colloidal and dissolved radionuclide concentrations.

3. Parameters Addressed

A preliminary list of parameters to be addressed by this test program include waste form performance parameters: such as alteration and dissolution of both the SNF and HLW glass waste forms

4. Test Interfaces and Constraints

This test shall interface with other performance confirmation programs and other activities to obtain further definition of the in-package chemistry, cladding performance, and transport processes.

5. Period of Performance/Schedule

This testing will be performed during the early construction (pre-emplacement) phase of the MGR and will continue until sufficient data has been obtained.

DESCRIPTION PE-04
WASTE PACKAGE TESTING

Test Category: **Development Testing**

Test Element: **Pre-Emplacement Testing**

Location: **Surface**

1. Purpose

The purpose of waste package testing is to address data and model validation needs as identified in the Waste Package Degradation PMR.

2. Description

The present definition of waste package testing is based on a preliminary assessment of data needs to be identified in the PMR for the waste package degradation model. As this PMR is in draft form, the identified testing program will be adjusted to address the final data needs when the PMR and relevant TSPA sensitivity studies are completed.

The following three tasks will be performed:

Task 1: Stress corrosion testing of barrier materials–This task involves laboratory testing on the stress corrosion cracking of barrier materials such as nickel-alloy (UNS N06022), Titanium Grade 7, and 316 Nuclear Grade (NG) stainless steel to obtain additional data in support of model validation.

Task 2: Long-term phase stability testing–This task involves laboratory testing on the phase stability of barrier materials such as nickel-alloy (UNS N06022), Titanium Grade 7, and 316 NG stainless steel. This testing is performed to obtain more long-term data on phase stability in support of model validation.

Task 3: Long-term phase stability of passive films testing–This task involves laboratory testing on the phase stability of passive films on barrier materials. Materials to be tested include nickel-based alloy (UNS N06022), Titanium Grade 7, and 316 NG stainless steel. This testing is done to examine the longevity of the films under expected repository conditions, and to obtain additional data in support of model validation. This testing will be supplemented by subsequent field testing (e.g., dummy waste package testing [see Description PM-09]).

3. Parameters Addressed

A preliminary list of parameters to be addressed by this test program include:

- Corrosion parameters for pitting corrosion, crevice corrosion, stress corrosion cracking, and hydrogen embrittlement
- Film properties: thickness, durability, and composition.

4. Test Interfaces and Constraints

This test will interface with other performance confirmation programs and other activities to obtain further definition of the corrosion process, including dummy waste package testing [PM-09], recovered material coupon testing [Description PM-08], and long-term materials testing [Description PM-03].

5. Period of Performance/Schedule

This testing will be performed during the early construction phase of the MGR (i.e., before waste emplacement) and will continue until sufficient data has been obtained.

DESCRIPTION EB-01
BOREHOLE SEAL TESTING

Test Category: **Prototype Testing**

Test Element: **Engineered Barrier System Testing and Verification**

Location: **Surface**

1. Purpose

To evaluate the performance of prototype borehole seals under actual field conditions.

2. Description

Prototype testing of borehole seal tests will be performed in surface-based boreholes using appropriate drilling technology to install and test the seals. This testing will involve representative prototype seals emplaced in shallow boreholes to allow for seal recovery and ease of testing. Seals will be installed into representative rock conditions and tested using available borehole testing technology. After testing, the seals will be removed from in situ by the use of large core bits (significantly larger than the original boreholes) which would drill over the seal sections and recover the seals and the adjacent rock (termed "overcoring"). The recovered seals would then be transported to the laboratory for additional testing and examination.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Properties of the emplaced seal materials including strength, density, hydraulic conductivity, particle-size gradation, porosity, hardness, durability, and chemical reactivity
- Completed geometry of the seal configuration
- Areas of seal non-uniformity including particle segregation, voids, and zones of density variation.

4. Test Interfaces and Constraints

The borehole seal tests will interface with other test programs involved in the development of the seal design. Borehole seal testing will have only limited interface with other performance confirmation testing.

Associated laboratory testing of seal material properties will be measured at the onsite performance confirmation support facilities and/or at an offsite laboratory.

5. Period of Performance/Schedule

The borehole seal program will be started during the developmental stages of construction (as early as is practical) and consistent with identified requirements. The test duration is estimated

to be on the order of a few years and is to be completed before the end of the operation phase of the MGR.

DESCRIPTION EB-02
SHAFT AND RAMP SEAL TESTING

Test Category: **Prototype Testing**

Test Element: **Engineered Barrier System Testing and Verification**

Location: **Subsurface**

1. Purpose

To evaluate the performance of full-scale ramp and shaft seal prototypes.

2. Description

In situ prototype testing of ramps and shaft sealing will be performed in the subsurface facility to demonstrate seals constructability and to evaluate in situ performance. Test facilities will be developed along the south ramp in rock conditions representative of final seal design locations. Seals will be placed using construction techniques identified for repository closure.

Before in situ seal testing, the test alcove area will be developed, including drilling of instrument holes, mapping of the alcove test facilities, installation of monitoring equipment, and testing the rock mass quality of the alcoves. Baseline testing will be performed (i.e., continuous temperature and displacement monitoring) to verify that conditions have stabilized within the test alcoves prior to full scale testing.

The testing of seal performance will require an extended test duration to identify any significant time-dependent response. The seal test facilities will be designed to permit monitoring of the seal performance over a period of several years after seal installation. Initially after seal installation and periodically thereafter, the seals will be non-destructively tested to evaluate performance and to identify any areas of concern. After completion of the test period, the seal configuration will be carefully disassembled (de-constructed) to verify the uniformity of conditions and placement.

Laboratory testing will be performed as required to identify material parameters, which include the compressive strength of engineering natural materials (e.g., concrete and rock), thermal-mechanical curing behavior of materials such as concrete or epoxy, chemical reactivity between seal materials, and the geochemical interaction of the seal materials with the repository host rock and groundwater.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Properties of the emplaced seal materials including strength, density, hydraulic conductivity, particle-size gradation, porosity, hardness, durability, and chemical reactivity
- Completed geometry of the seal configuration
- Areas of seal non-uniformity including particle segregation, voids, and zones of density variation.

4. Test Interfaces and Constraints

The ramp and shaft seal tests shall interface with other test programs involved in the development of the seal design. Development of the seal test area(s) will be coordinated with scheduled construction and other operational activities in the south ramp area. In addition, associated laboratory testing of seal material properties will be measured at the onsite performance confirmation support facilities and/or at an offsite laboratory.

In situ seal testing will have only limited interface with other performance confirmation testing.

5. Period of Performance/Schedule

The in situ seal program will be started during the developmental stages of construction (as early as is practical) and consistent with identified requirements. The test duration is estimated to extend several years, with completion expected before the end of the operation phase of the MGR.

DESCRIPTION EM-01
GROUNDWATER QUALITY

Test Category: **Technical Specifications and Monitoring**

Test Element: **Environmental Monitoring**

Location: **Surface**

1. Purpose

This testing is for the identification of possible water quality changes at the point of compliance.

2. Description

The measurements of water quality and chemistry (specifically to detect radioactive and metal content) of the local aquifer will be taken from monitoring wells to identify any impact(s) of the repository on the aquifer. The wells are to be located both upgradient and downgradient of the GROA, with the downgradient wells at the point of compliance in accordance with applicable regulations. All wells are to be monitored periodically and controlled samples taken and transported to offsite commercial laboratories.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Radionuclide content of the groundwater: radium content, gross alpha activity (including radium-226 but excluding radon and uranium), gross beta activity (from cesium-137 and stronium-90), and content of soluble radionuclides
- Metals content
- Content of chemicals used in facility construction.

4. Test Interfaces and Constraints

Monitoring will be performed outside the GROA, and little impact on repository construction and operations (or other performance confirmation activities) is anticipated. Water quality measurements will be coordinated with and performed after measuring water levels and water temperatures.

5. Period of Performance/Schedule

Wells shall be installed and sampling started (to establish a baseline) a minimum of one year prior to the first underground emplacement of nuclear waste. A sampling baseline of one year in duration is required to identify the full annual cycle of variation. Monitoring will be performed during operational and monitoring phases of the MGR.

DESCRIPTION DE-01
GROUNDWATER LEVEL AND TEMPERATURE MONITORING

Test Category: **Technical Specifications and Monitoring**

Test Element: **Disruptive Event Monitoring**

Location: **Surface**

1. Purpose

This monitoring is for the identification of possible water level and temperature changes as a precursor to significant local geologic changes.

2. Description

The measurement of the water levels (i.e., the zero-potential surface of the upper-most aquifer) and temperature in the available monitoring wells will be measured to identify any significant changes as a precursor to significant geotectonic or volcanic activity.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Characteristics of water level movement: elevation, elevation change between measurements, rate of change, location of measurements, and surficial pattern
- Characteristics of water temperature: water temperature, change between measurements, and surficial pattern
- Temporal: time of observation(s)
- Related observations: surface deformation and seismicity.

4. Test Interfaces and Constraints

This testing uses the same well monitoring system as the groundwater quality measurement program (see EM-01). Water level and temperature measurements will be coordinated with and performed prior to retrieving water samples. Monitoring will be performed outside the GROA, and little impact on repository construction and operations (or other performance confirmation activities) is anticipated.

5. Period of Performance and Schedule

Sampling will be started (to establish a baseline) a minimum of one year before the first emplacement of underground nuclear waste. Monitoring will be performed during operational and monitoring phases of the MGR.

DESCRIPTION DE-02
SURFACE UPLIFT MONITORING

Test Category: **Technical Specifications and Monitoring**

Test Element: **Disruptive Event Monitoring**

Location: **Surface**

1. Purpose

The purpose of this test is to evaluate surficial deformation of the repository site and local area to identify any significant change in the rate of uplift.

2. Description

A system of permanent markers (survey points) will be established across the site, at monitoring well locations, and at reference point(s). The reference points will be solidly affixed into rock or anchored into the local soils to restrict localized deformation of the points. A high-precision survey will be periodically performed using these reference points to determine any significant changes in elevation between measurement cycles, with reference to the reference point(s). The survey precision shall be sufficient to measure surface (crustal) deformations of 1 mm/year.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Characteristics of surface deformation: elevation, elevation change between measurements, rate of change, location of measurements, and surficial pattern
- Temporal: time of observations
- Related observations: evidence of surface deformation and seismicity.

4. Test Interfaces and Constraints

Monitoring will be performed generally outside the GROA, with little impact on repository construction and operations (or other performance confirmation activities) anticipated.

5. Period of Performance and Schedule

Sampling will be started (to establish a baseline) at least one year before the first underground emplacement of nuclear waste. Monitoring will be performed during operational and monitoring phases of the MGR.

DESCRIPTION DE-03
SUBSURFACE SEISMIC MONITORING

Test Category: **Technical Specifications and Monitoring**

Test Element: **Disruptive Event Monitoring**

Location: **Subsurface**

1. Purpose

To evaluate the seismic response of the repository horizon and identify any significant change in the local seismicity.

2. Description

Digital seismic monitoring station(s) will be established at the repository emplacement horizon to record seismic events that occur at the site. Instruments will be placed in shallow boreholes, and integrated with a data acquisition system. Data is to be recorded on a continuous basis to record ground motion and acceleration and transmitted to the surface for processing. Observations of rock mass response will be made after all significant seismic events to correlate the event with observed deformations.

3. Parameters Addressed

Parameters to be addressed by this test program include:

- Seismic parameters: location, magnitude, acceleration, and ground motion record
- Temporal: time and duration of event
- Rock mass response: displacement, fracture growth, and rockfall (if any).

4. Test Interfaces and Constraints

Monitoring will be performed both within the construction and the operational areas of the repository and will require coordination of entry to maintain the equipment and data acquisition system. Little impact on other performance confirmation activities is anticipated. Data is to be correlated with surface seismic monitoring to evaluate the influence of depth.

5. Period of Performance/Schedule

Subsurface seismic monitoring is to start as soon as possible after the niches for seismic monitoring become available and instruments are installed. Monitoring will establish a baseline of one year prior to emplacement drift construction, if possible. Seismic monitoring will be performed during the operation and the monitoring phases of the MGR.

following is a brief synopsis of each scenario, indicating where parameter values are changed from the higher-temperature operating mode (also see Table H-1):

1. **Increased in-drift spacing and extended ventilation**–In this scenario, waste packages would be emplaced an average of 1.9 m (6.2 ft) apart (i.e., the in-drift spacing) to create an approximately 1 kW/m drift thermal load at emplacement. For the first 75 years after the start of emplacement, fans would actively ventilate the drifts with an airflow rate of 15 m^3/s per drift. Thereafter, the repository would be allowed to ventilate naturally for 250 years to meet the thermal goal and then the repository would be closed and sealed.

2. **De-rated or smaller waste packages**–In this scenario, the thermal loading is reduced to create a 1 kW/m linear thermal load by reducing the number of spent nuclear fuel assemblies in a designated waste package to less than the waste package design capacity (derating). This can also be achieved by replacing the large waste packages (e.g., ones containing 21 pressurized water reactor fuel assemblies) with smaller waste packages that have a lower thermal output. The repository would also be ventilated as in Scenario 1 to meet the thermal goal and closed and sealed at 300 years after the end of emplacement.

3. **Varying drift-to-drift spacing and duration of forced ventilation**–To create an approximately 1 kW/m drift thermal load at emplacement, this scenario increases the distance between emplacement drifts (i.e., the drift-to-drift spacing) to 125 m (410 ft). It also increases the forced ventilation period to 300 years to achieve thermal goal. Waste packages would be emplaced closely together (an average of 0.1 m (0.3 ft) apart) as in the higher-temperature mode. Closure would (as in Scenario 1 and 2) occur at 300 years after the end of emplacement

4. **Increased in-drift spacing and duration of forced ventilation**–Lower temperatures could be achieved emplacing waste packages an average of about 6 m (20 ft) apart in this scenario. This would create a drift thermal load at emplacement of approximately 0.7 kW/m. The loaded drifts would also be actively ventilated for 125 years from the start of waste emplacement. The repository would then be closed and sealed.

5. **Extended surface aging with forced ventilation**–In this case, surface aging of the hotter portion of the commercial spent nuclear fuel inventory, combined with the spacing of waste packages approximately 2 m (6.6 ft) apart within the drifts, reduces the linear thermal load to about 0.5 kW/m at emplacement. Forced drift ventilation would also continue for approximately 125 years from the start of waste emplacement to meet the thermal goal. Closure of the repository would then be initiated. Note that surface aging of the hottest wastes would extend the total emplacement period from approximately 25 years to 50 years. However, initiation of repository operations would not be delayed because the cooler commercial spent nuclear fuel, along with the generally cooler DOE waste forms, could be emplaced immediately while the hotter commercial spent nuclear fuel cools through aging.

Table H-1. Comparison of Parameters for Example Lower-Temperature Operating Modes Vs Higher-Temperature Mode

Variable Parameters	Higher-Temperature Operating Mode [1]	Example Lower-Temperature Scenarios [2]					
		Alt 1 (Representative Scenario)	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
		Increased In-Drift Spacing and Extended Ventilation	De-Rated or Smaller Waste Packages	Varying Drift-to-Drift Spacing	Increased In-Drift Spacing and Duration of Forced Ventilation	Extended Surface Aging with Forced Ventilation	Extended Natural Ventilation
Waste package spacing (m)	0.1	1.9	0.1	0.1	6	2	0.1
Maximum waste package thermal loading (kW)	11.8	11.8	<11.8	11.8	11.8	<11.8	11.8
Linear thermal loading objective at emplacement (kW/m)	1.45	1.0	1.0	1.0	0.7	0.5	1.45
Drift-to-drift spacing (m)	81	81	81	125	81	81	81
Forced ventilation period after start of the emplacement (years)	50	75	75	300	125	125	75
Emplacement period (years) [3]	24	24	24	24	24	50	24
Natural ventilation period after forced ventilation period (years)	0	250	250	0	0	0	>300
Size of pressurized water reactor waste packages	21 PWR [4]	21 PWR	<21 PWR	21 PWR	21 PWR	21 PWR	21 PWR

NOTES: [1] See BSC (2001a).

[2] Modified from BSC (2001b).

[3] The 24-year period is based on receipt rate per YMP (2001a, pg. 1.3-9).

[4] PWR = pressurized water reactor. "21 PWR" designates a waste package type containing 21 pressurized water reactor assemblies.

6. **Extended Natural Ventilation** –For this scenario, a lower-temperature repository is created by increasing the period of forced ventilation duration to approximately 75 years after the start of emplacement, followed by an extended period of natural ventilation. The period of the extended natural ventilation would be indefinite (roughly, in excess of 300 years).

The first scenario is designated as the "representative scenario" as it provides a reasonable description of the lower-temperature operating mode (BSC 2001b, p. 40). This scenario is used as the basis for assessing potential impacts discussed in subsequent sections of this appendix, but the arguments presented can be applied to any of the listed examples.

DIFFERENCES BETWEEN THE OPERATING MODES

Parametric Differences in Repository Configuration

The representative scenario differs from the higher-temperature operating mode in a number of parametric values (see Table H-2). These differences, in turn, result in changes in the repository configuration and operation. Specifically, the following differences are noted that have implications for performance confirmation:

- The reduced waste package thermal output during postclosure period will eliminate the envelop of above-boiling conditions near each emplacement drift, and will reduce the expected increase in rock mass temperature occurring shortly after closure (e.g., BSC 2001a, p. 23).

- The reduced waste package surface temperature during preclosure period (achieved by increased ventilation) will reduce the in-drift maximum temperatures of the waste package and the surrounding rock mass. These changes will also reduce the extent of the thermal field (i.e., zone of increased-temperature around emplacement drifts) in the rock mass.

- The increased in-drift spacing will increase the variability of thermal load. Instead of the roughly two-dimensional aspect of closely spaced waste packages along the drift axis, the thermal field will reflect the spacing between packages, with high temperatures at each waste package and lower temperatures between packages as one travels down the axis of the emplacement drift.

- Further, the increased in-drift spacing increases the number of emplacement drifts and drift length that need to be monitored. For the representative scenario, there is a 38% increase in the total emplacement drift length to be excavated (from 59.3 km to 82.0 km) and a 63% increase in the number of drifts (from 52 to 85).

Table H-2. Comparison of Design Parameters for Representative Lower-Temperature Operating Mode and Higher-Temperature Operating Mode

Design Parameters[1]	Higher-Temperature Operating Mode[2]	Lower Temperature Representative Scenario[3]
Number of waste packages	11,184	11,184
Waste package spacing (m)	0.1	1.9
Drift-to-drift spacing (m)	81	81
Areal mass loading (kg-HM/m^2) (See Note 5)	13.8 [56 MTHM/acre]	9.6 [39 MTHM/acre]
Linear thermal loading objective at emplacement (kW/m)	1.45	1.0
Forced ventilation period after start of the emplacement (years)	50	75
Natural ventilation period after forced ventilation period (years)	0	250
Number of emplacement drifts[4]	52	85
Approximate emplacement area (km^2)	4.6 [1125 acres]	6.5 [1628 acres]
Length of emplacement drifts[4] (km)	59.3	82.0
Average waste package maximum temperature (°C)	>96	<85

NOTES: [1] For 70,000 MTU case.

[2] See BSC (2001a).

[3] See BSC (2001b).

[4] Number and length of emplacement drifts do not include contingency drifts or turnouts.

[5] U.S. Customary units are shown in brackets where source document provided value in these units rather than in metric units.

- The reduction in average thermal loading (i.e., from 13.8 kg-HM/m^2 to 9.6 kg-HM/m^2) increases the areal extent of the emplacement area by about 41% (from 4.6 km^2 to 6.5 km^2), extending the repository footprint further north and south in the Upper Block.

- The increased forced ventilation period increases the time to closure from 50 to 75 years after the start of emplacement and therefore increases the duration of performance confirmation by 25 years.

- The natural ventilation period also postpones the time to closure, and therefore increases the duration of performance confirmation by 250 years.

The impact of each of these implications is discussed in more detail in the following sections.

Differences in System Performance

In addition to the specific differences in the repository configuration between the higher- and lower-temperature modes, any differences in system performance need to be evaluated as to determine the implications and impact on performance confirmation. Implications include both changes in overall performance and in the identification of factors important to postclosure performance.

Examining system performance analyses, supplemental science and performance analyses have been performed on defined higher-temperature and lower-temperature operating modes (BSC 2001c, Table 2-1). From the standpoint of uncertainties at the total system level, these supplemental analyses show essentially comparable nominal performance of the higher- and lower-temperature operating modes defined for the analyses (e.g., BSC 2001d, p. 4-10). In contrast, there are some thermal impacts on nominal performance at the subsystem level during the first thousand years (e.g., BSC 2001d, Figure 4.2.2-5). However, these subsystem effects have only a relatively minor impact on system level performance and the expected annual dose (BSC 2001d, p. 5-2). For nominal performance, the yield mean annual dose estimates for the lower-temperature modes are generally slightly less than those for the higher-temperature operating mode.

Further, in review of these analyses, no change in principal factors is noted, and hence no differences in the factors important to safety are identified between the lower- and higher-temperature operating modes. Consequently, the factors that define the performance confirmation program (as discussed in Section 3.4.2 of the plan) remain unchanged.

ASSESSMENT OF IMPACTS

Impacts Due to Decreased Thermal Output During Postclosure

The impact of the reduced thermal output of the waste package (thereby reducing temperatures to below boiling in the rock mass) and reducing the temperature "bump" of the higher-temperature mode immediately after closure will impact the any testing focused on postclosure conditions. Specifically, the rock mass around the emplacement drift will not be subject to boiling, eliminating steam as a thermal-hydrologic transfer process and thereby reducing (to some extent) coupled thermal-hydrologic and thermal-geochemical processes. Also, the postclosure

conditions will be more similar to preclosure conditions reducing concerns that the postclosure is a more extreme situation. As performance confirmation activities terminate at closure, these changes would directly affect only the Postclosure Simulation test element (specifically, Test PS-01, Postclosure Simulation Testing; see Table G-1).

For this simulation testing, the reduction of the thermal output and maximum temperatures will simplify (to some extent) the type and amount of instruments required to monitor conditions, and can be expected to increase instrument life. This would, in turn, reduce test costs. However, as the magnitude of the changes in thermal-geomechanical-geohydrological-geochemical processes would be reduced, instruments would be required to have increased resolution and accuracy. With increased resolution, the removal of background noise (experienced in all monitoring) would be more problematic for data reduction and test evaluation. Both these items would tend to increase costs. In toto, the sum of these effects is expected (in terms of cost) to roughly balance.

The remaining impact that of reducing concerns that the postclosure period poses more extreme conditions than monitored during preclosure, is more problematic to evaluate. There are a number of arguments (such as design optimization) that support the need to conduct a postclosure test. However, from a confirmation viewpoint, if the preclosure conditions are very similar to postclosure ones, the question can be raised as to the need to conduct such a test as part of performance confirmation, or to re-scope the program into several individual smaller programs studying the affects on barriers installed at closure. Therefore, there may a need to re-evaluate the scope of this testing as part of performance confirmation if a lower-temperature modes is adopted.

Impacts Due to Decreased Waste Package Temperatures

Reducing the surface temperatures of the waste package and the surrounding rock mass will impact the performance monitoring of the conditions within and around the emplacement drifts. Specifically, the volume of rock mass around the emplacement drift that experiences a significant temperature change due to waste storage is expected to be reduced to a large extent. In addition, the temperatures within the drift during preclosure period are expected to be reduced in proportion to the reduction of waste package's surface temperature (approximately 10°C).

These changes will affect the Process Monitoring activities (see Table G-1) and data evaluation activities (from the Baseline Development test element) including:

- PM-02 In Situ Waste Package Monitoring
- PM-03 Long-Term Materials Testing
- PM-04 Ventilation Monitoring
- PM-05 Rock Mass Monitoring
- PM-06 In-Drift Monitoring
- PM-08 Recovered Material Coupon Testing
- BD-03 Baseline Analyses and Evaluations

Upon review, the approximately 10°C reduction of the in-drift temperatures will have only a minimal impact on the type and amount of in-drift monitoring (i.e., for test activities: PM-02,

PM-03, PM-04, PM-06 and PM-08) as the temperatures to be measured remain within the same order of magnitude. The reduced temperatures will also reduce the maximum operating temperature requirement for in-drift instrumentation, especially the ROV, but again, this is expected to have only a minor impact.

However, the reduction in extent of the thermal zone (i.e., the rock volume that will experience a significant temperature change) will have a more decisive effect on test activities PM-05 and BD-03. Reducing the thermal zone reduces the volume of rock to be monitored by PM-05 and therefore reduces the amount of instrumentation as well as reducing the attendant costs for the instruments, monitoring and data evaluation. Assuming about 30% decrease in volume, this may reduce the extent and cost of rock mass monitoring by a 30% to 50%, and the data evaluation for this monitoring by a similar factor. Thermal analyses are as yet unavailable to further define this aspect.

Impacts Due to Increased In-Drift Spacing / Variable Thermal Loading

As noted, the increased in-drift spacing of the lower-temperature operating mode will increase the variability of thermal load. For the representative mode, the thermal field will reflect the increased spacing of about 2 meters between packages, with peak temperatures at the center each waste package and temperature-lows between packages as one travels down the axis of the emplacement drift. This high-low-high type of variation contrasts with the roughly linear trend that would be seen with the waste packages closely spaced together as designated for the higher-temperature operating mode. This variation will make monitoring within and around emplacement drifts more complex, requiring additional instrumentation to correctly capture this variation and requiring more complex analyses and evaluations (changing a primarily 2-dimensional problem into a 3-dimensional problem to explicitly include thermal variation along the tunnel axis).

The extent and cost of following performance confirmation activities would be impacted by this variability:

- PM-02 In Situ Waste Package Monitoring
- PM-04 Ventilation Monitoring
- PM-05 Rock Mass Monitoring
- PM-06 In-Drift Monitoring
- BD-03 Baseline Analyses and Evaluations

It is not possible to identify the extent of the cost increase due to this increased complexity, but it may be estimated to be roughly balance or exceed the decrease in costs due to the decreased thermal output identified in the prior section.

Impacts Due to Increased In-Drift Spacing / Increased Length of Emplacement Drifts

The increased in-drift spacing of waste packages for lower-temperature operating mode significantly increases the total length of emplacement drifts. In turn, this increases the extent (and costs) of activities for test elements such as Baseline Development and Process Monitoring where the extent of the activity is a function of the total drift length. For example, increased drift

length requires additional geologic mapping, index testing, and increases the extent of in situ waste package monitoring (as the remote inspection system would be required to travel further). However, the intent of, and the methods employed for, these performance confirmation activities would remain largely unaffected.

Specifically, the following performance confirmation activities would be impacted:

- PM-02 In Situ Waste Package Monitoring
- PM-04 Ventilation Monitoring
- PM-05 Rock Mass Monitoring
- PM-06 In-Drift Monitoring
- BD-01 Geologic Observations and Mapping
- BD-02 Subsurface Sampling and Index Testing
- BD-03 Baseline Analyses and Evaluations

The cost increase due to the increased extent of these activities would be (roughly) directly proportional to the increase in drift length, representing about a 60% increase of the cost for these activities in implementing the representative lower-temperature operating mode.

Impacts Due to Reduced Thermal Loading / Increased Areal Extent

The reduction in the average thermal loading will increase the areal extent of the emplacement area (i.e., the repository footprint). This in turn increases the extent of monitoring activities that are dependent on the size of the footprint. It will also increase the amount of baseline data to be evaluated. However, the intent and methods of these performance confirmation activities would not be impacted.

An increased area will affect (to some extent) activities of Disruptive Event Monitoring, Process Monitoring and the Baseline Development test elements. Specifically, the following performance confirmation activities would be impacted:

- DE-02 Surface Uplift Monitoring
- DE-03 Subsurface Seismic Monitoring
- PM-01 Seepage Monitoring
- BD-03 Baseline Analyses and Evaluations

The cost increase due to the increased extent of these activities would be (roughly) directly proportional to the increase in areal extent, representing about a 40% increase of the cost for these activities in implementing the representative lower-temperature operating mode.

Impacts Due to Increased Forced Ventilation Period

Increasing the forced ventilation period will impact the duration of surface and subsurface performance monitoring of the repository, but not significantly impact the scope of these activities. Test elements such as Process Monitoring, Environmental Monitoring and Disruptive Event Monitoring (see Table G-1) are, for the most part, envisioned to continue throughout the forced ventilation phase. Therefore, increasing the duration of the preclosure period will result

directly in an increase of performance confirmation costs. The extent of this increase is significant but attenuated as the costs for these test activities are considered to be front-loaded (i.e., a majority costs are incurred within the first few years). Therefore, increasing the duration of the program by 50% (i.e., from 50 to 75 years for the representative lower-temperature mode) may only increase the activity costs by roughly 17% in current fiscal year dollars [This can be computed assuming that 70% of monitoring costs are incurred in the first ten years and this set of monitoring costs represent 90% of the total costs for performance confirmation].

Impacts Due to Natural Ventilation Monitoring

Introducing a natural ventilation period prior to closure will increase the preclosure period and thereby increase the duration of surface and subsurface performance monitoring of the repository. This will impact monitoring elements such as Process Monitoring, Environmental Monitoring and Disruptive Event Monitoring, which are envisioned, for the most part, to continue throughout the natural ventilation phase. Again, assuming front-loaded activities, the increase of 500% in duration (i.e., an additional 250 years), would increase the activity costs by roughly 150% in current fiscal year dollars.

Further, additional costs may be incurred to operate the repository solely to allow performance confirmation testing and monitoring activities. During the natural ventilation period, it can be assumed that repository operations are at a minimum, as active ventilation has ceased, and that surface facilities have been (to large degree) decommissioned (with the exception of testing and monitoring facilities). Therefore, performance confirmation activities may require operational, ventilation and safety measures (and hence incur costs) in addition to the normal operations to allow personnel access to, and operate within, the subsurface. However, these costs are not possible to assess without additional definition of normal repository operations for the lower-temperature operating mode during this period.

On the other side of the ledger, in conducting these monitoring activities over a very long time period (i.e., more than 100 years), some cost-mitigating factors may be employed. For monitoring activities that are conducted periodically (e.g., PM-02 In Situ Waste Package Monitoring and DE-02 Surface Uplift Monitoring) the duration of time between measurements may be increased assuming that prior measurements were well within the expected range for the monitoring. The increase in the interval could be gradually increased (say from 1 to 2 and then to 5 years), as sufficient number of measurements has been made and confidence increases. Reductions in the scope of measurement may also occur, based on reevaluations of the activity scope in light of numerous prior measurements. Further, it is expected that instrumentation technology will advance with time and potentially such advances could reduce costs to some degree.

The long-duration of the natural ventilation program may also require a re-assessment of the scope of the performance confirmation monitoring during this period. The monitoring program can possibly be re-directed (or transitioned) after initial period of natural ventilation, perhaps allowing for the use of remote monitoring methods instead of more-costly in situ methods within the repository footprint to confirm continued performance is still within expected bounds. Obviously, this proposal does not consider the status of institutional controls and the licensing

framework for the repository, which are at this time undefined for this long-term monitoring period.

CONCLUSIONS

In review of the foregoing, the impact of the lower-temperature operating modes on the current performance confirmation program will be primarily to change the details of measurement and increase the cost of the performance confirmation program. The identified testing concepts will remain essentially unaffected, but there will be a change in instrumentation utilization, including the type, extent, accuracy and location of instruments as presently envisioned. However, there may be a need to re-evaluate the scope of monitoring during an extended natural ventilation period (to allow for a transition in approach) and the scope of postclosure simulation testing (to assess the approach to postclosure confirmation).

The total cost of the performance confirmation program will increase significantly, due primarily to the increased duration of the preclosure period (encompassing both the forced and natural ventilation phases). Further, additional increased costs will be incurred due to the larger repository footprint and the longer length of emplacement drifts. However, for the increased preclosure period, the increase in such costs is not directly proportional to the increase in total years, as activity costs tend to be front-loaded (with a majority of costs spent in the initial years). Therefore, increases in total duration (at the end of the activity, so to speak) induce only a moderate (but still significant) cost increase. In addition, mitigating measures such as increased time periods between measurements, reductions in scope and expected advances in instrumentation methods will also reduce costs to some degree.

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