Goal of Active Controls: The objective of the DOE with respect to surface excavation is to ensure that the development of mineral leases does not affect the integrity of the disposal system. In accordance with the LWA requirement that no surface or subsurface mining unrelated to the DOE may be conducted within the boundaries of the land withdrawal area, the DOE and the state of New Mexico have entered into a memorandum of understanding (MOU). This MOU dictates that the state will forward any mining and reclamation plans to the DOE for review and comment in determining issuance of such permits within one mile of the withdrawal area boundary. In addition to the commitments in the MOU, the DOE will conduct perimeter surveillance and evaluate potential encroachment of ancillary activities associated with mines.

7.1.3.1.8 Potash Exploration and Extraction

Description of the Activity: Potash mineralization is known to exist beneath the WIPP site (see Section 2.3.1.1). The extent of mineralization is generally determined through the drilling of core holes and the examination and analysis of rock cores. Sufficient core holes have already been drilled within the WIPP site boundary to characterize the resident mineralization. Future drilling, however, is prohibited by the LWA. Holes drilled for the exploration of potash must be closed in accordance with state or federal regulations, depending on the location of the potash lease (see ***CCA*** Appendix DEL, Section DEL.5.5). The closure of potash holes within the WIPP site boundary is discussed in Section 3.3.4.

Extraction of potash in the Delaware Basin is accomplished through the use of conventional underground mining technologies. Development of resources within the WIPP site boundary would require that a mine be built in the vicinity or that an existing mine be expanded to include the WIPP. Potash mining is conducted in accordance with the rules and regulations of the BLM on federal lands and the State of New Mexico on state lands. The impacts of mining are evaluated in the performance assessment in accordance with the requirements of 40 CFR § 194.32(b) and are discussed in Section 6.4. Figure 7-7 shows a map of the distribution of potash exploration holes and the extent of currently economically minable reserves.

Goal of Active Controls: The active controls program***, especially routine security patrols,*** will ensure that mineral leasing and development within the WIPP site boundary are prevented and that existing or near future mines do not encroach on the site.

7.1.3.1.9 Hydrocarbon Exploration

Description of the Activity: Hydrocarbon resources are assumed to exist below the WIPP site. The amount of these resources and their locations are projected from information that the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) compiled and interpreted for the DOE in 1995. (See Section 2.3 for a discussion of this report.) Exploration companies use surface-based geophysical techniques to determine likely locations for hydrocarbon accumulations and then investigate the prospect using deep drilling. Both the geophysical and the drilling activities have historically occurred on the WIPP site, but further drilling is prohibited by the LWA. Figure 7-8 shows the location of hydrocarbon wells within the WIPP site boundary.

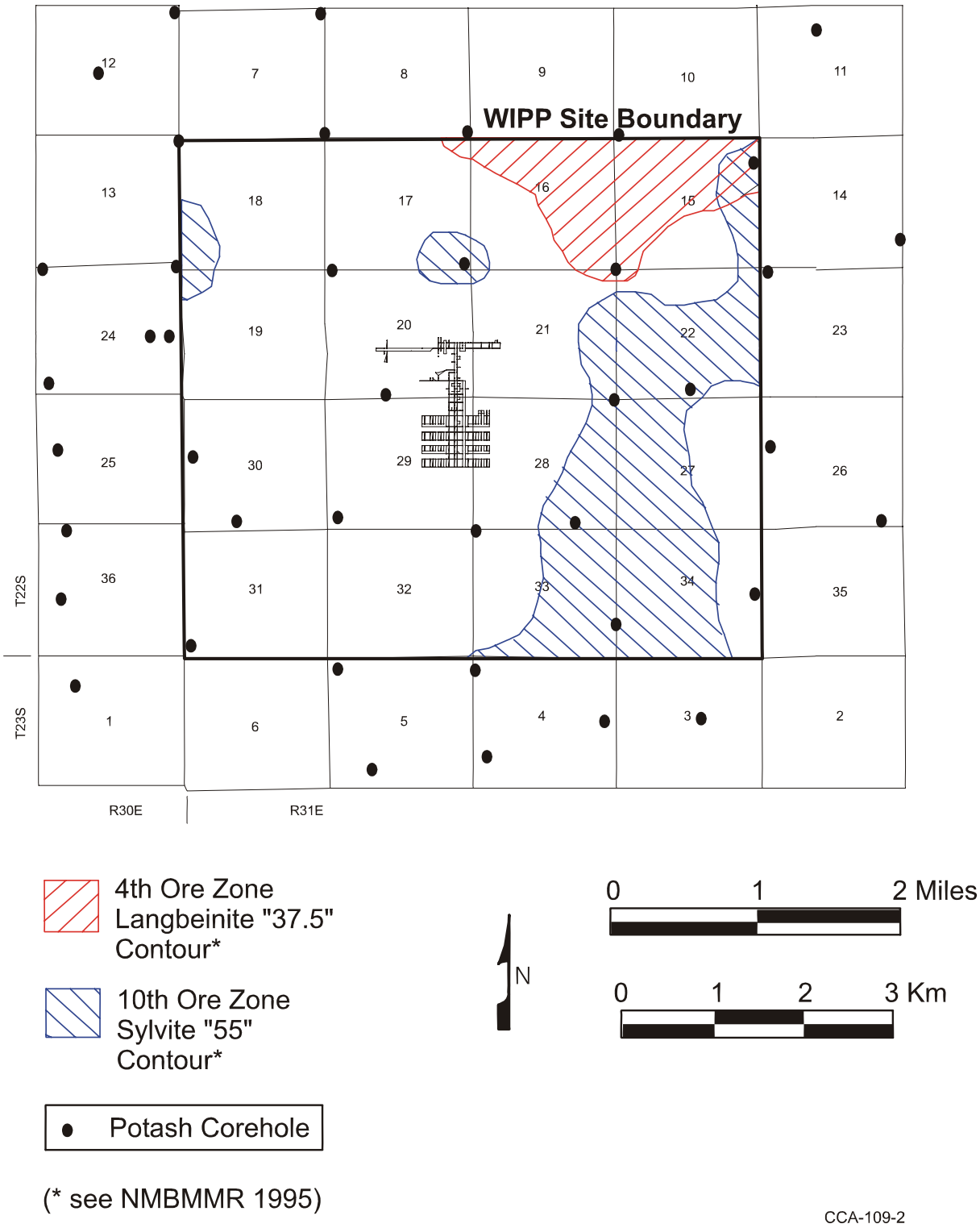

Figure 7-7. Location of Potash Exploration Holes and Economically Minable Potash Within the WIPP Site Boundary as of *September 2002*

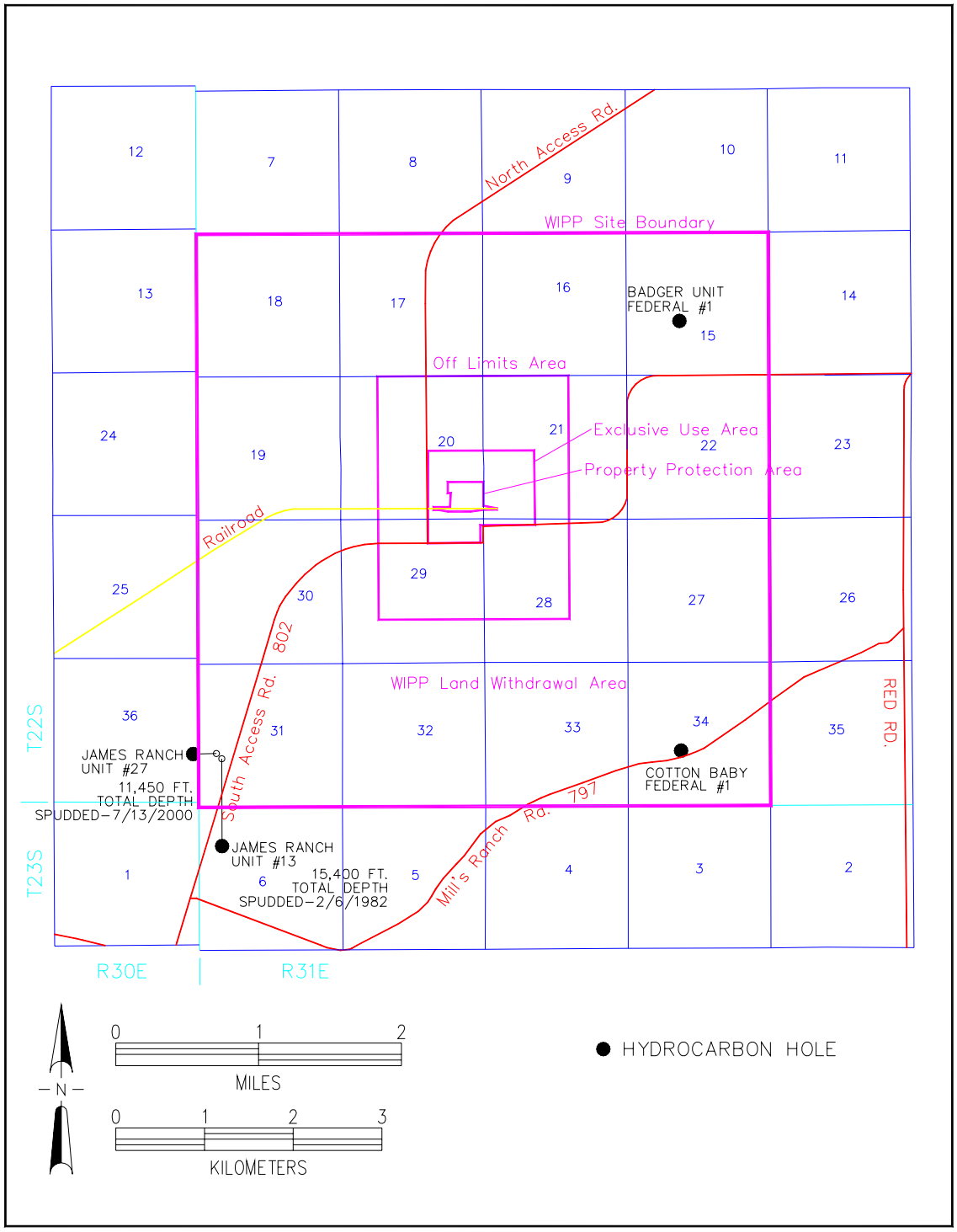

Figure 7-8. Hydrocarbon Holes Located Within the WIPP Site Boundary as of *September 2002*

Goal of Active Controls: The active controls program will ensure that the prohibition on the drilling of hydrocarbon wells is enforced. In addition, the BLM and the state of New Mexico will administer permits to perform geophysical investigations.

7.1.3.1.10 Construction

Description of Activity: The construction of a permanent building typically involves activities that disturb the surface only to a depth of a few meters, with the exception of the drilling of a groundwater well. Construction is currently prohibited by the DOE for public protection reasons during disposal operations. Because the WIPP site is federally owned, only federal facilities can be built there and any construction will require federal permits. After the conclusion of operations and during the active institutional controls period, construction will not be allowed within the areas reserved for the permanent marker system.

Goal of Active Controls: Controls will ensure that construction does not occur within the WIPP site boundary prior to the end of the active institutional controls period and that no construction will interfere with the goals of the passive controls system.

7.1.3.1.11 Hostile and Illegal Activities

Description of Activity: Activities in this category include vandalism, sabotage, theft, and artifact hunting. All of these activities are prohibited by federal and state law. None is expected to have an impact on the disposal system, although they could impact monitoring efforts, the construction and preservation of permanent markers, the integrity of fences and test areas, and other authorized uses.

Goal of Active Controls: Active controls will prevent the occurrence of hostile and illegal activities to the extent practicable within the WIPP site boundary. Controls may include access control and other security measures.

7.1.3.2 Active Controls Design Features

Based on these possible land uses, the DOE has specified the following design features for the active controls system. Additional detail is presented in ***CCA*** Appendix AIC (Section 1).

- Signage will be established to control access to the WIPP site. A fence will be erected along the perimeter of the repository surface footprint. The fence will have gates placed approximately midway along each of the four sides.

- Roadways will be constructed as needed to provide easy visual inspection and ready vehicle access to any point around the fenced perimeter and to facilitate maintenance of the fence line. These roadways will connect to the paved south access road.

- The fence line and the WIPP site perimeter will be posted with signs having as a minimum a legend reading “Danger—Unauthorized Personnel Keep Out” and a warning against entering the area without specific permission of the DOE. Signs prohibiting hunting will also be posted as appropriate. In addition, the DOE will include the area in the local one-call system.

- Upon installation of the permanent marker system, the active institutional controls program will be revised as deemed appropriate.

- Guidelines will be developed for identifying and implementing the appropriate corrective measures to address any abnormal conditions identified during periodic surveillance and inspections.

- Reports of activities associated with the postdisposal active access controls will be prepared in accordance with regulatory requirements for submittal to the appropriate regulatory and legislative authority.

7.1.3.3 Description of Active Institutional Controls Features

Most of the active institutional controls measures, such as long-term site monitoring and site remedial actions, will be implemented simultaneously with facility closure and D&D. It may be possible, however, to implement some measures earlier. For example, salt disposal may begin prior to final facility closure. Reclamation and restoration of unused disturbed surface areas have already begun. Guarding and maintenance activities, which are in place, could evolve into an appropriate type of postclosure activity.

During the disposal phase, the DOE will manage and store waste in a manner that limits the public's exposure to radiation ***in accordance with***~~to~~ the standards of 40 CFR 191, Subpart A. Subsequent to disposal and after shafts are backfilled and sealed, radioactive releases to the accessible environment, exposures to humans, and concentrations in groundwater cannot exceed the standards of 40 CFR Part 191, Subparts B and C. The periods of active institutional controls and passive institutional controls begin when the disposal phase ends, and according to the EPA, run concurrently for at least 100 years. Also per the EPA, after 100 years, credit for active controls must end, but credit for passive controls may continue for up to 700 years after final facility closure ***(see Section 7.3.4.2)***.

The active controls program design described above is implemented through the following components. Additional detail is provided in ***CCA*** Appendix AIC (Section 2):

- Signage that indicates the areal extent of the WIPP and a fence that restricts access to the repository footprint, respectively, and includes the area in which the passive markers will be constructed. This area (shown in Figure 7-9) is referred to as the repository footprint and represents the surface projection of all areas underground that contain waste. Note that additional fencing may be needed for remote locations that are used for disposal system monitoring. Such fences will meet the same construction specifications as those for the perimeter footprint.

- A 16-foot (4.9 meter) wide roadway around the perimeter of the WIPP site boundary. Roads to remote sites will also be constructed and maintained as needed.

- Surveillance that includes drive-by patrolling two or three times per week. This frequency will be sufficient to detect and remove the most severe threats to the disposal system, such as drilling.

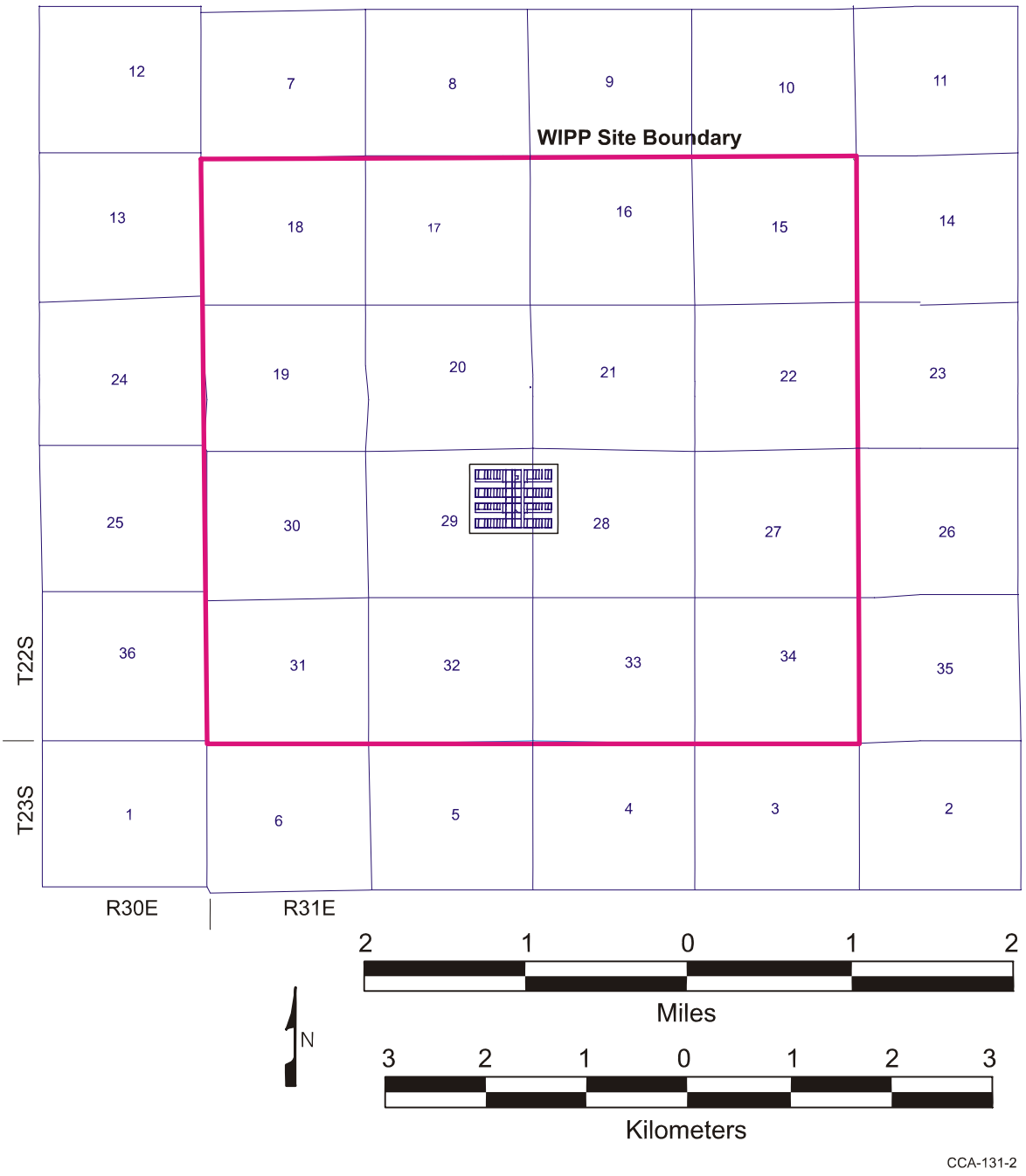

Figure 7-9. Planned Repository Footprint

- Maintenance services for fences, gates, cattle guards, signs, and monitoring equipment.
- Site restoration activities in accordance with the postclosure land management plan.
- Agreements with the BLM to administer grazing and other permitted land uses consistent with the DOE's postclosure land management plan.
- Monitoring of the disposal system.
- Construction of a permanent marker system.

7.1.4 Effectiveness of the Active Institutional Controls Program

Performance assessment for the WIPP assumes that the active institutional controls program will be one hundred percent effective in preventing human intrusion into the repository for the 100 years immediately following disposal. The DOE believes that this assumption is supported by the proposed design features alone (that is, fencing, postings, perimeter inspections, surveillance, and mitigation measures) and the defense-in-depth nature of the features and resulting controls. The DOE believes that taking one hundred percent credit for 100 years of active controls is justified by the repetitive and redundant nature of the active controls that will be implemented at the WIPP site. The DOE is committed to retaining active control over the site for as long as is practicable, but at least for 100 years.

Governments have successfully controlled and protected facilities of national importance for hundreds of years. The U.S. Government has existed and effectively maintained many facilities under its control for over 200 years. The DOE and its predecessor agencies have successfully maintained (preventing intrusion) several major facilities for over 50 years. Therefore, the DOE believes there is a reasonable expectation that active institutional controls will be effective for at least the assumed 100-year institutional control period, and are likely to be effective for substantially longer periods.

In its certification decision (63 FR 27395), EPA ". . . found it reasonable for DOE to assume credit in the PA for 100 years. The EPA found the assumptions regarding longevity and efficacy of the proposed AICs to be acceptable based on the fact that the types of inadvertent intrusion which AICs are designed to obviate are not casual activities, but require extensive resources, lengthy procedures for obtaining legal permission, and substantial time to set up at the site before beginning."

7.2 Monitoring

The requirements for disposal system monitoring are stated in 40 CFR § 191.14(b). In order to certify the DOE's compliance with these requirements, the EPA has established certification criteria that the DOE must satisfy in its application for certification. These criteria are stated in 40 CFR § 194.42. The requirements and the criteria form the basis for the DOE's monitoring program. Appendix MON-*2004*, Pre-Closure and Post-Closure (Long-Term) Monitoring Plan, describes the details of the DOE's monitoring program.

The criteria provided in 40 CFR § 194.42(a) state

The Department shall conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application. The results of the analysis shall be used in developing plans for preclosure and postclosure monitoring required pursuant to paragraphs (c) and (d) of this section. The disposal system parameters analyzed shall include, at a minimum:

(1) Properties of backfilled material, including porosity, permeability, and degree of compaction and reconsolidation;

(2) Stresses and extent of deformation of the surrounding roof, walls, and floor of the waste disposal room;

(3) Initiation or displacement of major brittle deformation features in the roof or surrounding rock;

(4) Ground water flow and other effects of human intrusion in the vicinity of the disposal system;

(5) Brine quantity, flux, composition, and spatial distribution;

(6) Gas quantity and composition; and

(7) Temperature distribution.

Attachment 1 (MONPAR) to ***CCA*** Appendix MON is an "Analysis of the Effects of Disposal System Parameters on Waste Containment" that the DOE has used to base decisions regarding disposal system monitoring. 40 CFR § 194.42 dictates the manner in which the stated analysis will be used in deriving the monitoring program, including the specification that the program consider preclosure monitoring as an integral component of meeting the monitoring requirements.

CCA Appendix MON, Attachment 1's (MONPAR's***)*** scope of analyzed parameters exceeds the minimum parameters identified in 40 CFR § 194.42(a). The following is a summary of the results of the analysis with respect to those parameters identified in 40 CFR § 194.42(a).

(1) *Properties of backfilled material, including porosity, permeability, and degree of compaction and reconsolidation;*

Backfill Material Properties. The mechanical and hydrologic properties of the backfill are not significant to the performance assessment. Therefore, they will not be monitored during the preclosure or postclosure periods. See ***CCA*** Appendix MON (Attachment 1, MONPAR, Section MONPAR.3.5) for additional detail regarding DOE's analysis of backfill.

(2) *Stresses and extent of deformation of the surrounding roof, walls, and floor of the waste disposal system;*

(3) *Initiation or displacement of major brittle deformation features in the roof or surrounding rock;*

Stress and Extent of Deformation. Creep closure of the repository will occur, and is included within compliance assessment and performance assessment models as a control on waste consolidation and other time-dependent disposal room conditions. The

individual creep closure parameters are not significant to performance assessment. Sufficient data have been collected for the purposes of verifying the underlying rock mechanics models. The numerical models of the repository used in performance assessment are based upon assumptions about long-term behavior that are not applicable to behavior during the operational period. Further monitoring of creep closure and stress would not provide information that is useful for calculating disposal system performance, nor would it lead to additional confidence in the performance assessment models.

The initiation or displacement of major brittle deformation features in the roof or surrounding rock, beyond that already accounted for in performance assessment calculations, is not significant to the containment of waste. The individual parameters that are used in modeling the mechanical behavior of brittle anhydrite interbeds are not significant to performance assessment. Monitoring mechanical behavior of the interbeds would not provide information that is useful for calculating system performance, nor would it lead to additional confidence in the performance assessment models.

Monitoring of creep closure and mechanical behavior ***is being***~~will be~~ conducted during preclosure monitoring to provide information that is relevant to repository operations.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.3.1 and MONPAR.3.2) for additional detail regarding DOE's analysis of creep closure and deformation features.

(4) *Ground water flow and other effects of human intrusion in the vicinity of the disposal system;*

Drilling Intrusions. Intrusion into the repository through drilling may occur during the regulatory time period. In accordance with regulatory requirements, such intrusions are modeled to occur randomly in time and space. Drilling leads to direct releases during the drilling itself and possible long-term releases due to effects on fluid flow in the disposal system. The drilling rate (boreholes per square kilometer per 10,000 years) is significant to repository performance. The DOE uses a drilling rate in performance assessment that is based on historical rates in the Delaware Basin.

The DOE will monitor the drilling activity in the Delaware Basin during the preclosure and postclosure periods and will use the results in performance calculations performed in support of recertification.

Borehole Properties. The properties of a borehole change over time, and are incorporated into performance assessment. The properties are established to be "consistent with practices in the Delaware Basin at the time a compliance application is prepared" (40 CFR § 194.33[c][1]). These parameters are significant to compliance. The current practices will be monitored and changes will be incorporated into the performance assessment models of borehole properties in future calculations in support of recertification.

Groundwater Flow. Historical, current, and near-future human activities in the vicinity of the repository could affect groundwater flow in the Culebra prior to closure of the repository, as well as subsequent to repository closure. The significance of these human activities depends on the extent and magnitude of the induced hydrological, geochemical, and mechanical disturbance. Changes in groundwater in the Culebra are moderately significant to performance. Such changes are incorporated into performance assessment as described in ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.4.4 and MONPAR.4.5). Changes to brine flow in the Salado as a result of any current or near future human activities in the vicinity of the repository are not anticipated, and therefore are not significant to performance assessment.

The DOE will monitor water levels and groundwater flow direction in the Culebra during the operational period. Monitoring of groundwater flow conditions in the Salado could create additional pathways for radionuclide transport, and would potentially jeopardize long-term performance of the disposal system; thus the DOE will not perform such monitoring.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.4.1, MONPAR.4.3, and MONPAR.4.4) for additional detail regarding DOE's analysis of drilling intrusions, borehole properties, and groundwater flow in the vicinity of the repository.

(5) Brine quantity, flux, composition, and spatial distribution;

Salado Hydrology. Hydrologic properties (quantity, flux, and spatial distribution) of the intact Salado Formation are incorporated into performance assessment through parameters that are consistent with extensive experimental observations. Variations in these parameters have a moderate effect on system performance assessment. There is no indication that properties of the intact (far-field) Salado will change during the regulatory period; thus, they will not be monitored during the operational period nor during the postclosure period. Composition of Salado brines has been well established through investigations. Brine composition is significant and is incorporated into performance assessment calculations. Based on the extensive experimental evidence collected, there is no indication that Salado brine composition will change over the regulatory period; thus it will not be routinely monitored during the operational period nor during the postclosure period.

The presence of a disturbed rock zone (DRZ) surrounding the repository has also been incorporated into performance assessment calculations. The properties of the DRZ have been well characterized; they include altered hydrologic properties that are expected to ***allow enhanced*** ~~enhance~~ near-field flow both to and from the repository. The initial conditions and enhanced fluid flow are moderately significant to disposal system performance. In an effort to simplify the calculations, the effects are maximized by the conceptual model and altered properties of the DRZ. This treatment is believed to be a conservative choice with respect to the ultimate impact on predicted release. ~~Monitoring the DRZ hydrologic properties would not provide relevant information or verify~~

~~assumptions used in performance assessment; therefore they will not be monitored during the operational period nor during the postclosure period.~~

Mechanical and hydrologic properties of the disposal room are incorporated into performance assessment as they affect gas generation and fluid flow into and out of the repository. These properties and parameters are moderately significant to disposal system performance. Additional properties are significant in the event of intrusion into the repository; these are discussed in ***CCA*** Appendix MON (Attachment 1, MONPAR, Section MONPAR.4.2.). The conceptual model of disposal room behavior is based on extensive experimental data that support a number of assumptions about long-term behavior that will not be applicable during the preclosure period. The closed disposal room will not achieve the expected long-term properties predicted in performance assessment during the operational or active control periods. Therefore, monitoring the mechanical and hydrologic properties would not provide relevant information or verify assumptions used in performance assessment. Thus the disposal room properties will not be monitored during the operational period nor during the postclosure period.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.2.1, MONPAR.2.2, MONPAR.3.3, and MONPAR.3.4) for additional detail regarding DOE's analysis of these parameters.

Culebra Hydrology. Hydrologic properties (quantity, flux, and spatial distribution) of the undisturbed Culebra Member of the Rustler Formation exhibit spatial variability and are incorporated into performance assessment through both fixed values and parametric ranges that are consistent with experimental observations to date. Variations in some of the parameters are significant to overall disposal system performance. ~~The hydrologic properties of the undisturbed Culebra are not expected to change during the regulatory period, thus they will not be monitored during the operational period nor during the postclosure period.~~ Culebra groundwater is less saline than Salado and Castile brines. The Culebra groundwater is spatially variable, and its composition has been well established through investigations. Groundwater composition is incorporated into performance assessment calculations; however, it is not significant to performance. Based on extensive experimental evidence, there is no indication that Culebra groundwater composition will change over the regulatory period; however, monitoring will provide information that is relevant to a comprehensive environmental monitoring program.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.2.3 and MONPAR.2.4) for additional details regarding DOE's analysis of these parameters.

Castile Hydrology. The Castile Formation underlying the WIPP may contain reservoirs of pressurized brine. This is incorporated into performance assessment through use of input parameters that address hydrologic properties and the probability that a reservoir will be encountered during an intrusion event. The hydrologic properties are significant to disposal system performance in such an intrusion event. The Castile is not significant to system performance except for the brine reservoirs. There is no indication that the properties of the undisturbed reservoirs will change over the regulatory period ~~although~~

~~the assumption is made in the modeling that intrusions into brine reservoirs lead to their eventual depletion~~. It is not possible to completely define the location and extent of brine reservoirs without jeopardizing the integrity of the disposal system. Composition of brines from two Castile brine reservoirs is moderately significant and is incorporated into performance assessment calculations. There is no evidence to suggest that the brine composition will change over the regulatory period. It is not possible to further investigate composition of any brine that may be present below the repository without jeopardizing the integrity of the disposal system. Therefore, no further investigations or monitoring will be performed during the preclosure period nor during the postclosure period. However, monitoring of drilling activity in the Delaware Basin for instances of encountering pressurized brine reservoirs in the Castile will be a part of the preclosure and postclosure monitoring programs.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.2.5 and MONPAR.2.6) for additional details regarding DOE's analysis of the Castile hydrology parameters.

(6) *Gas quantity and composition;*

Gas Quantity and Composition. Gas generated in the repository may retard creep closure, may fracture the anhydrite interbeds in the DRZ (enhancing fluid flow), and may enhance direct releases (***CCA*** Appendix MON, ***Attachment 1, MONPAR,*** Section MONPAR.4.2). These effects are moderately significant and are accounted for in performance assessment. Gas composition (carbon dioxide concentration) and the corrosion rate of metals are controlled chemically by the backfill and are not significant. Gas generation is moderately significant to system performance. The conceptual model of gas generation processes is based on experimental data and incorporates a number of assumptions about long-term behavior that will not be applicable during the operational period (such as anoxic conditions). Monitoring the quantity and composition of gas generated in the closed panels would not provide information that is useful for calculating system performance, nor would it lead to additional confidence in the performance assessment models.

~~However, in accordance with requirements under RCRA regulations, gas sampling and analysis will be conducted as described in Appendices MON and VCMP, Confirmatory Monitoring Plan.~~

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Section MONPAR.3.6) for additional detail regarding DOE's analysis of gas generation.

(7) *Temperature distribution.*

Temperature Distribution. Natural geological thermal gradients have been well characterized and are not significant: they will not affect repository performance, either directly by affecting the containers and repository chemistry, or indirectly by altering fluid flow through the Salado or the Culebra. Similarly waste-induced and repository-induced thermal gradients in the repository are not significant: they will not affect

repository performance, either directly by affecting the containers and repository chemistry, or indirectly by altering fluid flow through the Salado or the Culebra. Therefore, natural thermal gradients, waste-induced thermal gradients, and repository-induced thermal gradients will not be monitored during the preclosure period nor during the postclosure period.

See ***CCA*** Appendix MON (Attachment 1, MONPAR, Sections MONPAR.2.7 and MONPAR.3.8) for additional detail regarding DOE's analysis of natural temperature distribution.

The criteria state that the DOE is to base decisions regarding disposal system monitoring on "an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application." The rule goes on to dictate the manner in which the stated analysis will be used in deriving the monitoring program, including the specification that the program consider preclosure monitoring as an integral component of meeting the monitoring requirements.

The DOE has completed the analysis and has designed a monitoring program (including both preclosure and postclosure monitoring techniques) that meets the requirements of 40 CFR § 191.14(b). The program is documented in a manner that addresses the certification criteria of 40 CFR § 194.42, and is described in this section. ~~This monitoring program is described in this section.~~ More detailed information is provided in ***CCA*** Appendix MON.

Additional parametric areas of analysis included in MONPAR (Attachment 1 of ***CCA*** Appendix MON) are:

- repository chemical conditions,
- shaft seal system,
- radionuclide transport and retardation,
- direct releases, and
- mining.

Table 7-2 is a list of the specific disposal system parameters discussed in ***CCA*** Appendix ***MON, Attachment 1,*** MONPAR.

As part of the recertification effort, the analysis documented in CCA Appendix MON, Attachment 1, MONPAR was reviewed to determine if changes to PA methods or results of monitoring programs have impacted the conclusions in CCA Appendix MON, Attachment 1, MONPAR. The PA methodology has not changed since the CCA with the exception of additional refinements in Culebra groundwater modeling.

Results of Culebra monitoring have prompted additional groundwater investigations. These investigations are ongoing and involve additional well drilling and hydrological testing. The

Table 7-2. Potentially Significant Disposal System Parameters

NATURAL PARAMETERS	
Impure halite effective porosity	Culebra diffusional porosity
Impure halite permeability	Culebra longitudinal dispersivity
Impure halite pore compressibility	Climate change index
Impure halite far-field pore pressure	Culebra groundwater quantity
Anhydrite permeability	Culebra groundwater flux
Anhydrite pore compressibility	Culebra groundwater spatial distribution
Anhydrite two-phase flow model choice	Culebra groundwater composition
Salado pore shape	Castile brine volume in reservoir
Salado residual brine saturation	Castile brine reservoir volume selection index
Salado residual gas saturation	Castile brine reservoir pressure
Salado brine quantity	Castile brine reservoir permeability
Salado brine flux	Castile brine reservoir rock compressibility
Salado brine spatial distribution	Castile brine composition
Salado brine composition	Castile brine flux
Culebra transmissivity	Castile brine spatial distribution
Culebra advective porosity	Natural temperature distribution
Culebra fracture spacing	
WASTE AND REPOSITORY PARAMETERS	
Closure rates and stresses	Probability factor for types of microbial degradation
Extent of deformation	Gas quantity
Initiation of brittle deformation	Gas composition
Displacement of major deformation features	Choice of oxidation state distribution
DRZ permeability	Solubility of nine radionuclides in Salado brine
DRZ effective porosity	Solubility of nine radionuclides in Castile brine
DRZ brine flux	Humic colloid concentration in Salado brine
DRZ brine quantity	Humic colloid concentration in Castile brine
Waste area residual gas saturation	Clay shaft seal member permeability
Waste area residual brine saturation	Concrete shaft seal member permeability
Brine wicking	Asphalt shaft seal member permeability
Waste area permeability	Shaft DRZ permeability
Backfill porosity	Crushed salt seal component permeability (permeability selection index)
Backfill permeability	Seal residual gas saturation
Degree of backfill compaction	Seal residual brine saturation
Backfill reconsolidation	Seal pore shape
Inundated steel corrosion rate with CO_2	Waste- and repository-induced temperature distribution
Inundated steel corrosion rate without CO_2	Salado K_ds for dissolved radionuclides
Inundated microbial degradation rate	Culebra K_ds for six dissolved radionuclides
Humid microbial degradation rate	Salado K_ds for colloidal radionuclides
β-factor for microbial degradation process	Borehole permeability
Drilling rate	Borehole plugging pattern (probability index)
Waste particle diameter	Change in Salado brine flow
Effective shear resistance to erosion	

Table 7-2. Potentially Significant Disposal System Parameters— Continued

NATURAL PARAMETERS	
~~Gravity correction factor for spalling~~	Change in Culebra groundwater flow
~~Strength correction factor for spalling~~	Probability that mining will occur
Mud pump rate	Mining index for adjusting Culebra transmissivity
Drill penetration rate	Waste activity
Time between intrusions	Waste tensile strength
Borehole location	
Probability of encountering a Castile brine reservoir	
Borehole diameter	

information gathered since the CCA as part of the groundwater monitoring program has been addressed in the implementation of the groundwater conceptual model (see Section 2.2.1.4.1.2, Section 6.4.6.2 and Appendix DATA, Section DATA-11). Culebra groundwater monitoring was derived from the CCA Appendix MON, Attachment 1, MONPAR analysis and has proven to be an important element of the WIPP operational monitoring program. The program continues to monitor Culebra groundwater to ensure that changes to important activities and conditions related to WIPP long-term performance are identified and addressed. Future results of the ongoing investigations may necessitate changes to the monitoring program; however, the current monitoring parameters have not changed.

7.2.1 Monitoring Program Requirements

Requirements for monitoring of a disposal system[1] are included in the final disposal regulations as follows:

> Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring (§ 191.14[b]).

Within this context, monitoring becomes one of several activities to be implemented at the WIPP facility during the active institutional controls period. Monitoring the WIPP disposal system is designed to address significant concerns associated with the performance of the isolation system. The EPA points out that monitoring approaches to address significant concerns should be limited to those that can provide meaningful data in a relatively short period of time (50 FR 38081). In addition, the EPA points out that monitoring must not become a reason to relax the degree of care with which the compliance determination is made. Finally, the EPA specifies that monitoring must not jeopardize the integrity of the disposal system (50 FR 38081).

~~The DOE has addressed the need for monitoring the disposal system during both the preclosure period and the postclosure period in its application for a hazardous waste facility operating permit (see Appendix MON). In its Pre-Closure and Post-Closure (Long-Term) Monitoring Plan~~

[1] Disposal system means "any combination of engineered and natural barriers that isolate...radioactive waste after disposal" (40 CFR § 191.12).

~~(Appendix MON), the DOE incorporates three monitoring programs that will be used to ensure compliance with the hazardous waste regulations of RCRA as implemented by the NMED. These programs include (1) a confirmatory volatile organic compound (VOC) monitoring program to demonstrate that the numerical predictions of VOC releases are reasonable, (2) a groundwater monitoring program to verify knowledge regarding the characteristics of groundwater flow, including periodic testing for releases from the repository, and (3) a geomechanical monitoring program to support decisions regarding operations and maintenance of underground openings. Only the groundwater program is expected to extend into the 30-year RCRA postclosure period. The EPA has established, as a certification criterion, that the monitoring programs in this application must be complementary with the RCRA programs that the DOE will be required to implement.~~

7.2.2 Monitoring Program Design

The requirements in 40 CFR § 191.14(b) and the criteria in 40 CFR § 194.42 can be translated into five screening criteria for selecting monitoring parameters and for developing monitoring plans. The monitoring plan should

- address significant disposal system parameters,
- address important disposal system concerns,
- obtain meaningful data in a short time period (50 FR 38081),
- preserve disposal system integrity, and
- be complementary with ***other regulatory*** ~~RCRA~~ programs.

Each of these screening criteria is discussed below.

7.2.2.1 Significant Disposal System Parameters

In the certification criteria, the EPA states that

> The Department shall conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application. The results of the analysis shall be used in developing plans for preclosure and postclosure monitoring required pursuant to paragraphs (c) and (d) of this section (40 CFR § 194.42[a]).

The EPA also states that to the extent practicable, preclosure monitoring shall be conducted of significant disposal system parameter(s) as identified by the analysis conducted pursuant to paragraph (a) of this section (40 CFR § 194.42[c]). Though not explicitly stated in the criteria, it is appropriate that the same requirement hold for postclosure monitoring. The EPA defines significant parameters as follows: "A disposal system parameter shall be considered significant if it affects the system's ability to contain waste or the ability to verify predictions about the future performance of the disposal system" (40 CFR § 194.42[c]).

The terms significant, important, and sensitive have been used in the WIPP program to describe parameters with variability that impact the outcome of performance assessment. While these terms are for the most part interchangeable, the term significant is used in this discussion to maintain consistency with the terminology in the 40 CFR Part 194 criteria.

The DOE has conducted the requisite study of parameters that are inputs to the performance assessment. ***CCA*** MONPAR (Attachment 1 of Appendix MON) provides a description of the methodology and results of that study. The DOE has implemented the criteria for significance in ***CCA*** Appendix MON.

Verification of parameters used in the system performance analysis may occur in one or both of the following ways:

- measurement of physical or chemical conditions to see if they remain consistent with expected conditions or within the range of conditions incorporated into the assumptions and models, and

- measurement of physical and chemical processes that are currently based on professional judgment or regulatory guidance because data are not available.

The DOE considered the major processes and models described in Section 6.4 and the regulations and developed an initial list of potentially significant parameters as discussed in Attachment 1 to ***CCA*** Appendix MON (MONPAR). Parameters were screened for inclusion in the list based on the following criteria:

- the parameter represents one or more important aspects of a chemical or physical process or model,

- the parameter represents subjective uncertainty (such as spatial variability in a physical property or process),

- the parameter represents stochastic uncertainty (such as drilling rate), and

- the parameter proved to be moderately to highly sensitive in terms of modeling results in previous preliminary performance assessments.

The parameters identified through this screening process are summarized in Table 7-2 and discussed in ***CCA*** MONPAR (Attachment 1 of Appendix MON).

The parameters identified in Table 7-2 are assigned high, medium, and low significance values (EPA 1996c). Those parameters that would significantly affect a release are assigned a HIGH level. Parameters that influence a release are assigned a MEDIUM value. Parameters that are not significant (represent spatial variability or an uncertainty in a given value) are assigned a LOW value. Those that were determined as having a high significance are shown in Table 7-3.

Table 7-3. Disposal System Parameters Determined to be of Highest Significance to Disposal System Performance

Parameter	Significance to Containment	Significance to Verification
NATURAL PARAMETERS		
Salado anhydrite permeability	HIGH	HIGH
Salado brine composition	HIGH	HIGH
Culebra fracture spacing	HIGH	HIGH
Castile brine reservoir volume selection index	HIGH	HIGH
Castile brine reservoir pressure	HIGH	HIGH
Castile brine reservoir permeability	HIGH	HIGH
Castile brine reservoir rock compressibility	HIGH	HIGH
Castile brine reservoir volume selection index	HIGH	HIGH
Castile brine flux	HIGH	HIGH
Castile brine spatial distribution	HIGH	HIGH
Castile brine composition	HIGH	HIGH
WASTE AND REPOSITORY PARAMETERS		
Inundated steel corrosion rate without CO_2	HIGH	HIGH
Choice of oxidation state distribution	HIGH	HIGH
Solubility of nine radionuclides in Salado brine	HIGH	HIGH
Solubility of nine radionuclides in Castile brine	HIGH	HIGH
Humic colloid concentration in Salado brine	HIGH	HIGH
Humic colloid concentration in Castile brine	HIGH	HIGH
Culebra K_ds for dissolved radionuclides	HIGH	HIGH
Crushed salt seal component permeability (permeability selection index)	HIGH	HIGH
HUMAN INITIATED PARAMETERS		
Drilling rate	HIGH	HIGH
Waste particle diameter	HIGH	HIGH
Borehole permeability	HIGH	HIGH
Borehole plugging pattern (probability index)	HIGH	HIGH
Time between intrusions	HIGH	HIGH
Borehole location	HIGH	HIGH
Probability of encountering Castile brine reservoir	HIGH	HIGH
Waste activity	HIGH	HIGH
Effective shear resistance to erosion	HIGH	HIGH

7.2.2.2 Important Disposal System Concern

This criterion is closely tied with the first in that, in the final analysis, the most significant parameters are related to important disposal system concerns. However, the DOE has included this category as a separate criterion to identify any other parameters that, while they are not

significant in performance assessment, do describe important disposal system features. For example, the creep properties of the Salado can be considered an important feature of the disposal system, although the parameter analysis identified them as having a minor effect on the outcome of the analysis. Creep properties are identified in ***CCA*** Appendix MON (Attachment 1, MONPAR) because they can provide a body of information that allows the DOE to evaluate its conceptual model of Salado creep closure.

In order to select these parameters for further evaluation, the DOE divided the disposal system into five major components: Salado and repository physical properties, Salado and repository hydrological properties, non-Salado hydrological properties, waste properties, and engineered barrier properties. Based on this division, the DOE revisited the list of potentially significant parameters and determined those parameters that were related to a measurable property of the disposal system. Those parameters are shown in Table 7-4.

7.2.2.3 Meaningful Data in a Relatively Short Time

The amount of time available for the DOE to obtain data regarding important disposal system parameters is ***limited.*** ~~approximately 150 years.~~ This ***period consists of a*** ~~assumes a 50-year~~ preclosure period and 100 years of active institutional controls. However, the DOE will continue monitoring programs for as long as needed if meaningful data are collected or are expected.

In screening parameters using this criterion, the DOE applied two qualifications. First, parameters had to be amenable to measurement within the disposal system and, second, parameter changes expected to occur within the first ***127*** ~~150~~ years and affecting long-term disposal system performance had to be predictable. For example, parameters such as the shape of pore spaces cannot be reasonably measured and, therefore, would not become candidates for a monitoring program. Likewise, changes in parameters such as the actual brine concentration within the Salado are likely to be rapid initially and not necessarily diagnostic of the steady state that will exist over most of the regulatory time period.

The results of the screenings of the parameters in Tables 7-3 and 7-4 are given in Table 7-5.

In some cases, the parameter is indicated as a measurable parameter, meaning that it can either be directly monitored or be deduced from a monitoring program. Other parameters are indicated as observed. This means that the parameter represents an event that occurs at unspecified intervals or changes too slowly or too intermittently to be a viable monitoring candidate. For example, displacements of deformation features occur intermittently and can be observed only when they occur, even though other processes leading up to displacement (such as creep) can be monitored.

7.2.2.4 Preservation of Disposal System Integrity

Disposal system integrity could be compromised by drill holes, conduits, or other entries that are left in place to allow access to monitoring equipment. The requirement to avoid such conditions leads to the conclusion that the only viable monitoring systems are those that can be operated directly during operations, those that can transmit information without cabling (telemetry), and

1 ***Table 7-4. Parameters Related to Measurable Disposal System Properties***

Parameter	Significance to Containment	Significance to Verification
SALADO PHYSICAL PARAMETERS		
Creep closure and stresses	LOW	LOW
Extent of deformation	LOW	LOW
Initiation of brittle deformation	LOW	LOW
Displacement of major deformation features	LOW	LOW
Natural temperature distribution	LOW	LOW
SALADO HYDROLOGICAL PARAMETERS		
Impure halite pore compressibility	LOW	LOW
Impure halite far-field pore pressure	MEDIUM	MEDIUM
Salado pore shape	MEDIUM	MEDIUM
Impure halite effective porosity	MEDIUM	MEDIUM
Impure halite permeability	MEDIUM	MEDIUM
Anhydrite permeability	HIGH	HIGH
Anhydrite pore compressibility	MEDIUM	MEDIUM
Salado residual brine saturation	MEDIUM	MEDIUM
Salado residual gas saturation	MEDIUM	MEDIUM
Salado brine quantity	LOW	LOW
Salado brine flux	MEDIUM	MEDIUM
Salado brine spatial distribution	LOW	LOW
Salado brine composition	HIGH	HIGH
Salado K_ds for dissolved radionuclides	LOW	LOW
Salado K_ds for colloidal radionuclides	LOW	LOW
Salado change in groundwater brine	LOW	LOW
Natural temperature distribution	LOW	LOW
DRZ permeability	MEDIUM	MEDIUM
DRZ effective porosity	MEDIUM	MEDIUM
DRZ brine flux	MEDIUM	MEDIUM
DRZ brine quantity and spatial distribution	LOW	LOW
NON-SALADO HYDROLOGICAL PROPERTIES		
Culebra transmissivity	MEDIUM	MEDIUM
Culebra advective porosity	MEDIUM	MEDIUM
Culebra fracture spacing	HIGH	HIGH
Culebra diffusional porosity	MEDIUM	MEDIUM
Culebra longitudinal dispersivity	LOW	LOW
Culebra groundwater quantity	LOW	LOW
Culebra groundwater flux	MEDIUM	MEDIUM
Culebra groundwater spatial distribution	LOW	LOW
Culebra groundwater composition	LOW	LOW

2

Table 7-4. Parameters Related to Measurable Disposal System Properties — Continued

Parameter	Significance to Containment	Significance to Verification
Castile brine reservoir pressure	HIGH	HIGH
Castile brine reservoir permeability	HIGH	HIGH
Castile brine reservoir rock compressibility	HIGH	HIGH
Castile brine reservoir brine volume	HIGH	HIGH
Castile brine flux	HIGH	HIGH
Castile brine spatial distribution	HIGH	HIGH
Castile brine composition	MEDIUM	MEDIUM
Natural temperature distribution	LOW	LOW
Culebra K_ds for six dissolved radionuclides	HIGH	HIGH
Culebra K_ds for humic and actinide-intrinsic colloidal radionuclides	MEDIUM	MEDIUM
Drilling rate	HIGH	HIGH
Effective decay constant for microbes	MEDIUM	MEDIUM
Culebra change in groundwater flow	MEDIUM	MEDIUM
WASTE RELATED PARAMETERS		
Waste area residual gas saturation	MEDIUM	MEDIUM
Waste area residual brine saturation	MEDIUM	MEDIUM
Waste area permeability	MEDIUM	MEDIUM
Brine wicking	MEDIUM	MEDIUM
Inundated steel corrosion rate with CO_2	LOW	LOW
Inundated steel corrosion rate without CO_2	MEDIUM	MEDIUM
Inundated microbial degradation rate	LOW	LOW
Humid microbial degradation rate	LOW	LOW
Gas quantity	MEDIUM	MEDIUM
Gas composition	LOW	LOW
Choice of oxidation state distribution	HIGH	HIGH
Solubility of nine radionuclides in Salado brine	HIGH	HIGH
Solubility of nine radionuclides in Castile brine	HIGH	HIGH
Humic colloid concentrations in Salado brine	HIGH	HIGH
Humic colloid concentrations in Castile brine	HIGH	HIGH
Waste particle diameter	HIGH	HIGH
Effective shear resistance to erosion	MEDIUM	MEDIUM
Waste activity	HIGH	HIGH
Waste tensile strength	HIGH ~~MEDIUM~~	HIGH ~~MEDIUM~~
Mud pump rate	***LOW***	***LOW***
Drill penetration rate	***LOW***	***LOW***
~~Gravity factor for spoiling~~	~~MEDIUM~~	~~MEDIUM~~
~~Strength factor for spalling~~	~~LOW~~	~~LOW~~

Table 7-4. Parameters Related to Measurable Disposal System Properties — Continued

Parameter	Significance to Containment	Significance to Verification
ENGINEERED BARRIER PROPERTIES		
Shaft DRZ permeability	MEDIUM	MEDIUM
Backfill porosity	LOW	LOW
Backfill permeability	LOW	LOW
Degree of backfill compaction	LOW	LOW
Backfill reconsolidation	LOW	LOW
Clay seal member permeability	MEDIUM	MEDIUM
Concrete seal member permeability	MEDIUM	MEDIUM
Asphalt seal member permeability	MEDIUM	MEDIUM
Seal residual gas saturation	LOW	LOW
Seal residual brine saturation	LOW	LOW
Seal pore shape	LOW	LOW
Long-term borehole permeability	HIGH	HIGH

Table 7-5. ~~Listing of~~ Parameters That Can Produce Meaningful Data During Monitoring Period

Parameter	Comment
SALADO PHYSICAL PARAMETERS	
Creep closure and stresses	Can be measured during operations
Extent of deformation	Can be measured during operations
Initiation of brittle deformation	Can be measured during operations
Displacement of deformation features	Can be observed during operations
SALADO HYDROLOGICAL PARAMETERS	
Salado brine composition	Can be measured during operations
NON-SALADO HYDROLOGICAL PROPERTIES	
Culebra groundwater composition	Can be measured for entire period
Castile brine reservoir location	Can be observed for entire period
Drilling rate	Can be observed for entire period
Culebra change in groundwater flow	Can be observed for entire period
WASTE RELATED PARAMETERS	
Waste activity	Can be calculated using measurements made during waste characterization

those that can be used to evaluate parameters using remote sensing techniques. Each is discussed briefly below. Table 7-6 shows the final screening of parameters in order to determine those that are candidates for a monitoring program. Table 7-7 identifies those parameters included in the preclosure and postclosure monitoring programs. ~~The differences in Tables 7-6 and 7-7 are explained as follows.~~ The presence of a DRZ surrounding the repository has been

Table 7-6. Parameters That Can Be Measured Without Violating Repository Integrity

Parameter	Comment
SALADO PHYSICAL PARAMETERS	
Creep closure	Direct measurement in open areas of the repository
Extent of deformation	Direct measurement in open areas of the repository
Initiation of brittle deformation	Direct measurement in open areas of the repository
Displacement of deformation features	Directly observed from other open areas of the repository
NON-SALADO HYDROLOGICAL PROPERTIES	
Culebra groundwater composition	Can be measured using existing or additional groundwater surveillance wells
Probability of encountering a Castile brine reservoir	Can be developed based on observations of drilling activity in Delaware Basin
Drilling rate	Can be developed based on observations of drilling activity in Delaware Basin
Culebra change in groundwater flow	Can be determined using existing or additional groundwater surveillance wells
WASTE RELATED PARAMETERS	
Waste activity	Limited to observations during waste characterization activities

Table 7-7. Preclosure and Postclosure Monitored Parameters

Monitored Parameter	Preclosure	Postclosure
Culebra groundwater composition	X	X
Culebra change in groundwater flow	X	X
Probability of encountering a Castile brine reservoir	X	X
Drilling rate	X	X
Subsidence measurements	X	X
Waste activity	X	
Creep closure and stresses	X	
Extent of deformation	X	
Initiation of brittle deformation	X	
Displacement of deformation features	X	

incorporated into performance assessment calculations. The properties of the DRZ have been characterized; they include altered hydrologic properties that are expected to enhance near-field fluid flow both to and from the repository. The initial conditions and enhanced fluid flow are considered moderately significant to disposal system performance. ~~In an effort to simplify the calculations, the effects are maximized by the conceptual model and altered properties of the DRZ. This is believed to be a conservative choice with respect to the ultimate impact on predicted release.~~

Monitoring the DRZ hydrologic properties would not provide relevant information or verify assumptions used in performance assessment; therefore they will not be monitored during the operational period or during the postclosure period. For more detail regarding DRZ-related parameters, see ***CCA*** Appendix MON (Attachment 1, ***MONPAR,*** Section MONPAR.3.3).

Composition of Salado brines has been established through investigations. Brine composition is significant and is incorporated into performance assessment calculations. Based on the extensive experimental evidence collected, there is no indication that Salado brine composition will change over the regulatory period; thus it will not be routinely monitored during the operational period or during the postclosure period. For more detail regarding Salado brine composition, see ***CCA*** Appendix MON (Attachment 1, Section MONPAR.2.2).

7.2.2.4.1 Evaluation of Monitored Parameters

The preclosure and postclosure parameters identified in Table 7-7 ~~will be evaluated~~ ***have been evaluated for this CRA (see Appendix DATA)*** as a part of the plan described in Appendix MON***-2004.*** Significant deviations in expected values of any of these parameters from those ranges of values in the performance assessment models ***have been and will continue to*** ~~will~~ be evaluated. Where applicable, any new information will be incorporated into the performance assessment conducted for recertification. Parameter values outside of expected ranges will also prompt the evaluation of models and their modification, where appropriate, for use in recertification performance assessment activity.

Culebra groundwater composition, Culebra changes in groundwater flow, Castile brine reservoir encounters, Castile brine reservoir pressure, and drilling rate parameters ***are***~~will be~~ evaluated to substantiate that they remain within the range of values assumed in model development and performance assessment. Should there be a significant change outside the assumed range of values used in the ***2004*** ~~performance assessment~~***PA*** models, the DOE will evaluate and, where appropriate, modify models for incorporation into the next performance assessment recertification.

In the unlikely event that subsidence values fall significantly outside the range of values predicted and experienced elsewhere in the Delaware Basin, additional evaluation of the potential effects of such deviations will be conducted. If the evaluation requires changes to models used in the performance assessment, these changes will be made and the revised models incorporated into ~~the~~ ***a future*** recertification performance assessment.

The waste activity (see Appendix ***TRU WASTE*** ~~WCL~~ for a detailed discussion) ***is***~~will be~~ monitored to ensure compliance with the requirements of the LWA and that the values are within the range of values used in PA models. ***New inventory data, including waste activity information, have been incorporated into the 2004 PA; these values are tracked in the preclosure monitoring program.*** Any significant deviation from ***the*** ~~expected~~ values ***used in the PA baseline*** will be addressed by the DOE in a timely fashion to avoid any violation of the compliance certification.

Creep closure and stresses, extent of deformation, initiation of brittle deformation, and displacement of deformation features are all parameters that reflect on the geomechanical nature

of the repository. Evaluation of these parameters influence the operational aspects of safe operation of the repository. However, should any of these parameters exhibit properties that are significantly outside the experience and expectations of the information baselines developed to date, the DOE will evaluate the impact on the design of the repository and the design of the shaft seal system.

The EPA will be notified of any deviation that the DOE evaluates as significant with respect to complying with the regulations or the certification of the WIPP as a safe repository.

7.2.2.4.2 Direct Measurement

Direct measurement includes current programs such as the underground geomechanical monitoring program and the groundwater surveillance program. In such cases, the monitoring equipment can be inspected, calibrated, and used with high reliability. Malfunctioning equipment can be easily repaired or replaced. Power requirements are met with portable power units such as rechargeable batteries or generators. In some cases, analog measurements can be made mechanically and recorded in notebooks. In other cases, digital logging equipment is available to record large quantities of data and information. Direct measurement allows for changing the measurement parameters as environmental conditions change. Replicate samples can be taken easily if needed. Unusual conditions can be investigated to provide unambiguous interpretation of data.

7.2.2.4.3 Telemetry Systems

In the early 1970s to the mid 1980s, the U.S. Bureau of Mines and the Mine Safety and Health Administration demonstrated that reliable communications can be established between underground mines and the surface for the purpose of locating and rescuing trapped miners (see Powell 1976; Murphy and Parkinson 1978, ***p.*** 42). Low-frequency radio equipment was demonstrated in numerous mine environments and at many depths. The systems evaluated used low-duty cycle transmitters connected to loop antennae powered by miners' cap lamp batteries. Although through-the-earth transmission of signals is feasible, any system that uses this type of telemetry must deal with the following design problems.

First, because the purpose of the telemetry is to obviate the need for cabling to the surface, all power must be self-contained. For the WIPP, this will require extending battery or portable generators beyond the tens of years that can now be achieved for low-duty cycle systems. Second, issues regarding durability must be addressed since the environmental conditions will be severe. Components will have to withstand the brine and gas environments that are predicted, as well as the effects of creep closure and repressurization. Third, reliability will have to be addressed since failed sensors cannot be replaced nor can calibrations be performed or adjustments made. Finally, in addition to the equipment issues, there are concerns about interpreting results in an environment where interference, such as background electromagnetic noise, can only be, at best, poorly characterized. While these issues and concerns can be addressed with technology development programs, it is doubtful that the high cost is justifiable for the limited amount of data that may be obtained from such systems.

7.2.2.4.4 Remote Sensing Systems

The use of remote techniques to determine the characteristics of the earth have been well established. Generally classified as geophysical measurements, these systems look for variations in a parameter within the earth in order to determine geological relationships. Typical parameters that are measured remotely are resistivity, acoustic velocity, magnetism, density, temperature, moisture content, radioactivity, and radiometry (infrared). The general conclusion is that the changes in the repository are too small (in scale), too far from the surface, and too slow to be detectable using remote techniques.

7.2.2.5 Complementary With ***Other Regulatory*** ~~RCRA~~ Programs

~~The RCRA, as implemented by both the EPA Office of Solid Waste (OSW) and the NMED, requires that the owner and operator of a hazardous waste management facility prevent releases of hazardous constituents that are harmful to human health and the environment. Where feasible, credible release pathways must be monitored to demonstrate that no releases above regulatory limits are occurring. In some cases, if monitoring is not feasible or if releases can be shown to be either not measurable or inconsequential, monitoring is not needed.~~

~~To satisfy these monitoring requirements, the DOE plans to implement the following programs:~~

- ~~geomechanical monitoring program,~~
- ~~QC confirmatory monitoring program, and~~
- ~~groundwater surveillance program.~~

Monitoring is performed by the DOE at and near the WIPP site to comply with the requirements of other regulatory programs. This includes groundwater monitoring in support of the Resource Conservation and Recovery Act (RCRA) program for the project. None of the monitoring activities implemented by the DOE in support of 40 CFR Part 191 and Part 194 compliance demonstrations interfere with or contradict monitoring performed for other regulatory programs.

Based on the approach the DOE has taken to monitoring program implementation, the criterion of compatibility with ***other regulatory programs*** ~~the RCRA program~~ is met.

7.2.3 Monitoring Program Description

Based on the parameter screening described above and the analysis in ***CCA*** Appendix MON, the DOE has selected a monitoring program with the following components:

- preclosure monitoring
    - Geomechanical monitoring parameters ~~are (25 years or~~ until closure~~)~~:
      Creep closure and stresses,
      Extent of deformation,
      Initiation of brittle deformation, and

Displacement of deformation features.

~~VOC confirmatory monitoring parameters are (a minimum of 6 months after closure of first panel):~~

~~1,1-Dichloroethylene,~~
~~Carbon tetrachloride,~~
~~Methylene chloride,~~
~~Chloroform,~~
~~1,1,2,2-Tetrachloroethane,~~
~~1,1,1-Trichloroethane,~~
~~Chlorobenzene,~~
~~1,2-Dichloroethane, and~~
~~Toluene.~~

- Waste ***C***haracterization monitoring parameters ~~(25 years or~~ until last waste shipment ~~is made)~~:

Waste activity

- preclosure and postclosure monitoring parameters ~~are~~ (~~30~~ ***100*** years after closure ***or until DOE can demonstrate that there are no significant concerns to be addressed by further monitoring***) ~~and as required by RCRA):~~[2]

  - groundwater surveillance:

    Culebra ~~brine~~ ***groundwater*** composition,
    ~~Culebra change in groundwater flow direction, and~~
    ~~Culebra well water level.~~
    Change in Culebra groundwater flow

  - observation of drilling activities (100 years after closure):[2]

    ~~Castile brine reservoir encounter,~~
    ~~Castile brine reservoir pressure, and~~
    Probability of encountering a Castile brine reservoir, and
    drilling rate.

- postclosure monitoring parameter (100 years after closure ***or until DOE can demonstrate that there are no significant concerns to be addressed by further monitoring***)~~:~~[2]

  - subsidence monitoring.

[2] ~~Or until the DOE can demonstrate to the EPA that there are no significant concerns to be addressed by further monitoring.~~

The rationale for eliminating the volatile organic compound (VOC) monitoring component of the program is described in Section 7.2.3.2. Other changes to this list have been made to more clearly indicate DOE's intent.

Each of these programs is described in the following sections. Individual program plans are included in ***CCA*** Appendices GWMP, SMP, and DMP. ***Relevant information from these CCA appendices has been consolidated into Appendix MON-2004. Consistent with EPA concurrence (EPA letter of March 15, 2002 to DOE; EPA Docket A-98-49, II-B-3, Item 24), CCA Appendices GWMP, SMP, and DMP are not repeated in this recertification application.***

Waste monitoring is not discussed in the following sections because it is tracked in the WIPP Waste Information System (WWIS), as described in Chapter 4.0.

7.2.3.1 Geomechanical Monitoring Program

The geomechanical monitoring program at the WIPP facility is an integral part of the DOE's ground control program ~~(see Figure 7-10)~~. Disposal rooms, drifts, and operational area excavations will be monitored to provide confirmation of structural integrity. Geomechanical data on the performance of the repository shafts and excavated areas are currently collected as part of the geotechnical field monitoring program. The results of the geotechnical investigations are reported annually. The report describes monitoring programs and geomechanical data collected during the previous year.

The instrumentation in Table 7-8 is available for use in support of the geomechanical program. The minimum instrumentation for ~~the unexcavated disposal areas designated as~~ Panels 2 through 8 is one borehole extensometer installed in the roof at the center of each disposal room. The roof extensometers will monitor the dilation of the immediate salt roof beam and possible bed separations along clay seams. Additional instrumentation may be installed as conditions warrant. ~~Panel 1 has already been excavated and is heavily instrumented, as shown in Figure 7-10.~~ ***Panel 1 is more extensively instrumented than subsequent panels because it was the first panel excavated and because it remained open for a relatively long period of time. After the last emplacement of waste in Panel 1, the communication cables from the instrumentation were cut and geomechanical monitoring ceased in the panel. In a similar manner, other waste panels will be monitored until each is full and panel seals are emplaced.***

Polling of the geomechanical instrumentation will be performed at least once every month. This frequency may be increased to accommodate any changes that may develop. The results from the remotely read instrumentation will be evaluated after each scheduled polling. Documentation of the results ~~will be~~ ***are*** provided annually in the Geotechnical Analysis Report.

The instrumentation system provides for data maintenance, retrieval, and presentation. The instrumentation system cognizant engineer first retrieves the data from the instrumentation system and verifies their accuracy by assuring the measurements were taken in accordance with applicable instructions and procedures. Next, the cognizant engineer reviews the data after each polling to assess the performance of the instrument and the excavation. Data that look anomalous are detected during this polling and are investigated to determine the cause (for

Table 7-8. Instrumentation Used in Support of the Geomechanical Monitoring System

Instrument Type	Features	Parameter Measured	Range
Borehole extensometer	The extensometer provides for monitoring the deformation parallel to the borehole axis. Units suitable for up to five measurement anchors in addition to the reference head.	Cumulative deformation	0-2 inches
Borehole television camera	Closed circuit television may be used for monitoring areas otherwise inaccessible, such as boreholes or shafts.	Video image	N/A
Convergence points and tape extensometers	Mechanically anchored eyebolts to which a portable tape extensometer is attached.	Cumulative deformation	2-50 feet
Convergence meters	Includes wire and sonic meters. Mounted on rigid plates anchored to the rock surface.	Cumulative deformation	2-50 feet
Inclinometers	Both vertical and horizontal inclinometers are used. Traversing type of system in which a probe is moved periodically through casing located in the borehole whose inclination is being measured.	Cumulative deformation	0-30 degrees
Rock bolt load cells	Spool type units suitable for use with rock bolts. Tensile stress is inferred from strain gauges mounted on the surface of the spool.	Load	0-300 kips
Earth pressure cells	Installed between concrete keys and rock. Preferred type is a hydraulic pressure plate connected to a vibrating wire transmitter.	Lithostatic pressure	0-1,000 pounds per square inch
Piezometer pressure transducers	Located in shafts and of robust design and construction. Periodic checks on operability required.	Fluid pressure	0-500 pounds per square inch
Strain gauges	Installed within the concrete shaft key. Suitably sealed for the environment. Two types used—surface mounted and embedded.	Cumulative deformation	0-3,000 microinches per inch (embedded) 0-2,500 microinches per inch (surface)

example, instrumentation problem, error in recording, or changing rock conditions). The data are then processed to calculate various parameters such as the change between successive readings and deformation rates. The results of this assessment are reported to the ground control cognizant engineer and operations personnel. The stability of an open panel excavation is generally determined by the rock deformation rate. Unexpected deformation rates are investigated by Geotechnical Engineering to determine if remediation is needed.

The evaluation of the performance of the excavation is also performed by Geotechnical Engineering. These evaluations will provide an estimate of the stand-up time of the excavation. If the trend is toward adverse (unstable) conditions, then the results of these assessments are reported to the operations manager to determine appropriate operational responses.

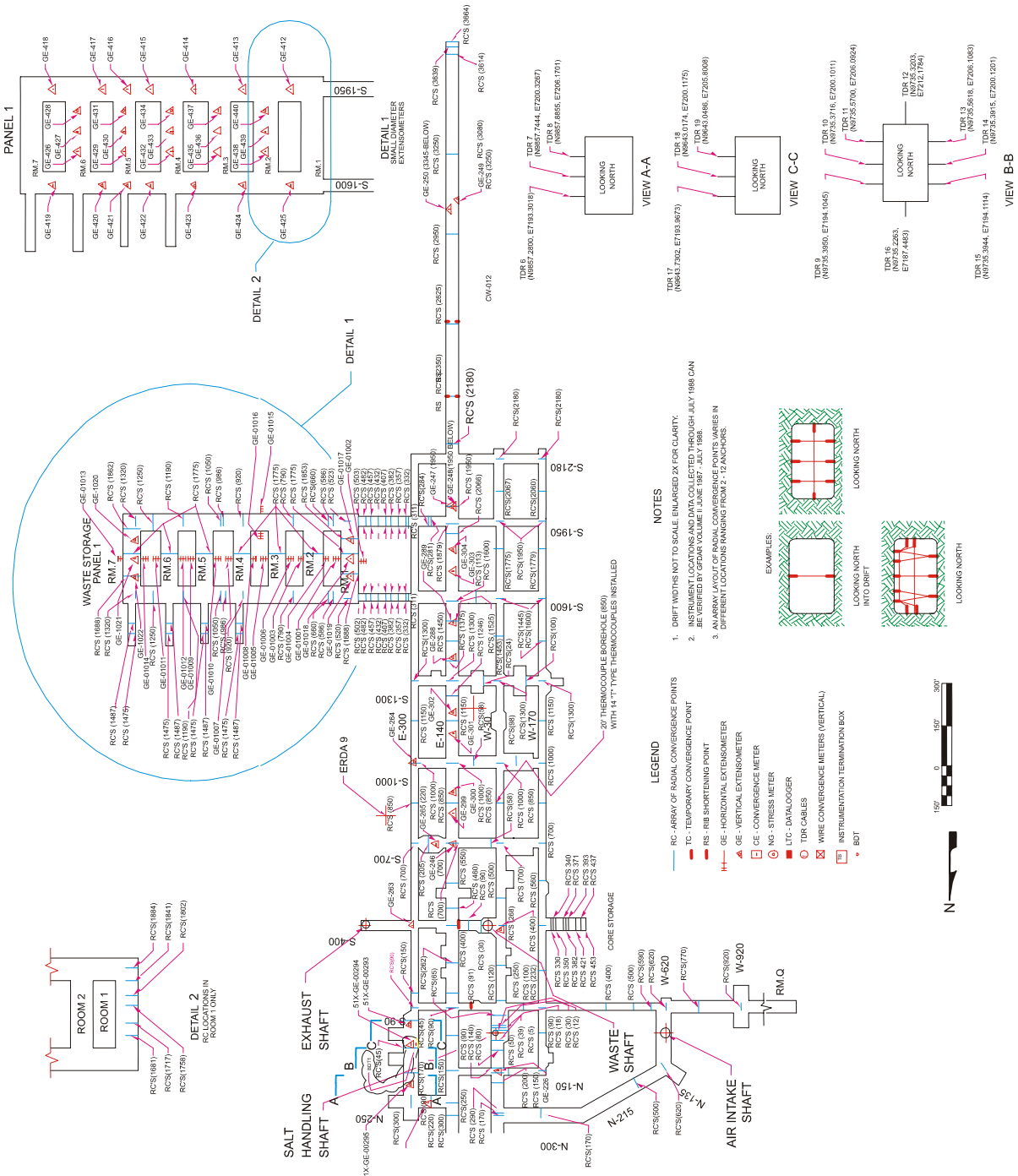

Figure 7-10. Layout and Instrumentation of Geomechanical Monitoring System as of January 1996

Roof conditions are assessed from observation boreholes and extensometer measurements. Measurements of room closure, rock displacements, and observations of fracture development in the immediate roof beam are used to evaluate the performance of a panel. A summary of the Panel 1 monitoring program was presented to the members of the Geotechnical Experts Panel in 1991, who concurred that the monitoring was adequate to determine deterioration within the rooms and could provide early warning of deteriorating conditions.

The assessment and evaluation of the condition of WIPP excavations is an iterative, continuous process using the data from the monitoring programs. Criteria for corrective action are continually reevaluated and reassessed based on total performance to date. Actions taken are based on these analyses and on planned utilization of the excavation. Because WIPP excavations are in a natural geologic medium, there is inherent variability from point to point. The principle adopted is to anticipate potential ground control requirements and implement them in a timely manner rather than to wait until a need arises.

Both creep closure of the excavation and the development of the DRZ are included in the conceptual model of disposal system performance. Creep closure is discussed in Section 6.4.3.1 and Appendix ***PA, Attachment*** PORSURF. The numerical model for predicting creep closure has been developed based on both theoretical considerations and observations. The goal of monitoring is to detect any substantial and detrimental deviations from the expected behavior of Salado halite and to determine the significance of such deviations. Data are analyzed after each round of measurements and results are distributed for use in making ground control decisions. A compilation of data (current and previous) is published annually in the Geotechnical ~~Field Data and~~ Analysis Report. This compilation is useful determining long-term trends in the behavior of underground openings and can be a diagnostic tool for determining substantial and detrimental deviations ***from*** ~~for~~ expected performance.

The DRZ is modeled as discussed in Section 6.4.5.3. It is assumed that the DRZ maintains its permeability throughout the model period as shown in Table 6-***19***~~17~~. Marker bed (MB) 138 and 139 are modeled to be separate geological units with permeabilities lower than those in the DRZ as shown in Table 6-***18***~~16~~. Substantial and detrimental deviations from these expectations may impact repository performance. Consequently, as discussed in Section 4.3 of ***CCA*** Appendix GTMP, observations of excavation effects, along with the other geotechnical measurements will be useful to detect deviations in expectations for near-term DRZ development.

7.2.3.2 VOC Confirmatory Monitoring Program

~~As documented in the WIPP Safety Analysis Report (SAR) (DOE 1990, 6.1-34), airborne emission is the only credible contaminant release pathway from the WIPP facility during disposal operations. The panel closure design basis requires this pathway to be controlled during operations and the final facility closure requires that it be eliminated. The panel closure design is described in Appendix PCS. Final facility shaft sealing is described in Appendix SEAL. In order to determine the effectiveness of panel closures, the DOE has targeted the measurement of VOC emissions as diagnostic of repository processes that may be underway within closed panels. The DOE has prepared a VOC confirmatory monitoring plan. The plan has been prepared so that the DOE can show that the assumptions and predictions used to demonstrate compliance to the environmental performance standards are valid. Verification is demonstrated when observed~~

~~emissions are equal to or less than those predicted. The VOC Confirmatory Monitoring Plan (VCMP) is provided in Appendix VCMP. The VCMP includes monitoring design, sampling and analysis procedures, and quality assurance objectives.~~

~~In its application to the NMED for a hazardous waste facility operating permit, the DOE demonstrated compliance with the environmental performance standards of 20 NMAC 4.1, Subpart V, § 264.601(c). Appendix VCMP describes a sampling and analysis program to confirm the theoretical calculations. The monitoring program is capable of quantifying VOC concentrations in the ambient mine air at the WIPP. The VCMP addresses the following information requirements:~~

- ~~rationale for the design of the monitoring program, based on possible pathways, operations, engineered and natural barriers, and monitoring locations optimized for detection, and~~

- ~~descriptions of the specific elements of the monitoring program, including the type of monitoring, the location of stations, the frequency of sampling, the target analytes, the schedule for implementation, the equipment used, the sampling and analytical techniques, and the data recording and reporting procedures.~~

~~While the quantification of VOCs is not of direct relevance to this application, the rate of VOC emission is of direct interest because it is a function of two inter-related repository properties. These are the extent of deformation (creep closure) and gas-producing processes. Both gas generation and creep closure will lead to the pressurization of the closed panel during operations. This pressurization will become the driving force for VOC emissions through and around the closure system. Abnormally high rates of pressurization may indicate a substantial and detrimental deviation from expected conditions requiring further investigation.~~

~~The DOE will collect air samples upstream and down stream of Panel 1 beginning just prior to waste emplacement and proceeding until at least six months following completion of panel closure. The DOE will continue monitoring until the criteria for terminating monitoring are met. These criteria are established in Appendix VCMP (Section 3.4). DOE's waste characterization program requires 100 percent measurement of headspace gases. This information will be available to the DOE through the WIPP Waste Information System (WWIS), which is described in Chapter 4.0.~~

In Docket A-93-02, Compliance Application Review Document No. 42, Section 42.C.5, the EPA concludes:

> ***The VOC monitoring acts only as a secondary indicator of creep closure because there is not a direct relationship between VOC levels and creep closure rates. While VOC levels might indicate changes in creep closure rates, such changes would be observed earlier and would be better defined by direct geomechanical monitoring, which will be conducted throughout the operation of the WIPP. DOE stated that VOC monitoring will also provide data on gas producing processes (p. 7-58). The DOE did not include gas producing processes as one of the parameters to be monitored, however, because the modeling of gas-producing processes is based on data and assumptions about long-term behavior that will not be applicable during the operational period (p. 7-36).***

The EPA indicated that VOC monitoring is not necessary as a secondary indicator of creep closure or to fulfill the requirements of Section 194.42. A planned change per 40 CFR § 194.4(b)(3) was submitted to the EPA in January 2002 requesting removal of CCA Appendix VCMP from the compliance baseline. In March 2002, the EPA approved the request to eliminate CCA Appendix VCMP from the WIPP certification basis. Based on the approval letter, this section and all references to CCA Appendix VCMP are eliminated from future recertification applications.

7.2.3.3 Groundwater Surveillance Program

In the development of the WIPP monitoring programs, potential pathways for release of hazardous constituents to the environment were evaluated. This evaluation indicated no credible release pathway via surface water. ~~The DOE has prepared a groundwater monitoring plan (GMP), as presented in Appendix GWMP. The appendix describes the basis for the GMP, the organization of the program, the quality assurance for the GMP, and the sampling program description. Sampling locations are shown in Figure 7-11. Sampling frequency will be annual. Analytes of interest for groundwater sampling and other sampling programs[3] are defined in Table 7-9. Analysis of samples is performed by a commercial laboratory that participates in the EPA contract laboratory program. Methods are specified in procurement documents and are selected to be consistent with EPA recommended procedures in SW-846 (EPA 1988). For the GMP, the principal goal of data analyses is the comparison of a data point or data set to equivalent data collected at another location and time (such as preoperational baseline data or data collected at a control location), or to a fixed standard.~~

Comparisons between data sets are performed using standard statistical tests. The selection of the specific test is dependent upon the relative power of the test and the degree to which the underlying requirements of the test are met. In addition to tests comparing data from distinct locations and times, trend analyses are performed on time series where sufficient data exist.

Citation of the source of the test method or the software used to perform the tests will be made when results are reported. Data and subsequent calculated values are reported in the annual site environmental report.

The two parameters of interest from the groundwater surveillance program are the composition of the Culebra groundwater and water levels. Significant and persistent changes in the composition of the Culebra groundwater ~~will be~~ ***are*** investigated and impacts to the modeling assumptions for long-term performance in Section 6.4.6.2 ~~will be~~ ***are*** evaluated. Large and rapid water-level fluctuations may be diagnostic of nearby human activity such as potash mining and fluid injection and withdrawal. Water-level changes within the groundwater modeling domain in Section 6.4.6.2 that cannot be explained either based on observed trends or on past experience ~~will be~~ ***are being*** investigated and assessed relative to the assumptions made in the regional groundwater flow model ***(see Appendix DATA, Section DATA-11)***.

[3] ~~Discussion of other sampling programs is provided in Appendix EMP.~~

~~**Table 7-9. Typical Environmental Surveillance Analysis Schedule**~~

Type of Sample	Analysis
Liquid influent	Radionuclides
Liquid effluent	Specific radionuclides, chemical constituents
Airborne effluent	Gross P, specific radionuclides
Meteorology	Temperature, wind speed, wind direction, precipitation, dewpoint, barometric pressure
Air quality	Total suspended particulates
Vegetation radionuclides	Specific radionuclides
Beef radioanalysis	Specific radionuclides
Game bird radioanalysis	Specific radionuclides
Rabbit radioanalysis	Specific radionuclides
Fish radioanalysis	Specific radionuclides
Deer radioanalysis	Specific radionuclides
Soil radioanalysis	Specific radionuclides
Surface-water radioanalysis	Specific radionuclides
Groundwater analysis	Specific radionuclides, chemical constituents[a]
Sediments radioanalysis	Specific radionuclides
Aerial photography	Area of land disturbed
Wildlife survey	Bird and small mammal population densities

Legend:

a. Specific radionuclides = 238Pu, 239Pu, 240Pu, 242Pu, 233U, 24lAm, 243Am, 244Cm, 232Th, 237Np, 226Ra, 137Cs, 90Sr, 60Co, Unat, and Thnat.

Chemical constituents = chloride; iron; manganese; phenols; sodium; sulfate; pH; specific conductance; total organic carbon; total organic halogen; specified RCRA constituents; antimony; arsenic; barium; beryllium; cadmium; chromium; fluoride; lead; mercury; nickel, nitrate; selenium, silver, thallium zinc; endrin; methoxychlor; toxaphene; 2,4-D; 2,4,5-TP silvex; radium; turbidity; coliform bacteria. Additional analytes may be specified in the WIPP facility hazardous waste permit.

a For the purposes of establishing baseline values in wells Water Quality Sampling Program (WQSP) 1-6 and 6a, the analyses will include all 40 CFR 264 Appendix IX constituents.

7.2.3.4 Observation of Drilling Activities

As part of the ongoing compliance activities, ~~In preparing this application,~~ the DOE ***has continued to populate and maintain the*** ~~developed a~~ database of drilling activity within the Delaware Basin. In addition, the DOE has an ongoing program of field checking each well that is drilled within one mile of the WIPP site boundary. Field checking includes verifying the location as listed on the Application for Permission to Drill (APD), monitoring drilling and completion activities, and noting abandonment and plugging. Both the maintenance of the database and the field observation program will be continued throughout the operational period to develop additional statistics on the following parameters:

- drilling rates,
- drilling practices,

- Castile brine reservoirs encountered,
- Castile brine characteristics (where available), and
- plugging practices.

Data collected ~~will be~~ ***are*** addressed as appropriate in the recertification process. Any analyses that indicate parameter values are changing ~~will be~~ ***are*** studied to evaluate the impact of the changes.

Significant changes in drilling practices, such as borehole diameters, plug and abandonment practices, mining techniques, Castile brine occurrence, and injection well use ~~will be~~ ***are*** evaluated for potential impacts on disposal system performance. Any significant deviations ~~will be~~ ***are*** reported to the EPA.

Annual reports of the Delaware Basin Monitoring Program provide the total number of deep boreholes drilled within the Delaware Basin. This information is reported in compliance with 40 CFR § 194.33(b)(3), which specifies the manner in which the frequency of deep drilling events assumed in performance assessments shall be determined. The rule specifies that the DOE shall:

> ***(i) Identify deep drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.***

In addition, the rule specifies that:

> ***(ii) The total rate of deep drilling shall be the sum of the rates of deep drilling for each resource.***

The specification of a 100-year period "prior to the time at which a compliance application is prepared" has had the effect of increasing the deep drilling frequency that must be assumed in performance assessment calculations. This is because significant deep drilling activity did not exist within the Basin in the early part of the 20th century, while the last 10 years has been a period of significant oil drilling activity in the basin. Consistent with this, it is anticipated that the intrusion rate assumed in performance assessments will continue to increase throughout the operational period of the WIPP, as long as drilling continues to occur. The intrusion rate calculated in this manner for the CCA in 1996 is 46.8 deep holes per square kilometer over 10,000 years. Based on current information, this rate is 52.2 deep intrusions per square kilometer over 10,000 years (supporting data are provided in Appendix DATA). The implications of this increased rate of deep drilling are addressed in Chapter 6.0.

7.2.3.5 Subsidence Monitoring

~~Subsidence monitoring is accomplished with a Class I leveling survey. The surveys will be performed every ten years during the operational phase and thereafter.~~ ***Subsidence monitoring is accomplished with leveling surveys having maximum errors not greater than Second Order, Class II specifications. The relevant subsidence monitoring information presented in CCA Appendix SMP is incorporated into Appendix MON-2004.***

Although the CCA indicates that surveys will be performed every 10 years, the surveys are currently performed annually. These surveys will be performed during the operational phase and thereafter in accordance with Appendix MON-2004.

The leveling survey procedures ensure that the data are documented and validated. The data ~~will be~~ ***are*** included in the baseline~~ database~~. ~~A procedure will be developed to implement the monitoring program.~~

The monitoring program includes the following:

- management of the disposal phase monitoring program,
- maintenance of monitoring procedures and quality assurance/quality control documents,
- performance of all necessary field work,
- maintenance of the subsidence network,
- maintenance (and revision as necessary) of the monitoring schedule,
- maintenance and storage of baseline database,
- review of data and evaluation of performance,
- eventual decommissioning of the disposal system monitoring program, and
- archiving of monitoring data.

Subsidence predictions exist ~~of~~ ***for*** the WIPP. These will be reevaluated at the time of closure. Subsidence measurements will be used to compare actual subsidence with predictions. Significant deviations between expected subsidence and actual subsidence will be investigated to determine if a substantial and detrimental deviation in the expected performance of the repository is indicated.

7.2.4 Reporting

The results of the DOE's monitoring program ~~will be~~ ***are*** submitted annually. The report ~~will~~ include***s*** the results from the previous year, plus any cumulative information that is useful in interpreting the data. The annual report ~~will~~ contain***s*** a summary assessment of results to ensure that the performance of the repository can be evaluated on a continuous and consistent basis. Other reports, such as those stipulated in 40 CFR § 194.4 (b)(3), ~~will be~~ ***are*** issued when necessary.

Since the submittal of the CCA, the DOE has prepared over 20 annual reports pertaining to geomechanical monitoring, groundwater surveillance, subsidence monitoring, Delaware Basin monitoring, and waste characteristics monitoring. Data resulting from the various monitoring programs are reported in Appendix DATA. These reports are submitted to the EPA with the Annual 194.4(b)(4) Change Report.