CONCEPTUAL MODELS

PEER REVIEW REPORT

Final

Waste Isolation Pilot Plant

Conceptual Models Peer Review Report

A Peer Review Conducted By

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FOREWORD

The U.S. Environmental Protection Agency promulgated "Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations Final Rule" in Code of Federal Regulations, Title 40, Part 194 (40 CFR Part 194) on February 9, 1996. The 40 CFR Part 194 regulation prescribes three specific peer reviews and also provides the opportunity for the Department of Energy to use peer reviews, conducted in accordance with NUREG 1297, as a means of qualifying data and information for use in the demonstration of compliance.

This report contains the results of a peer review of specific conceptual models to be used in the demonstration of WIPP compliance with 40 CFR Part 194. To ensure the independence of this review, the Department of Energy has directed the assignment of an independent contractor to administratively manage the peer review panel activities. Peer reviewers were selected based on their demonstrated independence from the work being reviewed and their technical expertise in the subject matter to be reviewed. The peer review panel members collectively possess an appropriate spectrum of knowledge and experience in the subject matter reviewed.

This peer review was conducted in full compliance with the quality assurance requirements as defined in 40 CFR Part 194.

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ACRONYMS

WIPP	Waste Isolation Pilot Plant
DOE	U.S. Department of Energy
SNL	Sandia National Laboratories
WID	Waste Isolation Division (Westinghouse)
EPA	U.S. Environmental Protection Agency
EEG	Environmental Evaluation Group
CCA	Compliance Certification Application
CFR	Code of Federal Regulations
TRU	transuranic (waste)
LWA	Land Withdrawal Act
CAO	Carlsbad Area Office
CTAC	Carlsbad Technical Assistance Contractor
ET	evapotranspiration
FEP	features, events, and processes
DRZ	disturbed rock zone
MB	marker bed
MDCF	multimechanism deformation coupled fracture
RM	reduced modules
FMT	fracture-matrix-transport
SIT	specific ion interaction

EXECUTIVE SUMMARY

This report presents the results of an independent technical peer review of the adequacy of 24 conceptual models representing features, processes, and events involved in assessing the long-term performance of the Waste Isolation Pilot Plant (WIPP). These models were identified by the U.S. Department of Energy (DOE) through its scientific advisor, Sandia National Laboratories (SNL). WIPP has been developed at a site near Carlsbad, New Mexico, by the DOE to become the nation's repository for geologic isolation of transuranic radioactive waste resulting from nuclear weapons programs. Westinghouse Electric Corporation, Waste Isolation Division (WID) is the operations contractor for the WIPP. SNL and WID have provided most of the information used in this review. This independent peer review is required by 40 Code of Federal Regulations (CFR) 194.27 as part of the compliance application prepared by the DOE. The U.S. Environmental Protection Agency (EPA) will use the peer review documentation to help ensure that an adequate scientific foundation exists for a national decision on whether to dispose of this waste at WIPP.

The independent review was conducted by a six-member interdisciplinary Review Panel (Panel) having the requisite broad experience and expertise to address the range of issues associated with the ability of WIPP to successfully isolate waste for the 10,000-year regulatory time frame. The peer review was conducted at SNL in Albuquerque, New Mexico, from April through June 1996. The Panel was given access to conceptual model descriptions, scientific reports, briefings, and SNL scientists, and to the SNL Nuclear Waste Management Program Library. During meetings of the Panel, representatives of the EPA, DOE, and New Mexico Environmental Evaluation Group (EEG) observed the Panel's deliberations. The Panel also had access to reports of prior peer reviews and had the full cooperation of the DOE, SNL, and WID throughout the review.

A conceptual model is a statement of how important features, events, and processes such as fluid flow, chemical processes, or intrusion scenarios, are to be represented in performance assessment. To be used in performance assessment, the conceptual model must be successfully translated into analytical statements and mathematical analogs. The Panel reviewed in detail the 24 conceptual models against criteria of the EPA, including the scientific information used to develop the model, the assumptions, alternative models considered, uncertainties, adequacy, accuracy, and validity of conclusions. The Panel also made an assessment of the information used and whether the conceptual model is adequate for implementation in an overall performance assessment model. The review process and review criteria are discussed in Section 2.

The Panel has applied the stringent assessment criteria provided in NUREG 1297 and has concluded that thirteen of the models are adequate for implementation. The remaining eleven models were not found to be adequate for use in performance assessment of the WIPP. Models were judged to be inadequate if they failed to convince the Panel of their adequacy in terms of nine criteria. These criteria addressed: adequacy of information; validity of assumptions; alternatives evaluated; uncertainties; adequacy of the model and its application, accuracy, results, and conclusions; and whether the model was ready for implementation in the performance assessment process. Following is a list of the 24 models and a statement of the Panel's conclusion.

Disposal System Geometry	Adequate
Culebra Hydrogeology	Not Adequate (no consequence)*
Repository Fluid Flow	Not Adequate
Salado	Adequate
Impure Halite	Adequate
Salado Interbeds	Not Adequate
Disturbed Rock Zone	Adequate
Actinide Transport in the Salado	Adequate
Units Above the Salado	Not Adequate (no consequence)*
Transport of Dissolved Actinides in the Culebra	Adequate
Transport of Colloidal Actinides in the Culebra	Not Adequate
Exploration Boreholes	Not Adequate
Cuttings/Cavings	Adequate
Spallings	Not Adequate
Direct Brine Release	Not Adequate
Castile and Brine Reservoir	Not Adequate
Multiple Intrusions	Adequate
Climate Change	Adequate
Creep Closure	Adequate
Shafts and Shaft Seals	Adequate
Gas Generation	Not Adequate
Chemical Conditions	Not Adequate
Dissolved Actinide Source Term	Adequate
Colloidal Actinide Source Term	Adequate

*Although the conceptual model was found to be inadequate, no consequence to performance assessment is anticipated.

Several of the issues raised by the Panel could have significant effects on performance assessment. The details of evaluations and issues raised for each model are contained in Section 3 of this report. The relationships among the models are described in Section 4, and a summary of the evaluations is contained in Section 5.

The Panel believes that careful resolution of the issues discussed in Section 3, and any resulting changes to the models, will help to improve the overall quality of the performance assessment and provide a firmer basis for a national decision on whether to emplace waste at WIPP.

1.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) Conceptual Models Peer Review is one of several peer reviews being conducted by the U.S. Department of Energy (DOE). The Conceptual Models Peer Review focused on the conceptual models developed and selected by DOE through its scientific advisor, Sandia National Laboratories (SNL), to determine if they adequately and reasonably represent future states of the WIPP disposal system for use in performance assessment. This review was conducted in support of and meets the regulatory requirements of 40 Code of Federal Regulations (CFR) 191 and the implementation of those requirements by 40 CFR 194. In these regulations, this peer review of conceptual models is specifically identified by the U.S. Environmental Protection Agency (EPA) as an activity required to supplement the DOE's Compliance Certification Application (CCA) for the WIPP.

According to 40 CFR 194.27, the peer review is to be conducted in accordance with the Nuclear Regulatory Commission's document NUREG 1297, stipulating requirements for conducting peer reviews. The adequacy criteria set forth in NUREG 1297 were used by the Review Panel (Panel) as a baseline for reviewing DOE's conceptual models. To implement 40 CFR 194, DOE-Carlsbad Area Office (CAO) developed Team Procedure TP-10.5, which stipulates that a peer review is an in-depth critique of assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed, and of conclusions drawn in the original work.

This report documents the results of the Conceptual Models Peer Review, as determined in accordance with the aforementioned requirements. Section 2 of this report presents background information relating to the WIPP facility and review methodology. This includes a description of the repository, its geologic and hydrogeologic settings, the scenarios used, review methodology, and evaluation criteria. Section 3 presents the evaluation of each of the 24 models as assessed against a predetermined list of nine evaluation criteria. Section 4 discusses the integration of the 24 models into an overall conceptual model for the waste disposal system. Section 5 provides a summary of the evaluations. These sections are followed by appendices which include administrative information and professional biographies for each of the Panel members.

2.0 BACKGROUND

The DOE was authorized in 1979 (by Public Law 96-164) and funded by the Congress to develop a facility for demonstrating the safe disposal of transuranic (TRU) radioactive wastes generated in national defense activities. The Land Withdrawal Act (LWA) of 1992 (Public Law 102-579) provided additional authorization to continue the project under a stipulated statutory process. This facility, the WIPP, is located in southeastern New Mexico. The WIPP is operationally ready to receive waste and is being proposed by DOE for EPA approval as an operating radioactive waste disposal facility through the CCA process. The purpose of the (Compliance Certification Application (CCA) is to demonstrate through performance assessments the ability of the WIPP to successfully isolate radioactive waste from the accessible environment for the 10,000-year regulatory time frame. If regulatory compliance is demonstrated and a decision to start disposal of waste at the WIPP is made, following the provisions of the LWA, the WIPP will be used for the permanent disposal of TRU wastes, including TRU wastes containing hazardous constituents (TRU mixed waste).

2.1. WIPP Overview

The WIPP facility has been constructed in southeastern New Mexico (Figure 2-1), 26 miles east of Carlsbad, on Federal land. Prior to October 1992, this land was administered by the U.S. Department of the Interior, Bureau of Land Management. In October 1992, Congress transferred jurisdiction of the land through the LWA to the Secretary of Energy. The site encompasses 10,240 acres in a sparsely populated area, with fewer than 30 people living within 10 miles of the WIPP. The immediate surrounding land is used for livestock grazing, potash mining, and oil and gas production.

Surface structures, the planned and partially developed underground repository, and four connecting shafts make up the WIPP facility. The purpose of the surface structures is to provide security and safeguards and to accommodate routine operations, administrative activities, and further scientific studies.

The underground excavation is 655 meters (2150 feet) below the surface in the bedded salt of the Salado Formation. It includes a 12-acre area used for conducting scientific investigations and experiments in which no waste will be placed, an operations area with equipment and maintenance facilities, an area in which the waste will be emplaced for permanent disposal if the disposal site approval decision is made, and four major interconnecting tunnels used for ventilation and traffic. The subsurface waste-disposal area is to cover 100 acres and will contain eight separately excavated panels, each containing

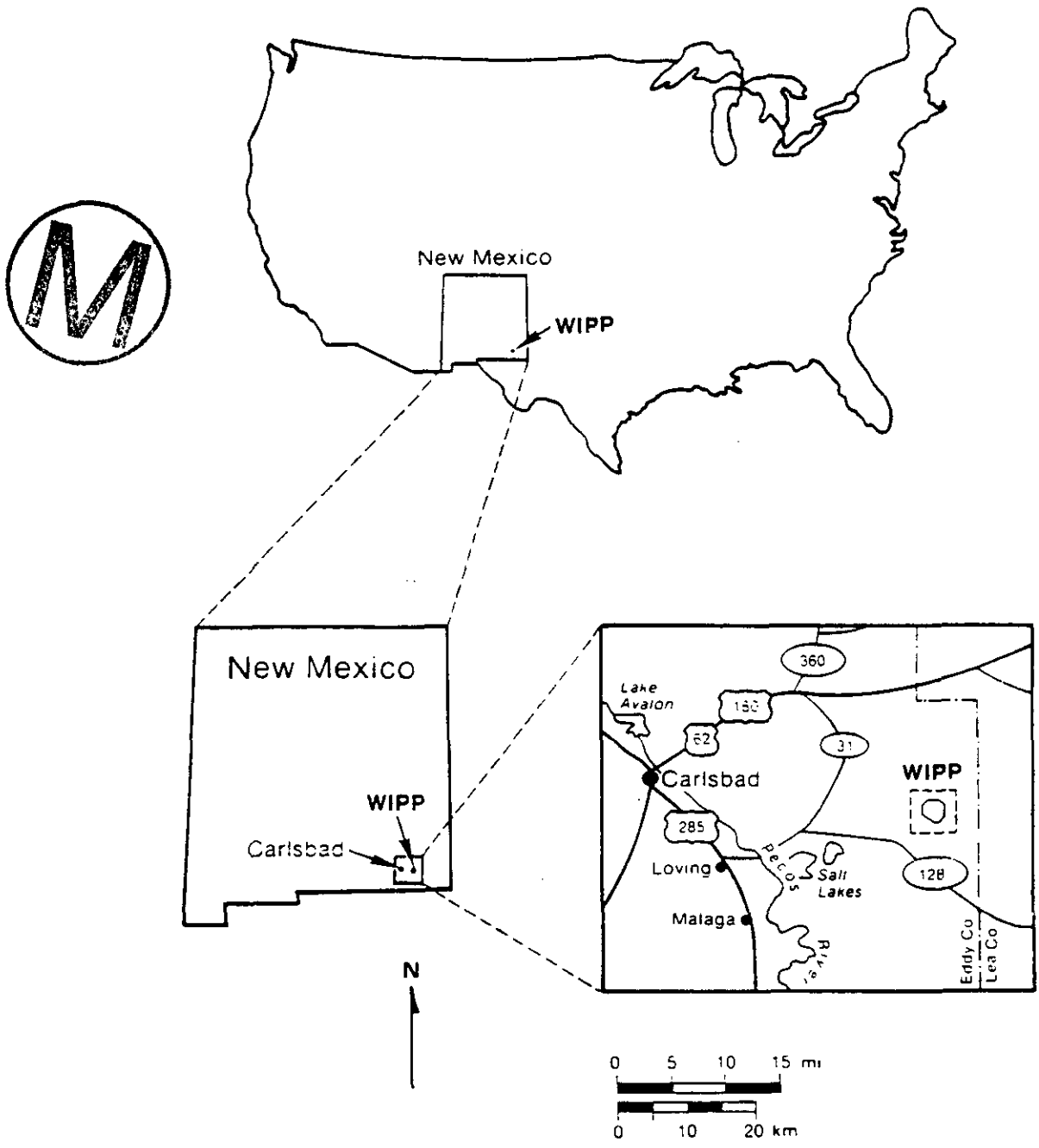


Figure 2-1. WIPP Facility Location

seven disposal rooms, and two additional panels in the area currently containing the drifts accessing the waste disposal area.

2.2. Peer Review Management

The Conceptual Models Peer Review was an independent review supported by the Office of Regulatory Compliance, DOE-CAO and delegated to its technical assistance contractor, known as the Carlsbad Technical Assistance Contractor (CTAC). CTAC commissioned Informatics Corporation, an independent firm, with the task of managing the peer reviews. The Conceptual Models Peer Review is the first of six peer reviews conducted between April 1 and August 15, 1996. The other peer reviews include: Engineered Systems Data Qualification Peer Review; Natural Barriers Data Qualification Peer Review; Waste Form and Disposal Room Data Qualification Peer Review; Passive Institutional Controls Peer Review; and Waste Characterization and Sensitivity Analyses Peer Review. Similar reviews are being conducted on engineered barrier evaluations by the WIPP operations contractor.

Each peer review was administered separately, with its own administrative coordinator and administrative assistant. Early in the review, a technical panel leader was selected from among the peer review members to serve as the focal point for the technical aspects of the review, analysis, and development of a report. The six panels shared access to an administrative document-gathering, recordkeeping, and document processing center comprised of several support staff.

The selection of panel members, training of coordinators and reviewers, and operation of the review process were governed by DOE-CAO's Team Procedure TP-10.5, the Conceptual Model Peer Review Plan, and Informatics' Desk Instruction IDI-1.0. Detailed information regarding the review process is further delineated in these documents and in the records of the Panel's review, both found in the SNL Records Center.

The Panel was requested to review the adequacy of the following 24 conceptual models that are being used by the DOE in assessing the future states of the geologic repository system.

1. Disposal System Geometry
2. Culebra Hydrogeology
3. Repository Fluid Flow
4. Salado
5. Impure Halite

6. Salado Interbeds
7. Disturbed Rock Zone
8. Actinide Transport in the Salado
9. Units Above the Salado
10. Transport of Dissolved Actinides in the Culebra
11. Transport Colloidal Actinides in the Culebra
12. Exploration Boreholes
13. Cuttings/Cavings
14. Spallings
15. Direct Brine Release
16. Castile and Brine Reservoir
17. Multiple Intrusions
18. Climate Change
19. Creep Closure
20. Shafts and Shaft Seals
21. Gas Generation
22. Chemical Conditions
23. Dissolved Actinide Source Term
24. The WIPP Colloidal Actinide Source Term

2.3. System Overview

The WIPP disposal system includes the underground repository and shaft system, the geologic host rocks, and the local and regional hydrologic system. Figure 2-2 shows the WIPP controlled area, the accessible environment, and the disposal unit boundary.

2.3.1. Repository

The WIPP surface facilities, shafts, and underground workings are shown in Figure 2-3. The WIPP repository includes four shafts (exhaust shaft, waste shaft, salt handling shaft, and air intake shaft), an experimental area, an operations area, and a waste disposal area.

Present plans call for mining eight panels of seven rooms each and two equivalent panels in the central drifts. As each panel is filled with waste, the next panel will be mined. Before the repository is closed

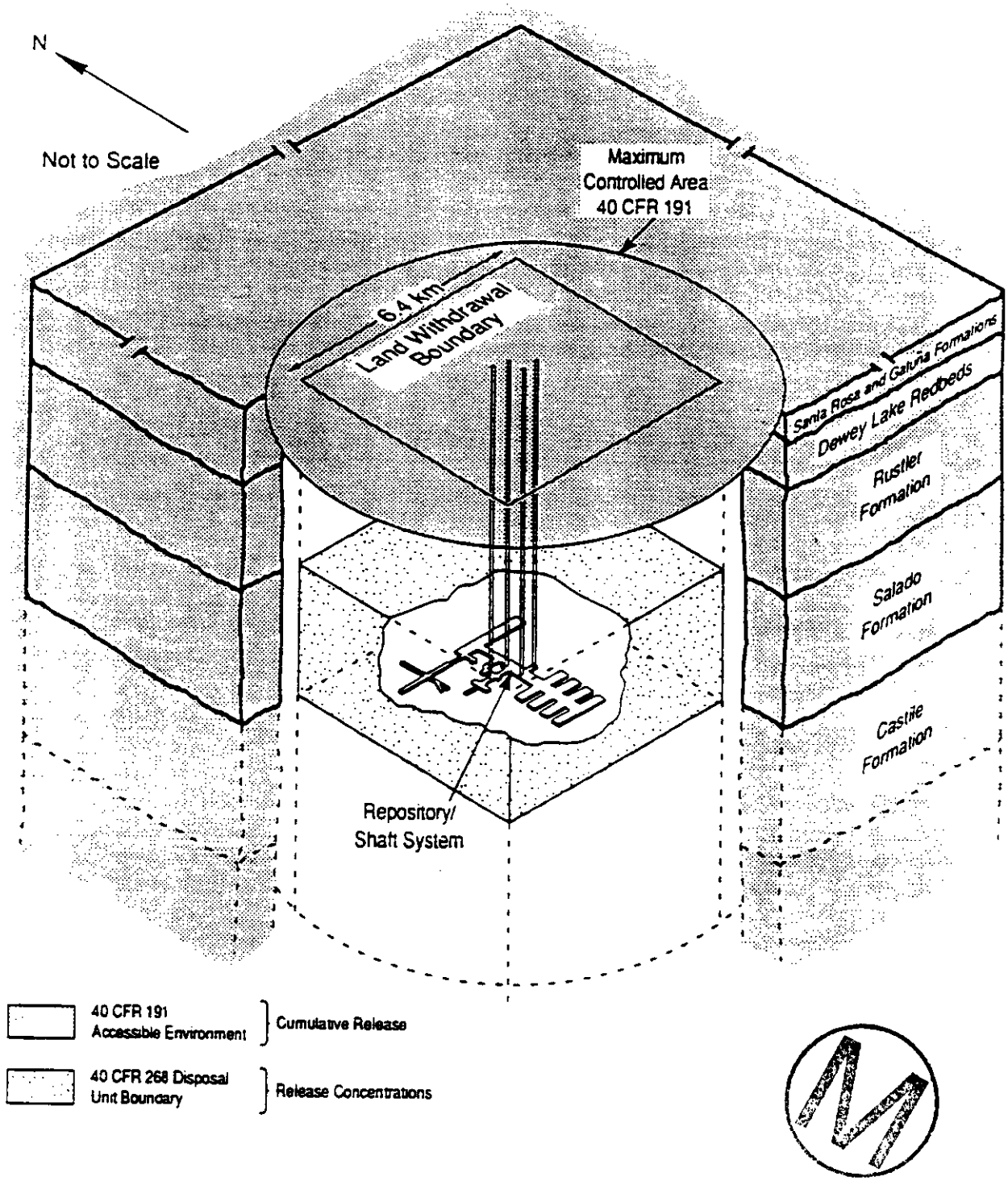


Figure 2-2. WIPP Controlled Area

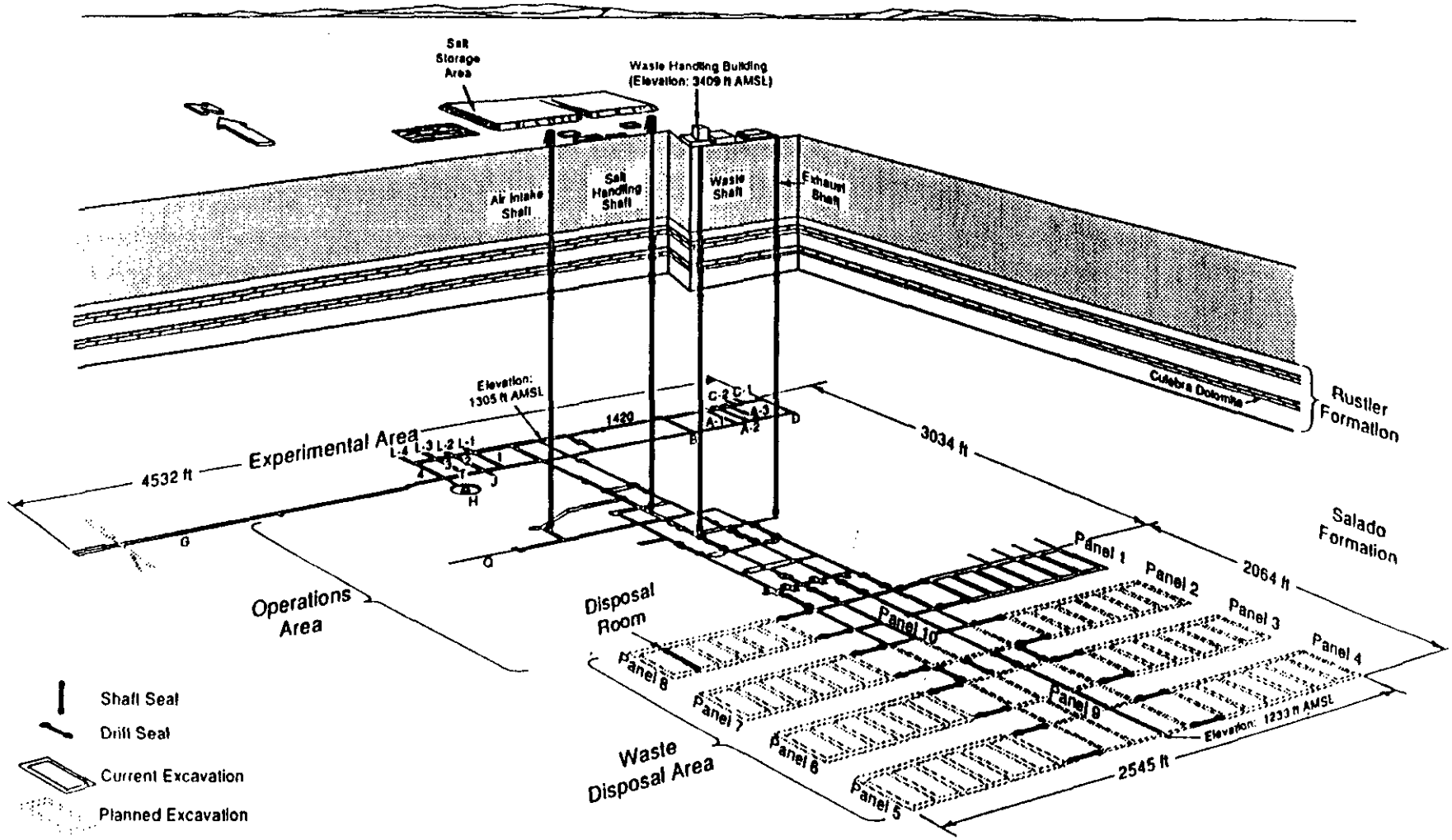


Figure 2-3. WIPP Facilities

permanently, each panel will be sealed, waste will be placed in the drifts between the panels, creating two additional panel volumes, and access ways will be sealed off from the shafts. The shafts will then be sealed to isolate the repository from the ground surface. Final closure of the facility will be facilitated by the creep closure of the salt.

2.3.2. Geologic Setting

The geologic history of southeastern New Mexico and the data collected regarding the subsurface stratigraphy at the WIPP site are important and are discussed extensively in Section 2 of the CCA (DOE 1996) and documents referenced in the CCA. The general stratigraphy at the WIPP site is presented in Figure 2-4. The relevant geologic background setting for the peer review, however, includes specific formations and their lithologies. The Bell Canyon, Castile, Salado, Rustler, Dewey Lakes, Gatuna, and Santa Rosa Formations are the lithologic units within which the conceptual models represent processes and predictions of future states of the proposed disposal system.

The sandstones, siltstones, limestones and shales of the Bell Canyon Formation define the first extensive, continuous, transmissive unit below the WIPP repository and provide a source of groundwater that could migrate vertically into the repository. The halite and anhydrite beds of the Castile Formation separate the Bell Canyon from the Salado and contain pressurized brine reservoirs. Brine reservoirs are a repository performance concern expressed in human intrusion scenarios. The halite-dominated Salado Formation contains the proposed repository and provides the primary natural barrier for containing radionuclides. The laterally extensive Culebra Dolomite Member of the Rustler Formation is the closest stratigraphic unit above the Salado with the potential to transport a radionuclide release to the accessible environment. Studies conclude that transmissivities in the Culebra vary by six orders of magnitude across the WIPP site area. Fracturing and vuggy zones account for much of the variability in the physical/hydraulic properties of the Culebra.

While other stratigraphic members of the Rustler Formation, beds of anhydrite and polyhalite, clays, and other inclusions may be important as each of the conceptual models is reviewed, the four formations and units described above define the most important components of the geologic setting for the WIPP conceptual models review.

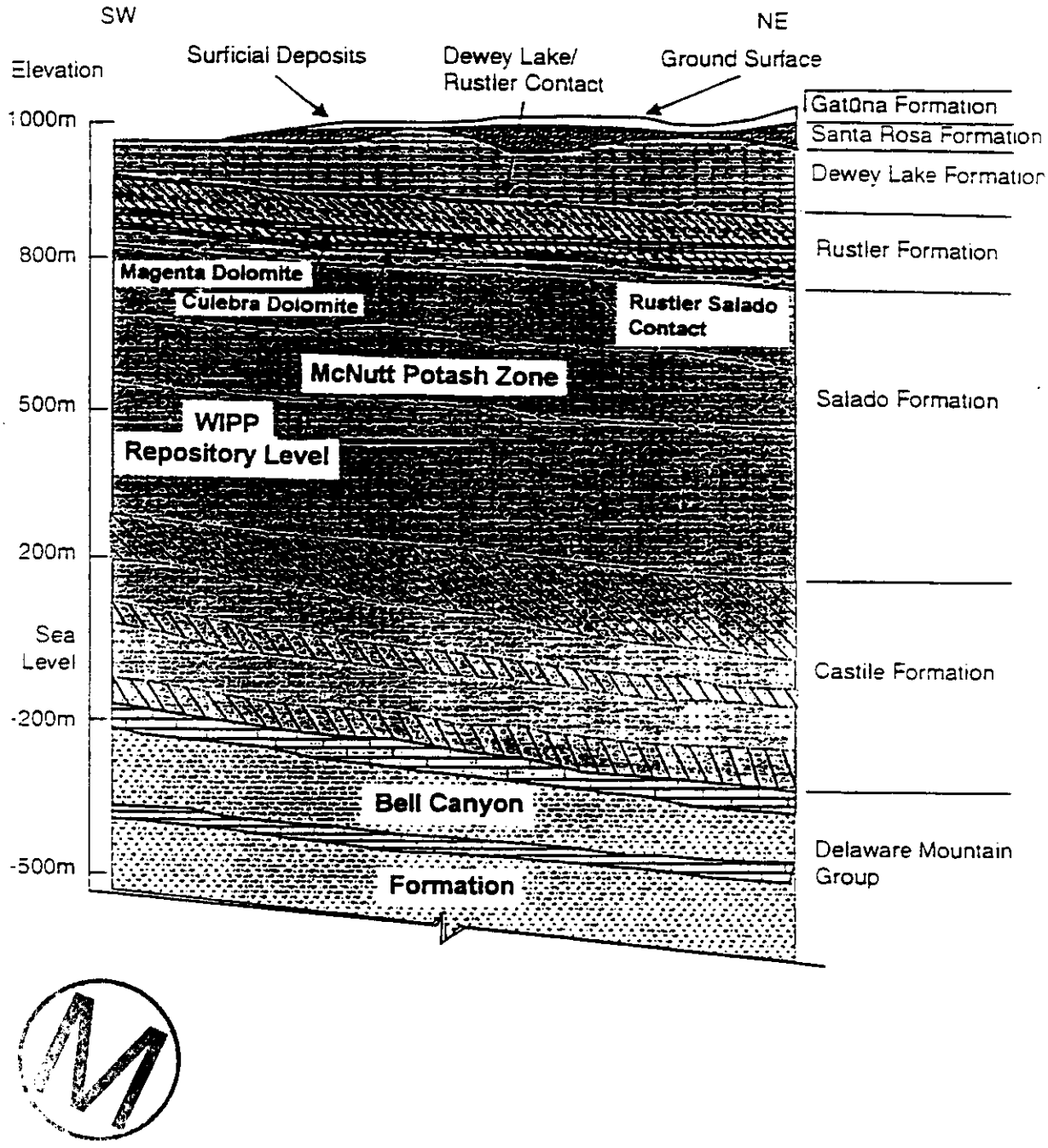


Figure 2-4. General Stratigraphy at the WIPP Site

2.3.3. Hydrologic Setting

2.3.3.1. Surface Water

The WIPP site is located within the Pecos River Basin. At its nearest point, the Pecos River flows approximately 12 miles southwest of the WIPP site boundary. There are no perennial streams at the WIPP site and in this semi-arid region, approximately 75% of annual precipitation results from intense, short-duration events between April and September. More than 90% of the mean annual precipitation is lost through evapotranspiration (ET) and on a mean annual basis, ET potential exceeds expected rainfall. EPA concluded in 1989 (EPA 1990a) that there were "no surface water features near the WIPP that could potentially affect repository performance in such a way as to influence the no-migration demonstration."

2.3.3.2. Groundwater

Extensive coring, logging and testing of boreholes in the vicinity of the WIPP site has provided data for the characterization of the hydrostratigraphy and hydrogeology important to the WIPP site region. While the deep Capitan Limestone, the Rustler-Salado contact zone near Nash Draw, and the shallower Dewey Lakes and Santa Rosa Formations are important in characterizing the WIPP region, the Bell Canyon, Castile, Salado, and Rustler Formations are the units critical to the evaluation of WIPP groundwater issues.

As presented in the geologic setting, the Bell Canyon Formation is the first continuous, transmissive, water-bearing unit beneath the WIPP. This formation provides a source of groundwater below the WIPP repository that could migrate into the repository if a pathway were available. The Bell Canyon Formation exhibits hydraulic conductivities in the range of 10^{-7} to 10^{-12} meters per second and pressures were measured in the range of 12.6 to 13.3 megapascals.

The Castile Formation is of interest to site characterization as a hydrologic barrier between the Salado and Bell Canyon Formations and because it contains isolated pressurized brine reservoirs. The Castile is predominantly low-permeability halite and anhydrite with greater permeabilities in zones of fracture and structural deformation. In the areas of higher permeability, brine pressures exist that are sufficiently above nominal hydrostatic pressure for brine to flow upward through a borehole to the surface.

The halite and anhydrite rocks of the Salado Formation are relatively impermeable and tests have shown that flows range from extremely low to no flow when appreciable pressures are applied. The Salado contains the proposed repository and provides the primary natural barrier for containing radionuclides.

The Magenta and Culebra Dolomite Members of the Rustler Formation are laterally extensive, transmissive, and display hydraulic characteristics sufficient for the lateral transport of radionuclides. Hydraulic conductivities in both members range over five to six orders of magnitude in the WIPP area, but the Magenta is generally less transmissive than the Culebra. The Culebra is the first, most extensive, and most transmissive unit above the Salado at the WIPP site. As such, the Culebra provides the most direct pathway from the WIPP repository to the accessible environment and is the most important component of the hydrogeologic setting for the conceptual models peer review.

2.4. Peer Review Panel Methodology

The review of the conceptual models commenced after a training/orientation period and was conducted in accordance with management plans, the conceptual model peer review plan, desk instructions, and other relevant protocols. Panel member qualifications are detailed in Appendix A of this report.

The work of the Panel began following training/orientation on April 5, 1996 and was scheduled to terminate on June 28, 1996 with the submittal of this final report. The Conceptual Model Peer Review Panel employed six basic approaches in their overall method of conducting and accumulating information for the reviews: 1) extensive review of available, referenced, and "roadmapped" literature relevant to the Panel; 2) attendance at briefings on conceptual models and relevant aspects of the performance assessment process; 3) conduct conceptual model or issue-focused presentations/question-and-answer sessions with DOE scientists and engineers; 4) intensive review of literature/documents discovered through continued research and focused question-and-answer sessions; 5) conduct formal and informal discussions among Panel members; and 6) participate in a tour of WIPP facilities and the local area outside the WIPP site, and in presentations/discussions associated with the tour.

The Panel was provided a list of 24 conceptual models to be independently reviewed with respect to whether or not they represent a reasonable view of future states of the proposed disposal system for the WIPP. For the review, conceptual models are defined as a set of qualitative assumptions used to describe a system or subsystem for a specific purpose. Although such a definition could limit the scope of a review, the Panel evaluated the models in accordance with NUREG 1297 criteria, from conception to their integration with mathematical representations, and paid careful attention to alternative models and approaches. In addition, the Panel recognized that individual models may warrant varying levels of reviews of their mathematical representations, computerized representations, and results.

Individual Panel members were assigned lead responsibility for specific conceptual model reviews and preparation of subsequent sections for the report. The Panel members collectively assumed writing responsibilities for introductory and conclusionary sections in the report.

Early in the review process five Panel members visited the WIPP site to tour surface and subsurface facilities and to view nearby geological features. The purpose of the visit was to view first hand the site-specific features that have potential impact on the long-term behavior of the WIPP. When touring the underground facilities, the Panel members observed the Q Room experiment site, the horizons of the Salado halite visible within the repository, fractures within the repository disturbed rock zone, and collapse features in a room where a roof had fallen. Panel members also visited the WIPP core library and observed selected core samples representative of the geological formations that could not be seen underground. Geological features viewed by the Panel near the WIPP included outcrops of the Culebra and Magenta Dolomites, Dewey Lakes Redbeds, and the Gatuna Formation. Two Panel members visited the Western AG potash mine northwest of the WIPP, where ore zones and anhydrite marker beds not visible at WIPP were seen.

Due to the large volume of project literature required for review, the Panel adopted a process in which each member would work independently in getting pertinent information on a given topic. Group briefings were reserved for the broader topics. All information was freely disseminated for consensus-building among Panel members in the completed analysis. On learning that complete information was not available to complete the Panel's scope of work on time, the Panel requested DOE to provide specific information on an accelerated interim basis. This proved to be highly beneficial to the timeliness of model reviews. It was recognized that much of this input had not been reviewed in accordance with SNL procedures and that some of the information reflected the current status of an ongoing decision process. The Panel members are aware that errors can be made in understanding and accuracy when using information of this type, and used the full access provided by DOE to those personnel necessary to provide guidance and clarification to the answers sought.

In organizing its work, the Panel established limitations on its review and the content of this report. Panel members did not review or offer comments on regulations. The Panel confined its review to the suite of conceptual models identified by DOE (Section 2.2). Finally, to maintain independence, the Panel will not offer recommendations for specific methods and approaches to address its concerns. A cutoff date of June 7, 1996 was established for receiving new information for inclusion in the review. It was

decided that if the Panel could not reach a conclusion due to a lack of information on a particular model, it would be so stated in the Panel's report.

Two additional activities were identified by DOE for the Panel. First, an overview of the Panel's finding would be presented to DOE, SNL, and observers, and the Panel would respond to questions raised to clarify the concerns identified in this report. The presentation is scheduled for July 1 and 2, 1996. Second, the Panel was requested to reconvene in August to review DOE's written responses to the Panel's findings, and prepare an addendum to this report, if necessary, indicating the adequacy with which the Panel's findings and concerns were resolved by SNL.

2.5. Criteria for Conceptual Model Review

The nine criteria used to review each of the 24 conceptual models are listed below along with a brief description of the way in which each was used by the Panel. Examples are provided where appropriate, to provide clarification. The nine criteria are based on the EPA regulation 40 CFR 194.27, NUREG 1297 Section IV.5, the EPA Compliance Application Guidance, and Panel discussions.

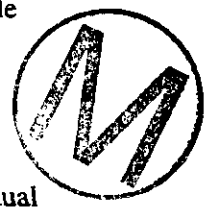
Information Used to Develop the Conceptual Model. This is an evaluation of data and information used to develop conceptual models and submodels. It includes attributes of the disposal system learned by DOE during site characterization activities, such as refinements to the room creep closure model or an improved understanding of disturbed rock zone characteristics.

Validity of Model Assumptions. The validity of key assumptions in the model and its application are assessed in terms of how they could affect the usefulness of the conceptual model. The review addresses the comprehensive inclusion of important features, events, processes, and other key assumptions. Examples are the assumption of Darcy flow in the various media, use of the ideal gas law at high pressures, or the method chosen to represent time-dependence of strain.

Evaluation of Alternatives. This section briefly identifies and assesses plausible alternative conceptual models or submodels seriously considered by DOE but not used, and the rationale why such alternative models were not used. Again, important features, events, and processes must be considered. The Panel does not expect the descriptions of alternative models to be as extensive as for the models chosen, but they should adequately document why the alternative models were not used. For example, the choice among matrix, dual porosity, or flow channeling in stratigraphic units, or the use of transmissivity fields versus uniform transmissivity, should be explained.

Uncertainties. This includes an evaluation of the key uncertainties in the selected conceptual models and a discussion of the consequences if aspects of the conceptual model chosen were inappropriate or incompletely constrained for the site or process. For example, if elements of the particular models used to estimate the effect of pH on actinide solubility or the permeability of the disturbed rock zone around the shaft were flawed or incorrect, how significantly would this affect performance? This is not expected to be an exhaustive evaluation, but it should raise the reasonable question, "What if the model were wrong?"

Adequacy of the Conceptual Model. Based primarily on the previous four criteria, this is a simple statement of whether the individual conceptual models and submodels represent a reasonable approximation of the actual disposal system elements.



Adequacy of Application. This is an assessment of whether it appears that the individual conceptual model is being adequately applied into an acceptable overall performance modeling system. This particular assessment does not cover the relationships among conceptual models, but whether the significant components of the individual conceptual models are appropriately implemented in support of performance assessment. For example, are the various geometrical systems and representations of the conceptual models adequately applied within the performance modeling system, or do there appear to be discontinuities between the conceptual model and its application? Also, are there apparently important alterations of key assumptions between the conceptual model and its implementation in performance modeling?

Accuracy of Results. This is a statement of whether the results of performance modeling using the conceptual model within the performance system are sufficiently accurate to adequately simulate the physical and chemical processes represented. This could either be a subjective judgment (if analytical results were not available with any necessary caveats) or a more robust and useful judgment (if results of analyses were available). Review of key results could also improve the basis for the Panel's statements about adequacy of application, overall validity of outcome of analyses, and adequacy for implementation.

Typical results that could be useful in providing a basis for these improved judgments include reports of sensitivity studies among key intermediate parameters, such as: 1) mean and extreme values of expected brine inflows, 2) gas pressurizations, 3) likelihoods of marker bed fracture, 4) directions of brine flow in the undisturbed condition, 5) the effect of mining in the vicinity of waste panels, 6) relative amounts of waste released from intrusion scenario components (direct brine releases, cuttings, cavings and spallings), and 7) initial typical complementary cumulative distribution functions. Similar results from

past performance assessments have provided a basis for improved judgments of models and modeling systems, and numerous improvements have been made in models since the 1992 performance assessment. A review of results is also desirable to facilitate making useful conclusions.

Validity of Conclusions. This is a judgment of the validity of any key conclusions that have been drawn based on results of the implementation of conceptual models in the modeling framework. The key question is whether or not conclusions from model implementations appropriately relate to the expected goal of assessing the long-term performance of the disposal system. Again, a judgment in the absence of some key output information would need to be accompanied by appropriate explanations.

Adequacy for Implementation. This is an overall, bottom-line assessment of whether the conceptual models, as intended for use in the compliance application, represent a reasonable approximation of the actual disposal system based on the eight previous criteria.