

**APPENDIX A**  
**Commitments**

## COMMITMENTS

During the review of the Yucca Mountain License Application by the staff of the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE) made commitments related to the construction and operation of the geologic repository at Yucca Mountain. These commitments were identified in DOE's Safety Analysis Report (SAR) and/or in response to Requests for Additional Information (RAIs). The following table lists a description of these commitments along with the referenced sources and implementation schedules for each.

No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
1.	DOE commits to controlling the parameters identified in SAR Table 1.9-9 to ensure the TSPA analysis basis is met.	Section 2.2.1.2.1.3.2	Section 2.2.1.1	After Construction Authorization and before License to Receive and Possess
2.	DOE commits to excluding from repository disposal, BWR fuel assemblies that contain enrichment greater than 4.5 wt% in U-235.	Section 2.2.1.2.1.3.2	Section 2.2.1.4.1.1.2.4.1	After Construction Authorization and before License to Receive and Possess
3.	DOE commits to validating its criticality analyses for DOE SNF using the accepted Radulescu, et al. (2007aa) methodology and submitting the analyses for NRC staff's review and approval, or providing other methods for NRC staff's review and approval, prior to emplacement of DOE SNF into the drifts.	Section 2.2.1.2.1.3.2	Section 2.2.1.4.1.1.2.4.2	After Construction Authorization and before License to Receive and Possess
4.	<p>DOE commits to revising the PWR loading curves subject to the following:</p> <ul style="list-style-type: none"> <li>— No burnup credit for <math>^{95}\text{Mo}</math>, <math>^{99}\text{Tc}</math>, <math>^{101}\text{Ru}</math>, <math>^{103}\text{Rh}</math>, and <math>^{109}\text{Ag}</math>.</li> <li>— Incorporate a penalty on <math>k_{\text{eff}}</math> (subcritical margin) of 0.02 in the critical limit analysis. This penalty shall also be applied to DOE SNF group three.</li> </ul>	Section 2.2.1.2.1.3.2	<p>Section 2.2.1.4.1.1.2.4.2</p> <p>And</p> <p>2.2.1.4.1.1.2.4.1</p>	After Construction Authorization and before License to Receive and Possess

No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
5.	DOE commits to using a maximum burnup of 50 GWd/MTU with respect to the burnup credit loading curves in criticality analyses for commercial pressurized water reactor fuel unless additional validation data are provided to extend the burnup beyond 50 GWd/MTU.	Section 2.2.1.2.1.3.2	Section 2.2.1.4.1.1.4  And  Supplemental RAI Response-RAI no. 21, Set 4 (DOE, 2009by)	After Construction Authorization and before License to Receive and Possess

## CHAPTER 22

### Glossary

This glossary is provided for information and is not exhaustive. Terms shown in italics are included in this glossary .

**absorption:** The process of taking up by capillary, osmotic, solvent, or chemical action of molecules (e.g., absorption of gas by water) as distinguished from *adsorption*.

**abstracted model:** A model that reproduces, or bounds, the essential elements of a more detailed process model and captures uncertainty and variability in what is often, but not always, a simplified or idealized form. See *abstraction*.

**abstraction:** Representation of the essential components of a process model into a form suitable for use in a *total system performance assessment*. A *model abstraction* is intended to maximize the use of limited computational resources while allowing a sufficient range of sensitivity and uncertainty analyses.

**adsorb:** To collect a gas, liquid, or dissolved substance on a surface as a condensed layer.

**adsorption:** The adhesion by chemical or physical forces of molecules or ions (as of gases or liquids) to the surface of solid bodies. For example, the transfer of solute mass, such as *radionuclides*, in groundwater to the solid geologic surfaces with which it comes in contact. The term *sorption* is sometimes used interchangeably with this term.

**advection:** The process in which solutes, particles, or molecules are transported by the motion of flowing fluid.

**aging:** The retention of *commercial spent nuclear fuel* on the surface in *dry storage* to reduce its thermal output as necessary to meet repository thermal management goals.

**airborne mass loading:** The amount of fine particulates resuspending above a surface deposit, generally expressed as mass per unit volume of air.

**aleatory uncertainty:** An uncertainty associated with the chance of occurrence of a feature, event, or process of a physical system or the environment such as the timing of a volcanic event. Also referred to as irreducible uncertainty because no amount of knowledge will determine whether or not a chance event will or will not occur. See also *epistemic uncertainty*.

**Alloy 22:** A nickel-based, corrosion-resistant alloy containing approximately 22 weight percent chromium, 13 weight percent molybdenum, and 3 weight percent tungsten as major alloying elements. This alloy is used as the outer container material in DOE's waste package design.

**alluvium:** Detrital (sedimentary) deposits made by flowing surface water on river beds, flood plains, and alluvial fans. It does not include subaqueous sediments of seas and lakes.

**alternative:** In the context of system analysis, plausible interpretations or designs that use assumptions other than those used in the base case, which could also be applicable or reasonable given the available scientific information. When propagated through a

quantitative tool such as performance assessment, alternative interpretations can illustrate the significance of the uncertainty in the base case interpretation chosen to represent the system's probable behavior.

**ambient.** Undisturbed, natural conditions, such as ambient temperature caused by climate or natural subsurface thermal gradients, and other surrounding conditions.

**anisotropy.** Variation in physical properties when measured in different directions. For example, in layered rock, permeability is often greater within the horizontal layers than across the horizontal layers.

**annual frequency.** The number of occurrences of an event in 1 year.

**aqueous.** Pertaining to water, such as aqueous phase, aqueous species, or aqueous transport.

**aquifer.** A saturated underground geologic formation of sufficient permeability to transmit *groundwater* and yield water of sufficient quality and quantity to a well or spring for an intended beneficial use.

**ash:** Fragments of volcanic rock that are broken during an explosive volcanic eruption to less than 2 mm [0.08 in] in diameter. See also *tephra* and *pyroclastic*.

**ash-flow tuff.** A type of volcanic rock formed by the deposition and accumulation of dominantly ash-size particles during an explosive eruption. Ash flows (also called *pyroclastic flows*) commonly result from eruptions of more viscous, silica-rich magma such as rhyolite. This rock type forms the host horizons for the proposed geologic repository at Yucca Mountain. See also *tuff* and *welded tuff*.

**basalt.** A common type of igneous rock that forms black, rubbly to smooth-surfaced lavas and black to red *tephra* deposits (frequently used as "lava rock" for barbecues).

**borosilicate glass:** A predominantly noncrystalline, relatively homogenous glass formed by melting silica and boric oxide together with other constituents such as alkali oxides. Borosilicate glass is a high-level radioactive waste matrix material in which boron takes the place of the lime used in ordinary glass mixtures.

**boundary condition:** For a model, the establishment of a set condition for a given variable, often at the geometric edge of the model. An example is using a specified *groundwater* flux for *net infiltration* as a boundary condition for an *unsaturated zone flow* model.

**bound:** An analysis or selection of parameter values that yields limiting results, such that any actual result is certain to exceed these limits only with an extremely small likelihood.

**breach:** A penetration in the waste package caused by failure of the outer and inner containers or barriers that allows the spent nuclear fuel or the high-level radioactive waste to be exposed to the external environment and may eventually permit *radionuclide* release.

**burnup:** A measure of nuclear reactor fuel consumption expressed either as the percentage of fuel atoms that have undergone fission, or as the amount of energy produced per unit weight of fuel.

**burnup credit:** The concept of taking credit for the reduction in reactivity (ability to undergo fission) due to fuel irradiation. The reduction in reactivity is due to the net reduction of fissile nuclides and the production of parasitic neutron-absorbing nuclides.

**caldera:** A volcanic depression in the Earth's surface more than 1 km [0.7 mi] wide, formed by the collapse of the upper crust into an evacuated *magma* chamber during or after a large volcanic eruption. Many calderas resulting from the explosive eruption of large amounts of rhyolite magma are several tens of kilometers [up to 20 mi] wide.

**calibration:** (1) Comparison of model results with actual data or observations, and adjusting model parameters to increase the precision and/or accuracy of model results compared to actual data or observations. (2) For tools used for field or lab measurements, the process of taking instrument readings on standards known to produce a certain response, to check the accuracy and precision of the instrument.

**canister:** An unshielded cylindrical metal receptacle that facilitates handling, transportation, storage, and/or disposal of high-level radioactive waste. It may serve as (i) a pour mold and container for vitrified high-level radioactive waste; (ii) a container for loose or damaged fuel rods, nonfuel components and assemblies, and other debris containing *radionuclides*; or (iii) a container that provides *radionuclide* confinement. Canisters are used in combination with specialized overpacks that provide structural support, *shielding*, or confinement for storage, transportation, and *emplacement*. Overpacks used for transportation are usually referred to as *transportation casks*; those used for emplacement in a *repository* are referred to as *waste packages*.

**carbon steel:** A steel made with carbon up to about 2 weight percent and only residual quantities of other elements. Carbon steel is a tough but ductile and malleable material that is used in some components in DOE's design of the engineered barrier system.

**cask:** (1) A heavily shielded container that meets applicable regulatory requirements used to ship *spent nuclear fuel* or *high-level radioactive waste*. (2) A heavily shielded container DOE and utilities use for the *dry storage* of spent nuclear fuel, usable only for storage, not for transportation to or *emplacement* in a *repository*. (3) A heavily shielded container that DOE would use to transfer *canisters* between waste handling facilities at the repository.

**cinder cone:** A steep, conical hill formed by the accumulation of *ash* and coarser erupted material around a volcanic vent. Synonymous with scoria cone.

**cladding:** The metal outer sheath of a fuel rod generally made of a zirconium alloy, and in the early nuclear power reactors of stainless steel, intended to protect the uranium dioxide pellets, which are the nuclear fuel, from dissolution by exposure to high temperature water under operating conditions in a reactor. Often referred to as "clad."

**climate:** Weather conditions, including temperature, wind velocity, precipitation, and other factors, that prevail in a region.

**climate states:** Representations of *climate* conditions.

**colloid:** As applied to *radionuclide* migration, colloids are large molecules or very small particles, having at least one dimension with the size range of  $10^{-6}$  to  $10^{-3}$  mm [ $10^{-6}$  to  $10^{-5}$  in]

that are suspended in a solvent. Colloids in groundwater arise from clay minerals, organic materials, or (in the context of a geologic repository) from corrosion of engineered materials.

**commercial spent nuclear fuel:** Nuclear fuel rods, forming a fuel assembly, that have been removed from a nuclear power plant after reaching the specified burnup.

**conceptual model:** A set of qualitative assumptions used to describe a system or subsystem for a given purpose. Assumptions for the model are compatible with one another and fit the existing data within the context of the given purpose of the model.

**conduit:** A pathway along which *magma* rises to the surface during a volcanic eruption. Conduits are usually cylindrical and flare upwards toward the surface vent. Conduits are near-surface features and develop along *dikes*, focusing magma flow from the longer and possibly narrower *dike* to the vent.

**consequence:** A measurable or calculated outcome of an event or process that, when combined with the probability of occurrence, gives a measurement of risk.

**conservative:** A condition of an analysis or a parameter value such that its use provides a pessimistic result, which is worse than the actual result expected.

**corrosion:** The deterioration of a material, usually a metal, as a result of a chemical or electrochemical reaction with its environment.

**coupled processes:** A representation of the interrelationships between *processes* such that the effects of variation in one process are accurately propagated among all interrelated *processes*.

**crevice corrosion:** *Localized corrosion* of a metal surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of close proximity between the metal and the surface of another material.

**criticality:** The condition in which a fissile material sustains a chain reaction. It occurs when the number of neutrons present in one generation cycle equals the number generated in the previous cycle. The state is considered critical when a self-sustaining nuclear chain reaction is ongoing.

**diffusion:** (1) The spreading or dissemination of a substance caused by concentration gradients. (2) The gradual mixing of the molecules of two or more substances because of random thermal motion.

**diffusive transport:** Movement of solutes because of their concentration gradient. *Diffusive transport* is the process in which substances carried in *groundwater* move through the subsurface by means of *diffusion* because of a concentration gradient.

**dike:** A tabular, generally vertical body of *igneous* rock that cuts across the *structure* of adjacent rocks. *Dikes transport* molten rock from depth to an erupting volcano.

**dimensionality:** Modeling in one, two, or three dimensions.

**direct exposure:** The manner in which an individual receives dose from being in close proximity to a source of radiation. Direct exposures present an external dose pathway.

**dispersion (hydrodynamic dispersion):** (1) The tendency of a solute (substance dissolved in groundwater) to spread out from the path it is expected to follow if only the bulk motion of the flowing fluid were to move it. The tortuous path the solute follows through openings (pores and fractures) causes part of the dispersion effect in the rock. (2) The macroscopic outcome of the actual movement of individual solute particles through a porous medium. Dispersion dilutes solutes, including *radionuclides*, in groundwater and is usually an important mechanism for spreading contaminants in low flow velocities.

**disposal canister:** A cylindrical metal receptacle designed to contain spent nuclear fuel and high-level radioactive waste that will become an integral part of the waste package.

**disruptive event:** An unlikely, off-normal event that, in the case of the potential repository, could include volcanic activity, seismic activity, and nuclear criticality. Disruptive events alter the normal or likely behavior of the system.

**dissolution:** Dissolving a substance in a solvent.

**distribution:** In a *total system performance assessment*, the overall scatter of values for a specific set of numbers (e.g., corrosion rates, values used for a particular parameter, dose results). A term used synonymously with frequency distribution or probability distribution function. Distributions have structures that are the probability that a given value occurs in the set.

**drift:** From mining terminology, a horizontal underground passage. In the Yucca Mountain repository design, drifts include excavations for emplacement (emplacement drifts) and access (access mains).

**drift degradation:** The progressive accumulation of rock rubble in a drift created by weakening and collapse of drift walls in response to stress from heating or earthquakes.

**drip shield:** A metallic structure placed along the extension of the emplacement *drifts* and above the *waste packages* to prevent seepage water from directly dripping onto the waste package outer surface. The drip shield may also prevent the *drift* ceiling rocks (e.g., due to drift degradation) from falling on the waste package.

**dry storage:** Storage of *spent nuclear fuel* without immersion of the fuel in water for cooling or shielding; it involves the encapsulation of spent fuel in a steel cylinder that might be in a concrete or massive steel *cask* or structure.

**effective porosity:** The fraction of a porous medium volume available for fluid flow and/or solute storage, as in the saturated zone. Effective porosity is less than or equal to the total void space (porosity).

**empirical:** Reliance on observation or experimentation rather than on a theoretical understanding of fundamental processes.

**emplacement drift:** See *drift*.

**enrichment:** The act of increasing the concentration of fissile isotopes from their value in natural uranium. The enrichment (typically reported in atom percent) is a characteristic of nuclear fuel.

**eolian:** Processes related to near-surface winds.

**epistemic uncertainty:** A variability that is due to a lack of knowledge of quantities or processes of the system or the environment. Also referred to as reducible uncertainty, because the state of knowledge about the exact value of a quantity or process can increase through testing and data collection. See also *aleatory uncertainty*.

**equilibrium:** The state of a chemical system in which the phases do not undergo any spontaneous change in properties or proportions with time; a dynamic balance.

**events:** In a *total system performance assessment*, (1) occurrences of phenomena that have a specific starting time and, usually, a duration shorter than the time being simulated in a model. (2) Uncertain occurrences of phenomena that take place within a short time relative to the time frame of the model.

**event tree:** A modeling tool that illustrates the logical sequence of events that follow an initiating event.

**expected annual dose:** The average annual radiological dose calculated for the reasonably maximally exposed individual, which includes the likelihood of the individual receiving a dose from all relevant exposure scenarios.

**expert elicitation:** A formal, highly structured, and well-documented process whereby expert judgments, usually of multiple experts, are obtained.

**Exploratory Studies Facility (ESF):** An underground laboratory at Yucca Mountain that includes a 7.9-km [4.9-mi] main loop (tunnel); a 2.8-km [1.75-mi] cross drift; and a research alcove system constructed for performing underground studies during site characterization.

**extrusive (extrusion):** In relation to *igneous* activity, an event where *magma* erupts at the surface. An extrusion is the deposit formed by an extrusive event. See also *intrusive*.

**fault (geologic):** A planar or gently curved fracture across which there has been displacement parallel to the *fracture* surface.

**features:** Physical, chemical, thermal, or temporal characteristics of the site or potential repository system. For the purposes of screening features, events, and processes for the total system performance assessment, a feature is defined to be an object, structure, or condition that has a potential to affect disposal system performance.

**finite element analysis:** A commonly used numerical method for solving mathematical equations in a variety of areas (e.g., hydrology, mechanical deformation). A technique in which algebraic equations are used to approximate the partial differential equations that comprise mathematical models to produce a form of the problem that can be solved on a computer. For this type of approximation, the area being modeled is formed into a grid with irregularly shaped blocks. This method provides an advantage in handling irregularly shaped boundaries (e.g., internal features such as faults) and surfaces of engineered materials. Values for parameters

are frequently calculated at nodes for convenience, but are defined everywhere in the blocks by means of interpolation functions.

**fissure:** In relation to *igneous* activity, a fissure is an elongate vent or line of vents, formed when a *dike* breaks to the surface to start a volcanic eruption.

**flow:** The movement of a fluid such as air, water, or magma. Flow and *transport* are processes that can move *radionuclides* from the proposed repository to the receptor group location.

**flow pathway:** The subsurface course that water or a solute (and dissolved material) would follow in a given *groundwater* velocity field, governed principally by the hydraulic gradient.

**fluvial:** Processes related to the downslope movement of water on the Earth's surface.

**fracture:** A planar discontinuity in rock along which loss of cohesion has occurred. It is often caused by the stresses that cause folding and faulting. A fracture along which there has been displacement of the sides relative to one another is called a fault. A fracture along which no appreciable movement has occurred is called a joint. Fractures may act as fast paths for groundwater movement.

**fragility:** Fragility of a structure, system, or component is defined as the conditional probability of its failure, given a value of the ground motion, or response parameter, such as stress, bending moment, and spectral acceleration.

**frequency:** The number of occurrences of an observed or predicted event during a specific time period.

**galvanic:** Pertains to an electrochemical process in which two dissimilar electronic conductors are in contact with each other and with an electrolyte, or in which two similar electronic conductors are in contact with each other and with dissimilar electrolytes.

**galvanic corrosion:** Accelerated corrosion of a metal resulting from electrical contact with a more noble metal or nonmetallic conductor in a corrosive electrolyte.

**geochemical:** The distribution and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere; the movement of the elements in nature on the basis of their properties.

**geophysics (geophysical survey; geophysical magnetic survey):** The study of the physical properties of rocks and sediment and interpretation of data derived from measurements made. Properties commonly measured are the velocity of sound (seismic waves) in rocks, density, and magnetic character. A program of measurements made on a series of rocks is usually termed a survey.

**groundwater:** Water contained in pores or fractures in either the unsaturated or saturated zones below ground level.

**half-life:** The time required for a radioactive substance to lose half of its activity due to radioactive decay. At the end of one half-life, 50 percent of the original radioactive material has decayed.

**heterogeneity:** The condition of being composed of parts or elements of different kinds. A condition in which the value of a parameter varies over the space an entity occupies, such as the area around the repository, or with the passage of time.

**hydrologic:** Pertaining to the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

**igneous:** (1) A type of rock that has formed from a molten, or partially molten, material. (2) A type of activity related to the formation and movement of molten rock, either in the subsurface (*intrusive*) or on the surface (*extrusive*).

**infiltration:** The process of water entering the soil at the ground surface. Infiltration becomes percolation when water has moved below the depth at which evaporation or transpiration can return it to the atmosphere. See also *net infiltration*.

**intrusive (intrusion):** In relation to *igneous* activity, an event where *magma* approaches the surface but does not break through in an eruption. An intrusion is the solidified rock formed below the surface by an intrusive event. See also *extrusive*.

**invert:** A constructed surface that would provide a level drift floor and enable emplacement and support of the waste packages.

**license application:** An application from the U.S. Department of Energy to the U.S. Nuclear Regulatory Commission for a license to construct and operate a repository.

**localized corrosion:** Corrosion at discrete sites (e.g., pitting and *crevice corrosion*).

**lithophysal:** Containing lithophysae, which are holes in *tuff* and other volcanic rocks. One way lithophysae are created is by the accumulation of volcanic gases during the formation of the *tuff*.

**magma:** Molten or partially molten rock that is naturally occurring and is generated within the earth. Magma may contain crystals along with dissolved gasses.

**mathematical model:** A mathematical description of a conceptual model.

**matrix:** Rock material and its pore space exclusive of fractures.

**matrix diffusion:** The process by which molecular or ionic solutes, such as *radionuclides* in *groundwater*, move from areas of higher concentration to areas of lower concentration. This movement is through the pore spaces of the rock as opposed to movement through the *fractures*.

**matrix permeability:** The capability of the *matrix* to transmit fluid.

**mean (arithmetic):** For a statistical data set, the sum of the values divided by the number of items in the set. The arithmetic average, sometimes referred to as expected value.

**mechanical disruption:** Damage to the drip shield or waste package because of external forces.

**median:** A value such that one-half of the observations are less than that value and one-half are greater than the value.

**meteorology:** The study of climatic conditions such as precipitation, wind, temperature, and relative humidity.

**microbe:** An organism too small to be viewed with the unaided eye. Examples of microbes are bacteria, protozoa, and some fungi and algae.

**microbially influenced corrosion:** Deterioration of metals as a result of the metabolic activity of microorganisms.

**migration:** Radionuclide movement from one location to another within the engineered barrier system or the environment.

**mineralogical:** Of or relating to the chemical and physical properties of minerals, their occurrence, and their classification.

**model:** A depiction of a system, phenomenon, or process, including any hypotheses required to describe the system or explain the phenomenon or process.

**model support:** A process used to gain confidence in the reasonableness of *model* results through comparison with outputs from detailed process-level models and/or empirical observations such as laboratory tests, field investigations, and natural analogues.

**natural analogues:** Observable features, events, or processes, which provide insights on similar features, events, or processes that are difficult to observe in the repository system.

**near-field:** The area and conditions within the potential repository including the *drifts* and waste packages and the rock immediately surrounding the *drifts*. The near-field is the region in and around the potential repository where the excavation of the repository *drifts* and the emplacement of waste have significantly impacted the natural *hydrologic* system.

**net infiltration:** The amount of infiltration that escapes the zone of evapotranspiration, which is generally the zone below the extent of plant roots.

**nominal scenario class:** The scenario, or set of related scenarios, that describes the expected or nominal behavior of the system as perturbed only by the presence of the potential repository. The nominal scenarios contain all likely features, events, and processes that have been retained for analysis.

**numerical model:** An approximate representation of a mathematical model that is constructed using a numerical description method such as finite volumes, finite differences, or finite elements. A numerical model is typically represented by a series of program statements that are executed on a computer.

**occupational dose:** The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals who were

administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public (10 CFR 20.1003, "Occupational dose").

**oxidation:** A corrosion reaction in which the corroded metal forms an oxide, usually applied to reaction with a gas containing elemental oxygen, such as air.

**parameter:** Data, or values, such as those that are input to computer codes for a total system performance assessment calculation.

**patch:** In the DOE modeling of waste package corrosion, a patch is the minimal surface area of the waste package over which uniform corrosion occurs, as opposed to localized corrosion in *pits*.

**pathway:** A potential route by which *radionuclides* might reach the accessible environment and pose a threat to humans. For example, direct exposure is an external pathway, and inhalation and ingestion are internal pathways.

**permeability:** A measure of the ease with which a fluid such as water or air moves through a rock, soil, or sediment.

**phase:** A physically homogeneous and distinct portion of a material system, such as the gaseous, liquid, and solid phases of a substance. In liquids and solids, single phases may coexist.

**phase stability:** A measure of the ability of a particular phase to remain without transformation.

**pit:** A small cavity formed in a solid as a result of localized corrosion.

**pitting corrosion:** *Localized corrosion* of a metal surface, confined to a small area, that takes the form of cavities (*pits*).

**porosity:** The ratio of the volume occupied by openings, or voids, in a soil or rock, to the total volume of the soil or rock. Porosity is expressed as a decimal fraction or as a percentage.

**probabilistic:** Based on or subject to *probability*.

**probability:** The chance that an outcome will occur from the full set of possible outcomes. Knowledge of the exact probability of an event is usually limited by the inability to know, or compile, the complete set of possible outcomes over time or space.

**probability distribution:** The set of outcomes (values) and their corresponding probabilities for a random variable. See *distribution*.

**processes:** Phenomena and activities that have gradual, continuous interactions with the system being modeled.

**process model:** A depiction or representation of a *process*, along with any hypotheses required to describe or to explain the *process*.

**pyroclastic:** In relation to igneous activity, this describes fragments or fragmental rocks and deposits produced by explosive volcanic activity, where the magma is ripped apart during the release of gas and/or by interaction with surface and near-surface water.

**Quaternary:** The period of geologic time from about 2.6 million years ago to the present day.

**radioactive decay:** The process in which one *radionuclide* spontaneously transforms into one or more different *radionuclides*, which are called daughter *radionuclides*.

**radioactivity:** The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) of an unstable atom. Radioactivity is also the term used to describe the rate at which radioactive material emits radiation.

**radiolysis:** Chemical decomposition by the action of radiation.

**radionuclide:** An unstable isotope of an element that decays or disintegrates spontaneously, thereby emitting ionizing radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

**range (statistics):** The numerical difference between the highest and lowest value in any set.

**receptor:** An individual for whom radiological doses are calculated or measured.

**redistribution:** Mobilization and transport of surface deposits by wind and water.

**reliability:** The probability that the item will perform its intended function(s) under specified operating conditions for a specified period of time.

**repository footprint:** The outline of the outermost locations of where the waste is proposed to be emplaced in the Yucca Mountain repository.

**retardation:** Slowing or stopping *radionuclide* movement in *groundwater* by mechanisms that include *sorption* of *radionuclides*, *diffusion* into rock *matrix* pores and microfractures, and trapping of particles in small pore spaces or dead ends of microfractures.

**rhyolite:** A common type of *igneous* rock that forms light-colored, rough blocky-surfaced lavas and white-grayish-yellow *tephra* deposits. A common fragment type is pumice. Rhyolitic magma has a high viscosity, and the resulting lava flows are usually quite short and thick. It more frequently erupts explosively from the volcano and forms *ash-flow tuffs*.

**risk:** The probability that an undesirable event will occur, multiplied by the consequences of the undesirable event.

**risk assessment:** An evaluation of potential consequences or hazards that might be the outcome of an action, including the likelihood that the action might occur. This assessment focuses on potential negative impacts on human health or the environment.

**risk informed, performance based:** A regulatory approach in which *risk* insights, engineering analysis and judgments, and performance history are used to (i) focus attention on the most important activities; (ii) establish objective criteria on the basis of *risk* insights for evaluating

performance; (iii) develop measurable or calculable parameters for monitoring system and licensee performance; and (iv) focus on the results as the primary basis for regulatory decision making.

**rockfall:** The release of *fracture*-bounded blocks of rock from the *drift wall*, usually in response to an earthquake.

**rock matrix:** See *matrix*.

**runoff:** Lateral movement of water at the ground surface, such as down steep hillslopes or along channels, that is not able to infiltrate at a specified location.

**scenario:** A well-defined, connected sequence of features, events, and processes that can be thought of as an outline of a possible future condition of the potential repository system. Scenarios can be undisturbed, in which case the performance would be the expected, or nominal, behavior for the system. Scenarios can also be disturbed, if altered by disruptive events such as human intrusion or natural phenomena such as volcanism or nuclear criticality.

**scenario class:** A set of related scenarios sharing sufficient similarities that they can usefully be aggregated for screening or analysis. The number and breadth of scenario classes depend on the resolution at which scenarios have been defined.

**scoria cone:** See *cinder cone*.

**seepage:** The inflow of *groundwater* moving in *fractures* or pore spaces of permeable rock to an open space in the rock such as a *drift*. For the Yucca Mountain repository, seepage refers to water dripping into a *drift*.

**seismic:** Pertaining to, characteristic of, or produced by earthquakes or Earth vibrations.

**seismic hazard curve:** A graph showing the ground motion *parameter* of interest, such as peak ground acceleration, peak ground velocity, or spectral acceleration at a given frequency, plotted as a function of its annual *probability* of exceedance.

**seismic performance:** Seismic performance of structures, systems, and components refers to their ability to perform intended safety functions during a seismic event, expressed as the annual probability of exceeding a specified limit condition (stress, displacement, or collapse). This is also referred to as the probability of failure, or probability of unacceptable performance,  $P_F$ .

**sill:** A tabular, generally flat-lying body of *intrusive igneous* rock that lies along (is concordant with) the structure of adjacent rocks. Sills are part of the transport system for molten rock (*magma*) rising from depth to the surface. See also *dike*.

**sorb:** To undergo a process of sorption.

**sorption:** The binding, on a microscopic scale, of one substance to another. Sorption is a term that includes both *adsorption* and *absorption* and refers to the binding of dissolved *radionuclides* onto geologic solids or waste package materials by means of close-range chemical or physical forces. Sorption is a function of the chemistry of the radioisotopes, the fluid in which they are carried, and the material they encounter along the *flow path*.

**sorption coefficient ( $K_d$ ):** A numerical means to represent how strongly one substance sorbs to another.

**source term:** Types and amounts of *radionuclides* that are the source of a potential release.

**spatial variability:** A measure of how a property, such as rock permeability, varies at different locations in an object such as a rock formation.

**speciation:** The existence of the elements, such as *radionuclides*, in different molecular forms in the aqueous phase.

**spent nuclear fuel:** Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction and that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. This fuel is more radioactive than it was before irradiation and releases significant amounts of heat from the decay of its fission product *radionuclides*.

**stainless steel:** A class of iron-base alloys containing a minimum of approximately 10 percent chromium to provide corrosion resistance in a wide variety of environments.

**stratigraphy:** The branch of geology that deals with the definition and interpretation of rock strata, including the conditions of their formation, character, arrangement, sequence, age, distribution, and especially their correlation by the use of fossils and other means of identification. See *stratum*.

**stratum:** A layer of rock or soil with geologic characteristics that differ from the layers above or below it.

**stress corrosion cracking:** A cracking process that requires the simultaneous action of a corrosive substance and sustained (residual or applied) tensile stress. Stress corrosion cracking excludes both the fracture of already corroded sections and the localized corrosion processes that can disintegrate an alloy without the action of residual or applied stress.

**structure:** In geology, the arrangement of the parts of geologic features or areas of interest such as folds or faults. This includes features such as fractures created by faulting, and joints caused by the heating of rock. For engineering usage, see *structures, systems, and components*.

**structures, systems, and components:** A *structure* is an element, or a collection of elements, that provides support or enclosure, such as a building, *aging pad*, or *drip shield*. A *system* is a collection of components, such as piping; cable trays; conduits; or heating, ventilation, and air-conditioning equipment, that are assembled to perform a function. A *component* is an item of mechanical or electrical equipment, such as a *canister* transfer machine, transport and emplacement vehicle, pump, valve, or relay.

**tectonic:** Pertaining to geologic features or events created by deformation of the Earth's crust.

**tephra:** A collective term for all clastic (fragmental) materials ejected from a volcano during an eruption and transported through the air.

**thermal chemical:** Of or pertaining to the effect of heat on chemical conditions and reactions.

**thermohydrologic:** Of or pertaining to changes in *groundwater* movement due to the effects of changes in temperature.

**thermal mechanical:** Of or pertaining to changes in mechanical properties from effects of changes in temperature.

**total system performance assessment:** A risk assessment that quantitatively estimates how the potential Yucca Mountain repository system will perform in the future under the influence of specific features, events, and processes, incorporating uncertainty in the models and uncertainty and variability of the data.

**transparency:** The ease of understanding the process by which a study was carried out, which assumptions are driving the results, how they were arrived at, and the rigor of the analyses leading to the results. A logical structure ensures completeness and facilitates in-depth review of the relevant issues. Transparency is achieved when a reader or reviewer has a clear picture of what was done in the analysis, why it was done, and the outcome.

**transpiration:** The removal of water from the ground by vegetation (roots).

**transport:** A process that allows substances such as contaminants, *radionuclides*, or colloids, to be carried in a fluid from one location to another. Transport processes include the physical mechanisms of *advection*, convection, *diffusion*, and *dispersion* and are influenced by the chemical mechanisms of *sorption*, leaching, precipitation, dissolution, and complexation

**tuff:** A general term for volcanic rocks that formed from rock fragments and magma that erupted from a volcanic vent, flowed away from the vent as a suspension of solids and hot gases, or fell from the eruption cloud, and consolidated at the location of deposition. Tuff is the most abundant type of rock at the Yucca Mountain site.

**uncertainty:** How much a calculated or measured value varies from the unknown true value. See also *aleatory uncertainty* and *epistemic uncertainty*.

**unsaturated zone flow:** The movement of water in the unsaturated zone driven by capillary, viscous, gravitational, inertial, and evaporative forces.

**variable:** A nonunique property or attribute.

**variability (statistical):** A measure of how a quantity varies over time or space.

**volcanism):** Pertaining to extrusive igneous activity.

**wash:** In a relation to landforms, a streambed, dry or running, usually in an arid environment.

**watershed:** The area drained by a river system including the adjacent ridges and hillslopes.

**welded tuff:** A *tuff* deposited under conditions where the particles that make up the rock remained sufficiently hot to cohere. In contrast to nonwelded tuff, welded tuff is denser, less porous, and more likely to be fractured (which increases *permeability*).

## APPENDIX A

### YUCCA MOUNTAIN COMMITMENTS (SAFETY EVALUATION REPORT VOLUME 2)

During the review of the Yucca Mountain License Application by the staff of the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE) made commitments related to the construction and operation of the geologic repository at Yucca Mountain. These commitments were identified in DOE's Safety Analysis Report (SAR) and/or in response to Requests for Additional Information (RAIs). The following table lists a description of these commitments, referenced sources and implementation schedules.

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**YUCCA MOUNTAIN COMMITMENTS  
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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
1	<p>The applicant commits to reassess nominal location of emplacement drift termination points (closest to Solitario Canyon fault), setbacks from faults, azimuthal drift orientation:</p> <p>-Emplacement drifts shall be located a minimum of 60 m from a Quaternary fault with potential for significant displacement [DCP 01-05]</p> <p>-Evaluate faults encountered during construction to determine whether setback is needed [Procedural Safety Control-25]</p> <p>-Assess fault displacement vectors encountered during drift construction to establish basis for setback distance accounting for slickenline evidence</p> <p>-Observe rock conditions, accounting for fracture characteristics, to determine whether drifts will be parallel and within azimuth of 70 to 80 degrees</p>	<p>1/2.1.1.1.3.5.1.1</p> <p>1/2.1.1.1.3.5.1.1</p> <p>1/2.1.1.1.3.5.1.1</p> <p>1/2.1.1.1.3.5.1.1</p>	<p>SAR Sect. 1.1.5.1.2 &amp; 1.3.4.2.2/DOE,2009as&amp; 2009bf</p> <p>SAR Sect. 1.1.5.1.2 &amp; 1.3.4.2.2/DOE,2009as &amp; 2009bf</p> <p>SAR Sect. 1.1.5.1.2 &amp; 1.3.4.2.2/DOE,2009as&amp; 2009bg</p> <p>SAR Sect. 1.3.4.2.3/SAR Table 1.9-9, DCP 01-08/DOE,2009as</p>	<p>Prior to update of geotechnical basis for drift layout</p> <p>"</p> <p>"</p> <p>"</p>
2	<p>Provide monitoring and maintenance plans for underground openings in nonaccessible areas of the subsurface facility and the invert and rail structures in the emplacement drifts that include sufficient details to demonstrate that the plans will assure (i) preservation of an operating envelope for the TEV and DSEG, (ii) repair of damaged emplacement drifts or exhaust airway opening, (iii) airflow for waste package ventilation, and (iv) repair of invert, rails, and power/communications equipment inside the emplacement drifts.</p>	<p>2/2.1.1.2.3.7</p>	<p>SAR 1.3.3, 1.3.3, 1.3.4/DOE 2009bb,ef,ea,gk</p>	<p>Prior to license to receive and possess radioactive material</p>
3	<p>The applicant commits to develop a plan that would be in place to restrict maneuvering and other activities while transiting the flight-restricted air space above the GROA, as assumed in the aircraft crash hazard analysis to estimate the annual crash frequency onto the repository facilities.</p>	<p>3/2.1.1.3.3.1.3.3</p>	<p>Response to RAI (DOE, 2009ah referenced in SER Chapter 3)</p>	<p>Prior to license to receive and possess radioactive material</p>
4	<p>The applicant commits to review the direct exposure event sequences in</p>	<p>3/ 2.1.1.3.3.2.3.4.2</p>	<p>Response to RAI (DOE,</p>	<p>Prior to license to</p>

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**YUCCA MOUNTAIN COMMITMENTS  
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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
	the waste handling facilities and update the preclosure safety analysis, as needed, to achieve safety margins similar to ESD18 with respect to the Category 1 threshold limit.		2009dx)	receive and possess radioactive material
5	The applicant commits to perform analyses for drop and tipover scenarios for transportation casks and STCs (while holding uncanistered fuel, unsealed DPCs, and unsealed TAD canisters) to maintain containment with a minimum number of bolts left in place.	4/2.1.1.4.3.4.1.2	Response to RAI (DOE, 2009fk referenced in SER Chapter 4)	Prior to license to receive and possess radioactive material
6	The applicant commits to verify that the final equipment design and its associated seismic fragility will satisfy the conclusions in BSC Table 6.2-2 (2008bg).	4/2.1.1.4.3.3.1.2.2	Response to RAI (DOE, 2009bl referenced in SER Chapter 4)	Prior to license to receive and possess radioactive material
7	The applicant commits to provide a detailed design of the flood control features proposed in the conceptual design	7/2.1.1.7.3.1.3	Response to RAIs (DOE, 2010ak,an referenced in SER Chapter 7)	Prior to license to receive and possess radioactive material
8	<p>The applicant committed to address the following items pertaining to waste canisters and overpacks:</p> <ul style="list-style-type: none"> <li>• Perform structural and thermal analyses for the 5-DHLW/DOE long codisposal, 2-MCO/2-DHLW codisposal, and naval canistered SNF short waste packages configuration for the repository operations and permanent disposal using the structural design methodology described in SAR Section 1.5.2.1.1.</li> <li>• Perform structural and criticality analyses for the DPC once receipt of a specific DPC type is planned.</li> </ul>	<p>7/2.1.1.7.3.9.1</p> <p>7/2.1.1.7.3.9.3.3</p>	<p>Response to RAI (DOE, 2009er)</p> <p>SAR Section 1.5.1.1.2.1.2</p>	<p>Prior to license to receive and possess radioactive material</p> <p>"</p>

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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
	<ul style="list-style-type: none"> <li>• Evaluate the specific aging overpack system for normal handling, dead, and thermal loads and loads that result from event sequences prior to use at the Yucca Mountain repository.</li> <li>• Perform structural failure analyses of the transportation cask for loads that result from event sequences prior to the use of any transportation cask at the Yucca Mountain repository.</li> </ul>	<p>7/2.1.1.7.3.9.3.5</p> <p>7/2.1.1.7.3.9.3.6</p>	<p>SAR Section 1.2.7</p> <p>SAR Section 1.2.8.4.5.1</p>	<p align="center">“</p> <p align="center">“</p>
9	DOE has committed to follow the guidance in NRC Regulatory Guide 8.38 to control access to the restricted area and to apply access controls to high and very high radiation areas in accordance with 10 CFR 20.1601 and 10 CFR 20.1602	8/2.1.1.8.3.2	1.10.2.4	Prior to license to receive and possess radioactive material
10	DOE has committed to follow the guidance in NRC Regulatory Guide 8.8 for design reviews and audits and NRC Regulatory Guide 8.19 for estimating doses during the design process	8/2.1.1.8.3.3	1.10.3.1; 1.10.2.11	Prior to license to receive and possess radioactive material
11	DOE has committed to incorporate ALARA guidance from NRC Regulatory Guides 8.8 and 8.10 into repository processes and procedures	8/2.1.1.8.3.4	1.10.4	Prior to license to receive and possess radioactive material
12	DOE has committed to integrate the information to facilitate Permanent Closure and Decontamination or decontamination and dismantlement (PCDDD) with respect to QA with Pre-closure QA program.	10/2.1.3.3.2	1.12.3.12	Implemented with the Pre-closure QA program
13	In a number of areas documented in SAR, RAI responses and supporting documents, the applicant committed to address the following items in the final design:			

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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
	<ul style="list-style-type: none"> <li>• Consideration of interface and boundary between ITS and non-ITS components in the P&amp;IDs for Emergency Diesel Generators</li>   <li>• Consideration of Lubricating Oil System potential leakage and seismic design of engine mounted components</li>   <li>• For all ROVs operating in nonaccessible areas provide description of design of electrical power SSCs located in nonaccessible areas including construction connections, configurable switching at turnouts, and plans for inspection and maintenance</li>   <li>• For all ROVs operating in nonaccessible areas provide description of design including tasking, configuration, major components, method of locomotion, power requirements, and methods of communication between each vehicle and remote operators/inspectors</li>   <li>• For all ROVs operating in nonaccessible areas and must communicate with remote operators/inspectors, provide detailed description of design of communication SSCs located in nonaccessible areas including maintenance and repair if needed</li>   <li>• Confirm stability of slopes, in the vicinity of Aging facility, under applicable seismic loading conditions</li> </ul>	<p align="center">2/2.1.1.2.3.2.8</p> <p align="center">2/2.1.1.2.3.2.8</p> <p align="center">2/2.1.1.2.3.2.3</p> <p align="center">2/2.1.1.2.3.6.2</p> <p align="center">2/2.1.1.2.3.6.2</p> <p align="center">1/2.1.1.1.3.5.4</p>	<p>SAR 1.2.8.2/DOE 2009dt,ec</p> <p>SAR 1.2.8.2.4/DOE 2009dt,ec</p> <p>SAR 1.3.2.4, 1.3.3.4, 1.3.3.5/BSC 2008ca (LA support document)</p> <p>SAR 1.3.1.2.1.6/BSC 2008ca (LA support document)</p> <p>SAR 1.4.2.4/DOE 2009ee</p> <p>SAR Section 1.1.5.3/DOE 2009aq,ej</p>	<p>Prior to license to receive and possess radioactive material</p> <p align="center">"</p> <p align="center">"</p> <p align="center">"</p> <p align="center">"</p> <p>Prior to excavation of Aging facility foundation</p>

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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
	<ul style="list-style-type: none"> <li>• Use finite element models, for the detailed design for construction, that will include SSI effects on the structural response of the IHF superstructure</li> <li>• Evaluate, as part of the process in the detailed design for construction, the effects of the alluvium stratum slope on the IHF foundation response</li> <li>• Perform Tier #2 analysis to support the detailed design of surface nuclear facilities</li> </ul>	<p align="center">7/2.1.1.7.3.1.1</p> <p align="center">7/2.1.1.7.3.1.1</p> <p align="center">7/2.1.1.7.3.1.1</p>	<p>Response to RAI (DOE, 2009ev)</p> <p>Response to RAI (DOE, 2009ev)</p> <p>BSC, 2007ba, ACN 02</p>	<p>Prior to license to receive and possess radioactive material</p> <p align="center">"</p> <p align="center">"</p>
14	<p>The applicant committed to future updates of the SAR in a number of areas documented in the SER. These updates include the following:</p> <ul style="list-style-type: none"> <li>• Update SAR Sections 1.2.4.4.2 and 1.2.8.3.1.2, and SAR Figures 1.2.4-105, 1.2.4-106, 1.2.4-109, 1.2.4-110, 1.2.5-88, 1.2.5-90, 1.2.8-28, and 1.2.8-33</li> <li>• Update SAR Section 1.2.5.3.4 on ITS classification of Cask Cooling subsystem</li> <li>• Update SAR Table 1.9-1</li> <li>• Update the event sequences for ESD18 and waste form throughputs in the SAR including revising appropriate SAR figures for CTM and port slide gate logic diagrams to illustrate modified safety functions of the ITS interlock</li> </ul>	<p align="center">2/2.1.1.2.3.2.7</p> <p align="center">2/2.1.1.2.3.2.8</p> <p align="center">2.2.1.1.2.3.2.8</p> <p align="center">3/2.1.1.3.3.2.3.4.2</p>	<p>SAR 1.2.4.4.2, 1.2.8.3.1.2/2.8/DOE 2009dm</p> <p>SAE 1.2.5.3/ DOE 2009du</p> <p>SAR1.9/DOE 2009ec</p> <p>Response to RAIs (DOE, 2009dx)</p>	<p>Prior to license to receive and possess radioactive material</p> <p align="center">"</p> <p align="center">"</p> <p align="center">"</p>

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No.	Description of Commitment	SER Reference (Chapter/Section)	SAR/RAI Response Reference	Implementation Schedule
	<ul style="list-style-type: none"> <li>• Update SAR Tables 1.8-25 and 1.8-36</li> <li>• Revise Figure SAR 5.3-1 and relevant text</li> </ul>	5/2.1.1.5.3.5	SAR Section 1.8/RAI (DOE, 2009el)	“
	<ul style="list-style-type: none"> <li>• Update SAR Section 1.9.1.10</li> </ul>	6/2.1.1.6.3.2.6	SAR Section 1.14.3 and Response to RAIs (DOE, 2009az)	“
		6/2.1.1.6.3.2.8.2.2	SAR Section 1.9.1.10 and Response to RAIs (DOE, 2009az)	“

## GLOSSARY

This glossary is provided for information and is not exhaustive. Terms shown in *italics* are included in this glossary.

***absorption***: The process of taking up by capillary, osmotic, solvent, or chemical action of molecules (e.g., absorption of gas by water) as distinguished from adsorption.

***abstracted model***: A model that reproduces, or bounds, the essential elements of a more detailed process model and captures uncertainty and variability in what is often, but not always, a simplified or idealized form. See abstraction.

***abstraction***: Representation of the essential components of a process model into a form suitable for use in a total system performance assessment. A model abstraction is intended to maximize the use of limited computational resources while allowing a sufficient range of sensitivity and uncertainty analyses.

***adsorb***: To collect a gas, liquid, or dissolved substance on a surface as a condensed layer.

***adsorption***: The adhesion by chemical or physical forces of molecules or ions (as of gases or liquids) to the surface of solid bodies. For example, the transfer of solute mass, such as radionuclides, in groundwater to the solid geologic surfaces with which it comes in contact. The term sorption is sometimes used interchangeably with this term.

***advection***: The process in which solutes, particles, or molecules are transported by the motion of flowing fluid.

***aging***: The retention of commercial spent nuclear fuel on the surface in dry storage to reduce its thermal output as necessary to meet proposed repository thermal management goals.

***aging overpack***: A cask specifically designed for aging spent nuclear fuel. Transport, aging, and disposal canisters and dual-purpose canisters would be placed in aging overpacks for aging on the aging pad.

***air mass fraction***: The mass of air divided by the total mass of gas (typically air plus water vapor) in the gas phase. This expression gives a measure of the "dryness" of the gas phase, which is used in waste package corrosion models.

***airborne mass load***: The amount of fine particulates resuspended above a surface deposit, generally expressed as mass per unit volume of air.

***aleatory uncertainty***: An uncertainty associated with the chance of occurrence of a feature, event, or process of a physical system or the environment such as the timing of a volcanic event. Also referred to as irreducible uncertainty because no amount of knowledge will determine whether or not a chance event will or will not occur. See also epistemic uncertainty.

***Alloy 22***: A nickel-based, corrosion-resistant alloy containing approximately 22 weight percent chromium, 13 weight percent molybdenum, and 3 weight percent tungsten as major alloying

elements. This alloy is used as the outer container material in the U.S. Department of Energy's waste package design.

**alluvium:** Detrital (sedimentary) deposits made by flowing surface water on river beds, flood plains, and alluvial fans. It does not include subaqueous sediments of seas and lakes.

**alternative:** In the context of system analysis, plausible interpretations or designs that use assumptions other than those used in the base case, which could also be applicable or reasonable given the available scientific information. When propagated through a quantitative tool such as performance assessment, alternative interpretations can illustrate the significance of the uncertainty in the base case interpretation chosen to represent the system's probable behavior.

**ambient:** Undisturbed, natural conditions, such as ambient temperature caused by climate or natural subsurface thermal gradients, and other surrounding conditions.

**anisotropy:** Variation in physical properties when measured in different directions. For example, in layered rock, permeability is often greater within the horizontal layers than across the horizontal layers.

**annual frequency:** The number of occurrences of an event in 1 year.

**aqueous:** Pertaining to water, such as aqueous phase, aqueous species, or aqueous transport.

**aquifer:** A saturated underground geologic formation of sufficient permeability to transmit groundwater and yield water of sufficient quality and quantity to a well or spring for an intended beneficial use.

**ash:** Fragments of volcanic rock that are broken during an explosive volcanic eruption to less than 2 mm [0.08 inches] in diameter. See also tephra and pyroclastic.

**ash flow tuff:** A type of volcanic rock formed by the deposition and accumulation of dominantly ash-size particles during an explosive eruption. Ash flows (also called proclastic flows) commonly result from eruptions of more viscous, silica-rich magma such as rhyolite. This rock type forms the host horizons for the proposed geological repository at Yucca Mountain. See also tuff and welded tuff.

**basalt:** A common type of igneous rock that forms black, rubbly-to-smooth-surfaced lavas and black-to-red tephra deposits (frequently used as "lava rock" for barbecues).

**borosilicate glass:** A predominantly noncrystalline, relatively homogenous glass formed by melting silica and boric oxide together with other constituents such as alkali oxides. Borosilicate glass is a high-level radioactive waste material in which boron takes the place of the lime used in ordinary glass mixtures.

**boundary condition:** For a model, the establishment of a set condition for a given variable, often at the geometric edge of the model. An example is using a specified groundwater flux for net infiltration as a boundary condition for an unsaturated zone flow model.

**bound:** An analysis or selection of parameter values that yields limiting results, such that any actual result is certain to exceed these limits only with an extremely small likelihood.

**breach:** A penetration in the waste package caused by failure of the outer and inner containers or barriers that allows the spent nuclear fuel or the high-level radioactive waste to be exposed to the external environment and may eventually permit radionuclide release.

**burnup:** A measure of nuclear reactor fuel consumption expressed either as the percentage of fuel atoms that have undergone fission, or as the amount of energy produced per unit weight of fuel.

**burnup credit:** The concept of taking credit for the reduction in reactivity (ability to undergo fission) due to fuel irradiation. The reduction in reactivity is due to the net reduction of fissile nuclides and the production of parasitic neutron-absorbing nuclides.

**caldera:** A volcanic depression in the Earth's surface more than 1 km [0.7 mi] wide, formed by the collapse of the upper crust into an evacuated magma chamber during or after a large volcanic eruption. Many calderas resulting from the explosive eruption of large amounts of rhyolite magma are several tens of kilometers [up to 20 mi] wide].

**calibration:** (1) Comparison of model results with actual data or observations, and adjusting model parameters to increase the precision and/or accuracy of model results compared to actual data or observations. (2) For tools used for field or lab measurements, the process of taking instrument readings on standards known to produce a certain response, to check the accuracy and precision of the instrument.

**canister:** An unshielded cylindrical metal receptacle that facilitates handling, transportation, storage, and/or disposal of high-level radioactive waste. It may serve as (i) a pour mold and container for vitrified high-level radioactive waste; (ii) a container for loose or damaged fuel rods, nonfuel components and assemblies, and other debris containing radionuclides; or (iii) a container that provides radionuclide confinement. Canisters are used in combination with specialized overpacks that provide structural support, shielding, or confinement for storage, transportation, and emplacement. Overpacks used for transportation are usually referred to as transportation casks; those used for emplacement in a proposed repository are referred to as waste packages.

**carbon steel:** A steel made of carbon up to about 2 weight percent and only residual quantities of other elements. Carbon steel is a tough but ductile and malleable material that is used in some components in the U.S. Department of Energy's design of the engineered barrier system.

**cask:** (1) A heavily shielded container used for the dry storage or shipment (or both) of radioactive materials such as spent nuclear fuel or other high-level radioactive waste. Casks are often made from lead, concrete, or steel. Casks must meet regulatory requirements and are not intended for long-term disposal in a proposed repository. (2) A heavily shielded container that the U.S. Department of Energy would use to transfer canisters between waste handling facilities at the proposed repository.

**Category 1 event sequences:** Those event sequences that are expected to occur one or more times before permanent closure of a proposed geologic repository.

**Category 2 event sequences:** Event sequences other than Category 1 event sequences that have at least one chance in 10,000 of occurring before permanent closure.

**chain reaction:** A continuing series of nuclear fission events. Neutrons produced by a split nucleus collide with and split other nuclei causing a chain of fission events.

**cinder cone:** A steep, conical hill formed by the accumulation of ash and coarser erupted material around a volcanic vent. Synonymous with scoria cone.

**cladding:** The metal outer sheath of a fuel rod generally made of a zirconium alloy, and in the early nuclear power reactors of stainless steel, intended to protect the uranium dioxide pellets, which are the nuclear fuel, from dissolution by exposure to high temperature water under operating conditions in a reactor. Often referred to as "clad."

**climate:** Weather conditions, including temperature, wind velocity, precipitation, and other factors, that prevail in a region.

**climate states:** Representations of climate conditions.

**code (computer):** The set of commands used to implement a mathematical model on a computer.

**colloid:** As applied to radionuclide migration, colloids are large molecules or very small particles, having at least one dimension with the size range of  $10^{-6}$  to  $10^{-3}$  mm [ $10^{-8}$  to  $10^{-5}$  in] that are suspended in a solvent. Colloids in groundwater arise from clay minerals, organic materials, or (in the context of a proposed geologic repository) from corrosion of engineered materials.

**colloid-facilitated, radionuclide transport model:** A model that represents the enhanced transport of radionuclides by particles that are colloids.

**commercial spent nuclear fuel:** Nuclear fuel rods, forming a fuel assembly, that have been removed from a nuclear power plant after reaching the specified burnup.

**common cause failure:** Two or more failures that result from a single event or circumstance.

**conceptual model:** A set of qualitative assumptions used to describe a system or subsystem for a given purpose. Assumptions for the model are compatible with one another and fit the existing data within the context of the given purpose of the model.

**conduit:** A pathway along which magma rises to the surface during a volcanic eruption. Conduits are usually cylindrical and flared upwards toward the surface vent. Conduits are near-surface features and develop along dikes, focusing magma flow from the longer and possibly narrower dike to the vent.

**consequence:** A measurable or calculated outcome of an event or process that, when combined with the probability of occurrence, gives a measurement of risk.

**conservative:** A condition of an analysis or a parameter value such that its use provides a pessimistic result, which is worse than the actual result expected.

**corrosion:** The deterioration of a material, usually a metal, as a result of a chemical or electrochemical reaction with its environment.

**corrosion resistant alloy:** An alloy that exhibits extremely high resistance to general or uniform corrosion in a given environment as a result of the formation of a protective film on its surface. Alloy 22, and other similar nickel-chromium-molybdenum alloys, are considered corrosion resistant alloys.

**coupled process:** A representation of interrelationship between processes such that the effects of variation in one process are accurately propagated among all interrelated processes

**crevice corrosion:** Localized corrosion of a metal surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of close proximity between the metal and the surface of another material.

**critical event:** See criticality.

**criticality:** The condition in which a fissile material sustains a chain reaction. It occurs when the number of neutrons present in one generation cycle equals the number generated in the previous cycle. The state is considered critical when a self-sustaining nuclear chain reaction is ongoing.

**criticality accident:** The release of energy as a result of accidental production of a self-sustaining or divergent neutron chain reaction.

**design concept:** An idea of how to design and operate the aboveground and belowground portions of a proposed repository.

**diffusion:** (1) The spreading or dissemination of a substance caused by concentration gradients. (2) The gradual mixing of the molecules of two or more substances because of random thermal motion.

**diffusive transport:** Movement of solutes because of their concentration gradient. Diffusive transport is the process in which substances carried in groundwater move through the subsurface by means of diffusion because of a concentration gradient.

**dike:** A tabular, generally vertical body of igneous rock that cuts across the structure of adjacent rocks. Dikes transport molten rock from depth to an erupting volcanic.

**dimensionality:** Modeling in one, two, or three dimensions.

**direct exposure:** The manner in which an individual receives dose from being in close proximity to a source of radiation. Direct exposures present an external dose pathway.

**dispersion (hydrodynamic dispersion):** (1) The tendency of a solute (substance dissolved in groundwater) to spread out from the path it is expected to follow if only the bulk motion of the flowing fluid were to move it. The tortuous path the solute follows through openings (pores and fractures) causes part of the dispersion effect in the rock. (2) The macroscopic outcome of the actual movement of individual solute particles through a porous medium. Dispersion dilutes solutes, including radionuclides, in groundwater.

**disposal canister:** A cylindrical metal receptacle designed to contain spent nuclear fuel and high-level radioactive waste as an integral part of the waste package.

**disruptive event:** An unlikely, off-normal event that, in the case of the proposed repository, could include volcanic activity, seismic activity, and nuclear criticality. Disruptive events alter the normal or likely behavior of the system.

**disruptive event scenario class:** The scenario, or set of related scenarios, that describes the behavior of the system if perturbed by disruptive events.

**dissolution:** Dissolving a substance in a solvent.

**distribution:** In a total system performance assessment, the overall scatter of values for a specific set of numbers (e.g., corrosion rates, values used for a particular parameter, dose results). A term used synonymously with frequency distribution or probability distribution function. Distributions have structures that are the probability that a given value occurs in the set.

**docketing:** Docketing is the acceptance of a document for placement in a docket. A docket is the information collection that constitutes the record of agency review of a license application or administrative action.

**drift:** From mining terminology, a horizontal underground passage. In the proposed Yucca Mountain repository design, drifts include excavations for emplacement (emplacement drifts) and access (access mains).

**drift degradation:** The progressive accumulation of rock rubble in a drift created by weakening and collapse of drift walls in response to stress from heating or earthquakes.

**drift scale:** The scale of an emplacement drift, or approximately 5 meters in diameter. Drift-Scale Heater Test: A test conducted in the Exploratory Studies Facility to investigate thermal-hydrologic, thermal-chemical, and thermal-mechanical processes.

**drip shield:** A metallic structure placed along the extension of the emplacement drifts and above the waste packages to prevent seepage water from directly dripping onto the waste package outer surface. The drip shield may also prevent the drift ceiling rocks (e.g., due to drift spallation) from falling on the waste package.

**dry storage:** Storage of spent nuclear fuel without immersion of the fuel in water for cooling or shielding; it involves the encapsulation of spent fuel in a steel cylinder that might be in a concrete or massive steel cask or structure.

**dual-purpose canister:** A canister suitable for storing (in a storage facility) and shipping (in a transportation cask) commercial spent nuclear fuel assemblies.

**edge effects:** Conditions at the edges of the proposed repository that are cooler and wetter because heat dissipates more quickly there than at the center of the proposed repository.

**effective porosity:** The fraction of a porous medium volume available for fluid flow and/or solute storage, as in the saturated zone. Effective porosity is less than or equal to the total void space (porosity).

**empirical:** Reliance on observation or experimentation rather than on a theoretical understanding of fundamental processes.

**emplacement drift:** See drift.

**enrichment:** The act of increasing the concentration of fissile isotopes from their value in natural uranium. The enrichment (typically reported in atom percent) is a characteristic of nuclear fuel.

**eolian:** Relating to processes caused by near-surface winds.

**epistemic uncertainty:** A variability that is due to a lack of knowledge of quantities or processes of the system or the environment. Also referred to as reducible uncertainty because the state of knowledge about the exact value of a quantity or process can increase through testing and data collection. See also aleatory uncertainty.

**equilibrium:** The state of a chemical system in which the phases do not undergo any spontaneous change in properties or proportions with time; a dynamic balance.

**error of commission:** A human failure event, resulting from an overt, unsafe action, that, when taken, leads to a change in facility configuration, with the consequence of a degraded facility state that may lead to an event sequence.

**error of omission:** A human failure event, resulting from a failure to take a required action, that leads to an unchanged or inappropriately changed facility configuration, with the consequence of a degraded facility state that may lead to an event sequence.

**events:** In a total system performance assessment, (1) occurrences of phenomena that have a specific starting time and, usually, a duration shorter than the time being simulated in a model. (2) Uncertain occurrences of phenomena that take place within a short time relative to the time frame of the model.

**event tree:** A modeling tool that illustrates the logical sequence of events that follow an initiating event.

**expected annual dose:** The average annual radiological dose calculated for the reasonably maximally exposed individual, which includes the likelihood of the individual receiving a dose from all relevant exposure scenarios.

**expert elicitation:** A formal, highly structured, and well-documented process whereby expert judgments, usually of multiple experts, are obtained.

**exploratory studies facility:** An underground laboratory at Yucca Mountain that includes a 7.9-km [4.9-mi] main loop (tunnel); a 2.8-km [1.75-mi] cross-drift; and a research alcove system constructed for performing underground studies during site characterization.

**extrusive (extrusion):** In relation to igneous activity, an event where magma erupts at the surface. An extrusion is the deposit formed by an extrusive event. See also intrusive.

**failure:** The loss of ability of a structure, system, or component to perform its intended safety function or operate as specified.

**fault (geologic):** A planar or gently curved fracture across which there has been displacement parallel to the fracture surface.

**fault tree:** A graphical logic model that depicts the combinations of events that result in the occurrence of an undesired event.

**features:** Physical, chemical, thermal, or temporal characteristics of the site or proposed repository system. For the purposes of screening features, events, and processes for the total system performance assessment, a feature is defined to be an object, structure, or condition that has a potential to affect disposal system performance.

**film flow:** Movement of water as a film along a surface such as a fracture plane.

**finite element analysis:** A commonly used numerical method for solving mathematical equations in a variety of areas (e.g., hydrology, mechanical deformation). A technique in which algebraic equations are used to approximate the partial differential equations that comprise mathematical models to produce a form of the problem that can be solved on a computer. For this type of approximation, the area being modeled is formed into a grid with irregularly shaped blocks. This method provides an advantage in handling irregularly shaped boundaries (e.g., internal features such as faults) and surfaces of engineered materials. Values for parameters are frequently calculated at nodes for convenience, but are defined everywhere in the blocks by means of interpolation functions.

**fissure:** In relation to igneous activity, a fissure is an elongate vent or line of vents, formed when a dike breaks to the surface to start a volcanic eruption.

**flow:** The movement of a fluid such as air, water, or magma. Flow and transport are processes that can move radionuclides from the proposed repository to the receptor group location.

**flow pathway:** The subsurface course that water or a solute (and dissolved materials) would follow in a given groundwater velocity field, governed principally by the hydraulic gradient.

**fluvial:** Processes related to the downslope movement of water on the Earth's surface.

**fracture:** A planar discontinuity in rock along which loss of cohesion has occurred. It is often caused by the stresses that cause folding and faulting. A fracture along which there has been displacement of the sides relative to one another is called a fault. A fracture along which no appreciable movement has occurred is called a joint. Fractures may act as fast paths for groundwater movement.

**fracture aperture:** The space that separates the sides of a fracture, and the measured width of the space separating the sides of a fracture.

**fracture permeability:** The capacity of a rock to transmit fluid that is related to fractures in the rock.

**fragility:** Fragility of a structure, system, or component is defined as the conditional probability of its failure, given a value of the ground motion, or response parameter, such as stress, bending moment, and spectral acceleration.

**frequency:** The number of occurrences of an observed or predicted event during a specific time period.

**galvanic:** Pertains to an electrochemical process in which two dissimilar electronic conductors are in contact with each other and with an electrolyte, or in which two similar electronic conductors are in contact with each other and with dissimilar electrolytes.

**galvanic corrosion:** Accelerated corrosion of a metal resulting from electrical contact with a more noble metal or nonmetallic conductor in a corrosive electrolyte.

**geochemical:** The distribution and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere; the movement of the elements in nature on the basis of their properties.

**geologic-framework model:** A digital, scaled, geometrically congruent, three-dimensional model of the geologic system.

**geophysics (geophysical survey; geophysical magnetic survey):** The study of the physical properties of rocks and sediment and interpretation of data derived from measurements made. Properties commonly measured are the velocity of sound (seismic waves) in rocks, density, and magnetic character. A program of measurements made on a series of rocks is usually termed a survey.

**groundwater:** Water contained in pores or fractures in either the unsaturated or saturated zones belowground level.

**half-life:** The time required for a radioactive substance to lose half of its activity due to radioactive decay. At the end of one half-life, 50 percent of the original radioactive material has decayed.

**heterogeneity:** The condition of being composed of parts or elements of different kinds. A condition in which the value of a parameter varies over the space an entity occupies, such as the area around the proposed repository, or with the passage of time.

**high-level radioactive waste glass:** A waste form produced by melting a mixture of high-level radioactive waste and components of borosilicate glass at a high temperature {approximately 1,100 °C [2012 °F]}.

**human error probability:** The probability of a particular human failure event occurring.

**human factors engineering:** The application of knowledge about human capabilities and limitations to plant, system, and equipment design. Human factors engineering provides reasonable assurance that the design of the facility, systems, equipment, human tasks, and the work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support the facility (NUREG-0711, Ref. 1).

**human failure event:** An event that would be modeled as a basic event in the logic models of a safety assessment, and that is the result of one or more unsafe actions.

**human-induced initiator:** A human failure event that represents actions that cause or lead to an initiating event. The proposed geologic repository operation area is expected to employ various manually controlled waste-handling and transport equipment that may be subject to human failure events that could initiate an event sequence.

**human reliability analysis:** Human reliability analysis evaluates the potential for, and mechanisms of, human errors that may affect the safety of the proposed geologic repository operation area operations, including consideration of human reliability, as it relates to design and programs such as training of personnel.

**hydrologic:** Pertaining to the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

**igneous:** (1) A type of rock that has formed from a molten, or partially molten, material. (2) A type of activity related to the formation and movement of molten rock, either in the subsurface (intrusive) or on the surface (extrusive).

**infiltration:** The process of water entering the soil at the ground surface. Infiltration becomes percolation when water has moved below the depth at which evaporation or transpiration can return it to the atmosphere. See also net infiltration.

**intrusive (intrusion):** In relation to igneous activity, an event where magma approaches the surface but does not break through an eruption. An intrusion is the solidified rock formed below the surface by an intrusive event. See also extrusive.

**invert:** A constructed surface that would provide a level drift floor and enable emplacement and support of the waste packages.

**isothermal:** Having a constant temperature.

**license application:** An application from the U.S. Department of Energy to the U.S. Nuclear Regulatory Commission for a license to construct and operate a proposed repository.

**lithophysal:** Containing lithophysae, which are holes in tuff and other volcanic rocks. One way lithophysae are created is by the accumulation of volcanic gases during the formation of the tuff.

**localized corrosion:** Corrosion at discrete sites (e.g., pitting and crevice corrosion).

**magma:** Molten or partially molten rock that is naturally occurring and is generated within the Earth. Magma may contain crystals along with dissolved gasses.

**mathematical model:** A mathematical description of a conceptual model.

**matrix:** Rock material and its pore space exclusive of fractures. As applied to Yucca Mountain tuff, the ground mass of an igneous rock that contains larger crystals.

**matrix diffusion:** The process by which molecular or ionic solutes, such as radionuclides in groundwater, move from areas of higher concentration to areas of lower concentration. For the

proposed Yucca Mountain repository, this process refers to the movement of radionuclides by diffusion between the fracture and matrix continua.

**matrix permeability:** The capability of the matrix to transmit fluid.

**mean (arithmetic):** For a statistical data set, the sum of the values divided by the number of items in the set. The arithmetic average, sometimes referred to as expected value.

**mechanical disruption:** Damage to the drip shield or waste package because of external forces.

**median:** A value such that one-half of the observations are less than that value and one-half are greater than the value.

**meteorology:** The study of climatic conditions such as precipitation, wind, temperature, and relative humidity.

**microbe:** An organism too small to be viewed with the unaided eye. Examples of microbes are bacteria, protozoa, and some fungi and algae.

**microbially influenced corrosion:** Deterioration of metals as a result of the metabolic activity of microorganisms.

**migration:** Radionuclide movement from one location to another within the engineered barrier system or the environment.

**mineral model:** A description of the kinds and relative abundances of minerals that is used to approximate the true mineralogical system.

**mineralogical:** Of or relating to the chemical and physical properties of minerals, their occurrence, and their classification.

**model:** A depiction of a system, phenomenon, or process, including any hypotheses required to describe the system or explain the phenomenon or process.

**model support:** A process used to gain confidence in the reasonableness of model results through comparison with outputs from detailed process-level models and/or empirical observations such as laboratory tests, field investigations, and natural analogues.

**natural analogues:** Observable features, events, or process, which provide insights on similar features, events, or processes that are difficult to observe in the proposed repository system.

**near-field:** The area and conditions within the proposed repository including the drifts and waste packages and the rock immediately surrounding the drifts. The near-field is the region in and around the proposed repository where the excavation of the proposed repository drifts and the emplacement of waste have significantly impacted the natural hydrologic system.

**net infiltration:** The downward flux of infiltrating water that escapes below the zone of evapotranspiration. The bottom of the zone of evapotranspiration generally coincides with the lowermost extent of plant roots. See infiltration.

**nominal behavior.** (1) The likely or expected behavior of the system as perturbed only by the presence of the proposed repository. (2) Behavior of the system in the absence of unlikely, disruptive events.

**nominal features, events, and processes:** Likely features, events, and processes, given the site conditions as described from current site characterization information.

**nominal scenario class:** The scenario, or set of related scenarios, that describes the expected or nominal behavior of the system as perturbed only by the presence of the proposed repository. The nominal scenarios contain all likely features, events, and processes that have been retained for analysis.

**nuclear criticality safety:** Protection against the consequences of a criticality accident, preferably by prevention of the accident.

**numerical model:** An approximate representation of a mathematical model that is constructed using a numerical description method such as finite volumes, finite differences, or finite elements. A numerical model is typically represented by a series of program statements that are executed on a computer.

**occupational dose:** The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals who were administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public (10 CFR 20.1003, "Occupational dose").

**on-site person:** A proposed geologic repository operation area worker or other person, within the controlled area boundary, with assigned duties other than receiving an occupational dose, and who is considered a member of the public, as defined in 10 CFR Part 20.

**oxidation:** A corrosion reaction in which the corroded metal forms an oxide, usually applied to reaction with a gas containing elemental oxygen, such as air.

**parameter.** Data, or values, such as those that are input to computer codes for a total system performance assessment calculation.

**patch:** In the U.S. Department of Energy modeling of waste package corrosion, a patch is the minimal surface area of the waste package over which uniform corrosion occurs, as opposed to localized corrosion in pits.

**pathway.** A potential route by which radionuclides might reach the accessible environment and pose a threat to humans. For example, direct exposure is a human external pathway, and inhalation and ingestion are human internal pathways.

**permeability.** A measure of the ease with which a fluid such as water or air moves through a rock, soil, or sediment.

**phase:** A physically homogeneous and distinct portion of a material system, such as the gaseous, liquid, and solid phases of a substance. In liquids and solids, single phases may coexist.

**phase stability:** A measure of the ability of a particular phase to remain without transformation.

**pit:** A small cavity formed in a solid as a result of localized corrosion.

**pitting corrosion:** Localized corrosion of a metal surface, confined to a small area, that takes the form of cavities named pits.

**Pliocene:** The epoch of geologic time from ~ 5 to ~ 2.5 million years ago.

**porosity:** The ratio of the volume occupied by openings, or voids, in a soil or rock, to the total volume of the soil or rock. Porosity is expressed as a decimal fraction or as a percentage.

**pre-initiator human failure event:** Events that lay the foundation for an initiating event to occur (e.g., latent failures introduced during maintenance acts). Examples of pre-initiator human failure events include: actions that leave valves misaligned or instruments miscalibrated, leading to unavailability of equipment when needed; unscheduled maintenance acts that lead to reconfiguration of a system which does not match the expectations of operating personnel, leading to a human failure event.

**post-initiator human failure event:** Post-initiator human failure events include both operator actions and inactions that have the result of degraded plant/facility conditions. An example of such a human failure event is the failure to manually actuate or manipulate systems or equipment that are required for response to an initiating event, to prevent propagation of an event sequence or to mitigate its consequences. Post-initiator can be further divided into recovery and non-recovery events, as appropriate for a given event sequence.

**pre-startup and startup testing:** Activities to evaluate the readiness to receive, possess, process, store, and dispose of high-level radioactive waste.

**probabilistic:** Based on or subject to probability.

**probability:** The chance that an outcome will occur from the full set of possible outcomes. Knowledge of the exact probability of an event is usually limited by the inability to know, or compile, the complete set of possible outcomes over time or space.

**probability distribution:** The set of outcomes (values) and their corresponding probabilities for a random variable. See distribution.

**processes:** Phenomena and activities that have gradual, continuous interactions with the system being modeled.

**process model:** A depiction or representation of a process, along with any hypotheses required to describe or to explain the process.

**pyroclastic:** In relation to igneous activity, this describes fragments or fragmental rocks and deposits produced by explosive volcanic activity, where the magma is ripped apart during the release of gas and/or by interaction with surface and near-surface water.

**qualitative human reliability analysis:** Human reliability analysis tasks that include: (1) identification of human failure events and unsafe actions; (2) identification of important factors influencing human performance; and (3) selection of appropriate human reliability analysis quantification method(s), if considered necessary.

**quaternary:** The period of geologic time from about 2.6 million years ago to the present day.

**radiation worker:** A proposed geologic repository operation area worker within the controlled area boundary, with assigned duties that involve exposure to radiation or radioactive material, and who receives an occupational dose, as defined in 10 CFR Part 20.

**radiation protection program:** A program for controlling and monitoring radioactive effluents and occupational radiological exposures to maintain such effluents and exposures in accordance with the requirements of 10 CFR 63.111 ("Performance objectives for the proposed geologic repository operations area through permanent closure").

**radioactive decay:** The process in which one radionuclide spontaneously transforms into one or more different radionuclides, which are called daughter radionuclides.

**radioactivity:** The property possessed by some elements (such as uranium) of spontaneously emitting energy in the form of radiation as a result of the decay (or disintegration) or an unstable atom. Radioactivity is also the term used to describe the rate at which radioactive materials emits radiation.

**radiolysis:** Chemical decomposition by the action of radiation.

**radionuclide:** Radioactive type of atom with an unstable nucleus that spontaneously decays, usually emitting radiation in the process. Radioactive elements are characterized by their atomic mass and atomic number.

**range (statistics):** The numerical difference between the highest and lowest value in any set.

**receptor:** An individual for whom radiological doses are calculated or measured.

**redistribution:** Mobilization and transport of surface deposits by wind and water.

**reliability:** The probability that the item will perform its intended function(s), under specified operating conditions, for a specified period of time.

**repository footprint:** The outline of the outermost locations of where the waste is proposed to be emplaced in the proposed Yucca Mountain repository.

**retardation:** Slowing or stopping radionuclide movement in groundwater by mechanisms that include sorption of radionuclides, diffusion into rock matrix pores and microfractures, and trapping of particles in small pore spaces or dead ends of microfractures.

**rhyolite:** A common type of igneous rock that forms light-colored, rough blocky-surfaced lavas and white-greyish-yellow tephra deposits. A common fragment type is pumice. Rhyolitic

magma has a high viscosity and the resulting lava flows are usually quite short and thick. It more frequently erupts explosively from the volcano and forms ash-flow tuffs.

**risk:** The probability that an undesirable event will occur, multiplied by the consequences of the undesirable event.

**risk assessment:** An evaluation of potential consequences or hazards that might be the outcome of an action, including the likelihood that the action might occur. This assessment focuses on potential negative impacts on human health or the environment.

**risk-informed, performance-based:** A regulatory approach in which risk insights, engineering analysis and judgments, and performance history are used to: (i) focus attention on the most important activities; (ii) establish objective criteria based on risk insights for evaluating performance; (iii) develop measurable or calculable parameters for monitoring system and licensee performance; and (iv) focus on the results as the primary basis for regulatory decision making.

**rock fall:** The release of fracture-bounded blocks of rock from the drift wall, usually in response to an earthquake.

**rock matrix:** See matrix.

**runoff:** Lateral movement of water at the ground surface, such as down steep hillslopes or along channels, that is not able to infiltrate at a specified location.

**runon:** Lateral movement of water along the ground surface from some upstream location that becomes available for infiltration. See runoff.

**safety question:** A question regarding the adequacy of structures, systems, and components important to safety and engineered or natural barriers important to waste isolation.

**scenario:** A well-defined, connected sequence of features, events, and processes that can be thought of as an outline of a possible future condition of the proposed repository system. Scenarios can be undisturbed, in which case the performance would be the expected, or nominal, behavior for the system. Scenarios can also be disturbed, if altered by disruptive events such as human intrusion or natural phenomena such as volcanism or nuclear criticality.

**scenario class:** A set of related scenarios sharing sufficient similarities that they can usefully be aggregated for screening or analysis. The number and breadth of scenario classes depend on the resolution at which scenarios have been defined.

**scoria cone:** See cinder cone.

**seepage:** The inflow of groundwater moving in fractures or matrix pores of permeable rock to an open space in the rock. For the proposed Yucca Mountain repository, seepage refers to water dripping into a drift.

**seismic:** Pertaining to, characteristic of, or produced by earthquakes or Earth vibrations.

**seismic hazard curve:** A graph showing the ground motion parameter of interest, such as peak ground acceleration, peak ground velocity, or spectral acceleration at a given frequency, plotted as a function of its annual probability of exceedence.

**seismic performance:** Seismic performance of structures, systems, and components refers to their ability to perform intended safety functions during a seismic event, expressed as the annual probability of exceeding a specified limit condition (stress, displacement, or collapse). This is also referred to as the probability of failure, or probability of unacceptable performance,  $P_F$ .

**sill:** A tabular, generally flat-lying body of intrusive igneous rock that lies along (is concordant with) the structure of adjacent rocks. Sills are part of the transport system for molten rock (magma) rising from depth to the surface. See also dike.

**sorb:** To undergo a process of sorption.

**sorption:** The binding, on a microscopic scale, of one substance to another. Sorption is a term that includes both adsorption and absorption and refers to the binding of dissolved radionuclides onto geologic solids or waste package materials by means of close-range chemical or physical forces. Sorption is a function of the chemistry of the radioisotopes, the fluid in which they are carried, and the material they encounter along the flow path.

**sorption coefficient ( $K_d$ ):** A numerical means to represent how strongly one substance sorbs to another.

**source term:** Types and amounts of radionuclides that are the source of a potential release.

**spatial variability:** A measure of how a property, such as rock permeability, varies at different locations in an object such as a rock formation.

**speciation:** The existence of the elements, such as radionuclides, in different molecular forms in the aqueous phase.

**spent nuclear fuel:** Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction and that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. This fuel is more radioactive than it was before irradiation and releases significant amounts of heat from the decay of its fission product radionuclides.

**stainless steel:** A class of iron-base alloys containing a minimum of approximately 10 percent chromium to provide corrosion resistance in a wide variety of environments.

**stratigraphy:** The branch of geology that deals with the definition and interpretation of rock strata; the conditions of their formation, character, arrangement, sequence, age, and distribution; and especially their correlation by the use of fossils and other means of identification. See stratum.

**stratum:** A layer of rock or soil with geologic characteristics that differ from layers above or below it.

**stress corrosion cracking:** A cracking process that requires the simultaneous action of a corrosive substance and sustained (residual or applied) tensile stress. Stress corrosion cracking excludes both the fracture of already corroded sections and the localized corrosion processes that can disintegrate an alloy without the action of residual or applied stress.

**structure:** In geology, the arrangement of the parts of geologic features or areas of interest such as folds or faults. This includes features such as fractures created by faulting, and joints caused by the heating of rock. For engineering usage, see structures, systems and components

**structures, systems, and components:** A structure is an element, or a collection of elements, that provides support or enclosure, such as a building, aging pad, or drip shield. A system is a collection of components, such as piping; cable trays; conduits; or heating, ventilation, and air conditioning equipment, that are assembled to perform a function. A component is an item of mechanical or electrical equipment, such as a canister transfer machine, transport and emplacement vehicle, pump, valve, or relay.

**tectonic:** Pertaining to geologic features or events created by deformation of the Earth's crust

**tephra:** A collective term for all clastic (fragmental) materials ejected from a volcano during an eruption and transported through the air.

**thermal chemical:** Of or pertaining to the effect of heat on chemical conditions and reactions.

**thermohydrologic:** Of or pertaining to changes in groundwater movement due to the effects of changes in temperature.

**thermal mechanical:** Of or pertaining to changes in mechanical properties from effects of changes in temperature.

**thermodynamics:** A branch of physics that deals with the relationship and transformations between work as a mechanical action and heat.

**total system performance assessment:** 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 uncertainty and variability of the data.

**traceability:** The ability to clearly follow the development of an analysis from initial to final stages. Traceability is achieved when a reviewer can independently follow the methods and data used throughout the analysis, from source to result.

**transparency:** The ease of understanding the process by which a study was carried out, which assumptions are driving the results, how they were arrived at, and the rigor of the analyses leading to the results. A logical structure ensures completeness and facilitates in-depth review of the relevant issues. Transparency is achieved when a reader or reviewer has a clear picture of what was done in the analysis, why it was done, and the outcome.

**transpiration:** The removal of water from the ground by vegetation (roots).

**transport:** A process that allows substances such as contaminants, radionuclides, or colloids, to be carried in a fluid from one location to another. Transport processes include the physical mechanisms of advection, convection, diffusion, and dispersion and are influenced by the chemical mechanisms of sorption, leaching, precipitation, dissolution, and complexation.

**transportation, aging, and disposal canister:** A canister suitable for transportation from a remote location, aging at Yucca Mountain, and disposal at the proposed repository.

**tuff:** A general term for volcanic rocks that formed from rock fragments and magma that erupted from a volcanic vent, flowed away from the vent as a suspension of solids and hot gases, or fell from the eruption cloud, and consolidated at the location of deposition. Tuff is the most abundant type of rock at the Yucca Mountain site.

**uncertainty:** How much a calculated or measured value varies from the unknown true value. See also, aleatory uncertainty and epistemic uncertainty

**uniform corrosion:** A type of corrosion attack (deterioration) more or less uniformly distributed over a metal surface. Corrosion that proceeds at approximately the same rate over a metal surface. Also called general corrosion.

**unsaturated zone flow:** The movement of water in the unsaturated zone, as driven by capillary, viscous, gravitational, inertial, and evaporative forces.

**variable:** A nonunique property or attribute.

**variability (statistical):** A measure of how a quantity varies over time or space.

**volcanism:** Pertaining to extrusive igneous activity.

**wash:** In a relation to landforms, a streambed, dry or running, usually in an arid environment.

**watershed:** The area drained by a river system including the adjacent ridges and hillslopes.

**welded tuff:** A tuff deposited under conditions where the particles that make up the rock remained sufficiently hot to cohere. In contrast to nonwelded tuff, welded tuff is denser, less porous, and more likely to be fractured (which increases permeability).