
Nuclear Waste Policy Act
(Section 112)



Environmental Assessment
Overview

Deaf Smith County Site, Texas

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Office of Civilian Radioactive Waste Management
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MASTER

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FOREWORD

The Nuclear Waste Policy Act of 1982 (the Act) established a process for the selection of sites for the disposal of spent nuclear fuel and high-level radioactive waste in geologic repositories. The first steps in this process were the identification of potentially acceptable sites and the development of general guidelines for siting repositories. In February 1983, the DOE identified nine sites in six States as potentially acceptable for the first repository. The Deaf Smith County site in Deaf Smith County, Texas, was identified as one of those sites. The general guidelines were issued in November 1984 as Title 10 of the Code of Federal Regulations, Part 960. The DOE is now proceeding with the next step in the site-selection process for the first repository: the nomination of at least five of the nine potentially acceptable sites as suitable for site characterization, which is a program of detailed studies.

The Act requires that site nomination be accompanied by an environmental assessment (EA). The DOE has prepared EAs for the nominated sites through a process that provided opportunity for public input. Public hearings were held during March, April, and May 1983 to obtain recommendations on the issues to be addressed in an EA. All such recommendations were considered in preparing the EAs. The DOE issued draft EAs for public review and comment in December 1984 and conducted a series of public hearings in February and March 1985. The issues raised in the comment letters and hearings were considered in preparing the final EAs. These issues are addressed in a comment-response document appended to the final EAs (Appendix C).

The information presented in the EAs is derived from hundreds of technical reports containing more-detailed data and analyses. All of these reference documents are available to the public in various libraries and reading rooms; a listing of their locations is given in Appendix B.

After the nomination, the Secretary is required by the Act to recommend to the President not fewer than three of the nominated sites for characterization as candidate sites for the first repository. This recommendation will be submitted and documented in a separate report that is being issued separately from this environmental assessment. After submittal, the Act provides the President 60 days to approve or disapprove the candidate sites. The President may delay his decision for up to six months if he determines that the information supplied with the recommendation of the Secretary is insufficient to permit a decision within the 60-day period. If the President does not approve, disapprove, or delay the decision, the candidate sites shall be considered approved. After the President approves the candidate sites, the DOE will start site characterization.

ABSTRACT

In February 1983, the U.S. Department of Energy (DOE) identified a location in Deaf Smith County, Texas, as one of nine potentially acceptable sites for a mined geologic repository for spent nuclear fuel and high-level radioactive waste. The potentially acceptable site was subsequently narrowed to an area of 9 square miles. To determine their suitability, the Deaf Smith County site and the eight other potentially acceptable sites have been evaluated in accordance with the DOE's General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories. These evaluations were reported in draft environmental assessments (EAs), which were issued for public review and comment. After considering the comments received on the draft EAs, the DOE prepared the final EAs.

The Deaf Smith County site is in the Permian Basin, which is one of five distinct geohydrologic settings considered for the first repository. This setting contains one other potentially acceptable site--the Swisher County site. Although the Swisher County site is suitable for site characterization, the DOE has concluded that the Deaf Smith County site is the preferred site in the Permian Basin. On the basis of the evaluations reported in this EA, the DOE has found that the Deaf Smith County site is not disqualified under the guidelines.

Furthermore, the DOE has found that the site is suitable for site characterization because the evidence does not support a conclusion that the site will not be able to meet each of the qualifying conditions specified in the guidelines. On the basis of these findings, the DOE is nominating the Deaf Smith County site as one of five sites suitable for characterization.



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OVERVIEW

1. INTRODUCTION

By the end of this century, the United States plans to begin operating the first geologic repository for the permanent disposal of commercial spent nuclear fuel and high-level radioactive waste. Public Law 97-425, the Nuclear Waste Policy Act of 1982 (the Act), specifies the process for selecting a repository site, and constructing, operating, closing, and decommissioning the repository. Congress approved geologic disposal by declaring that one of the key purposes of the Act is "to establish a schedule for the siting, construction, and operation of repositories that will provide reasonable assurance that the public and the environment will be adequately protected from the hazards posed by high-level radioactive waste and such spent nuclear fuel as may be disposed of in a repository" [Section 111(b)(1)].

A geologic repository can be viewed as a large underground mine with a complex of tunnels occupying roughly 2,000 acres at a depth between 1,000 and 4,000 feet. To handle the waste received for disposal, surface facilities will be developed which will occupy about 400 acres. The repository will be operational for about 25 to 30 years. After the repository is closed and sealed, waste isolation will be achieved by a system of multiple barriers, both natural and engineered, that will act together to contain and isolate the waste as required by regulations. The natural barriers include the geologic, hydrologic, and geochemical environment of the site. The engineered barriers consist of the waste package and the underground facility. The waste package includes the waste form, the waste disposal container, and materials placed over and around the containers. The underground facility consists of underground openings and backfill materials, not associated with the waste package, that are used to further limit ground-water circulation around the waste packages and to impede the subsequent transport of radionuclides into the environment.

In February 1983, the DOE carried out the first requirement of the Act by formally identifying nine sites in the following locations as potentially acceptable sites for the first repository (the host rock of each site is noted in parentheses):

1. Vacherie dome, Louisiana (domal salt)
2. Cypress Creek dome, Mississippi (domal salt)
3. Richton dome, Mississippi (domal salt)
4. Yucca Mountain, Nevada (welded tuff)
5. Deaf Smith County, Texas (bedded salt)
6. Swisher County, Texas (bedded salt)
7. Davis Canyon, Utah (bedded salt)
8. Lavender Canyon, Utah (bedded salt)
9. Reference repository location, Hanford Site, Washington (basalt flows).

The locations of these sites are shown in Figure 1.



Figure 1. Potentially acceptable sites for the first repository.

After identifying these potentially acceptable sites, the DOE published draft General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories (the guidelines) in accordance with the Act. The draft guidelines were revised in response to extensive comments and received the concurrence of the Nuclear Regulatory Commission (NRC) in June 1984. Final guidelines were published in December 1984 as 10 CFR Part 960.

The Act requires the DOE to nominate at least five sites as suitable for site characterization--a formal information-gathering process that will include the sinking of one or more shafts at the site and a series of experiments and studies underground. The DOE must then recommend not fewer than three of those sites for characterization as candidate sites for the first repository. After site characterization is complete, one of the characterized sites will be recommended for development as a repository.

The Act also requires the DOE to prepare environmental assessments (EAs) to serve as the basis for site-nomination decisions. These EAs contain the following information and evaluations consistent with the requirements of Section 112 of the Act:

- A description of the decision process by which the site is being considered for nomination (EA chapters 1 and 2).
- A description of the site and its surroundings (EA Chapter 3).
- An evaluation of the effects of site characterization activities on public health and safety and the environment and a discussion of alternative activities that may be taken to avoid such effects (EA Chapter 4).
- An assessment of the regional and local effects of locating the proposed repository at the site (EA Chapter 5).
- An evaluation as to whether the site is suitable for site characterization (EA Chapter 6).
- An evaluation as to whether the site is suitable for development as a repository (EA Chapter 6).
- A reasonable comparative evaluation of the site with other sites that have been considered (EA Chapter 7).

This overview highlights the important information and evaluations found in the EA for Deaf Smith. Section 2 of this overview presents a summary of the decision process and findings leading to the nomination of the Deaf Smith County site. Sections 3 through 7 summarize the results of the evaluations contained in corresponding chapters in the EA.

2. DECISION PROCESS AND PRELIMINARY CONCLUSIONS

2.1 DECISION PROCESS

The guidelines require the DOE to implement the following seven-part evaluation and decision process for nominating and recommending sites for characterization:

1. Evaluate the potentially acceptable sites against the disqualifying conditions specified in the guidelines.
2. Group all potentially acceptable sites according to their geohydrologic settings.
3. For those geohydrologic settings that contain more than one potentially acceptable site, select the preferred site on the basis of a comparative evaluation of all potentially acceptable sites in that setting.
4. Evaluate each preferred site within a geohydrologic setting and decide whether such site is suitable for the development of a repository under the qualifying condition of each applicable guideline.
5. Evaluate each preferred site within a geohydrologic setting and decide whether such site is suitable for site characterization under the qualifying condition of each applicable guideline.
6. Perform a reasonable comparative evaluation under each guideline of the sites proposed for nomination.
7. Consider an order of preference of the nominated sites as recommended sites and, on the basis of this order of preference, recommend not fewer than three sites for characterization to the President.

The DOE prepared a draft EA for each of the nine potentially acceptable sites to give all interested parties an opportunity to review the full evaluation of all sites considered. In preparing the final EAs for the five nominated sites, the DOE has considered all comments that were received.

With the issuance of the final EAs, the DOE will formally nominate five sites as suitable for characterization. The Secretary of Energy will then recommend not fewer than three of these sites to the President as candidate sites for characterization. After the President approves the Secretary's recommendation, characterization activities will begin at those sites. After characterization is completed, the DOE will again evaluate each site against the guidelines and, after completing an environmental impact statement, will recommend one site to the President for the first repository. The President may then recommend the site to Congress. At this point, the host State may issue a notice of disapproval that can be overridden only by a joint resolution of both Houses of U.S. Congress. If the notice of disapproval is

not overridden, the President must submit another repository site recommendation within 12 months. If no notice of disapproval is submitted, or if Congress overrides the notice of disapproval, then the site designation is effective, and the DOE will file an application with the NRC to obtain a construction authorization for a repository at that site.

2.2 FINDINGS AND DETERMINATIONS

Summarized below are the DOE's findings and determinations that apply to the Deaf Smith County site.

2.2.1 EVALUATION AGAINST THE DISQUALIFYING CONDITIONS

The evidence does not support the disqualification of the Deaf Smith County site under the guidelines, nor are any of the other eight potentially acceptable sites found to be disqualified.

2.2.2 GROUPING OF SITES BY GEOHYDROLOGIC SETTING

The nine potentially acceptable sites are contained within five distinct geohydrologic settings as defined by the U.S. Geological Survey. The sites are grouped by the DOE's geohydrologic designations as follows:

Geohydrologic Setting	Site
Columbia Plateau	Reference repository location, Hanford Site, Washington
Great Basin	Yucca Mountain, Nevada
Permian Basin	Deaf Smith and Swisher Counties, Texas
Paradox Basin	Lavender Canyon and Davis Canyon, Utah
Gulf Interior Region of the Gulf Coastal Plain	Vacherie Dome, Louisiana; Cypress Creek Dome and Richton Dome, Mississippi

The distinctions among the geohydrologic settings and the host rocks are clear not only among basalt, salt, and tuff, but also among the three basins in salt. The bedded salt of the Permian and Paradox Basins are distinct from the dome salt of the Gulf Interior Region in terms of their structure, rock properties, and the relationship of the host rock to the aquifers in the

geohydrologic environment; the Permian Basin is also distinct from the bedded salt in the Paradox Basin in terms of stratigraphic sequence, regional hydrologic setting, history of deposition, and physiography.

2.2.3 SELECTION OF THE PREFERRED SITE IN THE PERMIAN BASIN

On the basis of the information and evaluations contained in the EA, and on a comparison of the Deaf Smith County site with the Swisher County site, the DOE has identified the Deaf Smith County site as the preferred site because (a) a downward or predominantly horizontal gradient (geohydrology guidelines) is present, and (b) it is farther from highly populated areas than the Swisher County site. The Deaf Smith County site is approximately 27 kilometers (17 miles) from Hereford (22 kilometers [14 miles] from the smaller community of Vega), whereas the Swisher County site is 8 kilometers (5 miles) from Tulia.

The only other conditions that distinguish between the Deaf Smith County and Swisher County sites relate to the relation of the sites to regional transportation routes that connect to the national network. The Swisher County site is 10 kilometers (6 miles) and 0 kilometers (0 miles) from the closest major highway and rail line, respectively, while the Deaf Smith County site is 6 kilometers (4 miles) from the nearest major highway and 30.5 kilometers (19 miles) from the nearest rail line. In addition, for the Swisher County site, the cost of building an access railroad is \$3.5 million, while for the Deaf Smith County site, the cost is \$21-44 million. Because the siting guidelines specify that conditions relative to radiological safety are of primary importance, the difference in distance to transportation routes and their costs is considered to be of lesser importance than the difference in distance to population centers.

2.2.4 SUITABILITY OF THE DEAF SMITH COUNTY SITE FOR DEVELOPMENT AS A REPOSITORY

Section 112(b) of the Act requires the DOE to evaluate the suitability of a site for development as a repository under each guideline that does not require site characterization as a prerequisite for the application of the guideline. The intent is to preclude the investment of money and effort in sites that could be disqualified under those guidelines for which substantial information is available for site evaluation. The guidelines that do not require characterization primarily relate to those characteristics of a site that are related to the effects of a repository on public health and safety, the quality of the environment, and socioeconomic conditions before the repository is closed and sealed.

For a site to be suitable for repository development under each of those guidelines that do not require site characterization, no disqualifying conditions can be present, and each of the qualifying conditions under those guidelines must be met. A final determination of suitability for repository development cannot be made until site characterization is complete. However at this stage, the evidence does not support a finding that the Deaf Smith County

site is disqualified. Furthermore, the evidence does not support a finding that the Deaf Smith County site is not likely to meet all the qualifying conditions under the guidelines that do not require site characterization.

2.2.5 SUITABILITY OF THE DEAF SMITH COUNTY SITE FOR CHARACTERIZATION

To determine whether a site is suitable for characterization, the DOE must evaluate the site against all of the guidelines, including those that require site characterization. In order to judge that a site is suitable, the DOE must then conclude that the evidence does not support a finding that the site is not likely to meet all of the guidelines. As a result of the evaluations reported in Chapter 6 of the EA, the DOE has found that the Deaf Smith County site is suitable for characterization.

2.2.6 DECISION ON NOMINATION

Having made the above findings, the DOE has decided to nominate the Deaf Smith County site as suitable for site characterization. The other potentially acceptable sites selected for nomination are Davis Canyon, Utah; the reference repository location at the Hanford Site, Washington; the Richton Dome, Mississippi, and Yucca Mountain, Nevada.

3. THE SITE

As shown in Figure 2, the Deaf Smith County site is in the north-central part of Deaf Smith County, in the Southern High Plains of the Texas Panhandle. The surface of the High Plains is nearly flat, sloping gently to the southeast. The terrain in the area of the site includes small internally drained lake basins (playas) and narrow stream valleys that carry water after rainstorms.

Most of the land in the county is fertile, irrigated cropland, although there is some rangeland at the site and its vicinity.

The site covers 23 square kilometers (9 square miles), or 2,331 hectares (5,760 acres). More than 85 percent of the site area contains soils classified as prime farmland by the Soil Conservation Service. Part of this area is irrigated by pivot sprinkler systems, supplementing furrow systems which have been the most common irrigation systems in the county. Nearly all of the land at the site and in its vicinity is privately owned. A Texas farm-to-market road (FM 2587) passes through the southern part of the site and connects with U.S. Interstate I-40 via U.S. Highway 385. The closest railroad passes within 30.5 kilometers (19 miles) of the site.

The site lies in the Palo Duro Basin, a structural basin within the larger Permian Basin. The basement rock in the Palo Duro Basin is igneous and metamorphic; it is overlain by a sequence of sedimentary rocks and evaporites,

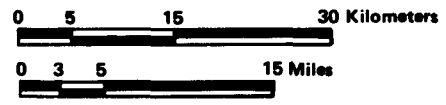
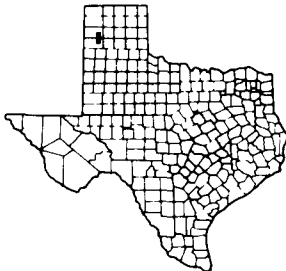
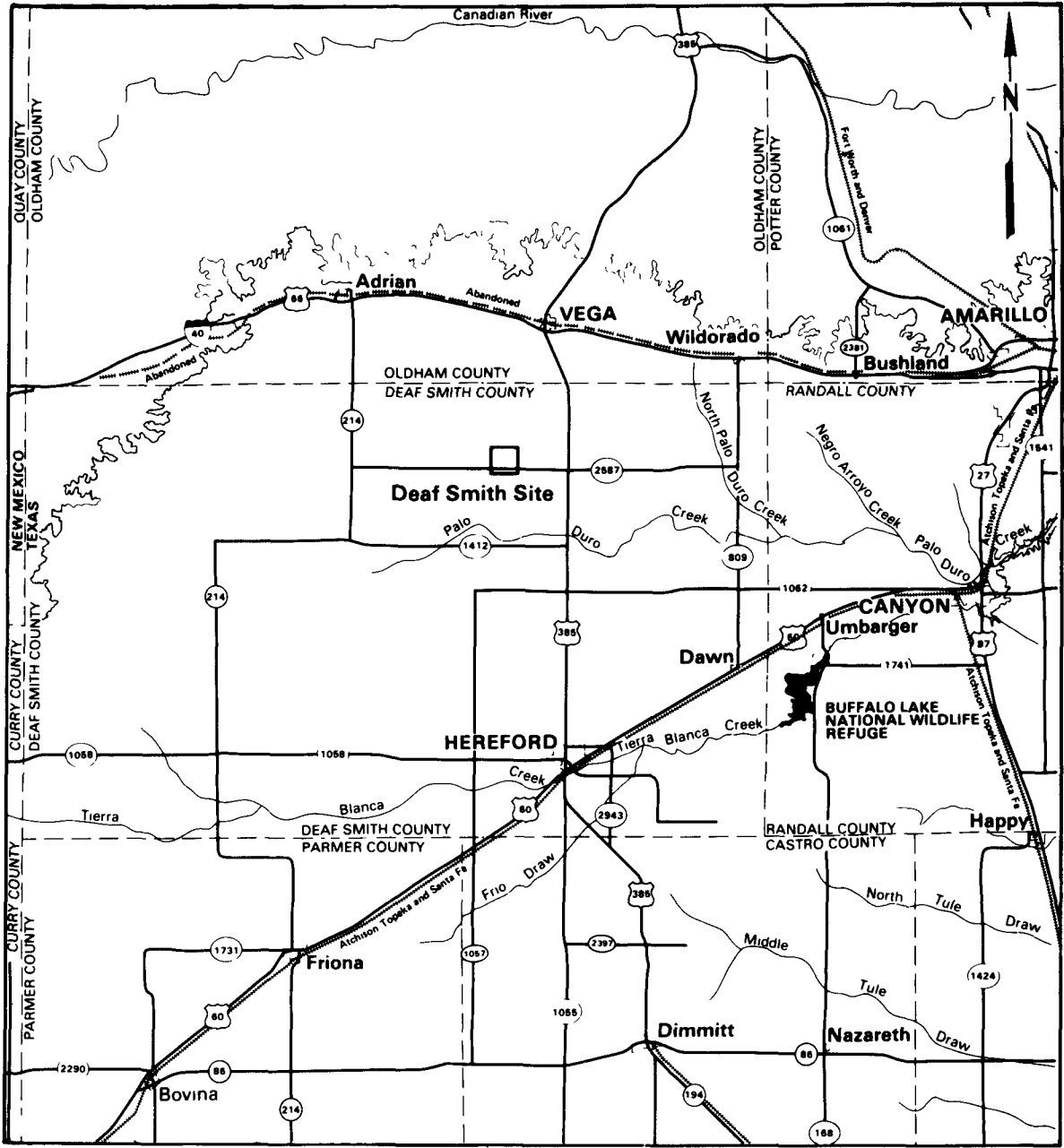


Figure 2. Deaf Smith site, Texas.

consisting mainly of sandstone, limestone, dolomite, shale, arkose, anhydrite, and salt.

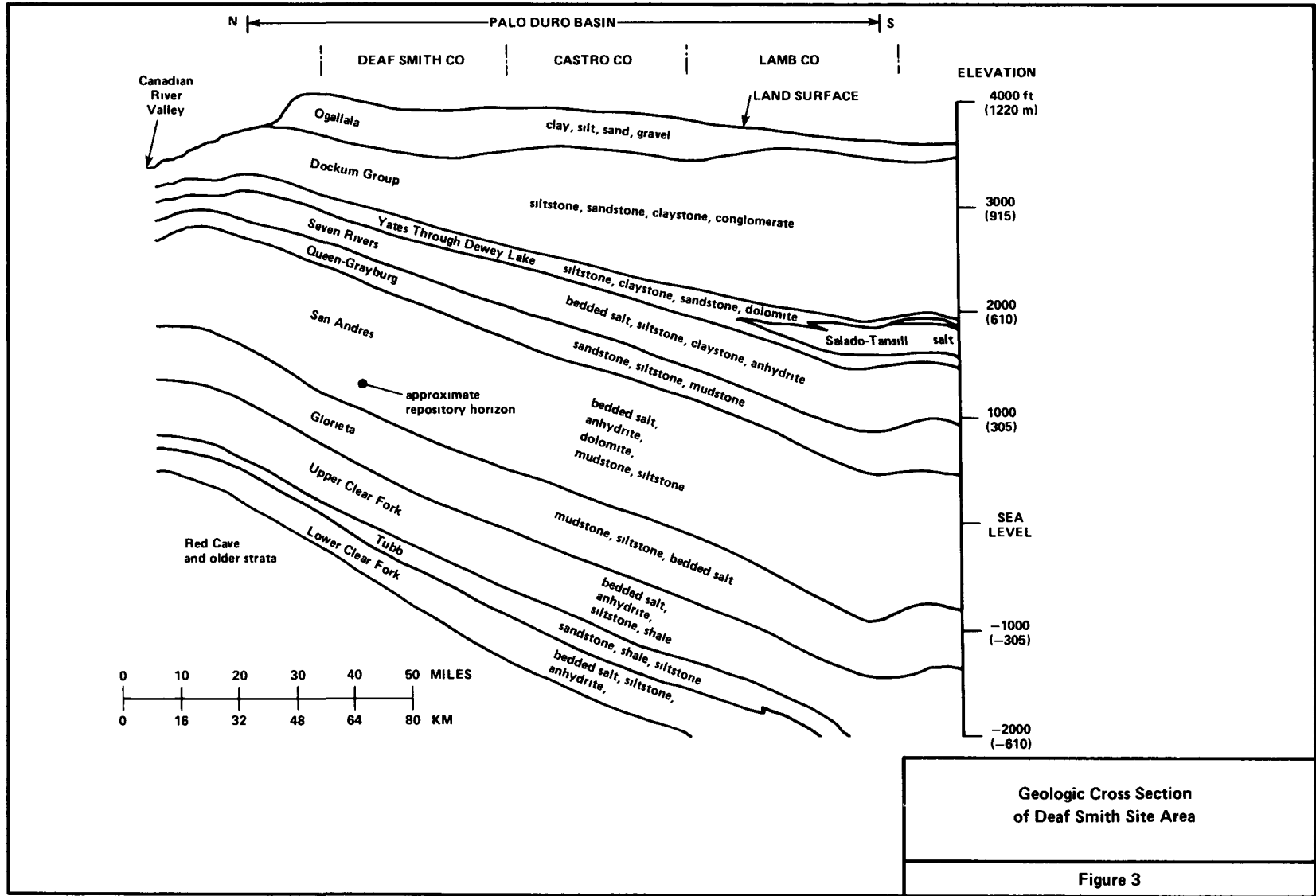
The host rock at repository depth is a sequence of bedded rock salt, about 48.8 meters (160 feet) thick, in the Lower San Andres Formation (see Figure 3). The top of the proposed repository level is about 2,400 to 2,500 feet below the surface. At the site and throughout the Palo Duro Basin, the host-rock bed does not consist of pure rock salt; it contains many impurities and interbeds.

Active fronts of salt dissolution have been identified along the western, northern, and eastern salt margins of the Palo Duro Basin. The site is about 100 kilometers (62 miles) from the eastern dissolution front of the Lower San Andres Formation, 29.8 kilometers (18.5 miles) from the northern front, and 174 kilometers (108 miles) from the western front. These fronts are advancing slowly toward the center of the basin, but, because the rate of their advance is low, no dissolution front is expected to reach a repository at the Deaf Smith County site for considerably longer than 10,000 years, which is the time required for waste isolation. There are no confirmed areas beneath the Southern High Plains where the uppermost salt has undergone interior dissolution during the past several hundred thousand years. While fractures have been identified in rock strata near the site, horizontal stresses at repository depth would make it unlikely that fractures would remain open.

In comparison with other regions of the United States, the Palo Duro Basin is stable tectonically. No active surface faults have been identified in the immediate vicinity of the Deaf Smith County site, but undetected faults may exist in the area. A fault striking northwest beneath the site has been inferred from oil exploration. The historical record, which covers less than 100 years, includes no reports of earthquakes closer than 48 kilometers (30 miles) from the site. However, a small earthquake was detected in April, 1985, in Oldham County approximately 24 kilometers (15 miles) northwest of the site, by a DOE microseismic network.

Economically important oil and gas resources are found in parts of the Palo Duro Basin, but neither oil nor gas is currently produced in Deaf Smith County. Oil and gas resources are not expected to be present in the immediate vicinity of the site, because the geologic conditions are not favorable for the accumulation of these resources. A variety of mineral resources are extracted from the Palo Duro Basin, but they are of marginal and mostly local value. Current and projected market conditions suggest that Deaf Smith County has little potential for the development of mineral resources in the future.

The Deaf Smith County site is nearly flat. There are no stream channels at the site, although there are playa wetlands. There are no water impoundments near the site except for small farm ponds. The Palo Duro Creek flows 3 to 5 kilometers (2 to 3 miles) south of the site, and there are two other creeks in the area: the North Palo Duro Creek to the east and an unnamed tributary of the North Palo Duro Creek to the north.



The ground-water regime beneath the Southern High Plains consists of three major hydrogeologic units. The uppermost unit is an unconfined aquifer that consists of the Ogallala Formation and the Dockum Group; it is often called "the High Plains aquifer." The middle unit is an aquitard consisting of some 1,524 to 1,828 meters (5,000 to 6,000 feet) of shales and evaporites that lie below the High Plains aquifer. The repository horizon is near the middle of this aquitard. The lower hydrogeologic unit, which lies below the aquitard, is a brine aquifer that consists of much older carbonate and clastic rocks. The High Plains aquifer is recharged to the west, in New Mexico. The most significant discharge of this aquifer occurs through pumping. The deep brine aquifer is believed to be recharged by lateral ground-water infiltration, possibly from units outcropping in New Mexico. No surface discharge from this aquifer has been identified.

The High Plains aquifer is the principal source of fresh water in the Southern High Plains. In 1980, 1.53 million acre-feet of ground water was used in the seven-county area surrounding and including the Deaf Smith County site. Most of this water was used for irrigation. Present and past pumping rates have exceeded the natural recharge rate, causing substantial declines in the water level and the removal of large volumes of water from the aquifer.

The natural plant cover in the region is a shortgrass prairie, but more than 85 percent of the area around the site is used as cropland, varying with the season. The long history of farming and grazing in the vicinity of the site has probably eliminated all traces of the prairie conditions that prevailed before the region was settled. Playa wetlands are ecologically important in the region, although many are plowed during dry years or modified for irrigation. The following eight animal species whose potential range may include the Deaf Smith County site are considered threatened or endangered by the Federal Government or the State of Texas: the Texas horned lizard, the Central Plains milk snake, the southern bald eagle, the American peregrine falcon, the arctic peregrine, the protected osprey, the woodstork, and the black-footed ferret. However, the site and its vicinity are not known to contain any critical or unique habitats. Because of the lack of preferred habitats, the variety and abundance of wildlife are expected to be low in the vicinity of the site.

The area that contains the Deaf Smith County site has a semiarid climate, which is characterized by sparse natural vegetation, warm temperatures, and periods of little precipitation. As measured in Amarillo, Texas, precipitation averages about 48 centimeters (19 inches) per year, and the average annual runoff is less than 2.5 centimeters (1.0 inch). Together with an average wind speed of 13.7 miles per hour, these semiarid conditions result in a relatively high potential for wind erosion of soil. However, they also favor the dispersion of pollutants in the atmosphere. The region meets or exceeds the applicable national standards for air quality. Severe weather includes tornadoes, thunderstorms, and heavy fog. On average, the area around the Deaf Smith County site experiences about eight tornadoes per year. Thunderstorms and heavy fog occur on about 50 and 20 days per year, respectively.

To date, no archaeological or historic sites have been recorded at the Deaf Smith County site or in the immediate vicinity. Areas with potential for containing unrecorded historic sites are located near water sources such as an

unnamed tributary immediately north of the site, Palo Duro Creek 5.6 kilometers (3.5 miles) south of the site, and nearby playa lakes. The landscape at the site shows little visual variety. The noise levels are characteristic of rural agricultural settings.

Seven counties in Texas and two counties in New Mexico are considered to be within a reasonable commuting distance of the site. These nine counties are the area that may experience socioeconomic effects from the repository. The 1980 population of this area was 281,060, and the average population density is 24 persons per square mile. The incorporated communities that are closest to the site (and their populations) are Hereford (15,853), Canyon (10,724), Vega (900), and Amarillo (149,230). These communities have an adequate base of community services, with Amarillo tending to have a slightly larger service base than the other three communities.

Much of the regional and local economy depends, either directly or indirectly, on agriculture. The region is a major producer of corn, sorghum, wheat, sugarbeets, vegetables, cotton, cattle, and seed for commercial farming. Irrigation is essential to the agricultural productivity of the region. Continuing depletion of the High Plains aquifer will reduce the amount of water available for irrigation and may change the character of the agricultural economy.

4. EFFECTS OF SITE CHARACTERIZATION

To obtain the information necessary for evaluating the suitability of the Deaf Smith County site for a repository, the DOE will conduct a site-characterization program of underground testing. To carry out this program, the DOE will construct two shafts down to the level of the repository (one shaft for removing rock and lowering construction materials into the facility and one for services and emergency egress), excavate drifts at the proposed repository depth, construct support structures on the surface, and improve the access roads to the site. In addition to the tests performed under the surface and in the exploratory shaft facility, geologic field studies will be conducted to characterize subsurface conditions.

At the same time, the DOE will study the environment of the site and its vicinity, including weather conditions, air quality, noise, plant and animal communities, and archaeological and cultural resources. Socioeconomic conditions will also be investigated in the nine-county area expected to be affected by the repository.

The site-characterization program will last several years. At the end of this period, if the Deaf Smith County site is found unsuitable for a repository, the shafts will be filled and sealed, and the site will be reclaimed.

Site characterization will entail some adverse effects. Current land uses in parts of the site will be disrupted. Approximately 25 hectares (61 acres) of land will be required for the construction of the Exploratory Shaft Facility (ESF), and an additional one-third acre will be needed for a new access road. The DOE will obtain the needed surface and subsurface rights to

this land through negotiation and purchase or, if necessary, condemnation. To conduct geotechnical field studies, the DOE will acquire rights to small parcels of land totaling 105 hectares (260 acres), of which approximately 93 hectares (230 acres) may be actually disturbed. Since field studies will be distributed over the entire site, the effects experienced by specific landowners will be small. On a county-wide basis, no more than a maximum of 350 acres of cropland and rangeland is expected to be disturbed for the shafts, the access roads, and geotechnical studies.

Since the DOE will not know precisely how much land would be needed for the repository until site characterization is completed, the DOE plans to protect an area of approximately 2,331 hectares (5,760 acres) by purchasing or leasing surface and subsurface rights. If this acreage is removed from agricultural use, the total reduction in cropland in the county will be almost 2 percent.

The excavation of salt from the subsurface test area will create a surface stockpile of approximately 118,000 cubic yards, covering an area of less than 5 acres. An impermeable liner will be placed beneath the pile and ponds will be used to control surface-water runoff in order to minimize the potential for surface- and ground-water contamination. During salt-handling operations, some windblown salt will be deposited on nearby ground. The DOE has managed salt excavation and stockpiling on a similar scale at two different sites. This experience has shown that salt emissions during excavation will not be significant. When stockpiled salt is wetted, after spreading and compacting, a hard surface crust forms in a few days. This crust prevents the spread of windblown particles. Waste salt and residues will be removed to an offsite licensed landfill.

Wildlife will be disturbed because of a loss of habitat and increased human activity. However, since the site and its immediate surroundings do not support any unique habitats and the area to be cleared is small in comparison with the surrounding undisturbed area, the effects on wildlife are expected to be minimal on a regional level.

Fugitive dust will be generated by road construction, site clearing and preparation, vehicle movement, drilling and trenching, development and wind erosion of spoils piles (including salt piles), and vehicle and machinery exhaust. The total concentration of suspended particles (TSP) will meet the 24-hour and annual NAAQ standards. Impacts from gaseous No_x emissions will not exceed the annual standards.

The construction of the exploratory shaft will produce noise levels that may exceed the sound-level guidelines of the U.S. Environmental Protection Agency (EPA) at the nearest residence. The noise of traffic on FM 2587 will also be increased during peak periods. A meteorological tower, drilling rigs, and the salt pile will be visible from outside the site. Previously undiscovered archaeological and historical resources may be disturbed by the development of access roads, the shafts, and field activities.

Site characterization is not expected to impose significant impacts on the quality of surface water. The water for exploratory-shaft activities will be obtained from the High Plains aquifer. The total expected fresh water demand of the exploratory shaft site will be 151 acre-feet (49.1 million gallons), including water for final disposition of shaft facilities after their use. The maximum drawdown on pumping wells within 2.4 kilometers (1.5 miles) of a water-supply well is estimated at about 0.6 meter (0.2 foot). The use of state-of-the-art mining techniques will ensure that the penetration of the High Plains aquifer during the excavation of the shafts will not significantly affect the quality of the ground water.

Site characterization is expected to create approximately 457 new jobs, drawing up to 893 new residents into the area. Most of these persons are expected to reside in Amarillo. The expected change in population for the affected communities is 0.3 percent for Amarillo, 1.3 percent for Hereford, 0.4 percent for Canyon, and 3.7 percent for Vega. The DOE expects that the increased demands for local services can be met with the existing service capacity. Deaf Smith County will be eligible for grants equal to taxes for the land used in site characterization.

Some transient effects are expected in the regional and local transportation network. Temporary congestion may result from the movement of equipment and personnel to the site. The greatest congestion will occur on FM 2587, which passes near the site.

5. REGIONAL AND LOCAL EFFECTS OF REPOSITORY DEVELOPMENT

To determine the effects of developing a repository at the site, three phases of repository development were examined: construction, operation, and closure and decommissioning. During the construction phase, which will last approximately 7 years, the DOE would construct surface and support structures, construct access shafts, excavate and prepare subsurface tunnels and waste-disposal rooms, and improve access roads and utility services. During the first few years of the operation phase, the repository would receive small amounts of waste -about 400 metric tons of radioactive waste per year - while the surface and underground facilities are completed. After construction is completed, the rate of waste receipt would increase to a maximum of 3,000 metric tons of radioactive waste per year. During the operation phase, underground development would continue concurrently with waste emplacement until the required area is excavated. This full-operation phase is estimated to last some 25 to 30 years; it would be followed by a "caretaker" period because the U.S. Nuclear Regulatory Commission requires the DOE to preserve the option of retrieving the waste for 50 years after the initial emplacement. During closure and decommissioning the underground repository would be backfilled, shafts and boreholes would be closed and sealed, land-use controls would be instituted, the surface facilities would be decontaminated and decommissioned, and permanent markers or monuments would be erected at the site to warn future generations about the presence of the underground repository.

Both adverse and beneficial effects may result from a repository at the Deaf Smith County site. About 162 hectares (400 acres) of land would be used for the surface facilities for the reference repository design. A total of 2,331 hectares (5,760 acres), including the 162 hectares (400 acres), would be withdrawn for a controlled area. Within this total there are approximately 2,091 hectares (5,168 acres) of active cropland. The removal of this land from agricultural use would represent less than 2 percent of the cropland in the county. The land inside the controlled area would be withdrawn from use for the period of repository operation, with the possible exception of dry-land farming and grazing. Landowners would be compensated at a fair market value for all land used for the repository.

Approximately 24 million tons of salt would be excavated for the reference repository design during the construction and operation of the underground facility. More than half of this salt would be returned underground for backfilling the repository, but about 11 million tons of salt would be removed from the site for disposal in an offsite mine or another salt disposal alternative. Although no salt disposal method has been selected, several mine sites have been tentatively identified for abandoned mine disposal within 100 miles of the Deaf Smith County site. A maximum of 3.7 million tons of salt would be stored at the site at any one time. The salt-storage pile would occupy an area of 22.4 hectares (55.5 acres) and reach a height of about 11.8 meters (39 feet). Although a hard crust would form over the salt pile, an insignificant amount of windblown salt is likely to be deposited in the immediate vicinity of the site. An impermeable liner would be used under the salt pile to minimize effects on ground water. To contain any water runoff from the salt pile, collection ponds would be constructed.

The ecological effects of a repository would be largely confined to the site. The construction of access roads and surface facilities would displace about 165 hectares (408 acres) of site and access-road soils. Increased noise and traffic levels would also disturb the local wildlife. On a regional level, the removal of cropland or rangeland for the repository would not be ecologically significant.

Air quality effects would be greatest during preparation of the site. However, during all phases of repository development, the 24-hour and annual NAAQ standards for suspended particulates (TSP) will be met at the boundary of the repository controlled area. The average annual NAAQ standards for gaseous NO_x emissions also will be met. The noise of repository construction may exceed the ambient sound level at the nearest residence, but during construction and operation all EPA noise-level guidelines would be met with the exception of short-term noises associated with building a railroad spur. Nonetheless, increased noise levels from passing vehicles may be a nuisance to people living close to FM 2587. The surface facilities, and the salt-storage pile may be visible from outside the site; their appearance would be in contrast with the visual character of the area.

A total of 559 acre-feet of water would be used during the 7 years of repository construction, of which 529 acre-feet would be used during the first year. During the period of full operations, the repository would use about 289 acre-feet per year, which is equivalent to the amount of water used to irrigate 170 acres of cropland. The water would be provided from onsite wells. The maximum drawdown due to ground-water withdrawal from an onsite

well is estimated to be 0.67 meter (2.2 feet) at 2.4 kilometers (1.5 miles) from the well. The maximum amount of municipal water needed for the in-migrants attracted by the repository would be approximately 50 to 60 acre-feet per year; this peak demand is expected to occur in the year 2005.

By the peak year of operation, the repository would generate about 1,150 direct and 1,150 indirect jobs in the region, with up to 2,520 persons expected to have migrated into the region. The maximum repository-related population increase in the year 2005 is estimated to be 1 percent for Amarillo, 2 percent for Hereford, 1 percent for Canyon, and 5 percent for Vega. The community of Vega is likely to experience more severe effects because its population is smaller.

Local business activity would increase. Local purchases for the construction of the repository are estimated at \$16.9 million per year. The total repository-related purchases in the region during the operation period would be about \$4.5 million per year.

Potentially adverse socioeconomic impacts would be mitigated by an increased tax base, grants equal to taxes, and financial assistance from the DOE. Such financial assistance has been mandated by Congress in the NWPA to mitigate repository-related impacts.

Two types of transportation effects would result from increased commuter traffic and the hauling of supplies, excess salt, and radioactive waste. They are radiological risks, which would result from the direct external radiation emitted by the radioactive waste as a shipment passes by, and nonradiological risks. The latter are traffic accidents and the health effects that result from the pollutants emitted by combustion engines; they would occur regardless of the cargo carried by the railcar or truck. In general, both types of risk will vary with the distance traveled and with the mode of transportation (road or rail). Since both the Deaf Smith and the Swisher County sites are closer to the sources of commercial waste from nuclear power plants than the other potentially acceptable sites, except for the three salt-dome sites, the nonradiological risks for these sites are likely to be relatively low. While the nonradiological risks would vary with the transportation mode, they are expected to be lower for rail transport.

The radiological risks for the Deaf Smith County site are expected to be much lower than the nonradiological risks. The actual radiological risks would vary with the number of shipments in each transportation mode; however, in any case, they are expected to be low. Texas has the capability to respond to waste-transportation accidents and has emergency response plans and procedures.

Road transportation of nuclear waste would reach the site from Interstate 40, going either east or west, via U.S. 385 from Vega to FM 2587 which would be improved for a short distance west to receive repository traffic. Rail shipments could come north on a special spur from Summerfield, a point on an Atcheson, Topeka, and Santa Fe (AT&SF) regional line. Estimated costs of transporting waste to the Deaf Smith County site are 1.13 billion dollars for road and 1.12 billion dollars for rail transport.

6. EVALUATIONS OF SITE SUITABILITY

The DOE has evaluated the Deaf Smith County site to determine its suitability as a candidate for site characterization. This evaluation was based mainly on the siting guidelines, but it was also based on the expected effects of site characterization and of repository development, as summarized in the preceding sections.

6.1 THE STRUCTURE OF THE GUIDELINES

The guidelines are divided into two sets: postclosure (the period after the repository is permanently closed) and preclosure (the period of repository siting, construction, operation, closure, and decommissioning). The postclosure and the preclosure guidelines contain both Technical and System Guidelines. The Technical Guidelines address the specific characteristics of the site that are considered to have a bearing on the preclosure and the postclosure performance of the repository. The System Guidelines address the expected performance of the total system, including its engineered components; their objective is to protect public health and safety and to preserve the quality of the environment.

The postclosure Technical Guidelines address the characteristics that could affect the long-term ability of the site to isolate the waste from the accessible environment. In particular, they cover geohydrologic conditions, geochemical conditions, rock characteristics, climatic changes, erosion, dissolution, tectonics, and human interference. The postclosure System Guideline requires the site to contain and isolate the waste from the accessible environment in accordance with the standards and the regulations specifically promulgated for repositories by the EPA and the NRC. In order to achieve the specified level of containment and isolation, both natural and engineered barriers may be used.

The set of preclosure guidelines is divided into three groups: (1) preclosure radiological safety; (2) the environment, socioeconomics, and transportation; (3) the ease and cost of siting, construction, operation, and closure. A preclosure System Guideline is specified for each of these groups. The associated Technical Guidelines address site suitability in terms of population density and distribution, site ownership and control, meteorology, offsite installations and operations, environmental quality, socioeconomics, transportation, surface characteristics, rock characteristics, hydrology, and tectonics.

6.2 SUMMARY OF SITE EVALUATIONS AGAINST THE POSTCLOSURE GUIDELINES

The features of bedded salt at the Deaf Smith County site that could contribute to its ability to isolate waste from the accessible environment include (1) the low permeability of the host rock (salt) and the long time predicted for ground-water travel to the accessible environment, (2) the presence of a downward ground-water gradient from the upper to the lower

aquifers, and (3) the favorable geomechanical and geochemical properties of the host unit. The candidate host rock at the Deaf Smith County site contains little water. Furthermore, estimates of the time of ground-water travel indicate that travel times to be accessible environment at a distance of 1 kilometer (0.62 mile) would be in excess of 10,000 years. In addition, the host rock has the ability to rapidly dissipate the heat generated by the emplaced waste, which reduces the potential for heat-induced fractures. Other favorable characteristics of bedded salt are its plasticity under confining pressure at depth and the resulting tendency of fractures and openings to close and seal. The favorable geochemical properties that would help retard the migration of radionuclides into the accessible environment are the presence of clays in the interbeds of the host rock and the overlying and the underlying evaporite sections, which would retard radionuclides by sorption, although such sorption would probably be mitigated by the presence of brines. There is also evidence of a potential for chemically reducing conditions, which would diminish the solubility of the waste and promote precipitation. Finally, since Texas is in a stable geologic region, there is little potential for earthquakes that are sufficiently large to disrupt the geohydrologic system.

A condition that could compromise the ability of the site to isolate the waste is the ongoing geologic process of salt dissolution. Although there is evidence of salt dissolution in the Palo Duro Basin, the predicted rates of dissolution are very low, and dissolution is not expected to adversely affect waste isolation. If dissolution continues at the rates estimated for the last 2 to 3 million years, the dissolution front would not reach the repository for considerably longer than 10,000 years, the time required by Federal standards for waste isolation.

With regard to the performance of engineered barriers at the site, the NRC standards specify that the waste package is to contain the waste for 300 to 1000 years and that the rate of radionuclide release beyond this period of containment is not to exceed 1 part in 100,000 per year. Current information on the corrosion of metals like those used for the waste canisters suggests that at the Deaf Smith County site the lifetime of the waste package is expected to exceed 10,000 years. The potential for corrosion will be addressed further during site characterization. The DOE estimates that the release rate beyond the period of containment will not only meet the regulatory limits--it may be much lower. Preliminary assessments of engineered-barrier performance under realistic but conservative assumptions indicate that the EPA's limit on the release rate to the accessible environment would be met at the Deaf Smith County site.

6.3 SUMMARY OF SITE EVALUATIONS AGAINST THE PRECLOSURE GUIDELINES

The evaluations of the Deaf Smith County site against the three groups of preclosure guidelines are summarized below.

6.3.1 RADIOLOGICAL SAFETY

Preliminary assessments of preclosure performance for the Deaf Smith County site do not indicate that any releases of radioactive material from the repository would exceed any applicable radiation standards during repository operation and closure. In addition, the site was evaluated against the following Technical Guidelines that are concerned with the radiological effects of repository operation on public health and safety: population density and distribution, site ownership and control, meteorology, and offsite installations and operations.

The Deaf Smith County site is far from highly populated areas. The closest highly populated area is Hereford, 27 kilometers (17 miles) away. The population density of the area within 80 kilometers (50 miles) is 31 persons per square mile, considerably below the national average of 64 persons per square mile. Furthermore, the weather conditions in the region, especially the high winds, would disperse any radioactive emissions. Severe weather, such as violent thunderstorms and tornadoes, does occur in the region, but the probability of operational accidents caused by such weather is very low because currently available construction practices can reduce any risk to surface facilities, and the subsurface facilities would not be affected. In order to establish a restricted zone of controlled access, the DOE intends to obtain ownership and control of the site.

The closest nuclear installation is the DOE's Pantex Plant; this plant is 77 kilometers (48 miles) from the site, and its radioactive emissions are negligible. No significant hazard is expected from any other installations or operations near the site.

6.3.2 ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

Three Technical Guidelines address the environmental, socioeconomic, and transportation effects of a repository before closure. These effects, which would be both beneficial and adverse, are summarized in Sections 4 and 5. Preliminary analyses indicate that the expected adverse effects can be mitigated.

With respect to the System Guideline for the environment, socioeconomic, and transportation, the evidence does not support a finding that the Deaf Smith County site is not likely to meet the qualifying condition of protecting the public and the environment from the potential hazards associated with waste disposal.

6.3.3 EASE AND COST OF SITING, CONSTRUCTION, OPERATION, AND CLOSURE

Four Technical Guidelines address the ease and cost of repository siting, construction, operation, and closure; they are concerned with rock characteristics, hydrology, surface characteristics, and the tectonic stability of the site. With respect to rock characteristics, the tendency of salt to creep under confining pressure may necessitate some reexcavation of

some subsurface openings over time. However, it is expected that, with routine maintenance, the openings of the repository will remain stable enough to allow the retrieval of waste is necessary.

The presence of many interbeds limits vertical flexibility in locating the underground repository in the preferred salt horizon, Unit 4 of the Lower San Andres Formation; the lateral flexibility, on the other hand, is very great because the salt extends for many miles. Since the site is in a tectonically stable region, minimal disruption from earthquakes is expected. With proper site preparation and facility design, there is little potential for disruption from surface flooding or severe weather.

These evaluations suggest that the repository can be constructed and operated with reasonably available technology, and the costs would be comparable to those of a repository at the other potentially acceptable sites.

7. COMPARATIVE EVALUATION OF NOMINATED SITES

7.1 INTRODUCTION

7.1.1 PURPOSE AND REQUIREMENTS

Chapter 7 presents a comparative evaluation of the five sites nominated as suitable for site characterization in order to satisfy the following:

1. Section 112(b)(1)(E)(iv) of the Nuclear Waste Policy Act of 1982, which requires that a "reasonable comparative evaluation" be included in the environmental assessments that accompany site nomination.
2. Section 960.3-2-2-3 of the DOE's siting guidelines (10 CFR Part 960), which requires that a reasonable comparative evaluation be made and that a summary of evaluations with respect to the qualifying condition for each guideline be provided to "allow comparisons to be made among sites on the basis of each guideline."

The evaluation in Chapter 7 is intended to allow the reader to compare the more detailed suitability evaluations of the individual sites that are presented in Chapter 6 of each environmental assessment. The comparison should assist the reader in understanding the basis for the nomination of five sites as suitable for characterization; it is not intended to directly support the subsequent recommendation of three sites for characterization as candidate sites.

7.1.2 APPROACH AND ORGANIZATION

This comparative evaluation of the five nominated sites is based on the postclosure and preclosure guidelines (10 CFR Part 960, Subparts B and C, respectively). The approach used to compare the sites with respect to each system and technical guideline is summarized below.

7.1.2.1 Technical guidelines

Major considerations that could be used to compare the sites on the basis of the qualifying condition of each technical guideline were derived by identifying the favorable, potentially adverse, and disqualifying conditions that deal with the same general topic. Contributing factors that represent the characteristics of the site that are potentially important in evaluating the sites with respect to each major consideration were also identified. The relative importance of the major considerations was determined primarily by the degree to which they contribute to the qualifying condition; that is, the stronger the tie between the consideration and the qualifying condition, the greater the importance of the consideration.

The purpose of identifying major considerations for each guidelines is to combine closely related site conditions so that the balance of the favorable and potentially adverse conditions can be considered directly. Most guidelines that contain a disqualifying condition also have one or more potentially adverse conditions that relate to the disqualifying condition. Since these potentially adverse conditions are considered in the formulation of a major consideration, the important aspects of the disqualifying conditions indirectly enter the comparative evaluation. Where a major consideration that is needed to evaluate the qualifying condition does not have a related favorable or potentially adverse condition, the consideration is derived directly from the qualifying or disqualifying condition.

7.1.2.2 System guidelines

The comparison of sites on the basis of the individual technical guidelines uses the major considerations to incorporate the favorable and potentially adverse conditions in an evaluation of a site's standing on the qualifying conditions for each technical guideline. It is not appropriate, however, to use this approach for a comparative evaluation of sites on the basis of the system guidelines. The qualifying conditions for the system guidelines do not lend themselves to the identification of major considerations in the way that the qualifying conditions for the technical guidelines do. The system guidelines for postclosure repository performance and preclosure radiological safety are stated in terms of regulatory requirements of the NRC and the EPA. The evaluations of these two system guidelines are based on preliminary performance assessments. These evaluations are summarized directly in Chapter 7 from Sections 6.3.2 and 6.2.2.1 of each environmental assessment.

The system guidelines for environmental quality, socioeconomics, and transportation, and for the ease and cost of repository construction, operation, and closure are not stated as regulatory standards, and they cannot be evaluated by a performance assessment as are the other two system guidelines. Instead, they are evaluated by considering the individual guidelines that make up these two system guidelines collectively to determine whether each site meets the qualifying condition of the relevant system guidelines. The evaluation of these system guidelines is summarized in Chapter 7 from information contained or referenced in Sections 6.2.2.2 and 6.3.4 in each environmental assessment.

This overview summarizes the major considerations and contributing factors for each technical guideline. It does not discuss the comparative evaluations of sites in Chapter 7; these comparisons are already a summary of information in Chapter 6 of each environmental assessment, and the DOE believes that a further synopsis of the evaluation in Chapter 7 for the purpose of this overview would distort the information and possibly mislead the reader. For the systems guidelines, this overview summarizes (1) the conclusions of the performance assessments for postclosure repository performance and preclosure radiological safety, and (2) the conclusion on the qualifying condition for environmental quality, socioeconomics, and transportation, and the ease and cost of constructing, operating, and closing the repository. For a discussion of the initial order of preference of sites, the reader is referred to the separate report on the multiattribute utility analysis of the nominated sites.

7.2 COMPARISON OF THE SITES ON THE BASIS OF THE POSTCLOSURE GUIDELINES

The postclosure guidelines are concerned with the characteristics, processes, and events that may affect the performance of the repository after closure. Their objective is to ensure that the health and safety of the public will be protected for thousands of years, until the radioactivity of the waste has diminished to safe levels.

7.2.1 TECHNICAL GUIDELINES

7.2.1.1 Geohydrology

Four major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the geohydrology guideline. The first consideration, ground-water travel time and flux, addresses geohydrologic conditions that control ground-water travel time between the disturbed zone and the accessible environment, and ground-water flux (volumetric flow rate) across or through the repository and through the host rock to the accessible environment. This is the most important major consideration because transport by ground water is the primary control of radionuclide movement from the repository to the accessible environment. At each of the sites there are uncertainties in the conceptual ground-water flow model and in the values of key hydraulic parameters that control ground-water

travel time and flux. Taking these uncertainties into account, there are ranges of possible travel times between the disturbed zone and accessible environment at each site. Therefore, ground-water travel time was stochastically modeled at each site, using reasonably conservative assumptions about the geohydrologic system and ranges of hydraulic parameters. In general, ground-water flux is expected to be low to very low at each of the nominated sites.

The second consideration, changes in geohydrologic processes and conditions, addresses potential changes in natural processes in the geologic setting that could change geohydrologic conditions so as to affect the ability of a repository to isolate the waste. The DOE has concluded that climatic change is the only factor that has a likely potential for significantly affecting the hydrologic system at any of the nominated sites during the next 100,000 years. Therefore, climatic change is the only potential cause of change to the geohydrologic system that is addressed in the evaluations of individual sites.

The third consideration is ease of characterizing and modeling the geohydrologic system. Since it is not an intrinsic physical characteristic of the geohydrologic setting, this consideration is not as important as the first two considerations. Some of the contributing factors that influence the ease of characterization and modeling are the presence of faults, folds, and brine pockets, dissolution effects, lithologic variations, interrelationships among hydrostratigraphic units, availability of testing techniques and analytic models, and understanding of flow mechanisms.

The last consideration, presence of suitable ground-water sources, addresses the possibility that radionuclides migrating from a repository could mix with ground-water sources suitable for crop irrigation or human consumption without treatment along flow paths to the accessible environment. This consideration is less important than the other three, because it is unlikely that ground-water resources could be contaminated if a site is selected on the basis of its ability to isolate wastes, as reflected in the other three considerations.

7.2.1.2 Geochemistry

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the geochemistry guideline. The first consideration, mass transfer of radionuclides, includes geochemical conditions within the immediate vicinity of the waste package after permanent closure of the repository. The mass transfer of radionuclides is the most important consideration because it describes the processes by which radionuclides that are initially sealed in the waste package as part of the solid waste form will be released to the ground-water system or be contained within the engineered-barrier system. The most important contributing factors include the volumetric flow rate of ground water near (within a few meters) the waste package and the chemistry of the ground water.

The second consideration, radionuclide transport, addresses geochemical conditions outside the immediate vicinity of the waste package after the permanent closure of the repository. Radionuclide transport near the waste package is considered to be slightly less important than the first major condition because geochemical conditions that influence transport may act as a secondary barrier to radionuclides escaping from the engineered barrier system. The contributing factors that are the most important for the quantitative evaluation of this consideration include the potential for sorption and precipitation, and redox conditions.

The last consideration addresses geochemical processes that could adversely affect the sorptive capacity or strength of the host rock, or both. This is the least important consideration under the geochemistry guideline because mineral alteration and changes in rock strength in the vicinity of the waste-package would affect only a small percentage of the total rock mass surrounding the repository. The major contributing factors for this consideration are the stability of mineral assemblage and effects of changes in the structure of minerals on sorption and rock strength.

7.2.1.3 Rock characteristics (postclosure)

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for rock characteristics guideline. The first consideration is the impact on waste isolation of repository-induced heat. The contributing factors for this condition are thermal properties of the host rock such as its ability to conduct heat or expand in response to heat; mechanical properties such as ductility; thermomechanical behavior such as the potential for thermally induced fractures; and geochemical factors such as the potential for brine migration, hydration, or dehydration of the mineral components. The impact of repository-induced heat is the most important of the three major considerations because it has the greatest potential for affecting waste isolation.

The complexity of engineering measures is the second major consideration. It addresses in situ characteristics and conditions that could require engineering measures beyond reasonably available technology to ensure waste containment and isolation. The major contributing factors to this consideration are the uncertainty in the integrity of man-made sealing materials during the postclosure period and the effects of the in situ environment on the performance of engineered-barriers (such as the effects of brine on the waste-disposal container). Complexity of engineering methods is considered less important than repository-induced heat effects because of the greater potential of repository-induced heat to impair the isolation capabilities of the site.

The last consideration for this guideline is whether the host rock is large enough to allow flexibility in determining the depth, configuration, and location of the underground facility. Added flexibility in locating the repository will help avoid geologic features or anomalies that could adversely affect the isolation capabilities of the site. Even after requirements for

preclosure host-rock flexibility have been satisfied, added flexibility is still necessary to satisfy this postclosure consideration in terms of depth of excavations, orientations of drifts and where they intersect, and location of seals. A greater volume of host rock could provide isolation capability over and above the degree deemed minimally acceptable. However, the contribution to waste isolation added flexibility in locating the underground facility is less than that of the other two considerations for this guideline.

7.2.1.4 Climatic changes

One major consideration, the effects of climatic changes in the future on the ability of the site to isolate waste, is identified that influences the favorability of the sites with respect to the qualifying condition for the climatic changes guideline. The major contributing factors to this consideration are climatic cycles during the Quaternary Period and in situ conditions at a site.

7.2.1.5 Erosion

The single major consideration under this guideline is the potential effects of erosion on the ability of the repository to isolate wastes. Contributing factors include the depth of waste emplacement, evidence of extreme erosion during the Quaternary Period, the potential for the waste to be exhumed by erosion, and the assessment of future erosion rates and geomorphic processes.

7.2.1.6 Dissolution

The single major consideration for this guideline is evidence of dissolution of the host rock during the Quaternary Period. The contributing factors for this consideration include the solubility of the host rock under nonextreme geologic and hydrologic conditions, and unusual ground-water chemistry.

7.2.1.7 Tectonics (postclosure)

The single major consideration for this guideline is the potential for increased igneous and tectonic activity during next 10,000 years and the effect that these processes have on radionuclide releases. The contributing factors include evidence of tectonic or igneous activity during the Quaternary Period, the likelihood of tectonic and igneous events during the next 10,000 years that could alter the regional ground-water flow system, the historical record of seismicity, the correlation of earthquakes with tectonic features, and evidence of tectonic activity during the Quaternary Period.

7.2.1.8 Human interference

The potential for human interference after the repository is closed and decommissioned requires an analysis of (1) the natural resources at or near a site, including past, current, and future exploration for and uses of these resources and (2) site ownership and control.

7.2.1.8.1 Natural resources

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the natural resources guideline. Although the major considerations are listed in decreasing order of importance, there are relatively small differences in importance, particularly between the second and third considerations.

The first consideration is evidence of subsurface mining, resource extraction, and drilling at the site. It assesses the impacts on the isolation and containment system from existing mines and drill holes within the site.

The second consideration is the potential for foreseeable human activities that could affect the ability of the site to contain and isolate wastes. Contributing factors include the potential for ground-water withdrawal, irrigation, injection of fluids, underground pumped storage, and large-scale surface-water impoundments. This consideration is not as important as the first major consideration because the first consideration is based on existing evidence of resources, while the second is based on projected, more speculative human activities. In evaluating this major consideration the environmental assessments have qualitatively considered the effectiveness of markers and records in reducing the potential for of human intrusion in the controlled area.

The last major consideration, potential for intrusion to extract resources after the repository is closed. Contributing factors include the presence or indications of resources (including water) at the site, their value, scarcity, and depth, and whether they are available from other sources. This consideration is third in importance because the potential for resources is based on speculative or indirect evidence.

7.2.1.8.2 Site ownership and control

The purpose of the postclosure guideline on site ownership and control is to help ensure that the repository can function far into the future without adverse human interference. This guideline specifies that the DOE, in accordance with the requirements of 10 CFR Part 60, must obtain ownership of surface and subsurface rights to land and minerals within the controlled area of the repository. A similar guideline on site ownership is also provided for the preclosure period. The DOE has determined that the necessary land area

and controls are the same for both the postclosure and preclosure periods at the five nominated sites. Whichever site is selected, the DOE must obtain ownership and surface and subsurface rights before beginning construction; there is no basis for distinguishing among the sites on the basis of their site ownership and control status at the beginning of the postclosure period.

7.2.2 POSTCLOSURE SYSTEM GUIDELINE

The results of preliminary system-performance assessments are described in Section 6.4.2 of each environmental assessment and briefly reviewed here. These preliminary assessments are based on limited geologic, hydrologic, and geochemical information, preliminary conceptual models, and relatively simple analytical techniques. The DOE is therefore not yet prepared to provide assurance that the regulatory criteria will be met at any of the sites. These preliminary assessments do, however, appear adequate to evaluate the sites in terms of the postclosure system guideline.

The guideline addresses the following capabilities of the geologic setting at a site:

1. The capability of the geologic setting at the site to allow for the physical separation of the waste from the accessible environment after closure in accordance with the requirements of the EPA standard in 40 CFR Part 191, Subpart B, as implemented by the NRC rule in 10 CFR Part 60.
2. The capability of the geologic setting at the site to allow for the use of engineered barriers to ensure compliance with the requirements of the EPA and the NRC. Two requirements are pertinent here: (1) the time of substantially complete containment (i.e., a period between 300 and 1,000 years); and (2) the limit on the rate of radionuclide releases from the engineered-barrier system (i.e., one part in 100,000 per year of the individual radionuclide inventory or one part in 100,000 per year of the total inventory calculated to be present at 1,000 years after repository closure, whichever is greater).

With regard to the capability of the geologic setting to separate the waste from the accessible environment, the results of the preliminary assessments do not exceed the EPA standard at any of the sites. For example, the mean ground-water travel time from the repository to the accessible environment is expected to be much longer than 10,000 years at all five nominated sites.

Because of the different characteristics of the sites, different approaches to the performance assessments and different levels of conservatism have been used for each site. Since site-specific data is limited prior to characterization, the degree of conservatism resulting from such assumptions in each case is not currently known. Nonetheless, the degree of conservatism is believed to be sufficient to establish outside bounds on actual site

performance. The preliminary performance assessments do not provide any reason to believe that any of the sites would not adequately isolate the waste from the accessible environment.

With regard to the requirements for the performance of the engineered-barrier system, the preliminary assessments indicate that the system would meet the regulatory performance objectives at all sites. For example, analyses of the waste-package performance indicate that the container lifetime is expected to exceed the 300- to 1,000-year requirement for substantially complete containment at each site. For each site, the calculations of the rate of radionuclide release after the failure of the waste package suggest that the criterion for the rate of release from the engineered-barrier system would not be exceeded. Extremely conservative assumptions have been used to make these estimates. Again, the degree of conservatism provided by these assumptions is not presently known. However, the DOE is confident that the use of conservative assumptions establishes outside bounds on actual performance of the waste package, and the analyses appear to be sufficient to indicate that there is no evidence that the criteria for the performance of the waste-package and engineered-barrier systems would not be met at each of the nominated sites. Furthermore, the available data and the preliminary analyses based on these data have not identified any conditions or features at any of the sites that would prevent these engineered components from meeting the performance requirements.

7.3 COMPARISON OF SITES ON THE BASIS OF PRECLOSURE GUIDELINES

The preclosure guidelines address (1) preclosure radiological safety; (2) the environmental, socioeconomic, and transportation-related impacts associated with repository siting, construction, operation, and closure; and (3) the ease and cost of repository siting, construction, operation, and closure. Both technical and system guidelines are provided for each of these three categories.

7.3.1 PRECLOSURE RADIOLOGICAL SAFETY

7.3.1.1 Technical guidelines

There are four technical guidelines that contribute to the assessment of preclosure radiological safety: (1) population density and distribution, (2) site ownership and control, (3) meteorology, and (4) offsite installations and operations. The objective of these guidelines is to protect the health and safety of the public and the workers at the repository by keeping exposures to radiation within the limits prescribed by regulations.

7.3.1.1.1 Population density and distribution

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the population density and distribution guideline. The first major consideration is the remoteness of a site as measured by the site's distance from highly populated areas of 2,500 people or more, or from a one mile by one mile (2.6 square kilometers) area that contains 1,000 or more individuals. The contributing factors for this consideration are the air distance of the site from population concentrations and the size of those concentrations.

The second major consideration, population density, is evaluated for each site on the basis of density within the projected site boundaries, near the site (within a radius of 10 miles), and in the general region of the site (within a radius of 50 miles). In the evaluation of this major consideration, a "low population density" is defined as being less than the average population density of the contiguous United States in 1980, or 76 persons per square mile.

7.3.1.1.2 Site ownership and control

The single major consideration for this guideline is the complexity of procedures for acquiring land needed for the repository. The DOE has evaluated this guideline on the basis of what property would be required for repository construction, operation, closure, and decommissioning. Land acquisition procedures, such as leasing, that might be employed during site characterization are not considered in the evaluation of this guideline.

Sites for which land will be easier to acquire from a procedural and legal point of view are more favorable than sites that are more difficult to acquire. This does not mean that the DOE discounts the socioeconomic impact of acquiring land, especially privately-owned land. The socioeconomic impacts of land acquisition are considered under the socioeconomic guideline.

7.3.1.1.3 Meteorology

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the meteorology guideline. The first major consideration is conditions that affect the transport of radionuclides in the atmosphere to unrestricted areas where the public might be exposed, and the significance of transport. Contributing factors include dispersion characteristics of the atmosphere, wind speed and direction, frequency of stagnation episodes, atmospheric mixing levels, local terrain, and locations of nearby population concentrations. This is the most important consideration under this guideline because the potential for radionuclides to be transported in the direction of population concentrations directly affects a site's ongoing ability to meet the requirements of the preclosure system guideline for radiological safety, and reflects the focus on routine exposures in the qualifying condition for meteorology.

The second major consideration, extreme-weather phenomena, addresses the historical frequency and intensity of extreme weather such as hurricanes, tornadoes, floods, and winter storms that could have a significant effect on repository operations or closure. This consideration is less important than the first major consideration because, unlike atmospheric transport characteristics, which tend to reflect on-going or frequent meteorological conditions, extreme weather phenomena reflect infrequent or episodic conditions.

7.3.1.1.4 Offsite installations and operations

Two major considerations are identified that influence the favorability of the site with respect to the qualifying condition for the offsite installations and operations guideline. The first major consideration is the presence of nearby nuclear installations or operations. This consideration addresses radionuclide releases from atomic energy defense activities and nuclear installations regulated by the NRC, which could, together with operational releases from the repository, subject the general public to radionuclide exposures above allowable limits. The evaluation of this consideration accounts for the proximity of nuclear installations and operations to the site and the level of radionuclide releases during accidents and routine operating conditions at these installations.

The second major consideration is the possible adverse effects of nearby hazardous operations and installations on repository, construction, operation, and closure. Such operations and installations could include chemical plants; fuel production, refining, transportation, and storage facilities; pipelines; major transportation routes that could carry hazardous materials; air traffic associated with nearby airports; military operations areas; and facilities that handle toxic materials including hazardous waste disposal sites.

7.3.1.2 Preclosure system guideline for radiological safety

For preclosure radiological safety the pertinent system elements are (1) the site-specific characteristics that affect radionuclide transport; (2) the engineered components whose function is to control releases of radioactive materials; and (3) the people who, because of their location and distribution in unrestricted areas, may be affected by radionuclide releases. This guideline is assigned the greatest importance among the three preclosure system guidelines because it is directed at protecting both the public and the repository workers from radiological exposures.

This guideline requires that projected radiological exposures of the general public and projected releases to restricted and unrestricted areas during the preclosure period shall meet applicable requirements set forth in 10 CFR Part 20, 10 CFR Part 60, and 40 CFR 191, Subpart A. The specific requirements of these regulations and how well each site performs against these regulations are detailed in performance assessments that are presented

in Section 6.4.1 of each environmental assessment. On the basis of these preliminary assessments it appears that a repository can be located and operated at any of the nominated sites with insignificant radiological exposure risks to the public.

7.3.2 ENVIRONMENT, SOCIOECONOMICS, AND TRANSPORTATION

7.3.2.1 Technical guidelines

Three technical guidelines are associated with the preclosure system guideline for environmental quality, socioeconomics, and transportation. Their objective is to ensure that the well being of the public and the quality of the environment are adequately protected from the hazards posed by the disposal of radioactive wastes.

7.3.2.1.1 Environmental quality

Four major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the environmental quality guideline. The first major consideration is the ability of a site to meet applicable environmental requirements. This consideration addresses the procedural and substantive requirements of environmental regulations with which the repository project must comply. A site's standing against this consideration is determined by evaluating the degree to which project activities will comply with applicable requirements as well as their ability to do so within specific time constraints.

The second major consideration is the significance of environmental impacts that could arise from the project and the degree to which such impacts can be mitigated. It also considers features of the mitigation measures such as their time requirements and technological feasibility, and the social, economic, or environmental factors that affect their applicability to a particular site. Because the environmental requirements and environmental impact considerations both reflect the requirement in the qualifying condition that the quality of the environment as a whole must be protected, these considerations are of equal importance. At the same time, they are each more important than either of the two remaining considerations.

The third major consideration is effects of the repository on protected Federal resource areas. It addresses the following Federal lands: the National Park System, the National Wildlife Refuge System, the National Wild and Scenic Rivers System, the National Wilderness Preservation System, and National Forest Land, as well as designated critical habitats for threatened or endangered species. The evaluation of sites for this consideration is based on their proximity to, and the degree of projected impacts on, the listed areas, except for critical habitats. Critical habitats are considered on the basis of whether they could be compromised by the repository.

The fourth major consideration under the environmental quality guideline is impacts on protected State or regional resource areas, Native American resources, and cultural sites. The evaluation of this consideration addresses the combined effects of a site's proximity to resource areas and the projected level of impact on those areas. Because these last two considerations address the protection of the environment in terms of a subset of environmental conditions (i.e., specific resource areas), they are equally important as a group, but less important than the first two considerations.

7.3.2.1.2 Socioeconomic impacts

Six major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the socioeconomics guideline.

The first consideration is potential impacts to community services and housing. This consideration relates to the requirement in the qualifying condition that impacts on community services or housing in affected areas and communities can be mitigated or compensated. Impacts on community services and housing depend on five contributing factors: population composition and density, the distribution of in-migrants, current capacity and trends in use of community services and infrastructure, housing supply and demand, and the ability of affected communities to accommodate growth.

The second major consideration is potential impacts on direct and indirect employment and business sales. Two factors contribute to the evaluation of this consideration: project-related needs for labor and expected local hires, and local project-related purchases of materials.

The third major consideration is potential impacts on primary sectors of the economy. The three contributing factors for this consideration are the major sectors of the economy, employment distribution and trends by economic sector, and the compatibility of a repository with the economic base of the affected area.

The fourth major consideration is potential impacts on the revenues and expenditures of public agencies in the affected area. Impacts on revenues and expenditures depend on three contributing factors: the sources of, and trends in, expenditures and revenues of local government, the additional needs for community services induced by the repository project, and economic growth in the area and resulting increases in tax revenues associated with the repository.

The fifth major consideration is the need to purchase or acquire water rights that could affect development in the area. The need to acquire water rights depends on two contributing factors: project-related water requirements, and current water rights, use, and capacity.

The last major consideration under the socioeconomics guideline is potential social impacts. Three factors contribute to the potential for social impacts: the quality of life and existing social problems in the

affected communities, the size of the in-migrating population in comparison to the existing population, and the compatibility of the in-migrating population with the lifestyles and characteristics of the current residents.

7.3.2.1.3 Transportation

Four major considerations are identified that influence the favorability of sites with respect to the qualifying condition for the transportation guideline. The first and most important major consideration is transportation safety. Contributing factors include the distance of travel, the location of access routes, local terrain, and regional weather conditions.

The second major consideration is the environmental impacts of improving the existing infrastructure and of constructing new access routes to the site. For example, transportation operations and development of access routes might adversely affect sensitive species on a large scale (over many miles), and the aesthetic quality of the region may be degraded by the construction of road and rail routes. This consideration focuses on local conditions around the site since the environmental concerns along the national highway and rail network were already considered during the development of those networks for regular commercial traffic. In this respect, the incremental environmental impacts of transporting radioactive wastes are not considered to be significant on a national scale. Contributing factors for this consideration include the need to construct lengthy access roads, conflicts with current land use plans, and the need for cuts, fills, tunnels, or bridges to reach the site.

The third major consideration is the cost of constructing and upgrading the access routes to the sites. This is not as important as the first consideration since the protection of health and safety is more important than reducing costs. The main contributing factors that influence costs are the extent of needed repairs, local terrain, and costs for rights-of-way.

The least important consideration is the cost of developing the cask fleet and shipping the wastes to the repository. The cost of transporting spent fuel to the repository is determined, in part, by the distance of the site from the spent-fuel sources. Nonetheless, it costs about as much to ship waste 1,000 miles as it does 500 miles. This consideration, as well as the consideration of transportation safety, is also affected by decisions about the configuration of the waste-management system, such as the second repository. The effect of the second repository is considered as quantitatively as possible. Other contributing factors include local weather conditions, availability of carriers, emergency-response capabilities, legal impediments to transport, and the number of railway crew changes.

7.3.2.2 System guideline on environment, socioeconomics, and transportation

Ranked second in importance in the preclosure system guidelines is environment, socioeconomics, and transportation. The pertinent system elements will, in general, consist of (1) the people who may be affected, including their lifestyles, sources of income, social and aesthetic values, and community services; (2) the air, land, water, plants, animals, and cultural resources in the areas potentially affected by such activities; (3) the transportation infrastructure; and (4) the potential mitigating measures that can be used to achieve compliance with this guideline.

On the basis of the evaluation of the guidelines for environmental quality, socioeconomics, and transportation, the evidence does not support a conclusion that the qualifying condition for this system guideline would not be met at any of the nominated sites.

7.3.3 EASE AND COST OF SITING, CONSTRUCTION, OPERATION, AND CLOSURE

7.3.3.1 Technical guidelines

The four technical guidelines in this group address the surface characteristics of the site, the characteristics of the host rock and the surrounding strata, hydrologic conditions, and tectonics. These guidelines are concerned with the ease and cost of siting, constructing, operating, and closing the repository.

7.3.3.1.1 Surface characteristics

Two major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the surface-characteristics guideline. The first consideration is the potential for flooding of surface or underground facilities. This is the most important consideration under this guideline because the effects of flooding can be important factors in the design of the repository. The primary contributing factors for this consideration include the location and likelihood of flooding due to natural causes at the surface or in the underground facilities, or the potential for failure of man-made surface water impoundments or engineered components of the repository.

The second consideration is the effects of the terrain and drainage characteristics of a site on repository construction, operation, and closure. It is less important than the first consideration because terrain and drainage are more closely related to the ease and cost of construction than to safety, and can generally be mitigated more readily than conditions that could cause flooding (i.e., the first consideration). Contributing factors for this major consideration include the configuration of the repository, the potential for landslides, and soil characteristics.

7.3.3.1.2 Rock characteristics (preclosure)

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the rock characteristics guideline. The first consideration addresses in situ conditions that could lead to safety hazards or difficulties during repository siting, construction, operation, and closure, including retrieval. Because of the DOE's emphasis on safety of personnel, this is the most important major consideration of the three related to this guideline.

The second consideration addresses in situ characteristics and conditions that could require engineering measures beyond reasonably available technology in the construction of shafts and underground facilities. Although the success of repository construction depends on its technical feasibility, the complexity of engineering measures is second in importance to personnel safety because of the DOE's primary emphasis on safety.

The third major consideration is whether the host rock is large enough to allow flexibility in selecting the depth, configuration, and location of the underground facility. This consideration is judged to be third in importance, because although adequate host rock to accommodate a repository is necessary, and additional host rock to provide flexibility is desirable, it is not as essential as worker safety and technical feasibility.

7.3.3.1.3 Hydrology

Three major considerations are identified that influence the favorability of the sites with respect to the qualifying condition for the preclosure hydrology guideline. The first major consideration is ground-water conditions that could necessitate complex ground-water control measures in shafts and drifts during repository siting, construction, operation, and closure. This is the most important consideration because it has the most impact on the ease and cost of repository construction, operation, and closure.

The second major consideration is the existence of surface-water systems that could flood the repository. This consideration includes ponds, lakes, streams, and man-made impoundments that could flood the underground workings. Surface-water flooding of the underground workings is a concern because it could endanger the safety of personnel and interrupt repository operations. However, standard engineering measures such as dikes and berms can minimize the risk of flooding. This consideration is considered second in importance because it is generally easier to manage the potential for surface flooding than underground flooding.

The last major consideration under this guideline is the availability of an ample source of ground or surface water for repository construction, operation, and closure. This consideration is third in importance because, although it affects the ease and cost of construction, it has a limited effect on the technical feasibility of developing the repository.

7.3.3.1.4 Tectonics (preclosure)

Two major considerations are identified that influence the favorability of the sites with respect to the preclosure tectonics guideline. The first consideration is the potential for earthquake ground motion at the site. This consideration requires an evaluation of whether ground motion at the site could lead to safety hazards or difficulties during repository siting, construction, operation, and closure. The evaluation of ground motion depends on the evaluation of potential surface faulting in the geologic setting. Contributing factors for this major consideration include the historical earthquake record, evidence of man-induced seismicity, estimates of ground motion from historical and man-induced earthquakes, correlation of earthquakes with tectonic structures and faults, and evaluations of the effects of ground-motion hazards on design.

The second consideration, expected impact of fault displacement at the site, requires an assessment of the potential for fault displacement at the site that could lead to safety hazards or difficulties during repository siting, construction, operation, and closure. This consideration is about equal in importance to the potential for earthquake ground motion. Although the likelihood of faulting at a site is generally lower than the likelihood of ground motion, the need to design for fault displacement can have a significant effect on the site's favorability. Successful construction experience where fault displacement conditions exist is an important contributing factor to this consideration. The other major contributing factors are the evidence and location of, and rates of movement on, Quaternary faults in the geologic setting.

7.3.3.2 System guideline on the ease and cost of siting, construction operation, and closure

The third preclosure system guideline is ease and cost of siting, construction, operation, and closure. It is ranked lowest because it does not directly relate to the health, safety, and welfare of the public or the quality to the environment. Here the pertinent elements are (1) the site characteristics that affect siting, construction, operation, and closure; (2) the engineering, materials, and services necessary to conduct these activities; (3) written agreements between the DOE and affected States and affected Indian tribes and the Federal regulations that establish the requirement for these activities; and (4) the repository personnel at the site during siting, construction, operation, or closure.

On the basis of the technical guidelines for ease and cost of repository siting, construction, operation, and closure, the evidence does not support a conclusion that the qualifying condition for this system guideline would not be met at any of the nominated sites.