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IMPLEMENTATION OF THE RESOURCE DISINCENTIVE IN 40 CFR Part 191.14(e) AT THE WASTE ISOLATION PILOT PLANT

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LIST OF ACRONYMS

ADM	Action Description Memorandum
AEC	Atomic Energy Commission
AECL	Atomic Energy Commission Limited (Canada)
BLM	Bureau of Land Management
BMI	Battelle Memorial Institute (Columbus, Ohio)
BNWL	Battelle Northwest Laboratory
C&C	Consultation and Cooperation Agreement
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DOE	Department of Energy
DOE-WPIO	U.S. Department of Energy Waste Isolation Pilot Plant Project Integration Office
DOE-WPO	U.S. Department of Energy Waste Isolation Pilot Plant Project Office (now DOE-WPSO)
DOE-WPSO	U.S. Department of Energy Waste Isolation Pilot Plant Project Site Office
EEG	Environmental Evaluation Group
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESAB	EPA Scientific Advisory Board
FEIS	Final Environmental Impact Statement
FSAR	Final Safety Analysis Report
FSEIS	Final Supplement Environmental Impact Statement
GCR	Geologic Characterization Report
IAEA	International Atomic Energy Agency
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NMBM&MR	New Mexico Bureau of Mines and Mineral Resources
NRC	Nuclear Regu'atory Commission
ORNL	Oak Ridge National Laboratory
RDR	Resource Disincentive Requirement
ROD	Record of Decision
SAR	Safety Analysis Report
SNL	Sandia National Laboratories
SPDV	Site and Preliminary Design Validation
TRU	Transuranic
USBM	United Stated Bureau of Mines

LIST OF ACRONYMS
(continued)

USGS	United States Geological Survey
WIPP	Waste Isolation Pilot Plant
WPIO	See DOE-WPIO
WPO	See DOE-WPO
WPSO	See DOE-WPSO

1.0 INTRODUCTION

1.1 Purpose

In 1986, the U.S. Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) Project Office (WPO) (DOE-WPO) prepared a strategy[1] for complying with the Environmental Protection Agency's (EPA's) Standards for the management of transuranic (TRU) waste.[2] Section 3.2.2.2 of the DOE's report addressed compliance with the Assurance Requirements found in 40 CFR §191.14[3]. One of the Assurance Requirements addresses the selection of repository sites that contain recoverable natural resources. The requirement, referred to as the Resource Disincentive Requirement, reads as follows:

> *Places where there has been mining for resources, or where there is a reasonable expectation of exploration for scarce or easily accessible resources, or where there is significant concentration of any material that is not widely available from other sources, should be avoided in selecting disposal sites. Resources to be included shall include minerals, petroleum or natural gas, valuable geologic formations, and ground waters that are either irreplaceable because there is no reasonable alternative source of drinking water available for substantial populations or that are vital to the preservation of unique and sensitive ecosystems. Such places shall not be used for disposal of the wastes covered by this part unless the favorable characteristics of such places compensate for their greater likelihood of being disturbed in the future.*[4]

The DOE states, in the strategy document, that the "*natural resources requirement has been addressed during the course of the WIPP Project. A finding will be prepared to show that the favorable characteristics of the disposal site compensate for the greater likelihood of disturbance because of the presence of natural resources.*"[5] This position was developed based on both EPA and Environmental Evaluation Group (EEG) comments to the draft of the compliance strategy. Specifically, the EPA stated, with regard to the comparison of favorable characteristics and resources, that the "*two factors must not only be 'weighed' and 'summarized', but a finding must be documented that the favorable characteristics compensate for the greater likelihood of WIPP being disturbed because of the presence of the natural resources.*"[6] Likewise, the EEG stated that "*something more than a 'summarized' discussion will be needed*" and that they expect "*a detailed report*

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[1] Westinghouse Electric Corp., 1989.

[2] U. S. Environmental Protection Agency, 1985a.

[3] U.S. Environmental Protection Agency, 1985a, pp. 38086.

[4] U.S. Environmental Protection Agency, 1985a, p. 38086.

[5] Westinghouse Electric Corp., 1989, pp. 35-36.

[6] U.S. Environmental Protection Agency, 1987.

analyzing the valuable and rare resources available at WIPP compared to any favorable characteristics."[7]

This document addresses 40 CFR §191.14 (e). The approach is to first summarize the development of the resource requirement to provide a proper perspective for evaluation of WIPP compliance. In addition, a summary of the discussions regarding resources at the WIPP is provided to demonstrate the extent to which the topic has been discussed between the DOE and various oversight groups. Finally, the process of selecting the WIPP site as a repository is shown to be in compliance with the resource disincentive requirement.

This report recognizes that in 1987, 40 CFR 191 was vacated and remanded by the First Circuit Court (National Resources Defense Council, et al. v. United States Environmental Protection Agency, et al.). The DOE believes that when a new standard is promulgated, the Assurance Requirements of 40 CFR 191 will remain intact, and therefore need to be addressed by the WIPP. In the second modification to the Consultation and Cooperation (C&C) Agreement with the state of New Mexico, it is stated that "*DOE agrees to continue its performance assessment planning as though the provisions of 40 CFR Part 191 effective November 19, 1985, remain applicable*"[8]

This report documents that the site selection process for the WIPP facility did indeed comply with the natural resource disincentive requirement in 40 CFR §191,14(e) at the time selected and therefore complies with the standard at this time. Thus, it shall be shown that it is reasonably certain that the WIPP site provides better **overall protection** than **practical alternatives** that were available when the site was selected. It is important to point out here, and it will be discussed later in the report, that the resource disincentive requirement is a preliminary siting criterion that requires further evaluation of sites that have resources (i.e, hydrocarbons, minerals and groundwater) in the vicinity or on the site. This further evaluation requires that for sites that do have resources, a qualitative determination must be made that the site will provide better **overall protection** than **practical alternatives**. The purpose of this report is not to provide a quantitative evaluation for selection of the WIPP site. A further discussion on the difference between the qualitative analysis required under 40 CFR §191.14(e) and the quantitative analysis under other sections of 40 CFR 191 is provided in §2.1 of this report.

1.2 Background

When the Congress of the United States enacted the National Environmental Policy Act (NEPA) of 1969, they recognized the conflict over the management of natural resources. Congress mandated that federal agencies find a balance between the social, economic, and other requirements of present and future generations of Americans and the critical importance of restoring and maintaining environmental quality. Federal agencies are required by the law to "*achieve a balance between population and resource use...*"[9] In

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[7] Environmental Evaluation Group, 1987.

[8] U.S. Department of Energy, 1987, p. 5.

[9] U. S. Congress, 1969.

this regard, federal agencies must provide statements which address "*Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.*"[10] The vehicle for documenting the consideration of resource conflicts and the commitment of resources is the Environmental Impact Statement (EIS) prepared for a federal project.

For waste repositories, such as the WIPP, consideration of "resource conflicts" in the decision making process, as required by the NEPA, is multifaceted. Of course, consideration must be given to the resources consumed by the construction and operation of the facility (e.g., building materials, fuels, and land resources). These considerations are the most common resource commitments that federal agencies address in their EISs. In addition to these, resources associated with the WIPP must be considered from two additional aspects. First, there are **denied resources.** These are resources that cannot be developed because such development may conflict with the long-term goal of waste isolation. Second, there are the risks associated with **resource attractiveness.** That is, resources associated with the location may be attractive to future generations, who may elect to exploit them, and thereby create the potential for a release of waste into the biosphere.

Resource attractiveness concerned the EPA when they promulgated the natural resources assurance requirement in 40 CFR 191.[11] Compliance with this part of 40 CFR 191 is the subject of this paper.

In 1985, nearly ten years after the Los Medanos site was identified for a transuranic (TRU) waste facility, the EPA issued federal regulations establishing criteria for the management and disposal of radioactive waste. These standards included limited guidelines regarding the selection of a site for a radioactive waste repository. These regulations are contained in 40 CFR 191 and consist of two subparts: Subpart A, "Environmental Standards for Management and Storage"; and Subpart B, "Environmental Standards for Disposal." Subpart B contains an assurance requirement that has the purpose of discouraging the location of disposal sites where minable resources are available.[12] The requirement is referred to as the Resource Disincentive Requirement (RDR).

The following sections of this report include a discussion of the development of the resource disincentive provision in the EPA's standard, including a discussion of WIPP specific issues associated with resources (Section 2.0); a brief description of the WIPP Project (Section 3.0); an overview of the WIPP site selection process, including a summary of the documentation that resources were considered in the WIPP Project decision-making process by the DOE (Section 4.0); and conclusions regarding the DOE's compliance with the RDR (Section 5.0).

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[10] U.S. Congress, 1969, Title I, Sec. 102, (2), (C), (v).

[11] U. S. Environmental Protection Agency, 1985a, §191.14(e), p. 38086.

[12] U.S. Environmental Protection Agency, 1985a, p. 38086.

2.0 DEVELOPMENT OF THE STANDARD

Nearly every federal entity associated with radioactive waste isolation has established natural resource conflicts as an important consideration in the selection of repository sites. Donna Goad, the author of EEG-1[13], summarized the criteria stated by the Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA), the DOE, the Nuclear Regulatory Commission (NRC), the United States Geological Survey (USGS), the Oak Ridge National Laboratory (ORNL), Battelle Institute (BMI and BNWL), Sandia National Laboratories (SNL), the National Academy of Sciences (NAS), the Atomic Energy Commission Limited (AECL) (Canada), and the International Atomic Energy Agency (IAEA). Ms. Goad's discussion is presented in Appendix A. The criteria can be summarized by the following two statements:

> Selecting sites with natural resources may result in the denial of access to important raw materials.
>
> Selecting sites with natural resources may lead to future disturbance of the geological/hydrological system through exploration or production, including direct intrusion into the repository.

2.1 Development of the EPA Resources Assurance Requirement

The EPA took the recommendations of these technical experts to heart when they promulgated the proposed 40 CFR 191 rules.[14] This is evident by the "prohibition" type statement that the EPA included in the proposed rule. It is as follows:

> *(f) Disposal systems shall not be located where there has been mining for resources or where there is a reasonable expectation of exploration for scarce or easily accessible resources in the future. Furthermore, disposal systems shall not be located where there is a significant concentration of any material which is not widely available from other sources.*[15]

In the preamble to the proposed standard, the EPA explained the application of the requirement by way of a comparison. On one hand the EPA points out that salt domes may have numerous uses such as salt production, oil storage, and others. Many of these uses would be in conflict with the long-term goals of waste isolation. On the other hand, the EPA cites salt bed structures as being of much less concern because bedded salt deposits are much more common. In addition, the EPA stated that they "*particularly seek comment on this provision because it could rule out sites which might otherwise be advantageous in meeting all of our other requirements.*"[16]

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[13] Environmental Evaluation Group, 1979.

[14] U. S. Environmental Protection Agency, 1982.

[15] U.S. Environmental Protection Agency, 1982, §191.14(f), p. 58205.

[16] U.S. Environmental Protection Agency, 1982, p. 58201.

Among the comments that the EPA received regarding the resource disincentive assurance requirement were written comments from the EEG[17] and testimony to the EPA's Science Advisory Board (ESAB) by a representative of the WIPP Project.[18]

In their comments, the EEG ties the natural resources assurance requirement to the "*...important concept that human intrusion is perhaps the most likely cause of significant repository releases and that the probability of human intrusion and the expectation of resource presence are interrelated to some extent.*"[19] The EEG goes on to point out that the restrictive wording in the requirement should be changed to allow more discretion in evaluating this requirement. The EEG states that there are two parts to the issue. These are the loss of the resources to society and the health and safety issues associated with the attractiveness of the resources. The EEG suggests that the first part "*is perhaps best handled by the NEPA process,*"[20] and that it may be possible to address the second part by evaluating "*the increased probability of human intrusion that would result from the presence of known mineral resources and use this in the decision-making process.*"[21]

The WIPP Project testimony to the ESAB expressed concern that the restrictions in the requirements "*could be construed to rule out most bedded and domed salt formations for permanent isolation of radioactive wastes, since such areas frequently contain hydrocarbons and other useful resources.*"[22] The testimony goes on to point out that human intrusion scenarios "*have been analyzed in the WIPP Final Environmental Impact Statement (FEIS), the WIPP Safety Analysis Report (SAR), and the analysis of a brine release from beneath the site as a result of human intrusion (Reference 2). The results project no significant impact on the public health and safety.*"[23] The WIPP Project recommended to the ESAB that resources "*should be considered in safety and environmental assessments of a potential site and should be discussed in an Environmental Impact Statement (EIS) or licensing document, but should not be arbitrarily specified as part of a standard, regulating releases from nuclear waste repositories.*"[24]

The ESAB formed a working group to address the Assurance Requirements. In a draft report, made available to the WIPP during an ESAB meeting in July 1983, the working

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[17] Environmental Evaluation Group, 1983a.

[18] WIPP Project, 1983.

[19] Environmental Evaluation Group, 1983a, p. 6.

[20] Environmental Evaluation Group, 1983a, p. 6.

[21] Environmental Evaluation Group, 1983a, p. 7.

[22] WIPP Project, 1983, pp. 2-3.

[23] WIPP Project, 1983, p. 3.

[24] WIPP Project, 1983, pp.3-4.

group indicates their thinking regarding the resource disincentive.[25] In their report, the working group recommends that the EPA allow for an analysis to demonstrate "*that the overall safety of the repository would not be jeopardized by the presence of the resources.*"[26] In their rationale for the modification to the Assurance Requirements, the working group acknowledged that the two concerns still exist (resource denial and resource attractiveness); however, the mere presence of natural resources should not automatically cause the site to be eliminated, particularly if other characteristics of the site are favorable. The group points out that "*it may be possible by suitable engineering techniques to recover the resources without disturbing a nearby repository or to mitigate the effects of potential human intrusion. The site and engineered barriers should be seen as a system, and a single weakness in a site should not automatically foreclose use of it, if the remaining characteristics are highly favorable and can compensate for the weakness.*"[27] The working group recommended the modified language that was ultimately incorporated into the final rule.

The ESAB had two findings with regard to the natural resources assurance requirement. These are as follows:

> *Finding 27: "We recommend that EPA not preclude consideration of a potential site because natural resources are at or near the site, but rather should note that the presence of such resources is a highly unfavorable factor which should be included in the site evaluation."*
>
> *Finding 28: "No site type should be precluded on the basis of site characteristics alone. Consideration of all factors, including engineered barriers, transportation, availability of utilities and labor, etc., may lead to different choices amongst acceptable sites and isolation technologies than those dictated by site characteristics alone."*[28]

In response to these findings, the EPA, for the most part, agreed with the recommendations. Their rationale is a follows:

> *Response (Findings 27 and 28): Because of the inherent uncertainties in the site selection and evaluation process, and because of the desirability of evaluating a variety of alternatives to increase the chances of achieving exceptional environmental protection, the Agency now agrees that automatically precluding a potential site because of one disadvantage is not desirable. At the same time, the Agency still believes that proximity to important or unique resources is a serious problem because of the potential for unplanned human intrusion, since institutional controls cannot be counted on over these periods of time to prevent such intrusion. Therefore the Agency has modified the assurance requirement in the final rule to*

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[25] Assurance Requirement Working Group, 1983.

[26] Assurance Requirements Working Group, 1983, p. 7.

[27] Assurance Requirements Working Group, 1983, p. 8.

[28] U.S. Environmental Protection Agency, 1985b.

indicate that proximity to resources should be considered a serious disadvantage, but not an outright prohibition, for site selection.[29]

In the preamble to the final rule, the EPA reiterated their logic with regard to the purpose of the requirement. They state that "*this assurance requirement has been revised in the final rule to identify resource potential as a disincentive but not as an outright prohibition for site selection.*"[30] The EPA also commented that this assurance requirement wording "*implies a qualitative comparison, because the Agency is not aware of quantitative formulas comprehensive enough to provide adequate comparisons to govern site selection.*"[31] In order to qualify this statement, the EPA points out that it is not enough to merely identify a few site features that might be more favorable. Instead, the EPA expects that **sites with resources would be used only "*if it is reasonably certain that they would provide better overall protection than the practical alternatives that are available.*"**[32] Thus, this becomes the ultimate test under the resource disincentive requirement (RDR).

It is important to note at this point that all quantitative analyses will be performed under other aspects of 40 CFR 191 (i.e., the containment requirements and other provisions of Subpart B) and not under 40 CFR §191.14(e). Any comparison of the overall protection afforded by one site to the overall protection of another, for purposes of compliance with §191.14(e), should be done on a purely qualitative basis. As stated in §1.1, the resource disincentive requirement is a preliminary siting criteria. Thus, its primary purpose is to distinguish between potentially acceptable and potentially unacceptable sites. It is then the purpose of the containment requirements, the other assurance requirements, the individual protection requirements and the groundwater protection requirements to determine the ultimate acceptability of the site as a disposal system for radioactive wastes.

2.2 Comments Relative to Resources at the WIPP Site

There has been significant discussion regarding the resources that exist beneath and in the vicinity of the WIPP site. This discussion is presented under four topics in the following paragraphs. These are (1) site characterization and the preparation of the initial NEPA documentation of the WIPP site; (2) the development of the DOE resource policy, including the WIPP Natural Resources Study; (3) the information and conclusions from the Site and Preliminary Design Validation (SPDV) program; and (4) supplemental NEPA documentation, including the Final Supplement Environmental Impact Statement (FSEIS).

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[29] U.S. Environmental Protection Agency, 1985b, p. 2-16.

[30] U.S. Environmental Protection Agency, 1985a, p. 38081.

[31] U.S. Environmental Protection Agency, 1985a, p. 38081.

[32] U.S. Environmental Protection Agency, 1985a, p. 38081.

2.2.1 Site Characterization and the Preparation of the Environmental Impact Statement

Consideration of the resources at the WIPP site was part of the WIPP program from the outset. These evaluations date back to 1974[33] and include evaluations of potash,[34,35,36] caliche, salt, brine, sulfur, uranium, gypsum,[37] and hydrocarbons.[38,39,40] A summary of these results is presented in the Geological Characterization Report (GCR) for the WIPP site prepared by SNL in 1978.[41] The WIPP site characterization activity was conducted to collect the information needed to evaluate the location relative to the site selection criteria established for the WIPP site. (A summary of the site selection process and the appropriate references for the criteria is included in Chapter 3.0.) The specific site selection factor, with regard to natural resources is stated in the GCR as follows:

> *Natural Resources - Unavoidable conflict of the repository with actual or potential resources will be minimized to the extent possible.*[42]

The GCR presents the following conclusions with regard to the resources at the WIPP site:

> *Potassium salts and fluid hydrocarbons are the only two resources thought to be economically significant in the WIPP site area.*
>
> *If reasonable technologic and economic restraints are considered for extracting, processing and marketing the resources, then both the amounts and types of exploitable deposits are greatly reduced. Only potash and natural gas are considered to be significant in this respect.*
>
> *Caliche, salt, and gypsum are also present, but the abundance of these minerals throughout the region leads to the conclusion that land withdrawal for the WIPP will have little effect on present or future requirements for them.*

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[33] New Mexico Bureau of Mines, 1974.

[34] U.S. Geological Survey, 1978a.

[35] U.S. Geological Survey, 1978b.

[36] U.S. Bureau of Mines, 1977.

[37] New Mexico Bureau of Mines and Mineral Resources, 1978.

[38] Sipes, Williamson, and Aycock, 1976.

[39] G.J. Long and Associates, 1976.

[40] Permian Exploration Co., 1976.

[41] Sandia National Laboratories, 1978.

[42] Sandia National Laboratories, 1978, p. 2-20.

Consideration was also given to the possible presence of uranium in the redbed-type sediments that overlie the evaporites. The conclusion is that no significant uranium deposit exists.

Lithium occurs in a brine reservoir within the Castile formation northeast of the present site and may be present in a similar reservoir to the southwest. However, care has been taken to avoid such brine reservoirs within the site area.

Consideration was also given to the possible existence of metalliferous deposits in the Precambrian basement under the site. However, the depth (about 18,000 feet below the ground surface) to Precambrian rocks would preclude mining even if mineral concentrations were present.[43]

The GCR became the principal source for the natural resource evaluation in Section 7.3.7 of the FEIS.[44] The Record of Decision (ROD), which resulted from the FEIS, documents that the DOE concluded, based on the information available at the time, and based on a comparison of alternatives, that the "*environmental impacts predicted for Alternative 2 are generally small and the Los Medanos site appears acceptable for long-term disposal of TRU waste with minimal risk of any release of radioactivity to the environment. There is no indication that an alternative site for the demonstration would pose reduced risk.*"[45]

Publication of the FEIS and the ROD stimulated considerable additional discussion with regard to natural resources. This discussion served the purpose of providing additional public comment and clarification with regard to the impacts due to resource denial and resource attractiveness. The DOE's responses to comments on the FEIS were published in two separate reports. In the first, the DOE responded to five consolidated comments from four organizations. The most significant of these had to do with the DOE's plans regarding the outermost WIPP control zone (Control Zone IV), and the potential radiation risks associated with future mining. These comments and responses follow:

1. *Comment:*

   The New Mexico EEG and the Southwest Research and Information Center stated that the DOE should clarify the restrictions it plans to place on gas recovery from Control Zone IV and from deviated drilling beneath the inner control zones. Furthermore, clarification is needed relative to the possibility of potash mining at the site. The EEG questioned the DOE confidence that such activities can be conducted without disturbing the integrity of the site. The EEG believes they should be party to decisions related to resource extraction at the site.

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[43] Sandia National Laboratories, 1978, pp. 8-20 to 8-21.

[44] U.S. Department of Energy, 1980.

[45] U.S. Department of Energy, 1981a, p. 9163.

Response:

The DOE recognizes that the language in the FEIS describing resource recovery at the WIPP is tentative. Detailed programs for resource recovery have not yet been formulated. However, to mitigate the adverse impacts of resource denial at the site, the DOE has committed to the policy of allowing maximum resource recovery at the site consistent with protection of site integrity. For purposes of environmental impact analyses, the scenarios discussed in the WIPP waste isolation assessment (FEIS Section 9.7) bound the potential consequences of resource extraction at the Los Medanos site in the long term. These scenario results demonstrate that the consequences of future events, including resource extraction, are acceptably small. The New Mexico EEG will be involved in future decisions regarding resource extraction at the Los Medanos site through their review of documented analyses.

2. *Comment:*

The New Mexico EEG emphasized the need to quantify potential radiation risks of resource extraction at the Los Medanos site. The SRIC stated that the potash mining at the site may lead to subsidence with water intrusion into the salt.

Response:

For purposes of environmental impact analysis, the scenarios presented in the WIPP long-term waste isolation assessment (FEIS Section 9.7) bound the potential consequences of resource extraction at the Los Medanos site. These analyses present a consequence rather than a risk assessment; the assumption is that the probability of occurrence is unity and the event will occur. The results of these analyses demonstrate that the consequences of resource extraction beyond the period of institutional control are insignificant.[46]

In the second report, the EEG raised an additional question regarding the interpretation of the data in the FEIS. In addition, a new issue surfaced with regard to the loss of revenues from royalties normally paid to the state of New Mexico. The comments and responses are reproduced below.

1. *Comment:*

The EEG stated that the DOE must provide more detailed information on the future control of the mineral hydrocarbon resources at or near the WIPP site. In addition, the EEG requested that the DOE provide the results of the hazard analyses that led to the conclusion that resources at the site can be safely extracted.

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[46] U.S. Department of Energy, 1981b, pp. 14-16.

Response:

The DOE recognizes that the FEIS language describing resource recovery at the WIPP site is tentative. Detailed programs for resource recovery have not yet been formulated; however, to mitigate the potential adverse impacts of resource denial at the site, the DOE has committed to the policy of allowing maximum resource recovery at the site consistent with the protection of site integrity. Final plans for resource recovery will be developed after in-situ data are acquired through the SPDV program.

For purposes of environmental impact analyses, the postulated breaching events discussed in the WIPP long-term isolation assessment (FEIS Section 9.7) bound the potential effects of breaching due to resource extraction at the Los Medanos site in the long term. This assessment provides a consequence (rather than risk) assessment; the assumption is made that the probability of occurrence is unity and the event will occur. The results of the consequence analysis demonstrate that the effects of future events, including resource extraction beyond the period on institutional control, are acceptably small.

2. *Comment:*

The EEG challenged the FEIS statement that very little potash exists above the WIPP (Zone II) itself stating that this assertion conflicts with data provided in the SAR. Specifically, SAR Figure 2.7-6 (i.e., the general lithology of the ERDA-9 core) states that the McNutt member of the Salado Formation at the site "contains potassic rock rich in sylvite, langbeinite, and other hydrous minerals." The EEG also stated the FEIS Figure 9-1 would suggest that at least one third of Control Zone II contains lease-grade sylvite.

Response:

As indicated in the FEIS Table 9-19, the sylvite resources within the WIPP inner control zones are considered subeconomic by the U.S. Department of the Interior, Bureau of Mines; significant resources are present but these are not classifiable as reserves. Lithologically, these deposits are potassic minerals, but they do not constitute economic mineral reserves. Accordingly, the lithological descriptions given in SAR Figure 2.7-6 are not inconsistent with the FEIS statements concerning the lack of sylvite reserves within the inner control zones at the WIPP site. FEIS Figure 9-1 is a composite map of mineralization in various ore zones that include lease-grade deposits of both sylvite and langbeinite. As indicated in Table 9-19, there are significant langbeinite reserves within the inner control zones at the WIPP site.

3. *Comment:*

The New Mexico Commissioner of Public Lands expressed concern that New Mexico could forego an estimated hydrocarbon royalty reserve of about $5 million and potash royalty reserve of about $15 million. These losses could be mitigated by a land exchange between the federal government and the state.

Response:

If current expectations are realized, resource recovery could occur without affecting the integrity of the WIPP and royalties would not be lost. Furthermore, the BLM [Bureau of Land Management] and the state are currently negotiating an exchange of federal lands for the state lands located within the site areas. The DOE expects that this exchange will be effected to the satisfaction of the site.[47]

2.2.2 DOE Resource Policy and the WIPP Natural Resources Study

Preparation of the FEIS caused the DOE to rethink its natural resource policy with regard to the control and possible denial of extractable minerals at the WIPP site. The DOE committed to the state of New Mexico to perform a study on the possible effects of recovering natural resources present at the WIPP site.[48] As a basis for conducting this study, called the Natural Resources Study,[49] the DOE issued an interim policy statement on resource recovery at the WIPP.[50] This interim policy reiterated the DOE's commitment to "*maximize the opportunity for resource recovery at the WIPP Site, consistent with the requirements to isolate the emplaced radioactive wastes from the biosphere.*"[51] The interim policy established by the department prohibited resource development in all control zones, pending the analysis completion to determine the possible radiation dose consequences resulting from resource development in Control Zone IV. The DOE committed to issue a revision to its natural resources policy in accordance with the results of the Natural Resources Study. The conclusions from this study are as follows:

The conclusion of this study is that activities related to potash and hydrocarbon resource extraction and solution mining from within (and outside of) Control Zone IV, using currently available and applicable technology, will not compromise the integrity of the WIPP waste emplacement facility and increase the likelihood of a breaching event.

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[47] U.S. Department of Energy, 1981c, pp. 9-10.

[48] U.S. District Court, 1981.

[49] Westinghouse Electric Corp., 1982a.

[50] U.S. Department of Energy, 1981d.

[51] U.S. Department of Energy, 1981d.

Specific conclusions drawn from this study follow:

- *The DOE policy for natural resource recovery is only important when considering communication events that could occur during the time period when this policy is in effect. After the loss of institutional controls, the types and magnitudes of events that could occur, such as those analyzed in the SAR, are fundamentally independent of former resource recovery restrictions at the site. Considering waste decay and geosphere transport rates, the DOE resource recovery policy has little influence on the time of waste isolation before a plausible waste-release event could occur and/or on the radiation dose consequences of such an event.*

- *The disturbances induced by potash exploration and conventional mining or solution mining in Control Zone IV are physically too far removed to affect the integrity of the WIPP facility. Breaching the waste storage area by these activities is not credible and induced changes in host rock hydraulic conductivity are not discernible.*

- *Exploration and production of hydrocarbons from within Control Zone IV likewise would not affect the waste emplaced in the WIPP facility. The extent of disturbance induced by production stimulation in the form of hydrofracing or acidizing is controlled by the specific design and execution of this operation. Evaluations of what can be considered typical operations, as discussed in this report, indicate no impact to the integrity of the WIPP facility.*

- *The communication events, including the types of breaching mechanisms, flow paths, and driving forces analyzed in the WIPP SAR, are applicable to current resource extraction technology in Control Zone IV and beneath Control Zones I, II, and III (for hydrocarbons). The SAR events represent, in fact, the potential effects of developing resources within the area of the WIPP facility itself, after institutional controls are lost.*

In summary, the DOE could reevaluate its interim policy to prudently allow resource recovery in Control Zone IV. This is supported by an evaluation of the consequence analyses for resource extraction, as discussed in this report, and the additional consideration that any resource recovery operation will be reviewed by the Bureau of Land Management (BLM) (for surface claims) and the Minerals Management Service (for underground claims) prior to its implementation. In this fashion, any planned activities will be evaluated on a case-by-case basis to ensure that the integrity of the WIPP facility will not be jeopardized.[52]

Subsequent to the publication of the Natural Resources Study, the DOE issued a revision to their policy on resource recovery. In this revision,[53] the DOE relinquished any resource development control over Zone IV. This policy is included as Appendix B. The criterion that the DOE used in developing this policy is that permanent denial resources should be

[52] Westinghouse Electric Corp., 1982, pp. 64-65.

[53] U.S. Department of Energy, 1982a.

limited to those areas in which extraction activities could potentially lead to measurable effects on the WIPP facilities or whose protection is needed for institutional considerations. All extraction activities that would not lead to measurable effects are allowable under the policy.[54]

Both the EEG and the Governor's Task Force commented on the interim policy, the Natural Resources Study, and the revised interim policy. These comments served to focus the policy and to clarify issues such as the extent and authority of DOE control of lands outside the WIPP site boundary. The EEG stated that they were "*generally satisfied with the revised Policy Statement*"; however, they requested that they be notified if anyone seeks to develop resources within one mile of the WIPP site boundary.[55]

The governor's office responded with the preparation of a report entitled Natural Resources at the Waste Isolation Pilot Plant (WIPP) Site. This report was compiled by the Subcommittee on Natural Resources at the WIPP site, a subcommittee formed by the Radioactive Waste Consultation Task Force.[56] The thrust of the state's report was the assessment of the resources that potentially exist at the WIPP site, and an estimate of the economic impacts associated with their denial. The summary addressed three issues, all of which dealt with resource denial. These were:

1. Exchange of State Trust Lands Within the WIPP Site Boundary for Federal Lands.

2. Compensation for Loss of Potential Revenues From State Trust Lands Within the WIPP Site Boundary.

3. Compensation for the Loss of Potential Revenues From Withdrawn Federal Lands.[57]

Finally, natural resource development was addressed in the first modification to the C&C Agreement between the DOE and the state of New Mexico.[58] This modification included a ban on resource development within the WIPP site boundary during the construction and operation of the WIPP facility, and allowed for the development of hydrocarbons beneath the WIPP site, provided they were accessed from outside the WIPP site boundary and that entry within the WIPP site boundary occurred below 6,000 feet. In addition, the agreement requires the DOE to reconsider the resources policy at least one year before decommissioning to determine necessary changes for long-term control of the site. Further discussion of the resources policy resulted in a second modification of the C&C Agreement and the imposition of the policy as it exists today. In this modification, the

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[54] U.S. Department of Energy, 1982a.

[55] Environmental Evaluation Group, 1983b.

[56] New Mexico Energy and Minerals Department, 1984.

[57] New Mexico Energy and Minerals Department, 1984, pp. 28-31.

[58] U.S. Department of Energy, 1984.

DOE agreed to the following language:

> *D. The DOE will not permit subsurface mining, drilling, or resource exploration unrelated to the WIPP Project on the WIPP site during facility construction, operation, or after decommissioning. This prohibition also precludes slant drilling under the site from within or outside the site.*[59]

2.2.3 Resource Issues Addressed During the SPDV

In 1981, the DOE initiated a program to provide confirmation of the characteristics of the then-proposed WIPP site. The program included the construction of shafts and tunnels at the location selected for the facility. Data collected during this investigation, referred to as the SPDV program, was to be used in making a decision regarding the full construction of the WIPP facility.[60] In a subsequent revision to the program plan, the SPDV was expanded to include stratigraphic studies in the vicinity of the site with the intent of issuing basic data reports on drill holes in the vicinity of the site.[61] The SPDV activity was summarized in a report that covered all site selection activities up to and including the SPDV. The report, which was prepared by SNL, included a section regarding natural resources, since natural resources were among the site selection criteria used for evaluation of the WIPP site. The summary report states the natural resources criterion as follows:

> *14.1 The site should be located so that losses of natural resources are reduced to acceptable levels, which shall be determined by the value of the resources and the alternative sources for these commodities.*[62]

The conclusion drawn in the summary document is that the WIPP site is qualified with respect to the criterion on natural resources. The rationale for drawing this conclusion is stated as follows:

> *In summary, some potash resources may be denied by present restrictions, but occurrences of potash and its possible attraction for future generations does not present a breach threat to the WIPP. Natural gas resources are not denied by present restrictions, but their possible presence and the overall geologic setting makes drilling through the WIPP a more likely occurrence than in a nonsedimentary geologic setting. Possible drilling breaches of the WIPP confinement integrity have been analyzed and shown to result in relatively benign consequences. It is therefore concluded that the site should not be ruled unacceptable because of potential resource conflicts; this potential is outweighed and compensated by the*

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[59] U.S. Department of Energy, 1987.

[60] Westinghouse Electric Corp., 1980.

[61] Westinghouse Electric Corp., 1982b.

[62] Sandia National Laboratories, 1983, p. 12.

very favorable hydrologic regime at the WIPP.[63]

The DOE published the results of the SPDV in a report inviting the public to provide comments that the DOE would use in making its decision on full WIPP construction.[64] Comments from the public and the state of New Mexico were handled separately by the DOE. In the volume summarizing the public's comments, the DOE discussed nine comments and provided responses.[65] For the most part, these comments dealt with the concerns of resource denial and resource attractiveness. In several of the responses, the DOE reiterated the fact that the decision-making process implemented through the FEIS did satisfy the requirements for evaluating the amounts of resources, the impacts of resource denial, the attractiveness to future generations, and a comparison of alternatives. The DOE did commit to working out arrangements with the BLM to assure that the DOE receives notification of resource development proposals in the vicinity of the WIPP site.[66] In the second volume of comments and responses, the DOE addressed input from the state of New Mexico.[67] As with the public's comments, the DOE was asked to clarify the issues of resource denial and resource attractiveness. In addition, the DOE was requested to comment on the topic of compensation for denied royalties that would normally be given to the state in the event minerals were mined. The DOE's responses on the first two topics were consistent with its previous positions, namely that the issues were adequately considered in the FEIS and were part of the decision-making process. With regard to resource attractiveness, the DOE pointed out that "*studies by both the DOE and the EEG (U.S. DOE, 1980; Woolfolk, 1982; Channell, 1982) show that future human intrusion in search of mineral resources will not significantly impact public health and safety.*"[68] Regarding resource denial, the DOE defined acceptable levels of loss of natural resources as "those levels at which the loss is exceeded by the expected benefits of the existence and operation of the WIPP. The extent of loss of natural resources that would be expected...is described in the WIPP FEIS. The result of the comparison indicating that the losses are acceptable was presented by issuance of the ROD to proceed with the WIPP Project (46 FR 9162)."[69] Finally, with regard to compensation to the state of New Mexico for lost revenues from foregoing future mineral production, the DOE responded that the issue "*merits further discussion.*" Further, the DOE adds that "*the State should recognize that very significant revenues that will be received for the engineering, construction, and operation of the WIPP facility in the state of New Mexico. These will*

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[63] Sandia National Laboratories, 1983, p. 25.

[64] U.S. Department of Energy, 1983a.

[65] U.S. Department of Energy, 1983b, pp. 3-16 to 3-19.

[66] U.S. Department of Energy, 1983b, p. 3-17.

[67] U.S. Department of Energy, 1983c, pp. 3-17 to 3-19, 6-3, 7-3.

[68] U.S. Department of Energy, 1983c, p. 3-81.

[69] U.S. Department of Energy, 1983c, p. 3-81.

likely far surpass the mineral revenue lost."[70]

The EEG published their own analysis of the results of the SPDV program.[71] In this report, the EEG devoted a chapter to the natural resources at the WIPP. They considered the subject very broadly, including the nature and extent of resources, a discussion of important criteria and standards, the DOE interim resource policy, and the potential effect of resource removal. The EEG focused their attention on the resource denial and the resource attractiveness concerns. In Chapter 2 of their report,[72] the EEG concludes for several reasons that caliche, halite, and gypsum are not of concern with regard to repository integrity. Likewise, lithium from brines is unlikely to be competitive on the world market. Even if it were of interest, it is bounded by other resource extraction scenarios. The EEG concluded that both potash and hydrocarbons represented denied resources that could be attractive for future development. In Chapter 3 of their report,[73] the EEG addresses the proposed EPA standard (see Section 2.1 above) and the NRC standards with regard to natural resources. Both agencies consider the presence of resources to be a potentially adverse condition. The EEG concluded that "*the WIPP site appears to have adverse conditions by virtue of the natural resources. It was on this basis that the EEG recommended that the DOE indicate its plans for control of exploration and recovery of the resources, and analyze the consequences of such exploration and recovery.*"[74] With regard to the DOE interim resource recovery policy, discussed in Chapter 4 of the EEG's report, the report states that "*the State intends to negotiate with BLM to obtain notification from BLM of any applications for mining activity within 1 mile of the Zone III boundary. Upon notification, EEG plans to evaluate such proposals and provide appropriate comments, if any, to BLM and DOE, concerning the potential effects on the repository horizon.*"[75] The EEG also raised the issue that the DOE did not consider the production of either halite or lithium as viable resources. Both, according to the EEG, are "*unlikely*" to be produced as resources and both are "*bounded*" by existing analyses.[76] In their Conclusions and Recommendations chapter, the EEG recommended that the mining of potash in Control Zones I, II, and III be "*banned indefinitely*" to minimize the possible future risk to the repository.[77] With regard to natural gas, however, the EEG concluded that "*the removal of natural gas does not present any radiological problems*" since natural

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[70] U.S. Department of Energy, 1983c, p. 7-3.

[71] Environmental Evaluation Group, 1983c.

[72] Environmental Evaluation Group, 1983c, pp. 94-107.

[73] Environmental Evaluation Group, 1983c, p. 98-100.

[74] Environmental Evaluation Group, 1983c, p. 100.

[75] Environmental Evaluation Group, 1983c, p. 101.

[76] Environmental Evaluation Group, 1983c, p. 103.

[77] Environmental Evaluation Group, 1983c, p. 142.

gas could be recovered using slant drilling techniques.[78]

The National Academy of Sciences (NAS) Panel on the WIPP produced a report at the end of the SPDV program.[79] The panel examined the body of information available with regard to potash and hydrocarbon. They credit the release of Zone IV for resource development as a major step in eliminating what appeared to be a "*major flaw in the case for site suitability.*"[80] The panel accepted the conclusion in the Natural Resources Study that the consequences of resource development should not be serious as long as the exploitation is limited to Zone IV and with the "*proviso that each proposal to develop resources should be carefully examined, with the burden of proof as to its safety, made the responsibility of the proposer.*"[81] Consequently, the NAS concluded that "*the presence of hydrocarbon and potash resources at the WIPP site is not a seriously adverse feature... .*"[82]

2.2.4 Natural Resource Considerations in NEPA Documentation Subsequent to the FEIS

Subsequent to the publication of the FEIS, there were three separate occasions where the DOE addressed the topic of natural resources in NEPA documentation. First, in 1982, the DOE prepared an environmental analysis to address an ambitious cost reduction program of the WIPP Project.[83] A part of the analysis included the proposal to release Control Zone IV for resource exploitation. The basis used in this environmental analysis was the Natural Resources Study. This environmental analysis formalized the DOE decision-making process for the release of the resources in Control Zone IV. DOE's NEPA Office reviewed the proposed actions with regard to cost reductions, including the proposed release of Control Zone IV and the revised DOE resource recovery policy. It concluded that the "*proposals would result in no new potential for significant environmental impacts from that described in the EIS for the WIPP facility as currently designed, and in fact, should result in an overall decrease in the potential for environmental impacts.*"[84]

The second NEPA review occurred after the completion of the SPDV and was conducted in support of the decision to proceed with full facility construction. Public comments were solicited regarding the results of the SPDV as discussed above. Based on the results and the comments, the DOE prepared an Action Description Memorandum (ADM) for full

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[78] Environmental Evaluation Group, 1983c, p. 142.

[79] National Academy of Sciences, 1984.

[80] National Academy of Sciences, 1984, p. 8.

[81] National Academy of Sciences, 1984, p. 11.

[82] National Academy of sciences, 1984, p. xii.

[83] U.S. Department of Energy, 1982b.

[84] U.S. Department of Energy, 1982c.

facility construction.[85] In Section III of the ADM, the topics of natural resource denial and natural resource attractiveness were addressed. In both cases, the DOE points out that the changes since the publication of the FEIS have resulted in no increases in risks or impacts. The DOE/NEPA office stated after their review of the ADM that "*we have determined, after consultation with the Office of General Council, that there are no significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts, within the meaning of NEPA and the Council on Environmental Quality (CEQ) regulations. Additional investigations since issuance of the WIPP Final EIS, including the SPDV activities, have generally confirmed the understanding of site characteristics and environmental impacts presented in the Final EIS...we concur with the proposed decision to proceed with the full WIPP facility construction based on available information.*"[86]

The topic of natural resources was included in the SEIS.[87] The SEIS examined new information regarding the facility and provided an opportunity for the DOE to obtain public comment regarding the implementation of a Test Phase for the WIPP Project. No new information was presented with regard to natural resources. However, by the time the SEIS was published, the DOE and the state of New Mexico had agreed to the language in the second modification to the C&C Agreement whereby the DOE would not allow any resource development at the WIPP site during construction, operations, or after decommissioning.[88] In general, the public comment on the SEIS, with regard to resources, requested further clarification of DOE land management policy, including the future regulation of resource development.[89] The SEIS did provide an update of the consequence analysis regarding the impacts of an inadvertent human intrusion into the repository related to resource development. Under some of the assumptions, the results exceeded the allowable EPA standard; in other cases, compliance was demonstrated. The uncertainty associated with these calculations were, in part, instrumental in the DOE's decision to proceed with the Test Phase as a means of addressing the uncertainty. An additional SEIS will be performed, prior to the initiation of the Disposal Phase, to evaluate the effects of intrusion into the repository motivated by resource development. If the impacts exceed the applicable environmental standards, alternative approaches to disposal (such as waste processing) will be evaluated.

2.3 Summary

The development of the RDR has involved a significant amount of discussion and thought, both scientific and nonscientific. The final version of the requirement does not automatically eliminate any sites that may contain resources. Instead, it provides the implementing agency with the opportunity to demonstrate that the favorable conditions of

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[85] U.S. Department of Energy, 1983d.

[86] U.S. Department of Energy, 1983e.

[87] U.S. Department of Energy, 1990a.

[88] U.S. Department of Energy, 1990a, p. 7-3.

[89] U.S. Department of Energy, 1990a, Vol. 3, pp. 193-195.

the site outweigh the potential increased risk associated with using the site. This demonstration involves a qualitative comparison of the risks associated with the site and the alternatives to using the site.

Concern for both resource denial and resource attractiveness has been evident in the technical and decision-making documents that the DOE has prepared for the WIPP site on the topic of natural resources. These documents have undergone a significant amount of public scrutiny, which served to focus the issues of resources. Two basic concerns have emerged: resource denial and resource attractiveness. The DOE's policy with regard to resource denial has been evolutionary, to the extent that initial restrictions have proven to be unnecessary, based on analysis in the Natural Resources Study. Consequently, the DOE has reduced the amount of denied resources significantly since the publication of the FEIS. With regard to resource attractiveness, the DOE has performed analyses to assess the impacts of unintentional disruption of the WIPP facility as the result of resource development. As the DOE's understanding of the facility, the surrounding geological and hydrological systems, and the waste has increased, the need for additional information has increased, and is to be addressed during the Test Phase. The DOE has obtained control over the surface and subsurface above 6,000 feet by successfully eliminating all mineral leases that could potentially lead to problems with the long-term isolation capability of the facility. In addition, the Congress has recently permanently withdrawn the land for the operation of the WIPP.

The following chapters discuss the qualitative comparison that was performed in the FEIS[90] prepared for the WIPP. Key to this comparison was the evaluation of the societal impacts of resource denial and the increased risks associated with the potential for human intrusion. Furthermore, the latter consideration is the subject of an ongoing assessment being prepared for the WIPP facility. Updates to the analysis in the FEIS were published in the SEIS.[91] In addition, SNL has the responsibility to complete the performance assessment required under other parts of 40 CFR 191. These performance assessments consider the risks associated with a human intrusion motivated by resource exploitation.[92]

It is important to note that the WIPP site was selected before the Assurance Requirements were issued in either proposed or final form. Consequently, it is not possible to reconstruct a compliance approach that is directed specifically at the EPA's standards. Instead, it is the purpose of the following sections to demonstrate that the extent to which the DOE considered resources was sufficient and that the intent of these requirements has been met. Furthermore, the decision to use the WIPP facility as a final disposal facility has not been made and will not be made until the DOE can demonstrate that even with increased risks associated with resource attractiveness, the site can meet the environmental protection requirements in 40 CFR 191.

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[90] U.S. Department of Energy, 1980.

[91] U.S. Department of Energy, 1990a.

[92] Sandia National Laboratories, 1990a.

3.0 THE WIPP PROJECT

3.1 Location

The WIPP facility is located in Eddy County, New Mexico, 26 miles east of Carlsbad (Figure 1). The WIPP site boundary encompasses 16 square miles (10,240 acres) located in an area known as the Los Medanos (the dunes). It consists of Sections 15-22 and 27-34 of Township 22 South, Range 31 East.[93] The area originally withdrawn for the WIPP facility covered 18,960 acres and was organized into four control zones (Figure 2).[94] The control zones were established so that the containment integrity of the salt beds used for disposal could be protected from mining and resource exploitation activities.[95] In 1982, a decision was made by the DOE to release control of the outermost control zone, effectively reducing the WIPP site boundary to the configuration in Figure 3.[96] As the result of an agreement with the state of New Mexico,[97] resource exploitation that could be harmful to the WIPP facility is not allowed within the 10,240 acres that lie within the WIPP site boundary.

3.2 WIPP Mission

Public Law 96-164 defines the WIPP mission as "*a defense activity...for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission.*"[98] The DOE is responsible for all aspects of the WIPP Project.

3.3 Overview of the WIPP Project

From 1973 to 1975 a site selection program was conducted to locate a site, within the Carlsbad area of eastern New Mexico, that would be suitable for a radioactive waste repository. During this period, there were no federal regulations that established criteria for selecting a radioactive waste repository site, but there were informal criteria.[99,100,101] These informal criteria were used to evaluate several candidate sites.

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[93] U.S. Department of Interior, 1991.

[94] U.S. Department of Energy, 1980, p. 8-4.

[95] Oak Ridge National Laboratory, 1973a.

[96] U.S. Department of Energy, 1982c.

[97] U.S. Department of Energy, 1987.

[98] U.S. Congress, 1979.

[99] Oak Ridge National Laboratory, 1973a.

[100] Sandia National Laboratories, 1978.

The Los Medanos site was selected for the WIPP Project. Appendix D of the FEIS summarizes the site selection criteria that were specifically applied to the selection of the location of the WIPP facility. These are included in this report as Appendix C.[102]

Upon selection of the Los Medanos site, a site characterization program was initiated.[103] Extensive studies (geophysical surveys, borehole corings, etc.) were conducted to verify that the site was as adequate as the criteria indicated. At the same time, in accordance with the NEPA, aspects of how the WIPP would impact the environment were evaluated. The results of these studies are summarized in the WIPP FEIS, a two-volume document issued in 1980.[104]

In 1981, the DOE decided to proceed with the WIPP Project, as authorized, at the Los Medanos site.[105] With this decision, mining at the WIPP facility commenced and the SPDV program was initiated.[106] The SPDV program provided additional proof of the favorable characteristics of the site as a mined geological repository.[107]

On June 28, 1983, the DOE rendered the decision to proceed with full construction of the WIPP facility.[108] As construction proceeded, the DOE continued to evaluate the geotechnical and hydrological characteristics of the site. In 1988, the impact of the human intrusion scenario on the site was reevaluated by SNL based on new information regarding the transmissivity of fluids in the Rustler Formation, the expected quantities of brine that could collect in the repository before closure, and the gas permeability of the in-situ salt. Based on this new information, and uncertainties surrounding the selection of model parameters for numerically evaluating the long-term performance of the repository, the DOE decided to initiate a Test Phase for the WIPP. The Test Phase was to provide an opportunity for the DOE to evaluate certain waste characteristics under controlled experimental conditions.[109,110,111,112] The NEPA documentation for the Test Phase

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[101](...continued)
[101] U.S. Department of Energy, 1980.

[102] U.S. Department of Energy, 1980, Volume 2, Appendix D, pp. D-1 to D-10.

[103] Sandia National Laboratories, 1978.

[104] U.S. Department of Energy, 1980.

[105] U.S. Department of Energy, 1981a.

[106] Westinghouse Electric Corp. 1980.

[107] Sandia National Laboratories, 1983.

[108] U.S. Department of Energy, 1983e.

[109] U.S. Department of Energy, 1990b.

[110] Sandia National Laboratories, 1990b.

was completed in 1990.[113] The DOE currently expects to begin the Test Phase experiments in the last quarter of 1993.

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[111](...continued)
[111] Sandia National Laboratories, 1990c.

[112] Sandia National Laboratories, 1990d.

[113] U.S. Department of Energy, 1990a.

4.0 WIPP SITE SELECTION AND NATURAL RESOURCES

4.1 Summary of Site Selection Activities

As stated in §2.1, the ultimate test for site suitability under the resource disincentive requirement is that sites with resources present would be used only "*if it is reasonably certain that they would provide better overall protection than the practical alternatives that are available*".[114] This section sets forth the site selection process for the WIPP and how that process complied with the resource disincentive requirement.

As will be discussed, the WIPP site selection process consisted of four distinct stages. An important aspect to keep in mind when going through this process is the comparison to practical alternatives requirements mentioned in the standard. It will be shown that at each stage of the site selection process practical alternatives were analyzed, and with the elimination of the various alternatives, the Los Medanos site in southeastern New Mexico was ultimately selected as the most favorable site of all of the practical alternatives.

4.1.1 General Description of the Site Selection Process Used to Select the WIPP Facility Location

A deductive-reasoning process was used to select the WIPP site. This process has been described as four distinct stages.[115] The following is a summary of the process.

STAGE 1: In stage 1, a geologic media, which in this case is salt, was selected and geographic regions that contain this media were identified. This was accomplished by gathering and evaluating existing information concerning rock types and geographic availability. A set of desirable criteria was established and a list of the most favorable regions was developed.

STAGE 2: In stage 2, a careful study of the literature relevant to stage 1 was performed to narrow down the number of regions identified in stage 1. Once a region was selected, candidate sites within the region were chosen. Selection criteria were used to compare the sites. Those sites which satisfied the most criteria were selected for further evaluation. Typically, resource conflict considerations are applied on a broad scale at this stage of site selection.

STAGE 3: In stage 3, the candidate sites identified in stage 2 undergo further investigations which cover geology, hydrology, archaeology, historical surveys, demography, and biology. The results of all the site evaluations were compared, and the site that best met the selection criteria (the Los Medanos site) was selected for Site Characterization. At this stage, the type and amount of resources were considered in detail.

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[114] U. S. Environmental Protection Agency, 1985a, p. 38081.

[115] U.S. Department of Energy, 1980, p. 2-7.

STAGE 4: In stage 4, a detailed full system analysis was performed. Full-system refers to the specific geologic environment, the waste forms, the plant design, and the potential failure modes in respect to radiation safety and environmental impacts.

Typically, the results of all of the studies performed to select and characterize the site are summarized in an EIS prepared in accordance with the NEPA. The EIS was made available to all interested parties. Public comments were incorporated into the decision that determines whether or not to proceed with the project, as defined, at the location selected.

4.1.2 Selection of Salt as a Disposal Media

The rationale for preferring salt as the disposal medium for nuclear waste, in general, and for the WIPP facility, specifically, resulted from two decades of repository program activities. In 1955, the NAS National Research Council (NAS-NRC) was asked by the AEC to examine the issue of permanent disposal of radioactive waste. In a report published in 1957,[116] the committee stated that it was "*convinced that radioactive waste can be disposed of safely*" and concluded that "*the most promising method of disposal of high level waste at the present time seems to be in salt deposits.*"[117]

Salt was determined to be the most promising disposal medium because of its unique thermal and physical properties. Salt has a relatively high thermal conductivity, which serves to rapidly conduct heat away from waste. Salt has favorable plastic, or creep, properties which permit sizeable strains to be absorbed without fractures.[118] The existence of large salt deposits demonstrates isolation from circulating groundwaters for long periods of geologic time. The depositional nature and preservation of large salt deposits demonstrate regional stability for long periods of geologic time.

From 1957 to 1961, the AEC sponsored research at the ORNL on the suitability of salt as a disposal medium for defense generated radioactive waste.[119] In 1962, the USGS completed a study that summarized rock salt deposits in the United States as possible storage sites for radioactive waste.[120]

In 1963, an existing salt mine in Lyons, Kansas, was selected for further study. The ORNL began a large-scale field program known as Project Salt Vault. Simulated wastes (irradiated fuel elements), supplemented by electric heaters, were placed in the mine for observation.

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[116] National Academy of Sciences, 1957.

[117] National Academy of Sciences, 1957, pp. 3-4.

[118] Oak Ridge National Laboratory, 1973a, p. 3.

[119] U.S. Department of Energy, 1980, p. 2-6.

[120] U.S. Geological Survey, 1962.

Conclusions made from the studies that took place from 1963 to 1970 were favorable and, in 1970, the Lyons site was selected by the AEC as a potential location for a radioactive waste repository. The NAS endorsed this recommendation. However, subsequent studies identified some technical problems and, in 1972, the integrity of the site was judged to be unacceptable. There were too many drill holes in the area that could not be positively located, and solution mining, which was taking place nearby, was experiencing unexplainable water losses.[121]

Table 4-1 provides a comparison of the geologic media considered for the WIPP.[122] As stated in the FEIS, "*salt is the best understood of all candidate geologic media with respect to its possible use as a waste-repository medium, and it offers advantages in thermal properties and plasticity. It is found in many places in the United States.*"[123] Therefore, of the disposal media considered for the WIPP site (limestone, shale, and salt), salt was selected the best of the practical alternatives.

4.1.3 Selection of Eastern New Mexico

The WIPP site selection process began in 1973, when the AEC, ORNL, and the USGS began seeking a repository site to replace the site abandoned in Lyons, Kansas. A nationwide survey was conducted to locate a region that contained a salt deposit suitable for use as a repository.[124,125,126,127,128,129,130]

Of the areas in the United States underlain with bedded salt, the Salina Basin in portions of New York, Pennsylvania, West Virginia, Ohio, Michigan, and southern Ontario, and the Permian Basin including parts of Kansas, Oklahoma, Texas, Colorado, and New Mexico, were considered for further study under the waste management program.[131] The Permian Basin was eventually selected over the Salina Basin. The reason for this was

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[121] U.S. Department of Energy, 1980,p. 2-7.

[122] U. S. Department of Energy, 1980, p. A-4.

[123] U. S. Department of Energy, 1980, p. A-5.

[124] U.S. Geological Survey, 1962.

[125] U.S. Geological Survey, 1973a.

[126] U.S. Geological Survey, 1973b.

[127] U.S. Geological Survey, 1973c.

[128] U.S. Geological Survey, 1973d.

[129] U.S. Geological Survey, 1973e.

[130] U.S. Geological Survey, 1974a.

[131] U. S. Department of Energy, 1980, p. 3-9.

because potential areas in the Salina Basin were *"much more densely populated, the land is more intensively used, and the complex hydrologic characteristics are likely to be much more difficult to define and evaluate."*[132] Thus of the alternatives in bedded salt, the Permian Basin was determined to the **best of the practical alternatives.**

The most promising region identified within the Permian Basin was located in the Delaware Basin of eastern New Mexico. This region was selected because the salt is shallow and flat. Although the Delaware Basin is a known oil and gas producer, the eastern New Mexico area is not very productive, and has not been subjected to a lot of drilling.[133] Selection of this area of the Delaware Basin was consistent with the criterion of avoiding locations in known oil and gas production trends. Thus, of the alternatives in the Permian Basin, eastern New Mexico was considered to the **best of the practical alternatives.**

4.1.4 Selection of the Carlsbad Area

An extensive literature study was performed to locate an area in eastern New Mexico for further evaluation. Three areas in eastern New Mexico were chosen for further study: (1) the Carlsbad area;[134] (2) the Clovis-Portales area;[135] and (3) the Mescalero Plains of Chaves County.[136]

The Clovis-Portales area was disqualified because the salt being studied was too shallow and clayey. The Mescalero Plains area was disqualified because of excessive resource development (oil production) in the area. The Carlsbad area, in the northern portion of the Delaware Basin, was ultimately selected as the **best of the practical alternatives.**[137]

4.1.5 Selection of the Los Medanos Site

Site selection efforts within the Carlsbad area were initiated in 1972 by ORNL, the USGS, and the AEC. A plan issued by ORNL, in October of 1973,[138] states that resource-high areas should be avoided. Specifically, the plan states:

> *Significant quantities of potash ore and extensive deposits of oil and gas occur in selected localities of southeastern New Mexico. To preclude conflicts of interest in the economic development of the region, the rocks underlying the study area should*

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[132] U. S. Department of Energy, 1980, p. 3-10.

[133] U.S. Department of Energy, 1980, p. 2-10.

[134] U.S. Geological Survey, 1972.

[135] U.S. Geological Survey, 1974b.

[136] U.S. Geological Survey, 1974c.

[137] U.S. Department of Energy, 1980, p. 2-10.

[138] Oak Ridge National Laboratory, 1973b.

preferably have a low potential for oil and gas development and should not contain extensive high-grade potash ores.[139]

Appendix D of the WIPP FEIS[140] lists the criteria used to select the Los Medanos site, and explains how well the WIPP site fares against these criteria (see Appendix C of this paper). These criteria evolved through the selection and abandonment of a Project Salt Vault in Lyons, Kansas.

The first site selected for characterization within the Carlsbad area (ORNL site) had to be abandoned. It was centered on Sections 10 and 11 of Township 22 South, Range 31 East. Characterization studies showed that (1) rock strata were much shallower than expected; (2) beds showed severe distortion; (3) structural dips were as high as 75 degrees; (4) the site contained leasable grades of potash (AEC Nos. 7 and 8); and (5) a pocket of pressurized brine was encountered at a depth of 2,710 feet within the Castile Anhydrite.[141,142]

It was determined that the site was located too close to the Capitan Reef. Structural influence by the reef caused the actual geologic character to vary from the predicted geologic behavior.[143] Extensive drilling would have been required to thoroughly document the structure of the site, which is contrary to the principle of minimizing the number of holes drilled into the repository.

In late 1975, the USGS and the Energy Research and Development Administration (ERDA) went back to stage 2 of the site selection process, and began looking for an alternative location within the Carlsbad Area of the Delaware Basin. Site selection criteria and characterization factors were revised to include knowledge gained from several studies.[144,145,146,147,148,149] These revised criteria are referred to as stage 2 siting

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[139] Oak Ridge National Laboratory, 1973a, p. 3.

[140] U.S. Department of Energy, 1980, Vol. 2, Appendix D.

[141] U.S. Department of Energy, 1980, p. 2-10.

[142] Sandia National Laboratories, 1978.

[143] U.S. Geological Survey, 1973d.

[144] Oak Ridge National Laboratory, 1974a.

[145] U.S. Geological Survey, 1973b.

[146] Oak Ridge National Laboratory, 1973c.

[147] U.S. Geological Survey, 1975.

[148] Oak Ridge National Laboratory, 1974b.

[149] Sandia National Laboratories, 1978, p. 2-11.

criteria.[150] The following is an abbreviated listing of the most restrictive stage 2 siting criteria:[151,152]

1. Avoid areas that are within one mile of any borehole that extends through the Ochoan evaporites and into the Delaware or deeper formations. (This automatically assures that a site will not be located over an existing oil or gas field.)

2. Salt of high purity at a depth between 1,000 and 3,000 feet.

3. Avoidance of areas where dissolution had advanced to the top of the Salado or deeper levels, by establishing a distance of one mile or more from dissolution fronts at the top of the Salado.

4. Avoidance of possible salt deformation in a belt six miles wide basin-ward from the Capitan Reef.

5. Avoidance of pronounced known anticlinal structures.

6. Avoidance of known oil and gas trends.

7. Avoidance of the known potash enclave above the repository and minimize conflict with the known enclave in the buffer zone.

Only two of the proposed alternatives withstood the stage 2 siting criteria. Alternative I, the Los Medanos site, was selected as the preferred location because seismic data indicated that the site was in a syncline, making the accumulation of oil, gas, and geopressurized brines less favorable. Alternative II was located adjacent to shallow oil fields where water flooding for secondary recovery was a possibility.[153]

Selection of the Los Medanos site did not prove that the "perfect" site had been selected. The selection criteria used, however, was sufficient to establish that the site selected was adequate, safe, and acceptable.[154] An effort was made to avoid resource-rich areas. This goal could not be completely satisfied by the Los Medanos site. Thus the Los Medanos site was selected as the **best of the practical alternatives** for the location of a waste repository.

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[150] Sandia National Laboratories, 1978, p. 2-22.

[151] Sandia National Laboratories, 1978, pp. 2-21 and 2-22.

[152] Sandia National Laboratories, 1977.

[153] Sandia National Laboratories, 1978, pp. 2-22 and 2-23.

[154] Sandia National Laboratories, 1978, p. 2-15.

The site contains potential economic quantities of both potash and hydrocarbons.[155] These resources will be discussed subsequently.

4.2 Resources at the WIPP Site

The language in the EPA's resource disincentive defines resources[156] that are of interest to include "*minerals, petroleum or natural gas, valuable geologic formations, and ground waters that are either irreplaceable because there is no reasonable alternative source of drinking water available for substantial populations or that are vital to the preservation of unique and sensitive ecosystems.*"[157] Accordingly, the following discussion centers on the specific resources defined in the standard. This includes a discussion of hydrocarbon resources, which include oil, gas, and distillate; minerals, which include potash, halite, and construction materials such as sand, gravel, and caliche; and groundwater.

4.2.1 Hydrocarbons

The New Mexico Bureau of Mines and Mineral Resources (NMBM&MR) conducted a hydrocarbon resource study in southeastern New Mexico under contract to the ORNL.[158] The NMBM&MR study was based on the known reserves[159] of crude oil and natural gas in the region and on the probability of discovering new reserves. A fundamental assumption of this study was that the WIPP area has the same potential for resources as the much larger region. The estimates do not take into account the economic value or the recoverability of the hydrocarbons. The NMBM&MR estimated that each section (640 acres) could contain 1.266 million barrels of oil, 16.544 billion cubic feet of gas, and 0.193 million barrels of distillate.[160] The SNL hired a consulting firm to prepare an estimate of the hydrocarbon reserves (economically producible resources) within the area.[161] Since there were no resource wells within the inner three control zones at the WIPP site, the study relied on information gained from nearby exploration. The study was updated just prior to the publication of the draft EIS for the WIPP. Based on the updated study, the reserve estimates in Table 4-1 were projected.[162]

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[155] U.S. Department of Energy, 1980, p. 8-8.

[156] The term "resources" means concentrations of materials in a form that makes their extraction currently or potentially feasible.

[157] U.S. Environmental Protection Agency, 1985a, p. 38086.

[158] New Mexico Bureau of Mines, 1974.

[159] The term "reserves" applies to resources that can be extracted profitably by existing techniques and under present economic conditions.

[160] U.S. Department of Energy, 1980, pp. 7-68 to 7-70.

[161] Sipes, Williamson, and Aycock, 1976.

[162] Sipes, Williamson, and Associates, 1979.

In order to gain control over the development of hydrocarbons within the WIPP site area, the DOE acquired the oil and gas leases within all the WIPP control zones. These acquisitions were necessary to keep the salt beds intact.[163] The only leases that are still intact are in Section 31. These leases only allow the production of resources by entry below 6,000 feet. The upper 6,000 feet of the leases were taken by the DOE through condemnation in 1979. This action was consistent with the developing policy on resource recovery.[164] Current policy would not allow any resource development inside the WIPP site boundary.[165] Table 4-2 puts the resources and the reserves into perspective. This table has been modified from Table 9-14 in the FEIS[166] to include the differentiation between the resources in the inner three control zones and those in Control Zone IV.

4.2.2 Mineral Resources

A comprehensive discussion of the nonhydrocarbon mineral resources affected by the WIPP site is included in the FEIS[167] and is based on information gathered for the GCR.[168] The conclusion in these documents is that the principal mineral resources that underlie the WIPP facility are caliche, gypsum, salt, lithium from brines, sylvite, and langbeinite. Potassium salts (sylvite and langbeinite), which occur in strata above the repository, are the only mineral resources of practical significance and are considered to be economically extractable (that is, reserves).[169,170]

When the Los Medanos site was initially screened for the WIPP Project, it was thought that the facility was positioned outside of the Known Carlsbad Potash District, and would therefore have a minimal impact on potash resources.[171] Information from studies

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[163] U.S. Department of Energy, 1980, pp. 8-8 to 8-10.

[164] U.S. Department of Energy, 1982a.

[165] U.S. Department of Energy, 1987.

[166] U.S. Department of Energy, 1980, p. 9-19.

[167] U.S. Department of Energy, 1980, Chapters 7, 8, and 9.

[168] Sandia National Laboratories, 1978.

[169] U.S. Department of Energy, 1980, p. 9-18.

[170] Environmental Evaluation Group, 1983, pp. 95-98.

[171] U.S. Department of Energy, 1980, p. 2-15.

conducted after site selection[172,173,174] has caused an enlargement of the Known Carlsbad Potash District to include most of the Los Medanos site.[175]

Table 4-3 illustrates the significance of the amount of potash mineral resources that cannot be mined or extracted because of the WIPP site. The mineral of greatest interest is langbeinite, which is used to manufacture a fertilizer. Denying the exploitation of langbeinite resources on the WIPP site does impact regional and national resources. Langbeinite is a relatively rare evaporite mineral that is found in commercial quantities only in the Carlsbad area and in eastern Europe. It contains soluble potassium, magnesium, and sulfur.[176]

The chief importance of langbeinite is as a fertilizer. It is desirable for soils which require soluble potassium, magnesium, and sulfur, but which cannot tolerate chlorine. The principle beneficial ingredient is potassium sulfate. Some langbeinite is sold as a refined mineral but some is mixed with sylvite to produce potassium sulfate.[177]

Substitutes for the principal beneficial ingredient of langbeinite (potassium sulfate) are available. Some langbeinite produced from Carlsbad is transformed into potassium sulfate by a base-exchange process between langbeinite and sylvite. Potassium sulfate can also be produced by a reaction between sylvite and sulfuric acid. Potassium sulfate is present in the brine water of the Great Salt Lake, Utah, and is now being exploited commercially.[178]

The supply of langbeinite in the Carlsbad potash area is exhaustible. It is projected that langbeinite operations will last another 28 years if reserves are considered, and 46 years if resources are considered. The WIPP Project originally excluded the mining or extraction of resources from 18,960 acres. In 1982, the DOE issued a revised Interim Policy Statement on Resource Recovery at the WIPP Site.[179] This policy states that "*the extraction of potash outside Control Zone III is allowable.*"

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[172] U.S. Geological Survey, 1978a.

[173] U.S. Bureau of Mines, 1977.

[174] Agricultural and Industrial Minerals, 1978.

[175] U.S. Department of Energy, 1980, p. 2-15.

[176] U.S. Department of Energy, 1980, p. 9-21.

[177] U.S. Department of Energy, p. 9-24.

[178] U.S. Department of Energy, 1980, pp. 9-14 to 9-25.

[179] U.S. Department of Energy, 1982a.

4.2.3 Groundwater

Groundwater in the area of the WIPP site has been studied extensively and the results of the studies have been summarized both in the WIPP FEIS[180] and the WIPP Final Safety Analysis Report (FSAR).[181] The following are the principal tasks that were conducted to evaluate the groundwater in the vicinity of the WIPP:

A review of available data and literature resulting from potash, oil and gas, and Pecos River investigations was conducted.

Hydrologic testing was performed in 52 exploration holes.

Extensive field testing programs were conducted, including drill stem tests, flow tests, pump tests, and packer tests.

Water samples from specific rock units have been laboratory tested for physical and chemical parameters.

The studies that were performed confirmed that groundwater exists both above and below the facility horizon. Below the facility horizon, groundwater is found in the Bell Canyon Formation. This groundwater is of very poor quality and, for the most part, can be considered a brine.[182] Groundwater above the facility horizon is found only in limited quantities, and is usually of such poor quality that it is not usable.[183,184,185]

At some locations, the water is of marginal quality and is used for watering livestock. The "Barn Well" (located 5.5 miles south-southeast of the WIPP site) supplies drinking water to a local ranch from the Dewey Lake Red Beds Formation.[186]

The WIPP does not impact any irreplaceable groundwater as defined by 40 CFR 191.14(e), which states that groundwaters are either irreplaceable because (1) "*no reasonable alternative source of drinking water is available for substantial populations*"; or (2) it is "*vital to the preservation of a unique and sensitive ecosystem.*"[187] No substantial population is affected by the WIPP site, and alternative supplies of drinking water are

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[180] U.S. Department of Energy, 1980, Section 7.4.

[181] Westinghouse Electric Corp., 1990.

[182] Sandia National Laboratories, 1978, p. 6-29.

[183] Westinghouse Electric Corp., 1987.

[184] Westinghouse Electric Corp., 1986.

[185] Westinghouse Electric Corp., 1988.

[186] Westinghouse Electric Corp., 1988.

[187] U.S. Environmental Protection Agency, 1985, p. 38086.

available from the wells 30 miles north of the WIPP site which are completed in the Ogallala Formation.[188]

4.3 WIPP Ecosystems

The terrestrial ecology of the WIPP site is characteristic of areas where rainfall is the limiting factor for vegetation. The area lies within a transition zone between the Chihuahuan Desert and the southern Great Plains. As a result, the area shares the floral characteristics of both areas. There are no endangered plant species known to occur within the WIPP site area.[189] Thirty-nine species of mammals have been observed in the area. None are on the threatened or endangered species list.[190] A total of 122 birds have been observed. None are on the endangered species list.[191]

With regard to the impacts on the ecological resources, the FEIS points out that the ecosystems found at the WIPP are not unique. No endangered species of plants or animals are known to inhabit the WIPP site or the vicinity of the site. The area contains vegetation and soil types that are common throughout the region. No unique species or populations have ever been identified at the site.[192]

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[188] Westinghouse Electric Corp., 1990, p. 2.5-1.

[189] U.S. Department of Energy, 1980, pp. 7-3 to 7-7.

[190] U.S. Department of Energy, 1980, p. 7-7.

[191] U.S. Department of Energy, 1980, p. 7-8.

[192] U.S. Department of Energy, 1980, pp. 9-14 to 9-15.

5.0 CONCLUSIONS

In 1981, the DOE decided that the available data, as summarized in the FEIS,[193] supported a decision to proceed with the WIPP project through facility construction. As documented by this paper, the information that the DOE used to make this decision evolved from site selection and site characterization activities, which included resource considerations in compliance with the resource disincentive requirements.

During the site selection process, the Los Medanos site was compared against several other candidate sites. An established list of selection criteria (which included resource considerations) was used to compare candidate sites, and the Los Medanos site best met the selection criteria. Based on the favorable characteristics of the Los Medanos site (good hydrological characteristics, salt medium, moderate depth, salt thickness, low population density, lack of significant economic conflicts, and others),[194] the decision was made to proceed with full construction and operation for the Test Phase. These favorable characteristics more than compensate for the possibility that the site will be disturbed in the future because of the presence of natural resources. The decision for full operations as a permanent disposal facility will be rendered only if the EPA guidelines for radioactive waste isolation are met.

In conclusion, the preliminary site selection intent of the RDR in 40 CFR 191(e) has been met for the WIPP facility. Resource conflicts were given adequate consideration, including extensive public comment. The conclusion is that the favorable characteristics of the site uniquely qualify it for a repository for defense TRU waste. These characteristics more than compensate for the likelihood of a future disturbance.

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[193] U.S. Department of Energy, 1980.

[194] Sandia National Laboratories, 1983.

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FIGURES

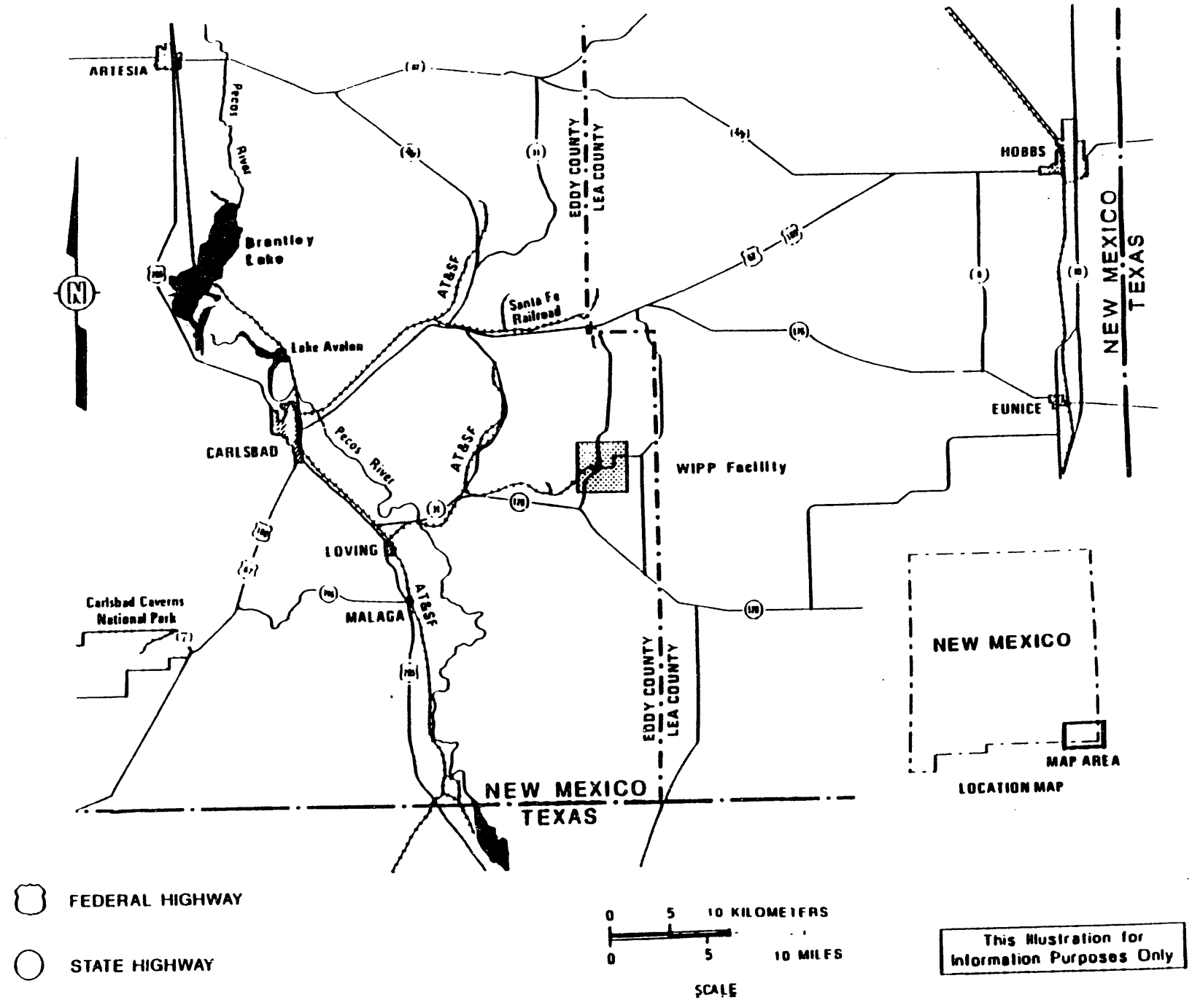

FIGURE 1 GENERAL LOCATION OF THE WIPP FACILITY

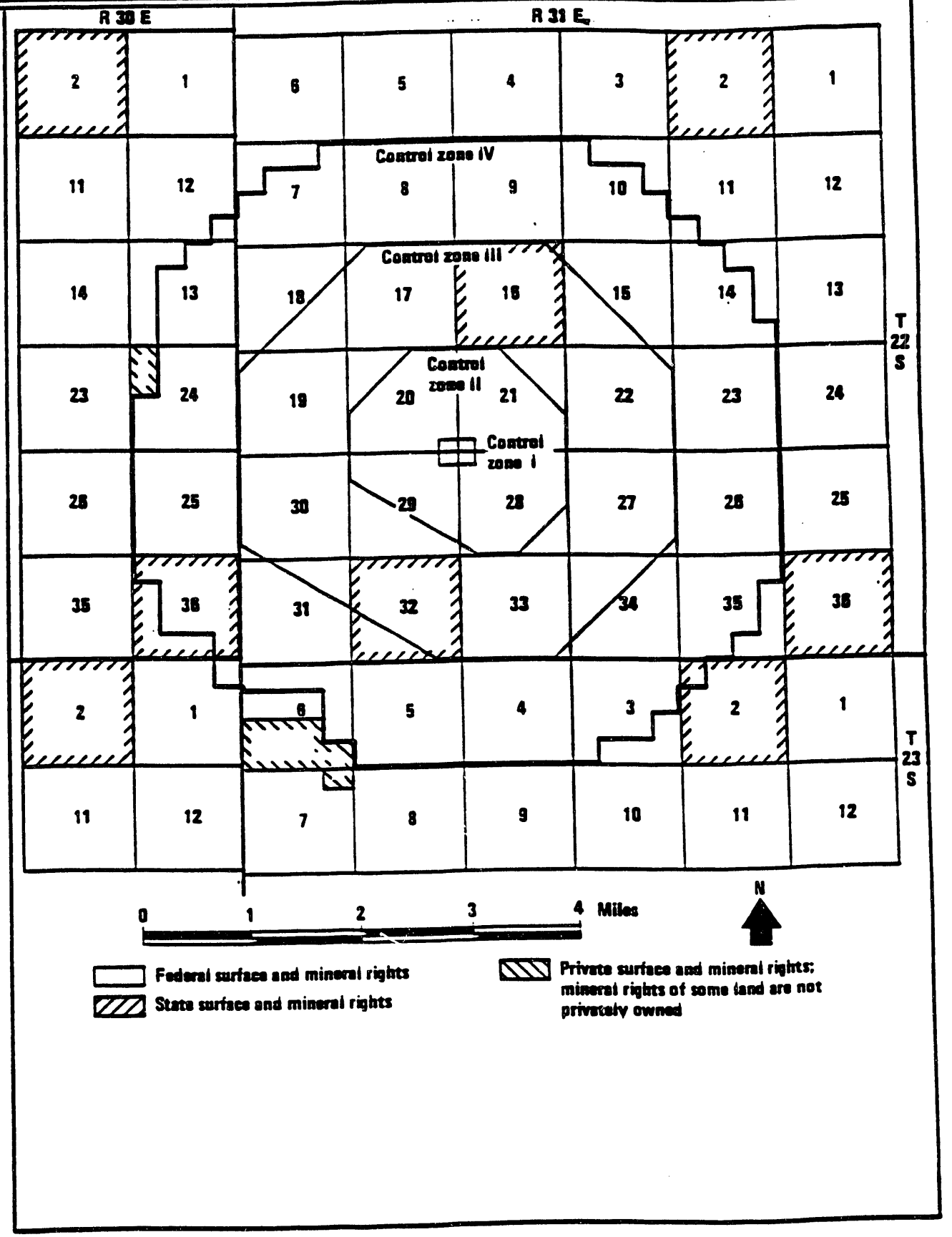

FIGURE 2 ORIGINAL CONTROL ZONES AT THE WIPP SITE

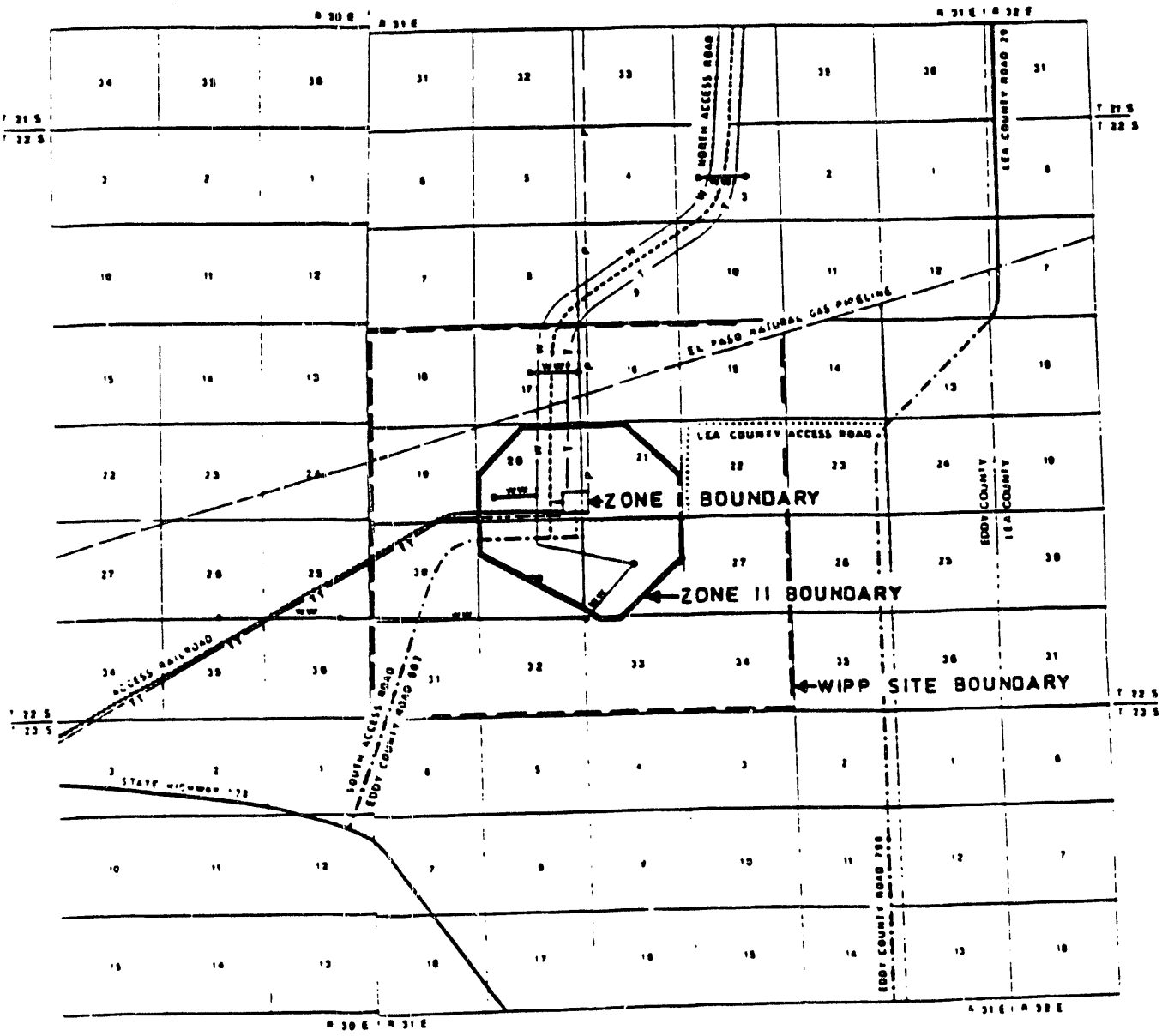

FIGURE 3 CURRENT WIPP FACILITY BOUNDARIES

TABLES

Table 4-1. Comparison of Geologic Media Considered for the WIPP Facility

Property	Salt	Basalt or Granite	Shale
BASIC PROPERTIES			
Plasticity	High	None	Variable
Solubility	High	Very low	Very low
Sorptive Capacity	Low (depends on impurities)	Fair	High
Compressive Strength	Moderate	High	Moderate
Thermal Diffusivity	High	Low	Low
Thermal stability against chemical decomposition	High	High; potential dewatering of clay in basalt	High; potential dewatering of clay
IN-SITU PROPERTIES			
Porosity	0.5%, interstitial	1%, cracks	5-30%, cracks
Permeability	Essentially none	Decreases with depth	Very low
Water presence	Isolated from flowing groundwater	Present, open to flowing groundwater	Present, open to flowing groundwater
Corrosiveness of indigenous fluid	High	Low to moderate	Low to moderate
Tectonic stability	Very stable	Very stable areas can be found	Very stable areas can be found
Geologic structure	Relatively simple areas can be found	Fracture systems often complex	Like salt
Hydrology	Moderately difficult to characterize	Difficult to characterize	Difficult to characterize
PRACTICAL MATTERS			
Availability	Good	Good	Good
Need to use explosives	No	Yes	Possibly
Understanding of medium for repository use	Well studied	Not well studied	Not well studied
Waste rock	Reuse some; pile needs protection from erosion and runoff	Reuse some; pile probably does not need protection	Reuse some; pile needs protection but less that salt
Mathematical modeling	Relatively simple; well developed	Relatively complex; not fully developed	Relatively complex; not fully developed

Source: U. S. Department of Energy, 1980, p. A-4.

Table 4-2. Hydrocarbon Reserves and Resources at the WIPP Site

	Condensate (bbl)			Gas (10^6 ft^3)		
CATEGORY	ZONES I,II,III	ZONE IV	CATEGORY TOTAL	ZONES I,II,III	ZONE IV	TOTAL
Proved but undeveloped reserves	0	81,758	81,758	0	11,610	11,610
Probable reserves	11,640	9,822	21,462	9,050	10,094	19,144
Possible reserves	14,169	1,135	15,304	12,002	1,866	13,868
Total reserves	25,809	92,715	118,524	21,052	23,570	44,622
Unassigned reserves and resources			272,319			39,352
Grand total			390,843			83,974

Source: U.S. Department of Energy, 1980, p. 7-74.

Table 4-3. Summary of the Impacts of Hydrocarbon Resource Denial

RESOURCES

DEPOSIT	SITE TOTAL	REGION	UNITED STATES	WORLD
Natural Gas (bill. ft³)	490	25,013	855,000	N/A
Control Zones I-III	211	0.8 %	0.025 %	
Control Zone IV	279	1.1 %	0.033 %	
Distillate (mill. barrels)	5.72	293	N/A	N/A
Control Zones I-III	2.46	0.84%		
Control Zone IV	3.26	1.11%		
Crude Oil (mill. barrels)	37.5	1915	200,000	N/A
Control Zones I-III	16.12	0.84%	0.008 %	
Control Zones IV	21.38	1.12%	0.0006%	

RESERVES

DEPOSIT	SITE TOTAL	REGION	UNITED STATES	WORLD
Natural Gas (bill. ft.³)	44.62	3865	208,800	2,520,000
Control Zones I-III	21.05	0.54%	0.01 %	0.0008%
Control Zone IV	23.57	0.61%	0.011 %	0.0009%
Distillate (mill. barrels)	0.12	169.1	35,500	N/A
Control Zones I-III	0.03	0.02%	0.00008%	
Control Zone IV	0.09	0.06%	0.00024%	
Crude Oil		471.7	29,486	646,000

Source: Based on U.S. Department of Energy, 1980, p. 9-19 and 9-28.

Table 4-4. Summary of Potash Resources at the WIPP Site

RESOURCES

DEPOSIT	SITE TOTAL	REGION	UNITED STATES	WORLD
Sylvite (mill. tons ore)	133.2	4260	8550	850.000
Control Zones I-III	39.1	0.92%	0.46%	0.0046%
Control Zone IV	94.1	2.21%	1.10%	0.01%
Langbeinite (mill. tons ore)	351.0	1140	N/A	N/A
Control Zones I-III	121.9	10.7 %		
Control Zone IV	229.1	20.1 %		

RESERVES

DEPOSIT	SITE TOTAL	REGION	UNITED STATES	WORLD
Sylvite (mill. tons K_2O)	3.66	106	206	11,206
Control Zones I-III	NIL			
Control Zone IV	3.66	3.45%	1.78%	0.33%
Langbeinite (mill. tons K_2O)	4.41	9.3	9.3	N/A
Control Zones I-III	1.21	13.0 %	13.0 %	
Control Zone IV	3.20	34.4 %	34.4 %	

Source: U.S. Department of Energy, 1980, p. 9-19 and 9-28.

APPENDIX A

LIST OF PUBLICATIONS ADDRESSING SITE SELECTION
(FROM EEG-1)

nflict with Natural Resources

1. Should be taken into account/information useful for site selection/evaluation:
   i. to be considered in making criteria - petrographical and mineralogical composition and economic value, p. 12-13; questions regarding salt as host media: often associated with potash and oil and may be an attractive target for exploratory boreholes, p. 9, AECL Canada 1976, E2
   ii. for salt formation, occurences of petroleum, potash mines, oil and gas production, USGS 4339-1, 1972, B2
   iii. Criteria - future value of potash deposits should be considered, p. 70-71; economic development - potash, ranches, oil and gas fields, p. 45, USGS 4339-6, 1973, B4
   iv. study considered oil and gas deposits, potash, p. 20, USGS 74-190, 1974, B9
   v. criteria considered - oil, gas and recreational potential development, p. 2-3, Supplemental Areas, Kn GS 1972, B11
   vi. in geologic study of areas, range of tasks includes natural resource evaluation, including those items relating to people's activities in the subsurface which would alter the natural geologic conditions, p. 22, OWI/ERDA Program Plan for NWTSP 1976, D19
   vii. petroleum, potash, sulfur - may be present near a salt deposit. Necessary to weigh need for rep and the availability of other sites against present and potential need for mineral resources at site.
   - p. 6, OWI/DOE Salt Dep of US 1978, D21
   - p. 48, IAEA SS Factors 1977, E11
   viii. potential for oil and gas - considered since it might attract drilling, ORNL McClain and Boch 1974, D3
   ix. potential sites in salt should be evaluated for potential exploitation and/or contamination of oil, gas, and water resevoirs, and of salt, potash and other valuable or potentially valuable commodities, p. 4.63, HLWM Alternatives, BNWL-1900, 1974, D16
   x. site selection - determine suitability of broad regions in terms of potential for denial of natural resources, p. 13; site evaluation - need detailed definition of distribution of physical properties throughout site (i.e. petrologic and mineralogic features), p. 14; ES aspects of long term risk analysis - need knowledge of processes that affect containment capability: identification of mineral resources that might serve to cause people to penetrate rep, p. 16-17, ESTP USGS and DOE 1979, D24
   xi. events taken into account in risk analysis - human intrusion: gas/oil exploration, mineral exploration, p. 95-103, AD Little, Assessment 1978, C3

2. Formation should not be associated with or be in the immediate vicinity of potentially valuable mineral resources:
   i. no area with present or past history of resource extraction except by surface quarrying should be considered, p. 13-15, NAS/NRC 1978, A1
   ii. to the extent possible, p. 2:10; unavoidable conflict with resources should be minimized to the extent possible (large scale site selection criteria), p. 2:20-21, GCR 1978, D10

iii) p 15, Canada AECL 1975, E1

iv) tract considered is most promising since it is 5 miles or more from any center of industrial activity, i.e. gas or oil wells or mines, p 34-35, USGS 4339-7, 1973, B5

v) preferred salt environment -where oil and gas potential is low; unsuitable area - where strata have high oil or gas potential, p 3 USGS 74-158, (B8) 1974; p 4.4, HLWM Alternatives, BWNL - 1900, 1974 (D16).

vi) p 21 AEC, Lyons E. S. 1971, D6

vii) Criteria must be met: waste must not be placed in potentially useful mineral deposits, p 13-14, Deep Rock, Klett/Sandra 1974, D8

viii) SS criteria p 12-13, SS WIPP/Sandia 1977, D9

ix) Site should not offer an attractive resource target p 5; actual or potential resource of site should be such that it will not unduly depri this or future generations of necessary and valuable resources, p 5-6, Nureg 0353, NRC-State Review 1977, C4

x) Would make site more favorable, p 6, OWI/DOE Salt Dep of US 1978, D21

xi) p 3-4, ORNL, Program Plan for BSPP 1973, D1

xii) Avoid areas where mineral resources are "known to abound" and where resources were "worked out" in formation below rep, Kehnemuyi, Battelle M, 1979, D23

xiii) avoid areas of existing production or extensive exploration as much as possible, p 10, mineral potential should be minimal to minimize probability of future operations. p 11, summary, BSPPSS Factors ORNL 1973, D2

xiv) presence of potentially mineable minerals detract from usefulness of hos rock for disposal, p 33, IAEA SS Factors 1977, E11

xv) as much as possible - p 5, Brunton & McClain, OWI/ERDA 1977, D20

xvi) de Marsily, etal, Guarantee Isolation? 1977, E5

xvii) p 2-9, 4-73, ES of WM of LWR Cycle, NRC 1976, C8

Reasons:

a. potential source of raw materials that would be denied:

i) p 13-15, NAS/NRC 1978, A1

ii) proposed criteria: actual or potential resource value of site should be such that it will not unduly deprive this or future generations of neces and valuable resources, p 5-6 NRC State Review, Nureg-0353 1977, C4

iii) p 36-40, EPA State of Geologic Knowledge 1978, C7

iv) waste disposal facilities shall be sited and operated to avoid as much as possible the foreclosure of future options. p 13, NRC - Proposed Goals for WM, 1978, C9

b. disturbance of hydrological/geological system by boreholes, shafts, fractures, cavities;

i) p 13-15, NAS/NRC 78, A1

ii) p 32 OWI/ERDA, Program Plan for NWTSP 1976, D19

iii) avoidance of areas over "worked out" mineral deposits because of danger of subsidence, Kenhemwyj, Battelle M, 1979, D23

iv) site should be located so that existing subsurface operations would be outside buffer zone and to minimize probability of future operations since current technology makes it difficult to predict what the eventual effects of mechanical or solution mining on rep might be. p 11, BSPPSS Factors ORNL 1973, D2

v) people are now one of the major driving forces for geologic change (erosion, solid movement and water movement for example) p-13, NRC Proposed Goals for RWM 1978, C9

vi) site should be where intrusion of people in a manner that will change conditions is minimal. p 4.5 HLWM Alternatives, BNWL-1900 1974, D16

c. Attract propspection - exploration that might penetrate rep:

i) p 13-15, NAS/NRC 1978, A1

ii) danger of reexploitation of already mined resources; Kehnemwyj, Batelle, M, 1979, D23

iii) minimize probability of future operations within buffer zone, p 11, BSPP SS Factors, ORNL 1973, D2

iv) Must have no natural resources in area that would attract prospection deMarsily, et al, Guarantee Isolation? 1977, E5

v) site should not offer attractive resource target, p 5, NRC, State Review, Nureg 0353, 1977, C4

vi) Recommendations have been presented p IV-57, KBS Rydberg & Winchester 1978 E9

vii) People will seek anything of value and are now one of the major driving forces of geologic change - to the extent predictable, we should design and locate facilities so as to avoid motivation for penetrating disposal volume, p 13 NRC-Proposed Goals for RWM 1978, C9

viii) p 35-40, EPA State of Geologic Knowledge 1978

3. Avoid conflicts with water as a natural resource:

i) esp in arid areas, groundwater is an important commodity - extensive deposits of fresh water above or below site could adversely affect its availability due to public opinion, p c 10-12, ERDA/BNWL, App c 1976, D1
p 41, IAEASS Factors 1977, E11

ii) special care needed if water near site is used by municipalities, industry, agriculture, p 5-6 OWI/DOE Salt Dep of US 1978, D21

iii) avoid areas where groundwater resources are extensively used and/or have potential for significant future development -Kehnemwyj, Battelle M, 1979;
-SS Factor, BSPPSS Factors, ORNL 1973, D2
-p 6 Brunton & McClain, OWI/ERDA 1977, D20
-p 4.4.H L WM Alternatives, BNWL-1900 1974, D16

iv) there may be conflict with industrial, recreational, scenic interest in large lakes and streams - p C 10-12, ERDA/BNWL, Alternatives App c 1976, D18
- p 41 IAEA SS Factors 1977, E11
- p 6 Brunton & McClain, OWI/ERDA 1977, D20

4. Waste placed in rep as a natural resource:

i) operation of the rep should not create a potential future source of valuable material; unreprocessed spent fuel elements, potentially highly valuable to future people, should not be placed in non-retrievable storage (temptation to penetrate rep), p 13-15, NAS/NRC 1978, A1

ii) consideration: since uranium ore is limited, it may become desirable to recover unreprocessed fuel rods, so a breach in the rep to recover them co be a serious problem in the future. p 3, p 35-36 State of Geologic Knowledge 1978 EPA, C7

iii) goals for RWM: to the extent predictable, we should design and locate facilities so as to avoid motivation for penetrating the disposal volume. p 13, NRC-Proposed goals for RWM 1978, C9

5. If the rep is located where there are natural resources present or near-by:

i) If possibility exists that some valuable resource is present, it will be necessary to show that credible attempts to recover the resources will nc have adverse effects on the effectiveness of the rep, p 5; Proposed criteria: site should have characteristics such that the consequences of unplanned intrusions will be ALARA p 5-6, Nureg 0353, NRC State Review 1977, C4

ii) accidental penetrations should not result in undue hazard. p 2:17 GCR 197

iii) Resources could be extracted from adjacent regions with proper evaluation and precautions. To be considered in evaluations: compatibil of operations, impact on rep from extraction operations, possibility of contamination of resource by waste. p 48, IAEA SS Factors 1977, E11

iv) "The expectation, but one that cannot yet be guaranteed is that these minerals (at WIPP site in Zone III) may be recovered in decades ahead should they be economically attractive. Certainly the time frame for the development would be within the next century while the rep site is still under administrative control. The small amounts of either resource within zone III would not be of significant interest in the absence of o production in the area." p 10, Letter from Beckner to Schueler, Dec. 19 D13

v) Rydberg -Though recommendations have been presented that rep be placed in area with no valuable minerals, "it seems probably that a future pers who is capable of mining and drilling to a depth of 500m, also will use instruments capable of detecting radioactivity." p IV-57- KBS Rydberg & Winchester 1978, E9

6. Can we predict the likelihood of intrusion of people into rep in search of resourc

i) Uncertainities are introduced into risk assessments because of uncertai of probabilities and consequences of human intrusion. p 4-94, ES of WM of LWR Cycle, NRC 1976, C8

ii) Another risk for which no trustworthy probability estimates can be appl

intrusion at some future date by people in search of minerals (including the uranium and TRU buried in rep) or to satisfy archeological or other curiosity. People's unpredictability far outstrips that of most of the imagined geologic hazards, p. 35-36; as raw materials dwindle there will be an increasingly desperate exploitation of them. What mineral resource exploitation might be like a thousand years from now is impossible to predict - should be considered, p. 36-40, EPA State of Knowledge, 1978, C7

iii. Do we adequately understand how to evaluate current resource conflicts? models tested, applying to specific site (including WIPP), p. 38; Can we estimate the long term effects of future resource conflicts? moderate understanding of principles, developing models, p. 44, ESTP USGS and DOE 1979, D24

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C2. EPA Crit for RW/Rec for Fed Guidance, Fed Reg 1978 - "Criteria for Radioactive Wastes/Recommendations for Federal Guidance", Federal Register, Nov. 15,1978, EPA

C3. AD Little Assessment 1978 - Arthur D. Little, Inc., "Subtask D: Assessment of Accidental Pathways/Technical Support for Radiation Standards for High Level Waste Management", Draft, done for EPA, Feb. 1978

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APPENDIX B

DOE REVISED INTERIM POLICY STATEMENT

Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

DEC 2 3 1982

Dr. George S. Goldstein
Chairman, Radioactive Task Force
Health and Environment Department
P.O. Box 968
Santa Fe, NM 87503

Dear Dr. Goldstein:

DOE Revised Interim Policy Statement on Natural Resource Recovery at the WIPP Site

Enclosed for your use and information is the DOE Revised Interim Policy Statement on Natural Resource Recovery at the WIPP Site. Under the terms of this policy statement no potash or other commercial mining in, or commercial drilling from, Control Zones I, II and III will be allowed; however, the DOE will exercise no control over mining or drilling outside Control Zone III. (Control Zone III is being redefined as the area withdrawn for SPDV which is a square containing 16 sections (10,240 acres) surrounding the center of the site.) Additionally, BLM will prohibit permanent inhabitation of Zone IV while the facility is in operation. Hydrocarbon resources below 6000 ft. beneath Control Zones I, II and III can be accessed by deviated drilling from outside the Control Zone III boundary. The DOE will rely on the review of State and Federal regulatory agencies, including the New Mexico Energy and Minerals Department and the U.S. Department of the Interior, Minerals Management Service, to protect the integrity of the WIPP Site boundaries from commercial exploration, mining or other extractive activities. So that the DOE can maintain information on resource recovery near the WIPP Site, the Bureau of Land Management will notify the DOE of any requests for resource recovery permits within one mile of the WIPP Site boundary.

The final DOE policy will be issued when the decision is made regarding retrieval of the waste. Should the DOE decide to retrieve all the radioactive waste, the WIPP Site will become available for complete resource recovery after retrieval and decommissioning are complete.

The initial Interim Policy Statement, which was transmitted to the State of New Mexico on November 3, 1981, was developed to serve as the basis for the performance of the Natural Resources Study. The initial DOE

Interim Policy, as indicated therein, was "temporary denial of all resource extraction within the four control zones of the WIPP Site until the decision is made relative to which, if any, of the emplaced waste will be retrieved." Based on the conclusions of the Natural Resources Study, which was transmitted to the State of New Mexico on October 5, 1982, we have determined that the initial Interim Policy can be revised as indicated above.

Not only does the DOE Revised Policy Statement reflect the conclusions of the Natural Resources Study but it also addresses comments provided by the New Mexico Environmental Evaluation Group on the Policy Statement.

If you require additional information or have questions on this matter, please contact me.

Sincerely,

J. M. McGough
Project Manager
WIPP Project Office

Enclosure

WIPP:JMM 82-0885/6366A

cc: w/encl:
J. K. Otts, Chairman, Radioactive Waste Consultation Committee, Santa Fe, NM
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DOE REVISED INTERIM POLICY STATEMENT ON RESOURCE RECOVERY AT THE WIPP SITE

The policy of the Department of Energy (DOE) concerning resource recovery at the Waste Isolation Pilot Plant (WIPP) site during facility construction and operation is as follows:

- No potash or other mining excluding that conducted for the WIPP Project will be allowed in WIPP Control Zones I, II, and III.

- No drilling excluding that conducted for the WIPP Project will be allowed from Control Zones I, II, and III.

- Drilling from outside Control Zone III to access locations beneath Control Zones I, II, and III at depths greater than 6,000 feet will be allowed if the planes formed by the downward vertical projections of the Control Zone III boundaries are not penetrated above a depth of 6,000 feet.

- DOE will rely on the review of State and Federal regulatory agencies, including the New Mexico Energy and Minerals Department and the Minerals Management Service, U.S. Department of the Interior, to protect the integrity of the WIPP site boundaries from commercial exploration, mining, and other extractive activities.

- If the DOE decides that all radioactive waste is to be retrieved, the WIPP site will become available for complete resource recovery once retrieval and facility decommissioning is accomplished.

This policy may be re-evaluated after facility decommissioning. The following paragraphs provide a measure of clarification of the rationale used to develop the resource recovery policy.

It is the policy of the DOE to maximize the opportunity for resource recovery at the WIPP site, consistent with the requirements to isolate the emplaced radioactive wastes from the biosphere. Within five years after the first emplacement of each type of TRU waste (i.e., contact and remotely handled), separate decisions will be made about the retrieval of each kind of waste. If the DOE decides that all waste is to be retrieved, the WIPP site will become available for complete resource recovery once retrieval and facility decommissioning are accomplished.

The criterion for the DOE policy is that permanent denial of resources should be limited to those areas in which extraction activities could potentially lead to measurable effects[1] on the WIPP facilities or whose protection is needed to satisfy institutional considerations, all extraction activities that would not lead to measurable effects on the WIPP site are defined as "allowable" under the DOE policy.

Potash (sylvite and langbeinite) and hydrocarbons (natural gas and distillate) comprise the resources present at the WIPP site that are of interest considering the technology and market conditions in the foreseeable future. These resources and the methods available to recover them are described in detail in the FEIS (U.S. Department of Energy, 1980).

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1 Measureable effects are those influences from extraction activities that could cause the assumptions made in the breach scenario consequence analyses (U.S. Department of Energy, 1980) to be unconservative.

Due primarily to institutional considerations, no potash mining in or commercial exploratory drilling (hydrocarbon or other) from Control Zones I, II, and III will be permitted. A study was conducted to investigate the possible effects of resource recovery within Control Zone IV on the WIPP facility (Natural Resources Study, Brausch et al., 1982). The following paragraphs provide a brief summary of the results and conclusions of that study.

The extraction of potash outside Control Zone III is allowable. Potential methods of mining potash include drill-and-blast, continuous mining, solution mining, shortwall, and longwall techniques. Since mining of potash is allowable, it is not reasonable to prohibit those mining techniques that make such an activity economically viable. To prohibit such activities is, in effect, to preclude mining. Accordingly, extraction ratios can be maximized in any mines developed outside Control Zone III of the WIPP site, consistent with mine safety considerations and other state and federal requirements. Solution mining will be allowable outside Control Zone III. Resource extraction by solution mining may be applied to recovery of sylvite. Solution mining for recovery of langbeinite would be ineffective because langbeinite is less soluble than the surrounding minerals (e.g., halite, sylvite). However, the lack of existing solution mining for sylvite in the Carlsbad potash mining district suggests that solution mining for potash within Control Zone IV may not be feasible.

The recovery of hydrocarbon resources outside Control Zone III is allowable. This activity includes drilling, production stimulation, and, possibly, secondary recovery. Resources located outside Control Zone III may be accessed by vertical drilling; resources located beneath the inner three control zones at depths greater than 6,000 feet may be accessed by drilling vertically outside Control Zone III to a depth of 6,000 feet and then deviating from vertical at the angle required to reach the target resource zone.

If oil or gas is found, it is not reasonable to prohibit those techniques available to the producer that maximize recovery. Enhancing the production from drilled wells by hydraulically fracturing the reservoir rock, acidizing the formation, or other applicable techniques would not be expected to affect the WIPP facility.

These types of production stimulation are used primarily to increase the permeability of the rock that contains the hydrocarbons. Secondary recovery methods (techniques used to enhance or replace the natural driving force that "pushes" the oil to the production well) and tertiary methods (techniques used primarily to decrease the viscosity of heavy crude oils) may also be employed but, because the crude oil resources at the site are not reasonably or economically extractable, these techniques, are not expected to be useful unless significant technological advances and adaptations are made.

State and federal regulatory agencies, including the New Mexico Energy and Minerals Department and the Minerals Management Service of the U.S. Department of Interior, are responsible for reviewing proposed mining and hydrocarbon exploration plans to prevent injury to adjacent leases or properties. The DOE will rely on this regulatory review process to protect the integrity of the WIPP site boundary from potash mining and hydrocarbon exploration on adjacent properties. The DOE will provide assistance to these agencies during the review process upon request. In addition, the BLM will notify the DOE of any requests for permits for resource recovery activities within one mile of the WIPP site boundary.

This policy will be modified if changes in institutional requirements occur or if significant new data relevant to the policy are obtained during development and operation of the WIPP facility.

APPENDIX C

FINAL ENVIRONMENTAL IMPACT STATEMENT APPENDIX D, SELECTION CRITERIA FOR THE WIPP SITE

CONTENTS

Appendix D

SELECTION CRITERIA FOR THE WIPP SITE

This appendix briefly describes how the geologic, hydrologic, and other characteristics of the WIPP site in southeastern New Mexico meet site-selection criteria and factors. The criteria and factors given here are from the Geological Characterization Report (Powers et al., 1978, pp. 2-15ff) and are based on criteria suggested earlier by the Oak Ridge National Laboratory (ORNL, 1973), the International Atomic Energy Agency (1977), and Brunton and McClain (1977).

The site-selection criteria described here were originally formulated under the expectation that the WIPP would be a repository that would contain spent fuel from nuclear reactors. The heat emitted by spent fuel would have had important effects on the salt in which it was emplaced; for that reason, some of the criteria were specifically intended to insure the safety of spent-fuel emplacement. The WIPP mission no longer includes the disposal of spent fuel or any other high-level waste. Furthermore, the design of the WIPP no longer includes the separate mined cavity for high-level waste called the "lower repository" or the "lower horizon" in the criteria. Accordingly, not all the criteria presented here are applicable to the WIPP under its current mission and design. Because the site was, however, actually selected under these criteria, no effort has been made to revise them for this document.

D.1 GEOLOGIC CRITERION AND SITE-SELECTION FACTORS

The geology of the site will be such that the repository will not be breached by natural phenomena while the waste poses a significant hazard to man. The geology must also permit safe operation of the WIPP repository.

Topography. The terrain must permit access for transportation. The effect on inducing salt flow during excavation must be considered. Surface-water flow and the potential for flooding must be evaluated.

The maximum relief over the WIPP repository is 120 feet. The regional relief is low and easily accommodates the required transportation corridors. The location near a broad surface and groundwater divide will minimize the development of future relief. Differential stress in the salt due to surface relief is not a significant factor in causing deformation in the salt. (See Powers et al., 1978, Sections 3.2 and 4.2.)

Depth. Repository horizons should be deeper than 1000 feet to insure that erosion and consequences of surficial phenomena are not a major concern. The depth of suitable horizons will not exceed 3000 feet to limit the rate of salt deformation around the excavations.

The selected repository bed for heat-producing waste varies between depths of 2750 and 2250 feet over the potential excavation area. The bed for TRU

waste ranges from 2200 to 1800 feet deep through the repository region. These depths are based on interpretations of seismic reflection data. (See Powers et al., 1978, Sections 3.3, 4.3, and 9.2.)

Thickness. The total thickness of the salt deposits should be several hundred feet to buffer thermal and mechanical effects. The desired thickness for the repository bed is 20 feet or more to mitigate the thermal and mechanical effects at nonhalite units.

The halite unit in which the heat-producing waste will be placed is about 100 feet thick. The total thickness of the evaporite section provides about a 1300-foot buffer above and below the repository horizons. This distance to the nearest potential aquifers insures that the thermal effects at these aquifers will be insignificant. (See Powers et al., 1978, Sections 4.3.2 and 9.2.)

Lateral extent. The distance to structural or dissolution boundaries must be adequate to provide for future site integrity. For the Los Medanos area a distance of 5 miles to the Capitan reef and 1 mile to regional Salado dissolution has been established.

From seismic data and drill-hole information, the selected horizons are believed to extend well beyond the repository site. The separations from the deformed salt belt parallel to the Capitan reef and from the natural dissolution fronts are adequate to insure the required site integrity. (See Powers et al., 1978, Sections 3.3, 4.3, and 6.3.)

Lithology. Purity of the salt beds is desirable. Brine in the salt could induce geochemical interactions; pending further investigations, 3% brine is established as a desirable upper limit for the heat-producing waste horizon. Additional geochemical interactions must be considered if significant chemical or mineral impurities are present.

The horizon within the lower Salado that will accommodate the heat-producing wastes averages more than 97% halite from the samples analyzed. Brine content averages less than 0.5%. (See Powers et al., 1978, Sections 4.3 and 7.2 through 7.6.)

Stratigraphy. Continuity of beds, character of interbedding, and nature of beds overlying and underlying the salt are important considerations in the construction of the facility; they are also important in insuring the long-term integrity of the repository.

There are no beds of clay or polyhalite near enough to the lower repository horizon to affect repository construction and operation or to affect the long-term performance of the repository. The significant nonhalite beds adjacent to the heat-producing-waste horizons are principally anhydrite, which has favorable thermal, mechanical, and chemical properties for bounding layers. The upper (TRU-waste) level of the repository can also be located to avoid rock-mechanics instabilities due to interbeds of nonhalite rock. (See Powers et al., 1978, Sections 3.3, 3.4, 4.3, and 4.4.)

Structure. Relatively flat bedding (less than 3 degrees) is desirable for operational purposes. Steep anticlines and major faults are to be avoided.

Seismic-reflection data and drill-hole information have been interpreted as showing relatively flat (less than 1 degree) bedding over most of the 3-square-mile repository horizon. Seismic data do show a small anticline at the northern edge of control zone II. Drilling on this anticline (WIPP-12) has shown that the elevation difference of the repository beds, from ERDA-9 at the center of the repository to WIPP-12, is less than 200 feet, an average of about 2 degrees. Photography, satellite imagery, surface mapping, geophysical techniques, and drilling have been used to search for indications of significant faulting. No post-Permian faults are known to exist in the site area. Seismic indications of faulting in older, deeper rocks do not extend through the Permian evaporite section.

The lack of severe structure and recent faulting satisfactorily meets the desired conditions for this factor. (See Powers et al., 1978, Sections 3.4 and 4.4.)

Erosion. While the depth of the repository reduces concern about erosion, it is desirable to avoid features that would tend to localize or accelerate erosion.

The site is located near a broad surface-water divide, and the local base level is at an elevation of about 2900 feet. Consequently, future erosion will proceed less rapidly over the site than in the established drainage channels. The expected erosion rates will not expose the Salado salt within the required lifetime of the repository. Future climatic changes will not alter this assessment, and glaciation is not expected to be a concern at this location. (See Powers et al., 1978, Sections 3.2.3, 3.6, 4.2, and 6.2.)

Dissolution. Regional and/or local dissolution must not breach the repository while the wastes represent a significant hazard to people. While there are various suggestions for the time a repository should remain isolated from the biosphere, a period of 250,000 years (10 half-lives of plutonium-239) is commonly used to represent the time over which the wastes are significantly hazardous.

Studies by the U.S. Geological Survey indicate that the maximum rate of horizontal progression of the salt-dissolution front in Nash Draw, averaged over the past 500,000 years, has been 6 to 8 miles per million years and less than 500 feet vertically per million years. The nearest active solution front is to the west, in Nash Draw. This is far enough from the site to provide repository isolation for more than 2 million years. (See Powers et al., 1978, Section 6.3.6.)

Subsidence. Subsidence due to dissolution of salt will be avoided when the subsidence adversely affects the repository beds or unduly accelerates the rate of dissolution to the jeopardy of the long-term integrity of the repository.

Subsidence has occurred over the western portion of the WIPP site area because of the natural removal of salt from the Rustler Formation. Hydrologic data from this region indicate that the major aquifers in the Rustler have different potential heads, and thus this regional subsidence has not caused them to be interconnected by permeable fractures. No sinks due to localized solutioning are present at the site.

D.2 HYDROLOGIC CRITERION AND SITE-SELECTION FACTORS

The hydrology of the site must provide high confidence that natural dissolution will not breach the site while the waste poses a significant hazard to man. Accidental penetrations should not result in undue hazards to mankind.

Surface water. Present and future runoff patterns, flooding potential, etc., should not endanger the penetrations into the repository while these openings are unplugged.

Because the site is near a broad surface-water divide, lacks established drainage, and is well above the Pecos River, simple construction techniques will prevent flooding of the repository. (See Powers et al., 1978, Section 6.2.)

Aquifers. For the WIPP, the overlying and underlying aquifers represent a secondary barrier if the salt is breached. Consequently, low permeability and transmissivity are desirable but not mandatory. Accurate knowledge of aquifer parameters is important to construction, decommissioning, and realistic calculation of the consequences of failure scenarios.

Aquifers above and below the repository have low transmissivity. Consequently, flooding of the repository during its operation through shafts or drill holes is not credible. These access points can readily be plugged to prevent water inflow after decommissioning.

The quantity of water carried by the major aquifers above and below the WIPP beds is too small to be useful. Furthermore, the water carries too many salts to be potable or otherwise useful.

The hydrologic parameters of the aquifers do not permit rapid flow of water. The low permeability would limit the flow even if heads were to be modified in future pluvial cycles. (See Powers et al., 1978, Section 6.3.)

Hydrologic transport. For the WIPP, this is a secondary factor that must be evaluated to allow quantitative calculations of the consequences of various failure scenarios. Slow transport of isotopes is acceptable if more critical factors have been satisfied.

Calculations based on various postulated failure scenarios show that the transport of radionuclides through the overlying and underlying aquifers would be so slow that a significant hazard to people would not exist even if the salt beds were breached. The nearest natural discharge point is near Malaga Bend on the Pecos River, over 14 miles away. At the maximum measured rate of water movement, it would take about 1700 years after a breach for the first trace of nonretarded nuclides (i.e., iodine-129) to appear at the Pecos. The long-lived transuranic nuclides would be retarded by the sorption of ions and would not begin to appear at Malaga Bend until 35,000 years after a postulated breach of the salt beds. The concentrations of radionuclides (or possible radiation doses) would never reach significant hazard levels in the Pecos River. (See Powers et al., 1978, Sections 6.3, 9.3, and 10.6.)

Climatic fluctuations. Possible pluvial cycles must be considered in estimating the effects of the hydrologic factors.

The dissolution and erosion rates established as averages over the past 500,000 years include the effects of several past pluvial cycles. It is expected that future cycles would also be shorter than the isolation time sought for the repository. Transport rates under different climates (rainfall) can be estimated by appropriate boundary conditions on the hydrologic model. The low permeability of the major aquifers above the site will not be significantly altered by the climatic changes expected for this area, and the resultant flow in the aquifers will not be grossly altered by changed climatic conditions. (See Powers et al., 1978, Sections 3.6 and 4.5, Chapter 6, and Section 10.3.)

Man-made penetrations. The effect of drill holes and mining operations must be included in evaluating the potential effects of dissolution.

The repository and control zone III are free of preexisting boreholes that extend through the salt, shafts, and mining activity. Any existing or future holes in any of the WIPP zones must be adequately plugged when abandoned.

D.3 TECTONIC STABILITY CRITERION AND SITE-SELECTION FACTORS

Natural tectonic processes must not result in a breach of the site while the wastes represent a significant hazard to people and should not require extreme precautions during the operational period of the repository.

Seismic activity. The frequency and magnitude of seismic activity impact facility design and safety of operation. Low levels of seismicity are desirable, but facility design can accommodate higher levels as well.

The WIPP site is in an area of relatively low seismic activity. The nearest seismic activity has been 10 or more miles north of the site and of small magnitude. It is not known whether the three nearest events were tectonic, related to salt dissolution, or a result of human activity. No faulting has been observed in the area of these seismic events. In any case, they and the potential future events pose no hazard for a properly constructed repository and are no threat to its long-term integrity. (See Powers et al., 1978, Chapter 5 and Section 10.5.)

Faulting and fracturing. While open faults, fractures, or joints are not expected in salt, the more brittle units within and surrounding the salt may support such features that can enhance dissolution and hydrologic transport. Major faults and pronounced linear structural trends should be avoided.

No major structural trends of recent geologic age are known to exist in the site area. The nearest recent faulting observed is on the west side of the Guadalupe Mountains, some 70 miles away. Seismic-reflection data have indicated small faults in deep, old rocks below the Salado Formation. There are no known tectonic faults in post-Permian rocks at the site area. Thousands of miles of drift in the potash mines in the Salado salt have not encountered any open fractures or faults through which groundwater had penetrated.

Salt-flow anticlines. Major deformation of salt beds by flow can fracture brittle rock and create porosity for brine accumulations. Major anticlines resulting from salt flow should be avoided or evaluated to check on brine presence and anhydrite fracturing.

The only anticlines within the site are relatively minor features. Both have been drilled, however, and the cores show little fracturing or porosity and no accumulation of fluids. These small anticlines will not hinder repository construction or jeopardize its long-term safety. (See Powers et al., 1978, Section 4.4.)

Diapirism. An extreme result of salt flow, this feature will be avoided for WIPP siting.

There are no known or indicated diapirs (salt domes) at the WIPP site. (See Powers et al., 1978, Section 4.4.)

Regional stability. Areas of pronounced regional uplift or subsidence should be avoided since such behavior makes prediction of future dissolution, erosion, and salt flow more uncertain.

Geologic mapping has failed to reveal any indicators of regional instability. Caliche formation and attitude indicate stable conditions in the site region over the last half-million years. The lack of scarps and the natural seismicity are consistent with regional stability. (See Powers et al., 1978, Sections 3.4, 4.4, and 10.3.2.)

Igneous activity. Areas of active or recent volcanism or igneous intrusion should be avoided to minimize these hazards to the repository.

No recent igneous activity is known in the region. Geophysical surveys, mining, and drill-hole intercepts have shown that an intrusive dike exists 9 miles northwest of the site. Radiometric dating shows it to be 35 million years old. No other intrusive features are known to exist in the region. (See Powers et al., 1978, Section 3.5.)

Geothermal gradient. Abnormally high geothermal gradients should be avoided to allow construction in salt at 3000 feet. High gradients may also be indicative of recent igneous or tectonic activity.

The geothermal gradient as determined in the AEC-8 drill hole shows a normal geothermal gradient averaging about 0.58°F per 100 feet. The heat flow is about one heat-flow unit. (See Powers et al., 1978, Section 4.4.1.)

D.4 PHYSICOCHEMICAL COMPATIBILITY CRITERION AND SITE-SELECTION FACTORS

The repository medium must not interact with the waste in ways that create unacceptable operational or long-term hazards.

Fluid content. The repository bed containing high-level waste should not contain more than 3% brine. The limit for TRU waste has not been established, but the value used for high-level waste is acceptable.

The average brine content of the lower repository is less than 0.5% by weight. The average brine content of the upper repository horizon beds is less than 1% by weight. (See Powers et al., 1978, Sections 7.5 and 10.7.8.)

Thermal properties. To avoid undesirable temperature rises, no major natural thermal barriers should exist closer than 20 feet of the repository horizons.

This is of significance to the lower horizon, where the halite unit of interest is about 100 feet thick. The adjoining beds are anhydrite, which, even though far enough away, has similar thermal conductivity and does not represent a thermal barrier in any case. (See Powers et al., 1978, Section 9.2.3.)

Mechanical properties. The medium must safely support excavation of openings even while thermally loaded. Clay seams and zones of unusual structural weakness should be avoided in the selection of the repository horizon.

The halite bed at the lower level is sufficiently thick and devoid of clay seams that stability of openings will not be a problem for repository operation. Clay seams and polyhalite beds are more common in the area selected for the upper repository level, but construction levels can be located to avoid significant structural stability problems from such nonhalite beds. (See Powers et al., 1978, Section 9.2.4.)

Chemical properties and mineralogy. Beds that are of unusual composition or contain minerals with bound water should not occur within 20 feet of the waste horizon. This will lessen the uncertainties with regard to thermally driven geochemical interactions.

The heat-producing waste horizon is quite pure halite, with more than 97% NaCl. No polyhalite, clay, or other water-bearing minerals occur near this horizon. The upper horizon beds are more than 92% NaCl, with impurities being mostly potassium and magnesium salts and clay. These impurities have no known negative implications for TRU-waste isolation and, in fact, have been shown to absorb radionuclides from brine. (See Powers et al., 1978, Sections 4.3 and 7.2 through 7.5.)

Radiation effects. While no unacceptably deleterious effects are postulated, these phenomena are best quantified in halite, and thus the purer rock salt beds are desired for high-level waste.

Samples of WIPP salt show no characteristics that would produce undesirable effects under irradiation. The low brine content will limit the amount and effects of radiolytic disassociation of water. (See Powers et al., 1978, Chapter 9.)

Permeability. Salt has a very low permeability. It is necessary to evaluate the permeability only of the interbeds and the surrounding media. Low permeability is desirable, but quantitative limits need not be specified for site selection. Salt permeability to gases may be important in establishing waste-acceptance criteria.

Laboratory measurements on cores show very low permeability. On a large scale, measurements at the WIPP horizons have not been made. Experience in other drill holes (absence of aquifers in salt and presence of small high-pressure gas pockets) would argue for very low in-situ permeability on larger scales. (See Powers et al., 1978, Section 9.2.3.)

Nuclide mobility. This is a secondary factor in siting since confinement by the salt and isolation from water are the basic isolation premises. Ion sorption must be determined to allow quantification of safety analyses and to indicate whether engineered barriers (clay) would be beneficial.

The distributed impurities in the rock salt provide significant ion-sorption capability for many radionuclides. The clay layers in higher salt beds will be still more sorptive. These properties will tend to minimize radionuclide migration due to such local mechanisms as brine migration in thermal gradients. (See Powers et al., 1978, Section 9.3.)

D.5 ECONOMIC AND SOCIAL COMPATIBILITY CRITERION AND SITE-SELECTION FACTORS

The site must be operable at reasonable economic cost and should not create unacceptable impacts on natural resources or the biological and social environment.

Natural resources. Unavoidable conflict of the repository with actual or potential resources will be minimized to the extent possible.

This factor is not well satisfied by the WIPP site. Both hydrocarbons and potash exist in potentially economic quantities within the site. While salt itself may be considered a valuable mineral, its economic potential at the site is very low. Since both potash and hydrocarbons may be recovered from control zone IV, the amounts that may be restricted from development within zones I, II, and III are the critical amounts. These quantities are not large in terms of national supply (even the langbeinite product is synthesized in quantity from brine lakes). These minerals may prove an enticement for future exploration and exploitation. For this reason, studies are under way to examine the effects of recovering the potash ore from above control zone III. Very little potash exists above the repository (zone II) itself. Similarly, once adequate borehole plugging is demonstrated, drilling in zone III could be permitted or the same zones developed from zone IV by slant drilling. The expectation, but one that cannot yet be guaranteed, is that these minerals may

be recovered in the decades ahead should they be economically attractive. Certainly the time frame for their development would be within the next century, while the site is still under administrative control. The small amounts of either resource within zone III would not be of significant interest in the absence of other production in the area. (See Powers et al., 1978, Chapter 8.)

Man-made penetrations. Boreholes or shafts that penetrate through the salt into underlying aquifers will be avoided within 1 mile of the repository. Existing mining activity, unrelated to the repository, should not be present within 2 miles of the repository. Future, controlled mining will be allowable up to 1 mile from the repository. Future studies may permit still closer mining and drilling if properly controlled.

The present site adequately fulfills this present restriction on man-made penetrations. (See Powers et al., 1978, Section 2.3 and Chapter 4.)

Transportation. Transportation should be capable of ready development. Avoidance of population centers by transportation routes is not a factor in the siting of the repository.

The present site meets this requirement and would utilize a spur line of the Santa Fe Railroad now running to the Duval mine.

Accessibility. The site should be readily accessible for transportation and utilities.

The site presents no problems for access by road, railroad, or utility lines.

Land jurisdiction. Siting will be on Federal land to the extent possible.

Of the 18,960 acres to be withdrawn by the DOE if this site is approved, 17,200 are Federal land controlled by the Bureau of Land Management and 1760 acres belong to the State of New Mexico. There are no private lands within the site.

Population density. Proximity to population centers and rural habitats will be considered in siting. A low population density in the immediate site area is desirable.

There are 16 permanent residents within 10 miles of the site. There is a transient population at potash mines. The nearest town is Loving, New Mexico, with a population of 1600. Carlsbad is 26 miles west and has a population of 28,600. Low population is not necessary to siting but, all other factors being equal, is desirable.

Effects on ecology and cultural resources. Major impacts on ecology due to construction and operation should not occur. Archaeological and historic features of significance should be preserved.

END

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