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3.0 FACILITY DESCRIPTION

Chapter 3.0 provides technical information about those engineered systems at the Waste Isolation Pilot Plant (WIPP) disposal system that are important to meeting the disposal standards of Title 40 of the Code of Federal Regulations (CFR) Part 191 Subparts B and C (EPA 1993). The U.S. Department of Energy (DOE) developed a facility design that facilitates the rapid encapsulation of emplaced waste by creep closure of salt, forming a nearly impermeable barrier around the waste. In addition, the DOE has taken a defense in depth approach in the design of engineered shaft sealing systems to ensure the shafts will not become pathways for radionuclide release. Shaft seals incorporate multiple engineered materials and compacted crushed salt which will effectively reduce the permeability of the shaft-seal system to values near those of unexcavated intact salt. The DOE also employs an engineered barrier to chemically condition any brine that may reach the waste in order to reduce radionuclide solubility. Finally, the DOE will close each panel of waste with a panel closure system to provide for operational protection of workers, the public and the environment from emplaced waste.

In this chapter, descriptions are provided for the shafts, the underground waste disposal excavations, and engineered systems that may be significant to long-term performance of the disposal system. Of these engineered systems, the Environmental Protection Agency (EPA) has determined that only magnesium oxide (MgO) meets the regulatory definition of an "engineered barrier" (63 Federal Register [FR] 27397, May 18, 1998). Detailed information on other aspects, such as general facility operations, waste handling, repository mining, ground control, ventilation, transportation, emergency preparedness, training, and maintenance are covered, as appropriate, in other WIPP documents, such as the WIPP Disposal Phase Supplemental Environmental Impact Statement (SEIS-II) (DOE 1997), Contact-Handled Waste Safety Analysis Report (DOE 2003), and other documents available from the DOE.

The facility has been divided into four areas designated for protection of human health and the environment: (1) the property protection area, which is surrounded by a chain-link security fence that encloses approximately 13.7 hectares (34 acres) and provides security and protection for all major surface structures; (2) the exclusive use area, which is approximately 112 hectares (277 acres) restricted exclusively for the use of the DOE, its contractors, and subcontractors in support of the project and posted against trespass and use by the general public; (3) the off limits area, which consists of approximately 5.9 km^2 (1,454 acres) posted and managed as off limits by the DOE; and (4) the WIPP land withdrawal area, the 41.4-km^2 (16 mi^2) federal land area under jurisdiction of the DOE and bounded by the WIPP site boundary (see Figure 3-1). The WIPP land withdrawal area is the controlled area for purposes of demonstrating compliance to 40 CFR Part 191 Subparts B and C. The waste area of the repository lies within the bounds of the off limits area, and within the WIPP land withdrawal area.

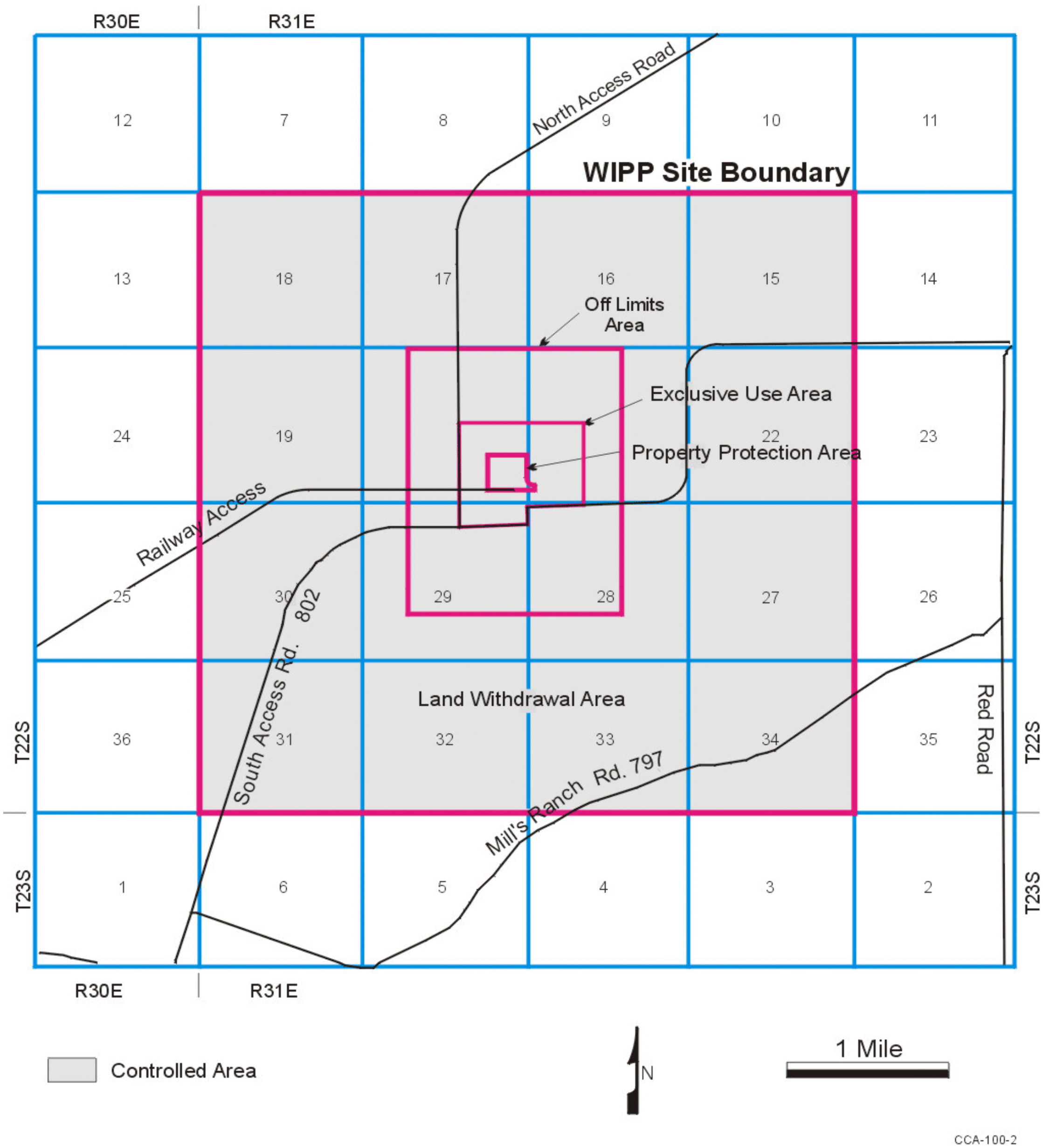


Figure 3-1. WIPP Property Sector Designators

The amount of waste to be received at the WIPP is governed by the WIPP Land Withdrawal Act, Pub. L. No. 104-201, Stat. 2422 (U.S. Congress 1992), which sets the total volume for contact-handled (CH-) and remote-handled (RH-) transuranic (TRU) waste combined at a maximum of 175,600 m^3 (6.2 million ft^3). The 6.2 million ft^3 technically corresponds to 175,564 m^3 but will be routinely represented in this application with four significant digits. The Land Withdrawal Act restricts RH-TRU waste to a maximum activity of 23 curies per liter and not to exceed a total of 5.1 million curies (U.S. Congress 1992) (see Chapter 4 for a description of the waste). There is a volume limit of 0.25 million ft^3 for RH-TRU waste (Agreement for Consultation and Cooperation, DOE 1988). The waste disposal area of the WIPP facility consists of eight panels, each of which contains seven rooms, and the access drifts and crosscuts adjacent to the disposal panels. This latter region has been labeled Panels 9 and 10 for convenience as shown in Figure 3-2. At the end of the operational period, the DOE will begin the process of sealing the shafts, which is a part of final facility closure.

Disposal operations in Panel 1 are complete and an explosion-isolation wall has been installed. In a typical configuration, waste will be emplaced in all seven rooms of a panel as shown in Figure 3-3 with RH-TRU waste inserted into the walls. Figure 3-4 provides the layout of the waste as it is emplaced in Panel 1. This is not the configuration typically described for WIPP (Compliance Certification Application [CCA]).

In a submittal dated April 26, 2001 [Docket A-98-49, II-B-3, Item 19], the DOE requested that EPA approve a different utilization plan for Panel 1. The flexibility to vary the utilization of Panel 1 was important from both a worker safety and operational efficiency perspective. The rooms of Panel 1 were over 12 years old at the time of the proposed change. The natural processes of room closure had reduced the vertical clearance to the extent that re-mining would be necessary to provide sufficient headroom and acceptable floor conditions for waste to be emplaced as described in the CCA, i.e., three containers high. Based upon the analyses performed by Sandia National Laboratories (SNL), the DOE concluded that this request was not a significant departure from the original design and that aspects of the repository system important to waste containment would not be affected or changed. The EPA agreed with DOE’s conclusion in a letter dated August 7, 2001 [Docket A-98-49, II-B-3, Item 19], stating “DOE’s proposed alternative use of Panel 1 is compliant with terms and conditions of WIPP’s certification.” There is no RH-TRU waste disposed in Panel 1.

Table 3-1 delineates pertinent site features of the WIPP facility.

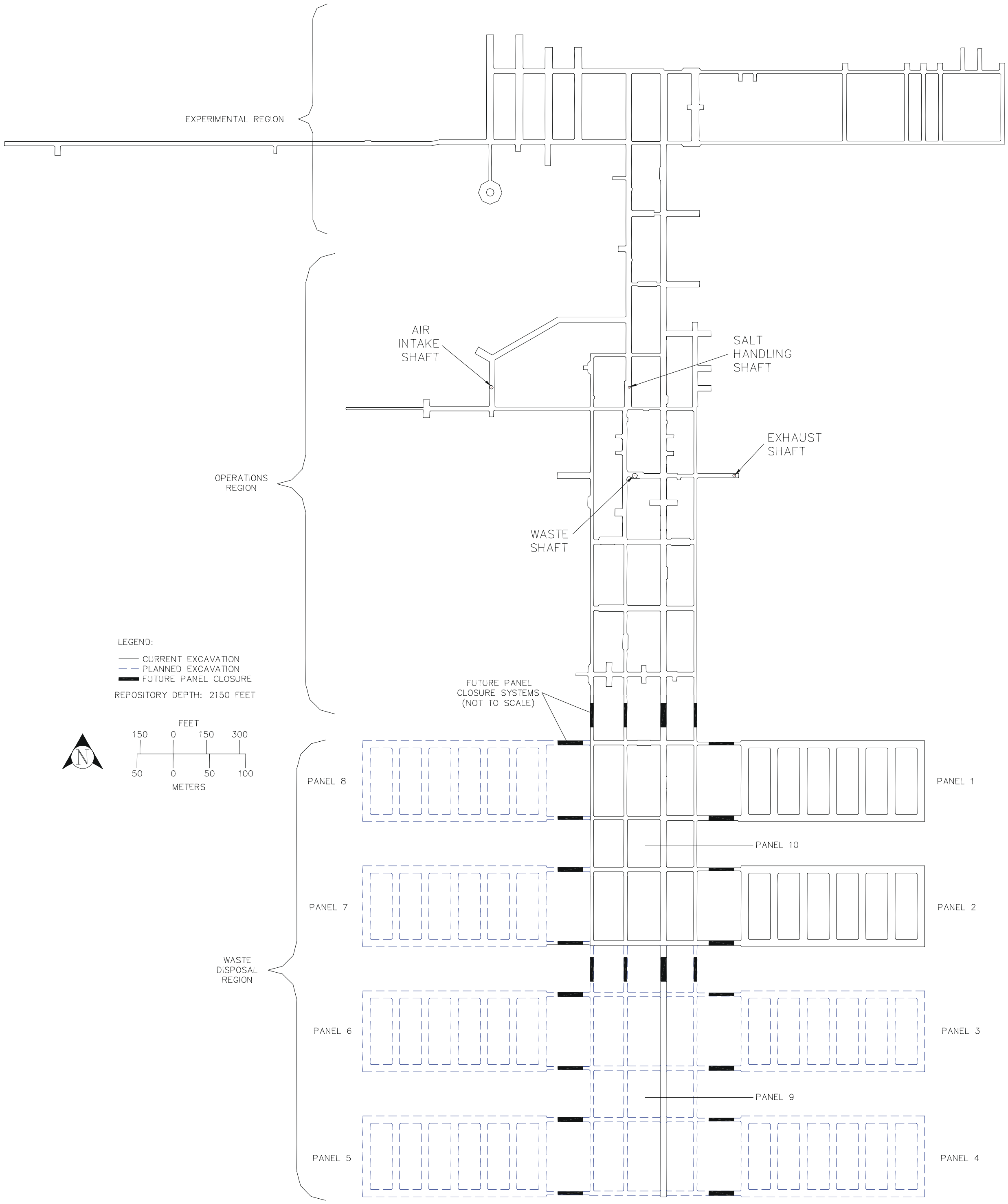
3.1 General Facility Design

The DOE has designed the WIPP facility to accomplish four primary goals:

1. to receive, handle, and dispose of TRU waste and TRU-mixed waste (in this document, the term TRU waste is used to describe both TRU and TRU-mixed waste unless otherwise noted);

2. to protect the health and safety of workers, the public, and the environment;

3. to comply with applicable radiation protection standards; and

1 

2 **Figure 3-2. Plan View of WIPP Underground Facility and Panel Closure Systems**

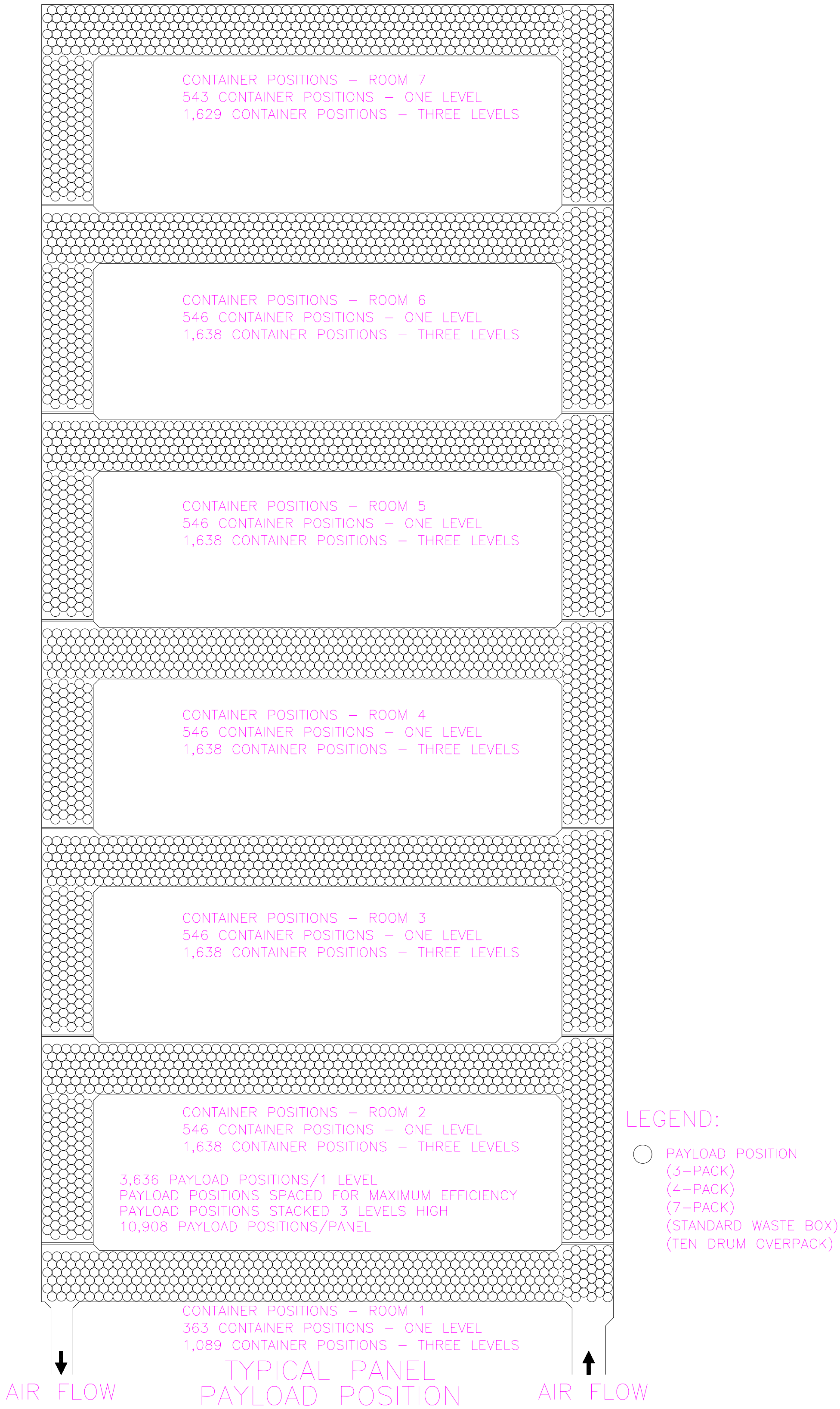
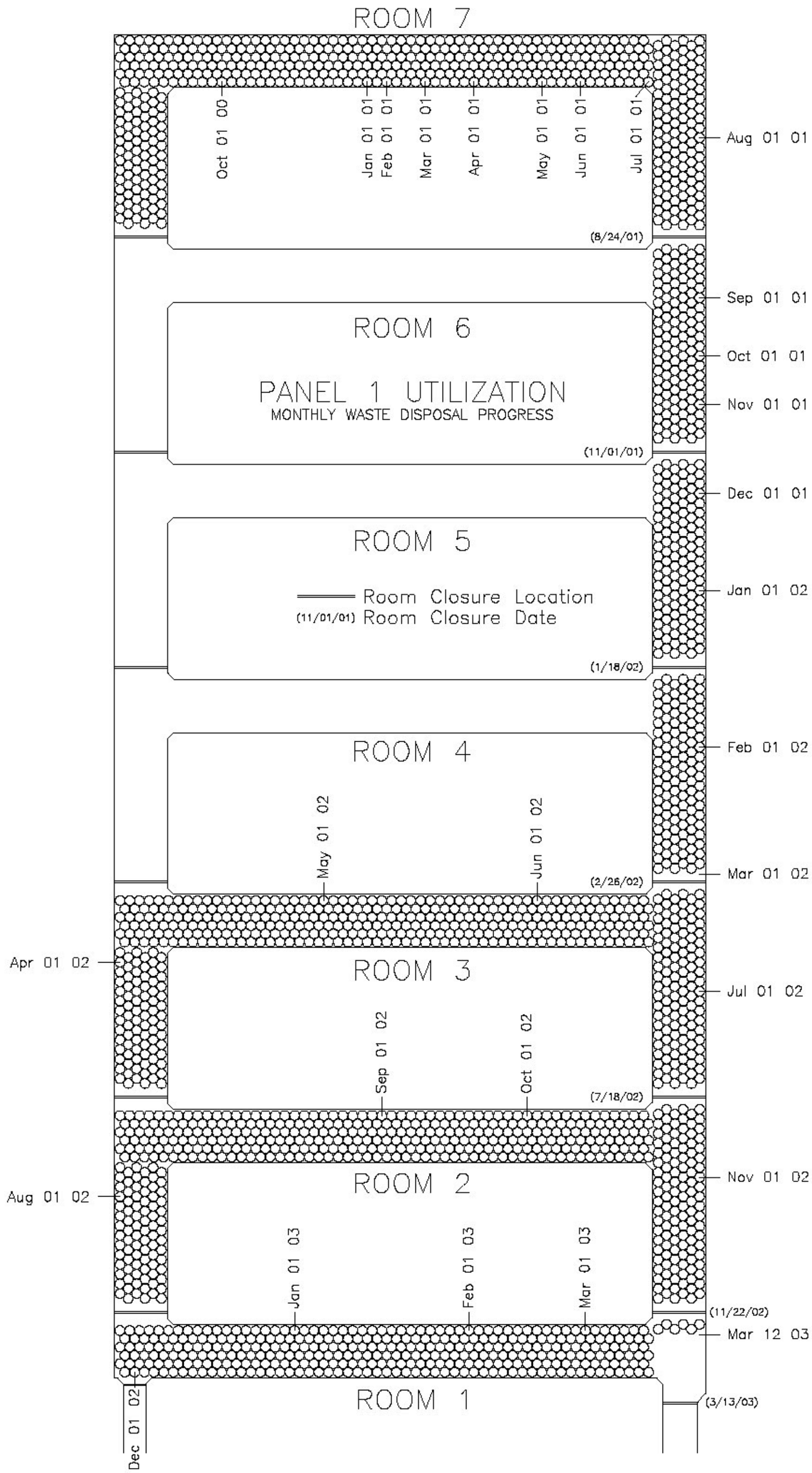


Figure 3-3. Typical Panel Waste Emplacement



1
2 **Figure 3-4. Panel 1 Waste Emplacement**

Table 3-1. WIPP Site Features

Facility Name	Waste Isolation Pilot Plant (WIPP)
EPA Identification Number	NM 4890139088
Location	41.84 km (26 miles) east of Carlsbad, New Mexico
Latitude	32°22'11"N
Longitude	103°47'30"W
County	Eddy
Section	15-22 and 27-34
Township	22S
Range	31E
Land Withdrawal Area	41.4 km^2 (16 mi^2)
Property Protection Area	13.7 hectares (34 acres)
Depth to repository horizon	655 meters (2,150 feet) below grade level

4. to comply with other environmental statutes and regulations, and requirements of federal, state, and local agencies as discussed in the WIPP Biennial Environmental Compliance Reports (DOE 2002, et seq.).

The surface facilities at the WIPP accommodate the personnel, equipment, and support services required for the safe receipt and transfer of TRU waste from the surface to the underground repository. The surface structures are located within a perimeter security fence. This area is the property protection area on Figure 3-1. Access is controlled by security officers 24 hours a day. Four vertical shafts connect the surface facilities to the underground. The underground facilities include the

- waste disposal area,
- shaft pillar area, and
- associated support facilities.

Figure 3-5 provides a spatial view of the WIPP facility.

The DOE acquisition process that was used for the design and construction of the WIPP determined the steps and processes taken to assure that the WIPP was constructed consistent with applicable codes and standards. This process defined key activities and milestones that were applicable and specified such project management activities as initial and final design, independent review, acceptance testing, start-up, and quality assurance (QA). Additional detail is provided in the following sections.

3.1.1 DOE Facility Acquisition Process

Federal facility acquisition policies were applied to the design and construction of the WIPP facility. WIPP structures are designed to meet the Carlsbad Field Office (CBFO) Functions,

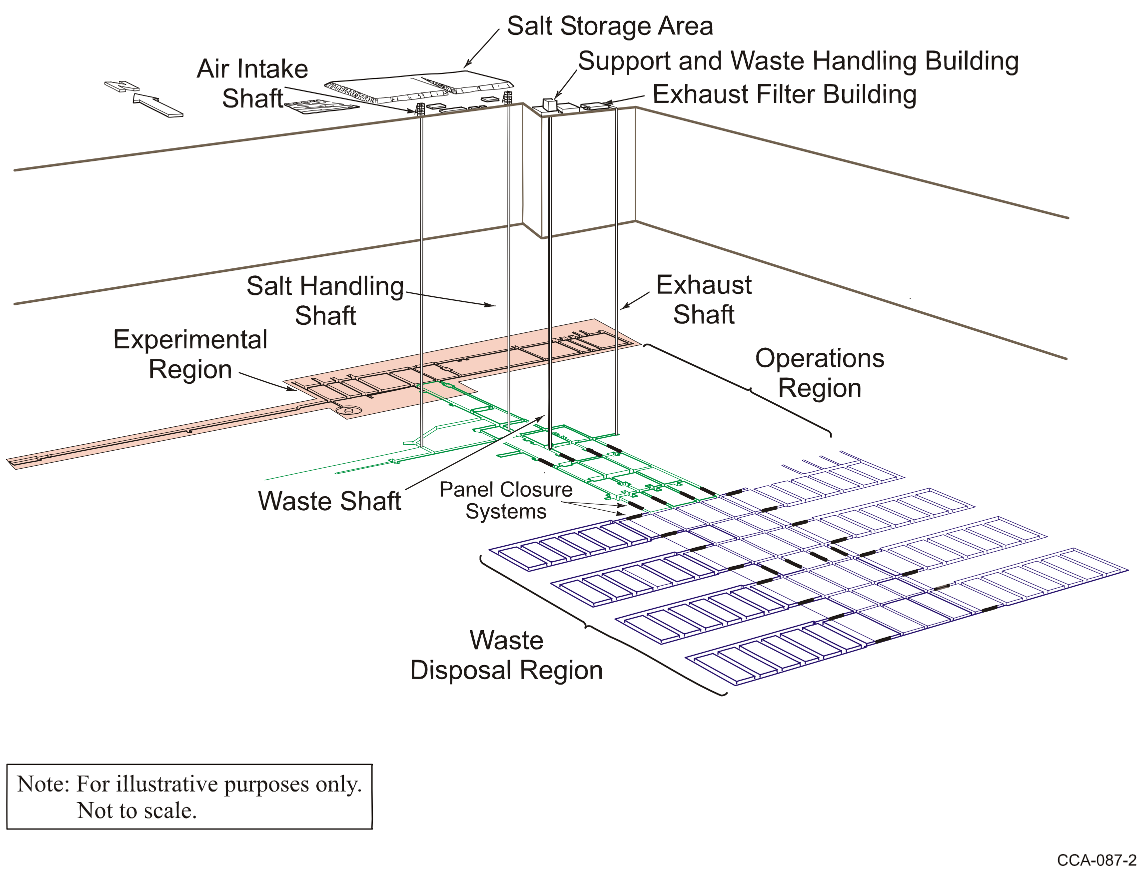


Figure 3-5. Spatial View of the WIPP Facility

Responsibilities, and Authorities Manual (DOE/WIPP 98-2287, 2001), 10 CFR Part 830, Subpart B (design qualifications), and the Quality Assurance Program Document (QAPD) (DOE 1996) for general issues of quality. Appropriate structures, systems and components are designed to meet the requirements applicable to Design Class II structures, systems, and components for nonreactor nuclear facilities. The design class designations are categorized in accordance with their importance relative to health and safety of the public and on-site personnel during plant operations.

3.1.2 Configuration Control

The DOE mandates that the configuration control of the WIPP facility be accomplished through written procedures and policies as set forth in DOE Orders and regulations. For example, the WIPP System Design Descriptions provide a framework for the configuration control. Any changes to the facility, and subsequently configuration documentation (design descriptions, as-built drawings, specifications, etc.), must be reviewed and approved by cognizant personnel. These documented reviews determine if the change will affect the ability of the facility to comply with applicable environmental, safety, and health requirements. The DOE must approve proposed changes that impact the safety of the facility and may elect to conduct an independent review of analyses supporting the change.

Quality assurance requirements applicable to the WIPP facility design and configuration control activities are founded on the basic and supplemental requirements of the American Society of Mechanical Engineers' QA program requirements for nuclear facilities (American Society of Mechanical Engineers' NQA-1 1989). As discussed in Section 5.2, the DOE now implements these requirements through the CBFO's QAPD, which is provided in Appendix QAPD. Design QA elements include (1) documentation, review, and approval of design inputs; (2) control of design analyses, design verification, and design changes; and (3) institution of design interface controls and records management practices. These and other applicable configuration management QA requirements are discussed in Section 5.3.3.

3.1.3 Surface Structures

WIPP surface structures accommodate the personnel, equipment, and support services required for the receipt, preparation, and transfer of waste from the surface to the underground areas. These surface structures serve the operational functions of the WIPP and are not intended to serve long-term performance functions. The surface facilities are located in the Property Protection Area within the perimeter fence. The principal surface structure is the Waste Handling Building; other surface structures include the following:

- hoist houses,
- support building,
- guard and security building,
- office trailers,
- exhaust filter building,
- warehouse and shops,
- water pump house,
- training building,
- engineering building,
- materials, tools, and electronics and tool crib building,
- safety and emergency services building.

In addition to these structures, the DOE has employed a system of berms and ditches to divert storm-water runoff away from the surface facilities. The WIPP facility drainage system is designed so that storm runoff caused by the probable maximum precipitation (PMP) event will not flood the WIPP facility (DOE 1995).

The WIPP facility does not lie within a 100-year floodplain. There are no major surface-water bodies within eight km (five mi) of the site, and the nearest river, the Pecos River, is approximately 19 km (12 mi) away. The general ground elevation in the vicinity of the surface facilities (approximately 1,036 m [3,400 ft] above mean sea level) is about 152 m (500 ft) above the riverbed and 122 m (400 ft) above the 100-year floodplain. (Chapter 2.0 provides more information on surface hydrology and climate.) Protection from flooding or ponding caused by PMPevents is provided by the diversion of water away from the WIPP facility by a system of peripheral interceptor diversions. Additionally, grade elevations of roads and surface facilities are designed so that storm water will not collect on the site under the most severe conditions.

Repository shafts are elevated at least 15.2 cm (6 in.) to prevent surface water from entering the shafts. The floor levels of all surface facilities are above the levels calculated for local flooding due to PMP events.

The mean annual precipitation in the region is about 30 cm (12 in.), and the mean annual runoff is 0.25 to 0.50 cm (0.1 to 0.2 in.). The maximum recorded 24-hour precipitation at Carlsbad was 13 cm (5.12 in.) in August 1916. The six-hour, 100-year precipitation event for the site is 9.1 cm (3.6 in.) and is most likely to occur during the summer. The maximum daily snowfall at Carlsbad was 76 cm (10 in.) in December 1923.

The WIPP facility design includes four shafts: the waste shaft, the salt handling shaft, the exhaust shaft, and the air intake shaft (AIS). Each shaft includes a shaft collar, a shaft lining, and a shaft key section. The shaft and shaft liner design information is discussed in detail in the Site Characterization and Validations studies from 1983 to 1987. The shaft design features have not changed.

The reinforced concrete shaft collars extend from the surface to the top of the underlying consolidated sediments. Each collar serves both to retain adjacent unconsolidated sands and soils and to prevent surface runoff from entering the shaft. The shaft linings extend from the base of the collar to the top of the salt beds approximately 259.1 m (850 ft) below the surface. The shaft lining serves to inhibit water seepage into the shafts from water-bearing formations, such as the Magenta and Culebra members of the Rustler. The liners are also designed to retain loose rock. The shaft liners are concrete except in the salt handling shaft, in which a steel shaft liner has been grouted in place.

The shaft key is a circular reinforced concrete section emplaced in each shaft below the liner at the base of the Rustler Formation and extending about 30.5 m (100 ft) below and into the Salado Formation. The shaft key functions to resist lateral pressures and to contain the water seals.

Two separate water-seal rings are incorporated in each key. Performance of the seals is monitored by inspection of the bottom of the key for seepage. If groundwater is detected flowing past the upper ring, this condition can be corrected by injecting chemical sealants or cementitious grouts to stop the leakage.

On the inside surface of each shaft, excluding the salt handling shaft, there are three water collection rings. The first is located just below the Magenta interval, the second just below the Culebra interval, and the last at the lowermost part of the key section. These collection rings function to collect any groundwater that may seep into the shaft through the liner. Therefore, flooding of the WIPP repository as a result of PMP events is not a credible event because of the site-runoff design.

Flood-control structures are inspected as part of a general facility inspection at least annually. During this inspection, the structures are checked to assure that there has been no wind or rain erosion or animal-caused damage that would cause the structures to fail. Further, the areas around the structures are inspected to ensure they are free of vegetation, debris, or other items that would impede the diversion of water. Experience with these structures has shown that annual structural inspections are adequate for the climate and soil conditions at the WIPP facility; however, inspections are also conducted after severe natural events, such as severe storms or earthquakes.

3.2 Repository Configuration

A preliminary design of the WIPP repository was presented in the Final EIS (DOE 1980). Validation efforts for the WIPP repository preliminary design began in 1981 with the Site and Preliminary Design Validation (SPDV) program. The SPDV program was implemented to further characterize and validate the WIPP site geology and to provide preliminary validation of the underground excavation. The SPDV program involved the excavation of four full-sized disposal rooms, excavated 4 m (13 ft) high, 10 m (33 ft) wide, and 91 m (300 ft) long, and separated by 31-m (100-ft)-wide pillars. Data obtained from geologic field activities and geomechanical instrumentation were analyzed to determine the suitability of the design criteria and design bases and to provide confirmation of the underground opening reference design. Analyses of these preliminary designs performed by the WIPP architect and engineer can be found in CCA Appendix DVR. These analyses considered expected creep closure rates in determining disposal room sizes. Information in CCA Appendix DVR (Section DVR.6.4.2) meets the criterion specified in 40 CFR § 194.14(b)(2). Figures 12-21 and 12-22 of the Final Design Validation Report in CCA Appendix DVR show the creep closure histories used for designing the disposal rooms. The specified size was selected to ensure no CH-TRU containers would breach due to creep closure while a panel is being filled with waste. A nominal five-year life is used for operational purposes for mining, emplacement, and closure with no risk of CH-TRU waste containers breaching. Remote-handled containers will not breach in this time period due to the canister wall thickness and the 5.08 to 10.16 cm (2 to 4 in.) creep tolerance in each RH-TRU emplacement hole.

The WIPP underground facilities are located on the repository horizon 655 m (2,150 ft) beneath the surface (see Figure 3-2). In Chapter 2.0, Figure 2-12 shows a stratigraphic column which displays the repository and its position relative to mean sea level. These facilities include the waste disposal region, the operations region, an experimental region, and associated support facilities. The underground support facilities service and maintain underground equipment for mining and disposal operations, monitor for radioactive contamination, and allow limited decontamination of personnel and equipment.

Waste panels consist of seven rooms. Each room has nominal dimensions of 91 m (300 ft) long, 10.1 m (33 ft) wide, and 4.0 m (13 ft) high. Pillars between rooms are 30 m (100 ft) thick. Eight waste panels will be separated from each other and the main entries by nominally 61-m (200-ft) pillars. In addition to the eight panels, the main north-south and east-west access drifts in the waste regions are available for waste disposal. These have been designated Panels 9 and 10 for permitting and modeling purposes (see Figure 3-2). Section 6.4.2.1 describes the treatment of all waste panels in BRAGFLO. Additional information can also be found in Appendix PA, Attachment MASS.5. Rockbolts, or related types of ground support, are used as necessary to maintain safe underground personnel access. In the panels, this will typically consist of localized bolting when needed. All panels will be closed using the panel closure system described in Section 3.3.3.

The underground is connected to the surface by four vertical shafts: the waste shaft, the salt handling shaft, the exhaust shaft, and the AIS. The waste shaft, salt handling shaft, and the air intake shaft have permanently installed hoists capable of moving personnel, equipment, and materials between the surface and the repository. All shafts will eventually be sealed using the seal design described in Section 3.3.2. A summary of information describing existing WIPP shafts is given in Appendix BARRIERS, Section BARRIERS-3.0.

Mining of the shafts and underground passages within the repository gives rise to a disturbed rock zone (DRZ) that is important to repository performance. The DRZ forms as a consequence of unloading the rock in the vicinity of the excavation. Increased permeability is created by microfractures along grain boundaries and by bed separation along lateral seems. The DRZ development begins immediately after excavation and continues as salt creeps into the opening. The DRZ surrounding the shafts is symmetrical and has been characterized and incorporated into the shaft seal design as discussed in Appendix BARRIERS. As shaft seal elements resist inward creep, the stress state becomes compressive and gives rise to fracture healing, and a return of the disturbed salt to its original extremely low permeability. The lateral DRZ along passages in the underground includes fracture in nonhalitic rock, such as anhydrite, and bed separation on clay seams. These zones will not naturally heal in a manner similar to healing of halite. Rigid components of the panel closure system will prevent further development of the DRZ.

In a letter dated June 26, 2000 [Docket A-98-49, II-A-3, Item 24, Attachment 1], the CBFO submitted a planned change to raise the repository horizon in Panels 3, 4, 5, 6, and 9 by approximately 2 m (6.6 ft) so that the back (roof) is at Clay Seam G. Positioning the back at Clay Seam G results in a more stable back configuration and improves repository ground conditions. Raising the horizon also reduces the rate of roof-beam deformation and slows the development of fractures, thus reducing risks during mining and waste handling in the underground repository. This change also results in less maintenance being required to assure acceptable ground conditions. In a letter dated August 11, 2000 [Docket A-98-49, II-A-3, Item 24], the EPA agreed "… that (this change) will enhance operational safety without significantly affecting the long-term performance of the facility." (Chapter 6.0 provides more detail related to Clay Seam G.)

3.3 Disposal-System Barriers

Disposal system barriers are used in the DOE's design of the WIPP to isolate waste and delay the migration of radionuclides to the accessible environment. Disposal-system barriers include the geology and hydrology of the disposal system or natural barriers, engineered systems, and an engineered barrier designed to meet the regulatory requirements of 40 CFR § 194.14(d). In addition, the incorporation of disposal-system barriers (both engineered and natural barriers) satisfies the criterion stated in 40 CFR § 194.44(a).

> Disposal systems shall incorporate engineered barrier(s) designed to prevent or substantially delay the movement of water or radionuclides toward the accessible environment.

In the CCA, the DOE proposed four elements of the disposal system as engineered barriers:

(1) shaft seals,

(2) panel closures,

(3) MgO around the waste, and

(4) borehole plugs.

In its certification decision, the EPA concluded that only MgO meets the regulatory definition of an engineered barrier. The certification decision includes the following regarding engineered barriers (63 FR 27397, May 18, 1998):

> The EPA finds that DOE complies with Sec. 194.44. The EPA found that DOE conducted the requisite analysis of engineered barriers and selected an engineered barrier designed to prevent or substantially delay the movement of water or radionuclides toward the accessible environment. The DOE provided sufficient documentation to show that MgO can effectively reduce actinide solubility in the disposal system. The DOE proposed to emplace a large amount of MgO around waste drums in order to provide an additional factor of safety and thus account for uncertainties in the geochemical conditions that would affect CO_2 generation and MgO reactions.

Although shaft seals, panel closures, and borehole plugs are not defined by EPA as engineered barriers, these features may affect disposal system performance and thus are included in the performance assessment (PA) (Appendix PA, Section PA-4.2). Shaft seals and borehole plugs will limit migration of liquid and gases in the WIPP shafts and boreholes. Panel closures will limit the communication of brine and gases among waste disposal panels. Designs of shaft seals, borehole plugs, and panel closures use common engineering materials that possess low permeability, appropriate mechanical properties, and durability.

The DOE performed an Engineered Alternatives Cost/Benefit Study (see CCA Appendix EBS) to examine the benefits and detriments associated with an array of engineered barrier alternatives. This study, in combination with past sensitivity and other analyses, was used to make a decision about MgO, which the DOE has chosen to buffer the chemical composition of brine that may enter the repository over the 10,000-year regulatory period. The principal beneficial performance characteristic resulting from MgO is a reduction in actinide solubilities in brine. Specific performance information on MgO is presented in Section 6.4.3 and Appendix BARRIERS.

3.3.1 MgO Engineered Barrier

The DOE has concluded that it is desirable to add MgO to the repository to improve the performance of the disposal system (see Appendix BARRIERS). This additive is being protected in supersacks until the supersacks are broken during creep closure of the room. The

MgO is being packaged in polypropylene supersacks for emplacement in the underground. Emplacement in supersacks (1) facilitates handling and emplacement of MgO; (2) minimizes potential worker exposure to dust; and (3) minimizes the exposure of periclase, the main, reactive constituent of MgO, to atmospheric carbon dioxide (CO_2) and water prior to rupturing of the supersacks. Supersacks, which contain 1900 $\pm$ 23 kg (4200 $\pm$ 50 lbs), are handled and placed using normal waste-handling techniques. Once each row of waste units is in place, a layer of supersacks is placed on top of them as shown in Figure 3-6. The supersacks are constructed of woven polypropylene, which serves as a barrier to CO_2 and moisture. The supersacks are placed on support sheets so that they can be handled and placed in a manner that is identical to how waste units are emplaced. Typically, the space above a stack of containers is 90 to 122 cm (36 to 48 in.), of which about (45 cm (18 in.) will contain MgO .

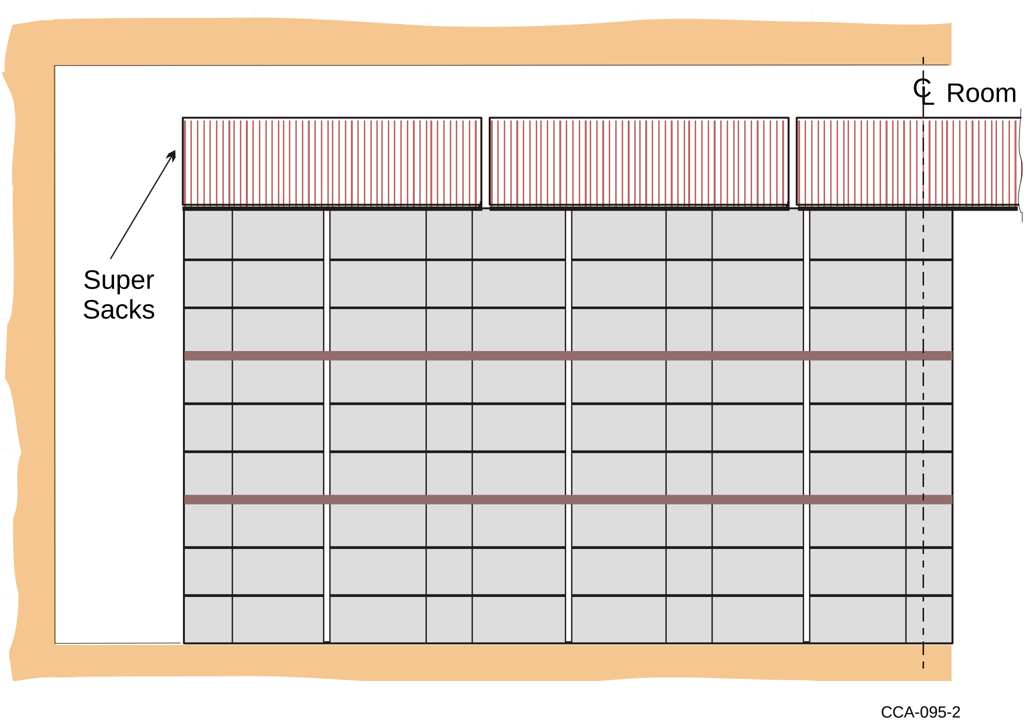


Figure 3-6. Room Cross-Section Showing the Position of Supersacks

The performance of MgO and its impacts on the disposal system are discussed in more detail in Section 6.4.3.4. Appendix BARRIERS provides the rationale for the use of MgO as an engineered barrier and contains information regarding its effects on chemical conditions in the repository. Laboratory experiments and thermodynamic modeling were used to predict the long-term effects of MgO on chemical conditions. Appendix PA, Attachment SOTERM describes how these conditions were used to calculate actinide solubilities.

Initially, MgO was emplaced in both minisacks and supersacks. Minisacks, which contained 11 kg (25 lbs.) of MgO, were placed among the waste containers and on the floor between the waste containers and the ribs. Supersacks, which contain 1900 $\pm$ 23 kg (4200 $\pm$ 50 lb) of MgO, are handled and emplaced using normal waste-handling techniques. Once each stack of waste containers is emplaced, a layer of supersacks is emplaced on top of them. Two changes related to MgO have occurred since the submittal of the CCA. These changes and their effects are described below.

3.3.1.1 Change of MgO Supplier

After the original supplier stopped producing MgO in 2000, another supplier was selected. The new MgO is slightly less dense than the previous product. To compensate for this, the volume of MgO emplaced in the repository was increased by approximately two percent to ensure the emplacement of the same mass of MgO proposed in the CCA. The product provided by the new supplier meets all of the technical specifications for MgO. The DOE evaluated the properties of the new MgO and concluded that the change has no impact on its expected performance as the engineered barrier (see Appendix BARRIERS).

3.3.1.2 Elimination of MgO Minisacks

In order to enhance worker safety and operational efficiency, DOE requested EPA approval of the elimination of the MgO minisacks. Elimination of the minisacks resulted in a 15 percent reduction in the total mass of MgO to be emplaced in the WIPP. An impact assessment carried out to support the DOE modification request demonstrated that the elimination of minisacks and the associated 15 percent reduction of MgO would not affect its performance as the engineered barrier (consumption of CO_2 from possible microbial activity and concomitant reduction of actinide solubilities). The assessment also demonstrated that the reduction of MgO would not reduce the additional benefits of brine consumption and constant chemical conditions.

In a letter from the EPA dated January 11, 2001 [Docket A-98-49, II-B-3, Item 15], the EPA approved the elimination of the MgO minisacks. Appendix BARRIERS provides additional information on MgO.

3.3.2 Shaft Seals

The purpose of the shaft seal system is to limit fluid flow within four existing shafts after the WIPP is decommissioned. Such a seal system will not be implemented for several decades, but in order to establish performance requirements now that can be achieved at a later date, a shaft seal system has been designed possessing excellent durability, performance, and constructability using existing technology. The design approach is conservative, with redundant functional elements and various common materials. Because this design is not the only possible combination of materials and construction strategies that would adequately limit fluid flow within the shafts, future developments may change the design.

Material specifications and construction techniques for the shaft seal system are given in Appendix BARRIERS; and in CCA Appendix SEAL in SEAL 5.0 and 6.0. Section SEAL 5.0 also provides the rationale and quantification methods used to develop parameter distribution functions. Appendix PA, Section PA-4.2.6 summarizes the representation of the shafts in PA; Appendix PA, Attachment PAR, Table PAR-17 provides parameter values in the modeling. The presently envisaged shaft seal system is described in this section at a summary level with detail provided in Appendix BARRIERS.

The shaft seal design explores function and performance of the WIPP shaft seal system and provides well-documented assurance that such a shaft seal system can be constructed using available materials and methods. Sections of CCA Appendix SEAL provide hydrologic and structural calculations, material specifications and properties, construction methods, and engineering drawings. Documentation of material properties and their satisfactory application in the site-specific environment for regulatory time periods aid in assuring that the WIPP shaft seal system will meet performance expectations. Documentation of the analyses conducted and the results can be referenced in CCA Appendix SEAL (Chapter 2.4 of Appendix A, and Chapter 3.1.2 of Appendix D).

3.3.2.1 Site Setting

The geologic setting and groundwater hydrology in the proximity of the WIPP site are presented in Sections 2.1 and 2.2. These sections describe low brine-flow quantities and low hydrologic gradients, both very positive features with regard to sealing shafts or boreholes. As noted in Section 2.2, one of DOE's site selection criteria was a favorable geologic setting that minimizes fluid flow as a transport mechanism. Although these positive hydrologic attributes are documented, the shaft seal design concentrates on further mitigating fluid transport. For the purposes of the hydrologic sealing evaluation, the lithologies have been divided into the Rustler (and overlying strata) and the Salado. The fluid transport phenomena of seal materials within Salado lithologies are the primary design concerns.

3.3.2.2 Design Objectives

Design objectives for the shaft seal system address the need for the WIPP to comply with system requirements and to follow accepted engineering practices using demonstrated technology. Shaft seal design objectives are summarized as follows:

- limit radionuclides from reaching regulatory boundaries,
- restrict groundwater flow through the sealing system,
- use engineered materials possessing good long-term stability,
- protect against structural failure of system components,
- minimize subsidence and prevent accidental entry, and
- use available construction methods and materials.

Details of the design respond to these qualitative design objectives and present an implementation approach. The shaft seal system design was completed under the QA program described in Chapter 5.0 and includes review by independent, qualified experts. Reviewers examined the complete design including conceptual, mathematical, and numerical models, and computer codes. The design reduces uncertainty associated with any particular element by using multiple sealing system components constructed from different materials.

3.3.2.3 Design Description

A schematic of the shaft seal system as configured for the AIS is shown in Figure 3-7. Slight differences in seal element geometry occur within the four shafts owing to different shaft diameters or stratigraphic variations. The shaft seal system has 13 elements that fill the shaft with engineered materials possessing high density and low permeability. Components of the seal system within the Salado provide the primary barrier by limiting fluid transport along the shaft

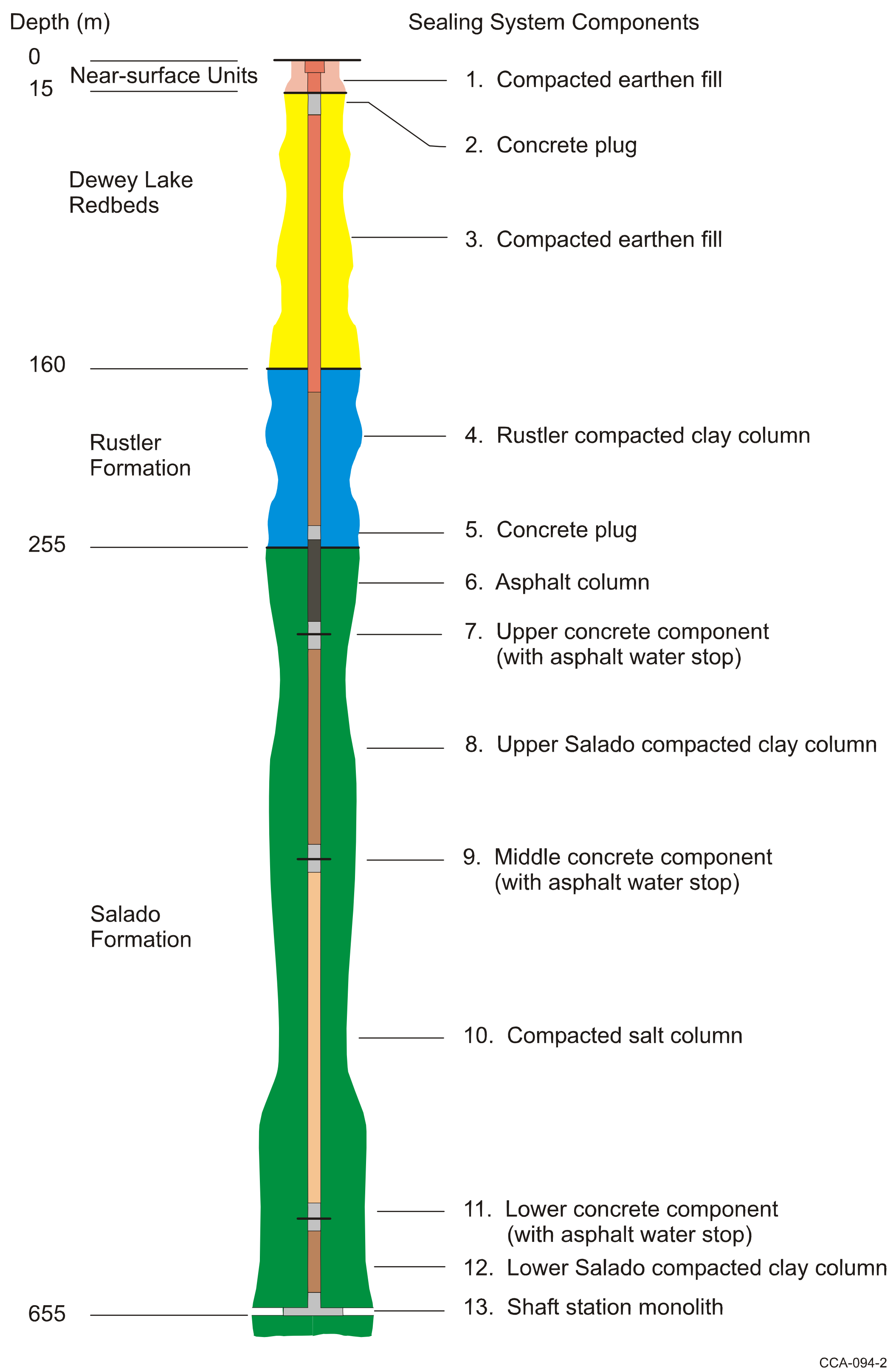


Figure 3-7. Proposed Seal Design for the WIPP AIS

during the 10,000-year regulatory period. Components of the seal system within the Rustler limit commingling of groundwater between water-bearing members. Components of the seal system overlying the Rustler fill the shaft with common materials of high density, consistent with good engineering practices. Appendix BARRIERS provides a detailed description of the shaft seal system and detailed design drawings for each shaft seal.

3.3.3 Panel Closure System

In its final certification decision for WIPP (63 FR 27354), the EPA added a new Appendix A to 40 CFR Part 194. The new appendix specifies four conditions that apply to the certification. Condition 1 pertains to panel closures. It states:

> Condition 1: § 194.14(b), Disposal system design, panel closure system. The Department shall implement the panel seal design designated as Option D in Docket A-93-02, Item II-G-1 (October 29, 1996, Compliance Certification Application submitted to the Agency). The Option D design shall be implemented as described in Appendix PCS of Docket A-93-02, Item II-G-1, with the exception that the Department shall use Salado mass concrete (consistent with that proposed for the shaft seal system, and as described in Appendix SEAL of Docket A-93-02, Item II-G-1) instead of fresh water concrete.

Option D involves installation of a concrete block "explosion-isolation wall," removal of the DRZ along a section of the panel access drifts, and emplacement of a concrete monolith composed of Salado Mass Concrete in that section of each access drift.

The EPA Preamble to 40 CFR Part 194 Final Rule Section VIII.A.b stated "if a design different from those listed above is identified, the appropriate permit modification will be sought." Since the certification of WIPP by the EPA, DOE has reevaluated a number of its engineering and construction aspects, including the panel closure systems. Therefore, DOE submitted a proposed change request to EPA on October 7, 2002 (DOE CBFO letter 2002). The EPA responded to DOE with a letter dated November 15, 2002. In this letter, EPA concluded that the panel closure request requires a modification to the rulemaking and "…will likely take a minimum of 12 months to complete from receipt of "complete" information on the requested changes. … Since the rulemaking likely would not be completed before we receive the WIPP compliance recertification application, … we are deferring review of this proposal until after we have issued our recertification decision." Consistent with this direction from EPA, the PA calculations assume a panel closure with characteristics consistent with Option D (see Figures 3-8 and 3-9). In the same letter, EPA agreed to a delay in completing the panel closure system.

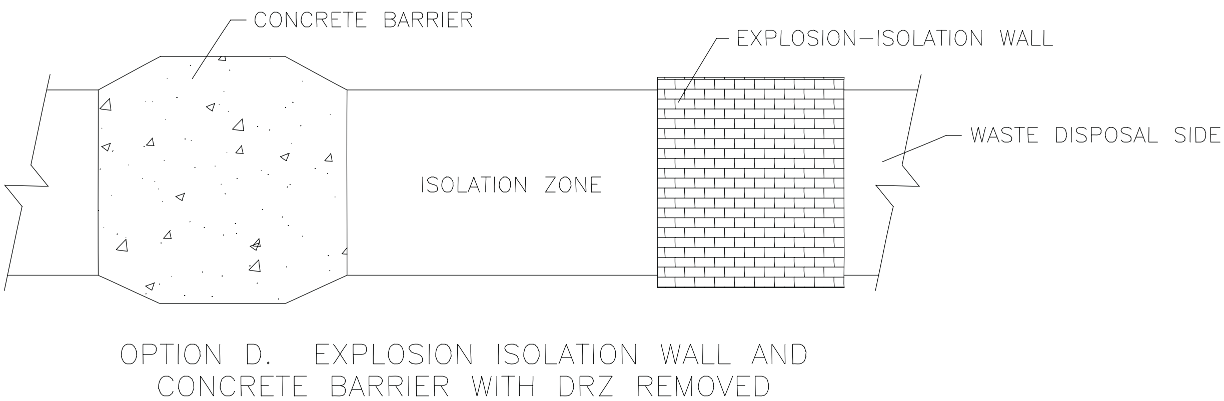


Figure 3-8. Panel Closure

Panel closures have been included for the purpose of Resource Conservation and Recovery Act disposal unit closure and to prevent potentially unacceptable levels of volatile organic compound release during waste management operations. The panel closure system was not designed or intended to support long-term repository performance. The panel closure system has been designed according to a number of operational objectives set out by the DOE, the main elements of which are:

1. the panel closure system shall restrict flow from the panels,

2. the panel closure system should perform its intended functions under loads generated by creep closure, and in general under the most severe ground conditions expected in the waste disposal area during the operational phase,

3. the panel closure system should be capable of containing and continuing to perform its intended function under conditions of a postulated methane explosion,

4. the panel closure system should be constructed of materials that are compatible with its emplacement environment and function,

5. engineering design of the panel closure system should include structural analyses using WIPP specific data, and should address such issues as the thermal cracking of concrete, and

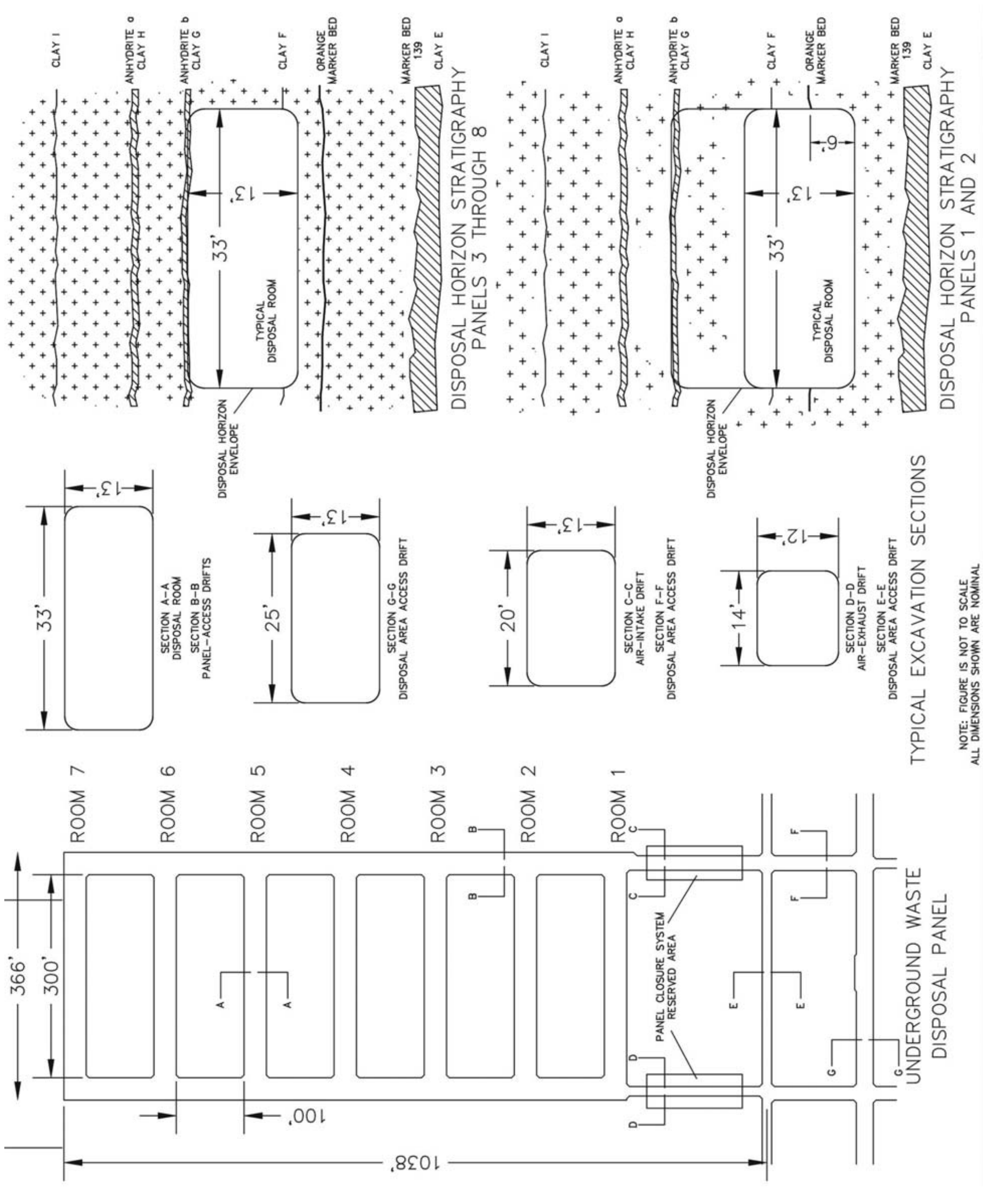


Figure 3-9. Location of Panel Closure System

6. the panel closure system should be designed and constructed using conventional mining practices, with full consideration of shaft and underground access and services. It should be constructed to generally accepted national design and construction standards, with a QA and quality control program used to verify material properties and construction practices.

See Appendix BARRIERS for a detailed discussion of panel closure. Representation of the panel closures in PA is described in Appendix PA, Section PA-4.2.7; parameters relevant to the panel closures are provided in Appendix PA, Attachment PAR, Table PAR-19.

3.3.4 Borehole Plugs

Figure 3-10 identifies existing unplugged boreholes that lie within the controlled area. Of these boreholes, four are deep boreholes that exceed the depth of the repository, and the remainder are shallow boreholes that do not reach the repository horizon.

To mitigate the potential for migration of contaminants toward the accessible environment, the DOE has specified that borehole plugs be designed to limit the volume of water that could be introduced to the repository from the overlying water-bearing zones and to limit the volume of contaminated brine released from the repository to the accessible environment.

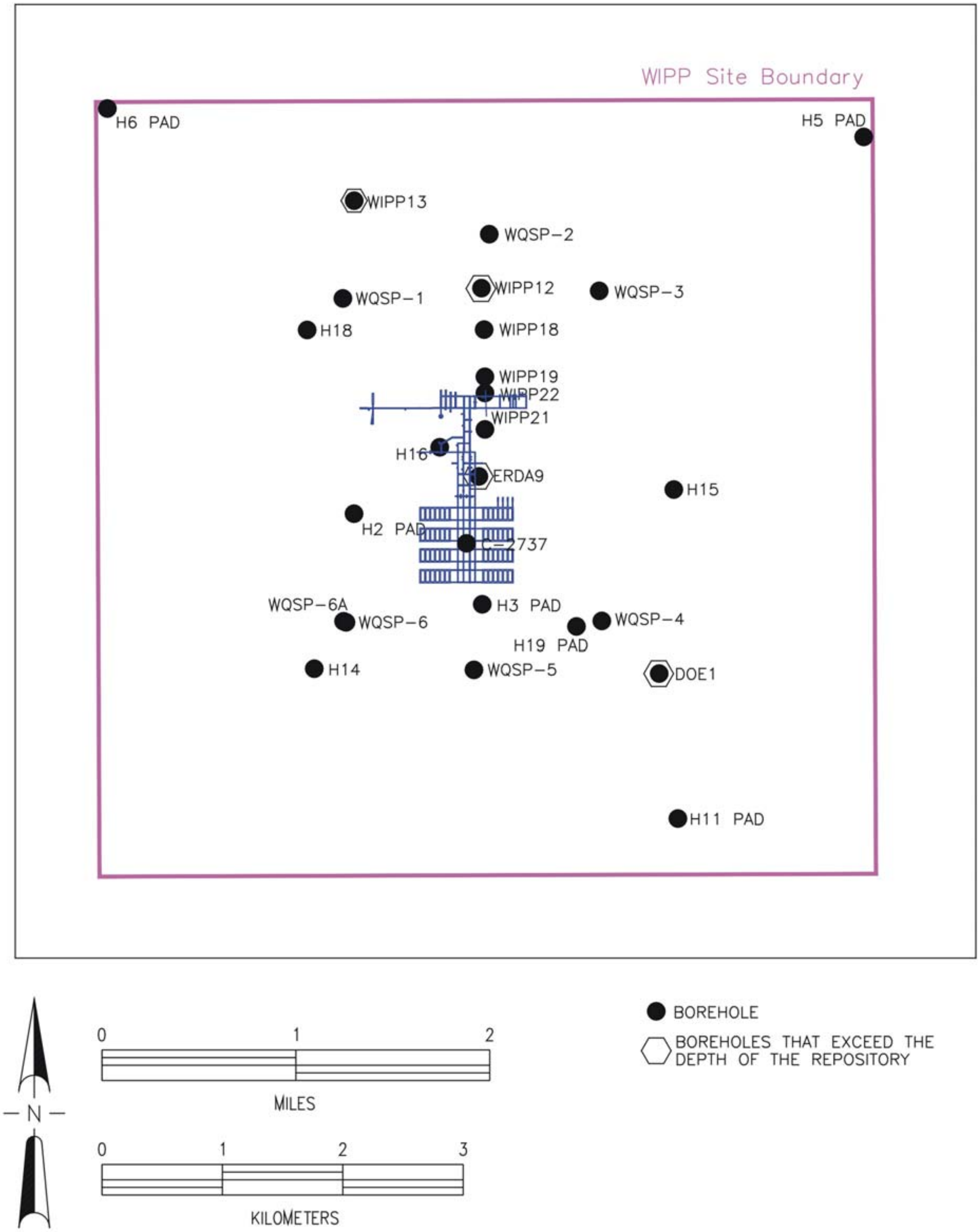
Grout-plugging procedures are routinely performed in standard oil-field operations; however, quantitative measurements of plug performance are rarely obtained. The Bell Canyon Test reported by Christensen and Peterson (1981, 25) was a field test demonstration of the use of cementitious plugging materials and modification of existing industrial emplacement techniques to suit repository plugging requirements. The test was performed in an 20 cm (8 in.) well bore near the top of the Bell Canyon. The test bore intercepted an aquifer at a depth of 1,370 m (4,495 ft) with a shut in pressure of 1,800 psi (12.4 megapascals). A 2-m (6-ft) grout plug was emplaced above the aquifer and tested by unloading the hole (that is, removing fluids) above the plug to allow the full pressure in the aquifer to bear on the plug. This plug was observed to reduce the flow by five orders of magnitude, to 0.6 liters per day (0.2 gallons per day).

Cement emplacement technology was found to be generally adequate to satisfy repository plugging requirements. Christensen and Peterson (1981) also report

> that grouts can be effective in sealing boreholes, if proper care is exercised in matching physical properties of the local rock with grout mixtures.

A significant amount of research has been completed by the DOE to optimize concrete mixtures for the conditions expected in the Salado. The results of this research have been used to design the shaft sealing system as discussed in CCA Appendix SEAL. (Concrete is discussed in Appendix A of CCA Appendix SEAL, Section A2.1.) Consequently, the DOE has identified materials that will provide suitable plugs for boreholes. In addition, appropriate national standards such as the American Petroleum Institute Specification 10 and American Society for Testing Materials specification Volume 04.02 are available to assure the quality of borehole plugging material and installation. Section 2.1.4 of the CAO QAPD (see Appendix QAPD) provides the quality assurance requirements for the control of special processes such as plugging.

1



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3 **Figure 3-10. Approximate Locations of Unplugged Boreholes**

As a result of the Christensen and Peterson (1981) report and subsequent evaluations of plugging materials, the DOE concluded that boreholes within the controlled area, which were previously plugged in accordance with the appropriate state and federal regulations in effect at the time plugging, will mitigate the potential for migration of fluids beyond the repository horizon. Shallow unplugged boreholes within the controlled area will be plugged in accordance with the current state or federal regulations using materials shown to be compatible with the underground environment. Deep unplugged boreholes within the controlled area will be plugged according to the state of New Mexico, Oil Conservation Division (1988), Order R-111-P (see Appendix BARRIERS). The governing regulations for plugging and/or abandonment of boreholes are summarized in Table 3-2. These solid cement plugs will go through the salt section and any water-bearing horizon to prevent liquids or gases from entering the hole above or below the salt section. The boreholes not being used for monitoring will be plugged at decommissioning. Appendix PA, Section PA-4.2.9 summarizes the representation of the borehole plugs in PA; Appendix PA, Attachment PAR, Tables PAR-14, PAR-15, and PAR-16 provide parameter values used in the modeling.

Table 3-2. Governing Regulations for Borehole Abandonment

Federal or State Land	Type of Well or Borehole	Governing Regulation	Summary of Requirements
Both	Groundwater Wells	State of New Mexico (1995), Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Groundwater in New Mexico, Article 4-14	Any specific plugging requirements and provisions made by the state engineer shall be set forth in the permit.
Federal	Oil and Gas Wells	43 CFR Part 3160, 3162.3 4 (DOI 1995a)	The operator shall promptly plug and abandon, in accordance with a plan first approved in writing or prescribed by the authorized officer.
Federal	Potash	43 CFR Part 3590, 3593.1 (DOI 1995b)	(b) Surface boreholes for development or holes for prospecting shall be abandoned to the satisfaction of the authorizing officer by cementing and/or casing or by other methods approved in advance by the authorized officer. The holes shall also be abandoned in a manner to protect the surface and not endanger any present or future underground operation, any deposit of oil, gas, or other mineral substances, or any aquifer.
State	Potash	State of New Mexico (1995), Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Groundwater, Article 4-20.2	In the event that the test or exploratory well is to be abandoned, the state engineer shall be notified. Such well shall be plugged in accordance with Article 4-19.1 so that the fluids will be permanently confined to the specific strata in which they were originally encountered.
State	Oil and Gas Well Outside the Oil-Potash Area	State of New Mexico, Oil Conservation Division (1991), Rule 202 (eff. 3-1-91)	B. Plugging (1) Prior to abandonment, the well shall be plugged in a manner to permanently confine all oil, gas, and water in the separate strata where they were originally found. This can be accomplished by using mud-laden fluid, cement, and plugs singly or in combination as approved by the Division on the notice of intention to plug. (2) The exact location of plugged and abandoned wells shall be marked by the operator with a steel marker not less than 10.16 cm (4 in.) in diameter, set in cement, and extending at least 1.22 m (4 ft) above mean ground level. The metal of the marker shall be permanently engraved, welded, or stamped with the operator name, lease name, and well number and location, including unit letter, section, township, and range.
State	Oil and Gas Wells Inside the Oil-Potash Area	State of New Mexico, Oil Conservation Division (1988), Order No. R-111-P (eff. 4-21-88)	F. Plugging and Abandonment of Wells (1) All existing and future wells that are drilled within the potash area shall be plugged in accordance with the general rules established by the Division. A solid cement plug shall be provided through the salt section and any water-bearing horizon to prevent liquids or gases from entering the hole above or below the salt selection. It shall have suitable proportions—but no greater than three percent of calcium chloride by weight—of cement considered to be the desired mixture when possible.

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