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U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

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SITE CHARACTERIZATION
PROJECT

TECHNICAL BASIS REPORT FOR SURFACE CHARACTERISTICS, PRECLOSURE HYDROLOGY, AND EROSION

PUBLIC SUMMARY

APRIL 1995
UNITED STATES DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE

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PUBLIC SUMMARY

BACKGROUND

In 1982, Congress established a national policy to address the problem of high-level nuclear waste disposal by passing the **Nuclear Waste Policy Act** (Act). The Act authorized the **Department of Energy** (DOE) to site, build and operate a geologic repository for spent nuclear fuel and high-level radioactive waste produced at commercial nuclear power plants and defense facilities. Under the Act, the DOE's **Office of Civilian Radioactive Waste Management** (OCRWM) was established and given the responsibility for siting the repository.

To recommend a site, DOE set forth detailed siting guidelines for a repository in **Title 10, Code of Federal Regulations (CFR), Part 960**, as required by the Act.

Initially, site characterization studies considered a number of potential sites for a geologic repository. However, a 1987 amendment to the Nuclear Waste Policy Act directed OCRWM to study only **Yucca Mountain, Nevada**. Currently, scientific studies are being conducted at Yucca Mountain to gather the information necessary for OCRWM to meet these goals:

- determining site suitability under 10 CFR Part 960
- complying with the provisions of the National Environmental Policy Act (NEPA)
- preparing and submitting a Site Recommendation Report to the President, and
- developing and submitting a License Application to the Nuclear Regulatory Commission for construction authorization under 10 CFR Part 60.

OCRWM's Program Approach is structured to ensure that efficient measurable progress is made toward determining the suitability of Yucca Mountain as a permanent repository, and that the technical approach and schedule are realistic and consistent with the established funding and with the expectations of Congress and other stakeholders.

THE SITE SUITABILITY PROCESS

The site suitability process centers on demonstrating compliance with each 10 CFR Part 960 siting guideline, or group of guidelines. The guidelines address both pre- and postclosure periods of a repository's lifetime (before and after a repository is sealed). Each guideline includes **qualifying, favorable, potentially adverse**, and **disqualifying conditions** for **technical** and **system** categories. To recommend a site for repository development, the Director of OCRWM must make a **positive higher level finding** for each qualifying and disqualifying condition in the guidelines. To make a **higher level finding** on a qualifying condition means being able to find that the condition is either present or not present, with confidence that additional data will not alter that conclusion.

To make a higher level finding on a disqualifying condition means being able to find that a disqualifying condition is either present or not present, with confidence that additional data will not alter that conclusion.

To make a **positive** higher level finding means being able to find that a qualifying condition is present at the site, plus confidence that additional data will not alter that conclusion.

Potentially adverse and favorable conditions will be considered as part of the overall evaluation, but findings will not be made on them specifically.

This process includes an opportunity for external peer review of the technical data and interpretations by the **National Academy of Sciences** (NAS) and public involvement at key points in the evaluation sequence. Review by an independent and qualified organization such as the Academy will provide feedback to help OCRWM decide if the data, analyses, and conclusions reported in Technical Basis Reports are sound. This review will help OCRWM decide if preparation of a Draft Guideline Compliance Assessment is appropriate, or if additional testing and analyses are needed before findings are made on guideline. NAS peer reviews will be conducted as site characterization data and analyses, accompanied by related design concepts, and performance assessments (computer modeling and projections) become available. The environmental aspects of the evaluation will use data and analyses developed to implement the NEPA process.

For each guideline, or group of guidelines, OCRWM will:

- develop a **Technical Basis Report**, then
- using the results of the Technical Basis Report, develop a **Draft Guideline Compliance Assessment**.

The process features three types of OCRWM evaluations:

- evaluation of individual Technical Basis Reports and Guideline Compliance Assessments to make a Higher Level Finding,
- evaluation of technical site suitability, and
- evaluation of overall site suitability.

These evaluations will provide the information needed either to disqualify Yucca Mountain as a repository site or, alternatively, if the site is found suitable to prepare a Site Recommendation Report for submittal to the President.

OCRWM has completed the first of seven Technical Basis Reports -- the **Technical Basis Report For Surface Characteristics, Preclosure Hydrology, and Erosion** -- and has submitted the document to the National Academy of Sciences for external peer review. Following completion of the Academy's peer review, OCRWM will evaluate the Academy's peer review recommendations, if any, prepare a Draft Guideline Compliance Assessment, and publish a Federal Register Notice announcing its availability for public review and comment. The draft assessment will contain DOE's rationale and logic as to whether or not the available information in the technical basis report is adequate to support findings on the guidelines under consideration.

The following sections of this public summary discuss the **technical guidelines** from 10 CFR Part 960 that are relevant to this Technical Basis Report.

TECHNICAL GUIDELINES

This Technical Basis Report presents the data, analyses and conclusions pertaining to three **technical** guidelines from 10 CFR Part 960:

- Section 5.2.8 Surface Characteristics
- Section 5.2.1 Preclosure Hydrology
- Section 4-2-5 Erosion

Surface Characteristics

The **qualifying condition** for Surface Characteristics is a site which meets the **system** guideline of ease and cost of siting, construction, operation, and closure using reasonably available technology.

Generally flat and well-drained terrain is a **favorable condition**. The only **potentially adverse condition** is surface characteristics that could lead to flooding of the surface or underground facilities of the repository by location on a flood plain or proximity to a dam. There are no **disqualifying conditions** identified for Surface Characteristics at the Yucca Mountain site.

Erosion

The **qualifying condition** for Erosion is a site where the underground facilities of the repository can be placed deep enough so that erosion at the surface will not be likely to expose the waste or lead to radionuclide releases greater than permitted by law.

There are three **favorable conditions** under erosion. The first pertains to the potential for the underground facilities of the repository to be located at least 300 meters (about 985 feet), below the ground surface. The second pertains to the nature and rate of erosion in the **Quaternary Period** (the last 1.6 million years of geologic time). Namely, that the projected erosion rates will not lead to radionuclide releases, greater than the limits permitted by law, into the surface environment or ground water over the next 10,000 years. Third, a site where surface exposure of the waste would not be expected during the first million years after repository closure.

A **potentially adverse condition** exists if there is evidence of a high rate of erosion over the Quaternary Period. Another potentially adverse condition would be present if the nature and rate of surface feature formation could impact the ability of the repository to isolate waste for the first 10,000 years after closure. A site would be **disqualified** if conditions prevented the repository from being placed at least 200 meters (about 650 feet) below the surface.

Preclosure Hydrology

The **qualifying condition** for Preclosure Hydrology is a site where the overall geologic and hydrologic characteristics of the site are compatible with the activities required for repository construction, operation, and closure. These characteristics must not compromise the functions of shaft liners and seals; and must meet the system guideline of ease and cost of siting, construction, operation, and closure using reasonably available technology.

Favorable conditions include the absence of aquifers (a rock layer containing enough water in pores and fractures that people might could use it) between the host rock and the surface; the absence of surface-water systems that could potentially cause flooding of the repository; and availability of the water needed during construction, operation,

and closure.

A site would be **disqualified** if, based on expected ground water conditions, it is likely that engineering measures beyond reasonably available technology would be required for repository construction, operation, or closure.

TECHNICAL BASIS REPORT FOR SURFACE CHARACTERISTICS, PRECLOSURE HYDROLOGY, AND EROSION

The objective of the Technical Basis Report is to provide sufficient technical data on each of the relevant guidelines so that a Draft Guideline Compliance Assessment may be written to evaluate the higher level findings on the qualifying and disqualifying conditions in the technical guidelines.

Since OCRWM's goal is waste isolation for a minimum of 10,000 years, an important aspect of evaluating the surficial processes against the technical guidelines in 10 CFR Part 960 is an awareness of the geologic timescale and the recorded rates of change in the Yucca Mountain region. The regulated performance period for a repository system, 10,000 years, is 0.6% of the geologic time spanned by the Quaternary Period.

This Technical Basis Report is divided into five major sections including an Introduction and Summary as well as three technical sections dealing with Surface Characteristics, Preclosure Hydrology, and Erosion.

Introduction

Yucca Mountain is located in southern Nevada (**Figure 1**), about 100 miles northwest of Las Vegas on land that is currently controlled by the Air Force (Nellis Range), the Department of Energy (Nevada Test Site), and the Bureau of Land Management. The proposed repository site lies within the southwestern Great Basin, which is part of the Basin and Range province of the United States. Long, north to northwest-trending up-faulted mountain ranges and down-faulted sediment-filled basins are predominant in the area.

Yucca Mountain itself is a fault-bounded block of volcanic rock formed by the movement of large blocks of rock relative to one another. The crest of the mountain is approximately 1,500 meters (about 4,900 feet) above sea level, and roughly 1,000 meters (about 3,250 feet) above sea level at the base. The regional climate is semi-arid, with an average of less than 10 inches of rain a year. There are no standing water bodies, or running streams present. **Figure 1** shows the geographic boundaries and major topographic elements of the Yucca Mountain area.

Surface Characteristics

There are two attributes for the surface characteristics guideline, surficial geology and surface water.

The first attribute pertains to the geology and terrain at Yucca Mountain. The surficial geology at needs to be understood well enough to determine if the terrain is flat and that the pattern of surface drainage allows the design, construction, and operation of repository facilities.

Geologic deposits now exposed at the surface began accumulating in the Yucca Mountain region about 10 to 11 million years ago following the end of a series of volcanic eruptions. These deposits are, 1)

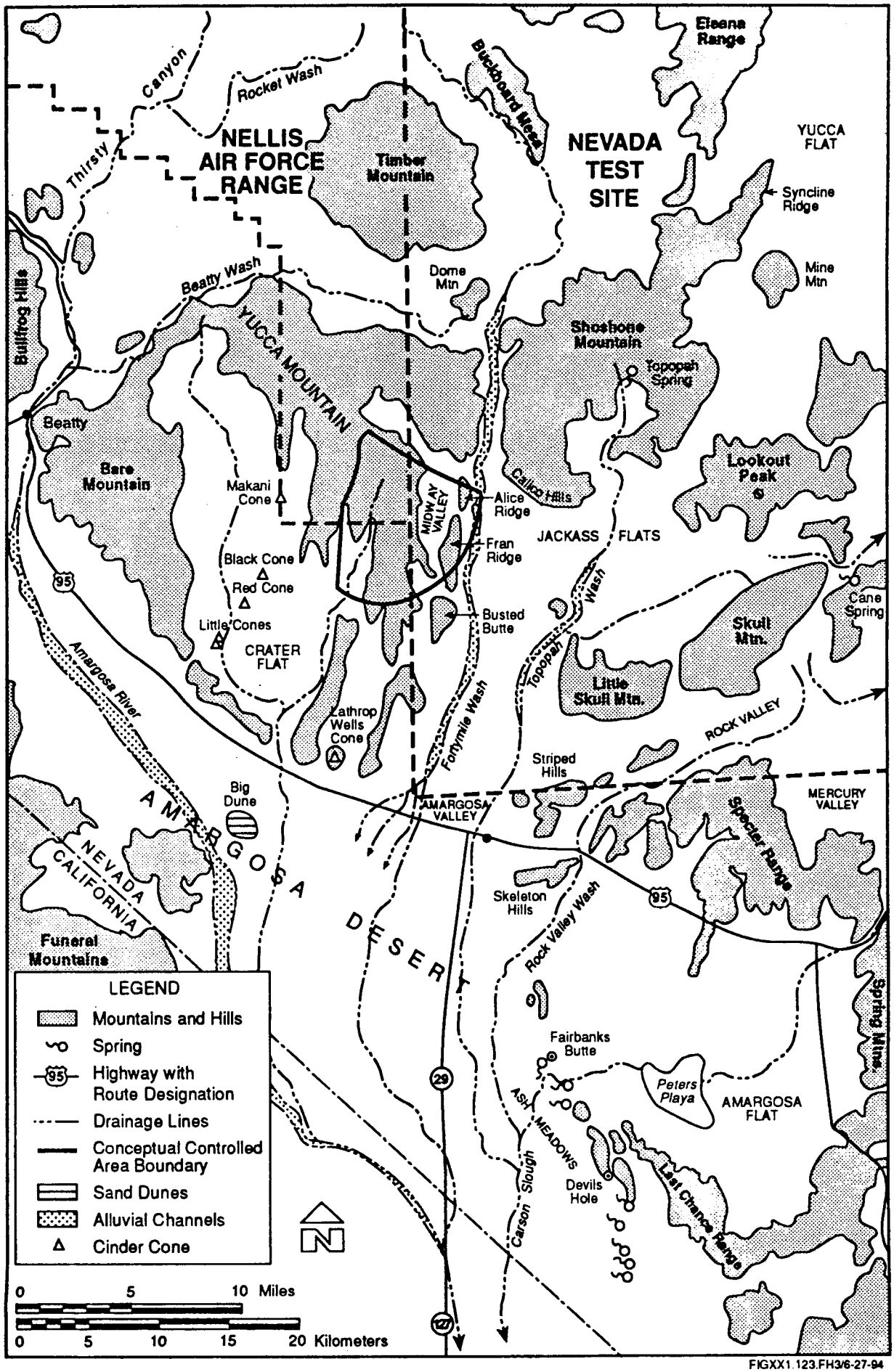

Figure 1 Location map

bedrock consisting of **volcanic tuff** (compacted volcanic ash - welded into a hard rock by its own heat), 2) **alluvium** (sediment laid down by streams and rivers), and 3) **colluvium** (coarse-grained sediments from in-place wearing down of hillslopes).

The basic topographic elements of the current landscape, including the dry Amargosa River and Fortymile Wash, have been present for the past few million years; there has been little modification of the landscape by erosion or faulting since the early Quaternary Period. Fortymile Wash has been draining the region for about 9 million years. Deposits in Midway Valley are at least 2 million years old, if not older.

Available information on the surficial geology of Yucca Mountain indicates that surface facilities for a repository can be built on relatively flat, well-drained terrain.

The second attribute of the surface characteristics guideline is understanding the nature of the surface water regime at Yucca Mountain. This regime needs to be understood well enough to determine if the potential for surface runoff and flooding could interfere with the ability to design, construct, and operate facilities and deploy sealing components.

The slopes of Yucca Mountain drain to the Amargosa River through the Fortymile and Beatty Washes, which are major tributaries to the river. There is very little surface water in the region and most comes from small springs. The Amargosa River is dry except for short lengths of the river that carry water from springs and for short periods after rain storms. Yucca Mountain is located inland and there are no lakes, dams, or reservoirs nearby, thus there is no potential for surges, dam failures, or ice jams.

Studies show that the basic regional drainage pattern was established about 11 million years ago. A change to its current location and direction of flow in the wash took place about 9 million years ago, as determined by the composition of cobbles in the alluvium cut by Fortymile Wash, but otherwise little change has taken place since then. In fact, one study notes that Fortymile Wash is aggrading (filling in) rather than cutting down or eroding under the climatic conditions since the last ice age.

The unvegetated valleys and slopes in the area allow rapid runoff of water during storms. The channels of Fortymile Wash and its tributaries are straight and full of porous gravel. Storm water flows quickly through channnels and soon trickles into gravelly bottom-fill, or forms viscous debris flows by picking up sediment and cobbles.

There are no running streams in the Yucca Mountain area, however water flows in stream channels and Fortymile Wash following significant rain storms. Moderate to large floods in Fortymile Wash or its tributaries are rare and usually result from intense storms during the winter and summer months. Flash floods or debris flows commonly result from summer cloudbursts. Flooding is usually limited to small areas that are active for short periods of time.

There is little opportunity to down-cut channels or erode channel banks. Very little hillslope erosion occurs on Yucca Mountain during rainstorms since there is not much material present that could be carried away by normal rains. Only during very intense or lengthy storms do debris flows strip material from the

hillslopes. These flows carry loose colluvium and sediment from hillslopes and deposit them at slope bases.

Available information on the surface water regime indicates that prospective surface facilities for a repository can be located outside flood-prone areas, thereby removing the potential for surface water to flood surface or underground repository facilities.

Preclosure Hydrology

For the preclosure hydrology guideline, data on the subsurface ground water regime needs to be understood well enough to determine if conditions would interfere with the ability to design, construct, and operate repository facilities and sealing components and to determine if adequate water is available for site characterization and repository development.

Existing drillholes have shown that no aquifers exist between the surface and the potential host rock for the repository. However, zones of **perched water** (ground water that is confined to pockets, or zones), have been found in drillholes in and near the potential repository block, above the general ground-water level.

None of the perched zones found to date are above or at the level of the proposed repository.
In fact, the known perched water zones are at least 100 meters, or about 320 feet, below the level currently planned for the repository. Tunnels constructed at the Nevada Test Site in volcanic tuff similar to that found in Yucca Mountain, did not require extraordinary engineering measures to deal with perched water. When perched water was encountered in these tunnels, the seeps stopped within a few weeks.

Ground-water resources in the Yucca Mountain area were first developed in the late 1950s to support operations at the Nevada Test Site. Because of this, about 30 years of data exists on the local ground water supply and recharge rates. Overall this data indicates that ground water pumping through the years at specific wells has had very little impact on the regional ground water supply. The entire regional water resource system appears to be recharging at a rate that exceeds the amount of withdrawal.

Available information indicates that there is accesible quantities of water that are more than sufficient for all planned site characterization activities, as well as for construction and operation of a potential repository, and that perched water occurrences are likely to be few and manageable.

Erosion

The erosion guideline pertains to the postclosure period. Data on depth to the potential repository rock layer and on erosional processes need to be understood well enough to determine if site conditions allow all portions of the underground facility to be situated at least 200 meters (about 650 feet) below the overlying ground surface and to establish an upper bound on potential releases of radioactivity to the environment that could result from erosional processes.

The Yucca Mountain area possesses a number of factors favoring landscape stability and very low erosion rates. The landscape has been stable throughout the Quaternary Period, despite location in a relatively active geologic province like the Great Basin. One factor is that these fine-grained volcanic rocks are very hard and resistant to erosion. Also, rates of

tectonic activity have been low since the volcanic rocks of Yucca Mountain were formed. The ridges and valleys of the current landscape were present 11 million years ago.

Another factor is the dry climate, which has changed little over the past several hundred thousand years. The climate is semi-arid now, and it would not change much in the next 10,000 to 100,000 years even during the height of another glacial period, when the climate would likely become slightly cooler and wetter. These conditions and attributes are expected to continue into the future so as not to cause erosion rates that depart from the low rates known for the Quaternary Period.

Studies conducted to measure bedrock erosion rates indicate that the rate of hillslope erosion has averaged about 0.19 centimeters, or less than one-tenth of an inch, per thousand years. To put this in perspective, the range of surface erosion over the entire United States is 2 to 15 centimeters, or about three-fourths of an inch to 6 inches each thousand years.

There are several lines of reasoning that support the low erosion rates that DOE has determined for the Yucca Mountain area. The hillslopes have on them large colluvial boulder deposits that were formed during a colder climate in the early part of the Quaternary Period. The boulders of volcanic bedrock and the deposits formed by their accumulation on hillslopes are resistant to erosion. Dating of rock varnish on boulders indicates that these deposits are very old, and have been stable on the hillslopes for hundreds of thousands of years. Boulder deposits armor the hillslopes where they occur because the boulders are often cemented to the underlying bedrock by thick layers of calcium carbonate. With the low rainfall in the current semi-arid climate, these boulder deposits are difficult to erode. Runoff of storm water moves down channels next to the boulder deposits, which isolates them from modern erosion processes.

In the valleys adjacent to the hillslopes, thick deposits of calcium carbonate (caliche) in the soils and alluvium require hundreds of thousands of years to form. These deposits are the products of a dry climate, that has been dry for a long time. All of these independent lines of evidence support a conclusion that the landscape has been a stable one through the Quaternary Period.

Stream cutting rates were also calculated for Yucca Mountain area drainages. The downcutting rates for Fortymile Wash were calculated based on the age of stream bed elevations and the total thickness of alluvium in the valley. The minimum downcutting rate is about 42 centimeters, or 16 inches, per thousand years; the maximum downcutting rate is about 222 centimeters, or 87 inches, per thousand years. The actual downcutting rate is believed to be much closer to the minimum number since the geologic deposits exposed along Fortymile Wash show that it has been filling in during the Quaternary Period rather than downcutting or eroding.

Available evidence on the rates and locations of erosion indicate not only that erosion rates in the area are low, they are very low. Erosion rates over the past 1.3 million years are significantly below average for similar rocks in a similar climatic setting.

SCHEDULE FOR HIGHER LEVEL FINDINGS

This Technical Basis Report was sent the the National Academy of Sciences for peer review in April 1995. The Academy requires up to 6 months to assemble the review panel and conduct the review. The Academy will request that the public provide information relevant to the technical issues surfaced in the Technical Basis Report to the Academy's peer review group. Written technical comments will be made available to the Director of OCRWM as input for evaluating compliance with DOE's siting guidelines.

Following the completion of the Academy's peer review, OCRWM will evaluate the peer review recommendations, if any, and will then prepare a Draft Guideline Compliance Assessment and announce its availability for public review and comment.

The Draft Compliance Assessment will contain DOE's rationale and logic as to whether or not the available information in the Technical Basis Report is adequate to support findings on the guidelines.

OCRWM will hold a public workshop on the Draft Guideline Compliance Assessment during the comment period to provide an open forum to discuss the arguments it contains. Such workshops constitute an opportunity for active predecisional input to OCRWM by the public during the decision process for evaluating the siting guidelines.

For More Information

The Technical Basis Report is available for public review at:

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