CARD No. 14
Content of Compliance Certification Application

14.A.1 BACKGROUND

The compliance application must include, at a minimum, basic information about the WIPP site and disposal system design, and must also address all the provisions of the compliance criteria. Section 194.14 lists those topics that DOE must discuss in the CCA. This CARD addresses all elements of Section 194.14, with detailed emphasis on:

- Section 194.14(a)(1-3)—location, geology, hydrology, hydrogeology, and geochemistry of the WIPP disposal system.
- Section 194.14(b)(1-2)—information on WIPP materials of construction and standards applied to design/construction.
- Section 194.14(g)—background radiation in air, soil, and water.
- Section 194.14(h)—topographic maps of the disposal system.
- Section 194.14(i)—past and current climatological and meteorological conditions.

In addition to the above, this CARD introduces requirements addressed in other CARDs including:

- Section 194.14(a)(4)—site conditions due to the presence of waste, discussed more fully in **CARD 24—Waste Characterization, CARD 32—Scope of Performance Assessments and CARD 54—Scope of Compliance Assessments**.
- Section 194.14(c)—results of assessments, discussed in **CARD 23—Models and Computer Codes, CARD 24—Waste Characterization, CARD 34—Results of Performance Assessments, CARD 42—Monitoring, CARD 44—Engineered Barriers, and CARD 55—Results of Compliance Assessments**.
- Section 194.14(d)—input parameters to PA, discussed in **CARD 23—Models and Computer Codes**.
- Section 194.14(e)—assurance requirements, discussed in **CARD 41—Active Institutional Controls, CARD 42—Monitoring, CARD 43—Passive Institutional Controls, CARD 44—Engineered Barriers, CARD 45—Consideration of Resources, and CARD 46—Removal of Waste**.

- Section 194.14(f)—waste acceptance criteria, discussed in **CARD 24—Waste Characterization, Section 194.24(c)**.

- Section 194.14(j)—other information needed for demonstration of compliance with Section 194.14.

This CARD focuses on the natural and engineered system associated with WIPP. Specifically, the CCA must describe the natural and engineered features that may affect disposal system performance, with the disposal system defined in 40 CFR 191.12 as "any combination of engineered and natural barriers that isolate spent nuclear fuel or radioactive waste after disposal" (50 FR 38066).

The WIPP is located in the Delaware Basin of New Mexico and Texas and is approximately 26 miles southeast of Carlsbad, New Mexico. This area of New Mexico is currently arid, and DOE believes that while this climate will likely persist quite some time into the future, precipitation increases are accounted for in the performance assessment (PA). The Delaware Basin contains thick sedimentary deposits (15,000 - 20,000 feet) that overlay 1.1-1.5 billion year old metamorphic and igneous rock. The WIPP repository is a mine constructed approximately 2,150 feet below ground surface in the Permian age (~200-250 million year old) Salado Formation (Salado), which is composed primarily of halite.

In some places of the Delaware Basin, the Castile Formation (Castile) contains deformed beds that have associated pressurized brine. DOE accounted for the potential presence of these "brine pockets" in WIPP PAs. See **CARD 23—Models and Computer Codes** and **CARD 32—Scope of Performance Assessments** for additional information. The Salado also contains a number of thin anhydrite marker beds that have been accounted for in PAs. These marker beds are somewhat more permeable than surrounding halite, and the possibility of fluid flow within these beds was also included in DOE's PA calculations. See **CARD 23—Models and Computer Codes** for additional information.

The Permian age Rustler Formation (Rustler) caps the Salado. The Rustler is composed of interbedded dolomites, anhydrites, and siliciclastic rocks. Rock units within the Rustler include the Culebra Dolomite (Culebra), which has been identified as the most likely contaminant transport pathway above the Salado. Contaminants are assumed to reach the Culebra via human intrusion into the repository and subsequent entrainment of radionuclides into the Culebra for lateral transport.

The WIPP repository is an underground mine that will eventually have eight panels, each of which will include seven football-field long rooms. The panels are to be connected by drifts. Currently, only Panel 1 and portions of the connecting drifts have been constructed. The WIPP also includes a separate area located north of the waste disposal area where in-situ experiments were conducted. Waste will be emplaced in the WIPP through the waste shaft. An exhaust shaft, salt handling shaft, and air intake shaft also penetrate the WIPP repository. The underground mine is attended by surface equipment and buildings that will handle waste prior to its emplacement in the WIPP. DOE intends to pack magnesium oxide (MgO)-filled bags around the waste containers, and will seal each panel after it is filled with waste. The MgO is intended to react with carbon dioxide in solution, reducing gas pressure and buffering the repository pH. The Salado salt will eventually “creep” around and close WIPP rooms and panels. The WIPP was designed to take advantage of this encapsulation so that transuranic waste emplaced in the WIPP will be completely enveloped by salt, thus minimizing the potential for waste migration.

14.A.2 REQUIREMENT

“Any compliance application shall include:

(a) A current description of the natural and engineered features that may affect the performance of the disposal system. The description of the disposal system shall include, at a minimum, the following information:

(1) The location of the disposal system and the controlled area.”

14.A.3 ABSTRACT

Section 194.14(a)(1) requires that a compliance application include a description of the disposal system and the controlled area.

DOE provided WIPP site location information in Table 3-1 of the CCA. DOE considered the WIPP Land Withdrawal Act (LWA) land withdrawal area to be the controlled area for purposes of demonstrating compliance 40 CFR Part 191. Area roads, communities, and a general location map are shown on CCA Figure 1-2, with site-specific roads and range and township boundaries shown on Figure 3-1. CCA Table 3-1 also provides the latitude and longitude designations and the size of the WIPP site.

DOE also described the physical setting of the land surface at the WIPP site. The average east-to-west slope at the WIPP is 50 feet per mile (9.4 meters per kilometer). The Pecos River, located 12 miles (19 kilometers) southwest of the site, is the closest perennial stream. DOE provided additional disposal system information, such as site hydrologic data, in Chapters 2, 3, 6 and 7 of the CCA, as well as numerous appendices (e.g. Appendices GCR, FAC, and HYDRO).

EPA examined the CCA to determine whether it contained the required information regarding the disposal system and controlled area. EPA also evaluated the accuracy and consistency of the information provided.

14.A.4 COMPLIANCE REVIEW CRITERIA

To demonstrate compliance with Section 194.14(a)(1), EPA expected the compliance application to identify the following information related to the WIPP site:

- Physical setting.

- Size.

- County.
- Township and range.
- Roads.
- Longitude and latitude.
- Appropriate graphics (maps, at a minimum).
- Boundaries of the disposal system and controlled area.

EPA examined the CCA to confirm the presence of adequate disposal system and controlled area information and also evaluated the accuracy and consistency of this information.

14.A.5 DOE METHODOLOGY AND CONCLUSIONS

DOE provided WIPP site location information in Table 3-1 of Chapter 3, which indicates that the WIPP is approximately 26 miles southeast of Carlsbad, New Mexico, in Eddy County. The U.S. Public Land Survey designation for the area within the WIPP Land Withdrawal Act boundary is Township 22S, Range 31E, Sections 15-22 and Sections 27-34. The CCA stated that the 16-section (41.4-square-kilometer) land withdrawal area is Federal land under jurisdiction of DOE (Chapter 3, p. 3-1). DOE considered the land withdrawal area to be the controlled area for purposes of demonstrating compliance to 40 CFR Part 191.

The CCA stated that the latitude of the WIPP site is 32^{o} 22' 11" N and the longitude is 103^{o} 47' 30" W. Area roads, communities, and a general location map are shown on Figure 1-2, with site-specific roads and range and township boundaries shown on Figure 3-1. Table 3-1 also provides the latitude and longitude designations and the size of the WIPP site, with areas defined by location, use, and control features in Chapter 3 (pp. 3-1 to 3-3). DOE stated that the depth to the WIPP mined rooms is approximately 2,150 feet below ground surface (Table 3-1).

DOE also described the physical setting of the land surface at the WIPP site as a semiarid, wind-blown plain sloping gently to the west and southwest, hummocky with sand ridges and dunes; see Chapter 2.1.4.2 (pp. 2-67 to 2-68). A hard caliche layer underlies the sand blanket. The elevation of the ground surface at the site ranges from 3,570 feet (1,088 meters) above mean sea level (amsl) in the east to 3,250 feet (990 meters) amsl in the west. The average east-to-west slope at the WIPP is 50 feet per mile (9.4 meters per kilometer). The surface drainage in the vicinity of the WIPP site is intermittent due to the dry climate and the Pecos River, located 12 miles (19 kilometers) southwest of the site. The Pecos River is the closest perennial stream. The CCA stated that there are no well defined drainage features at the WIPP site. Figure 2-18 provides a topographic map of the area around the WIPP site. DOE provided additional disposal system information such as site hydrologic data, in Chapter 2.2 (pp. 2-93 to 2-144), and Chapters 3, 6, and 7 of the CCA, as well as numerous appendices (e.g. Appendices GCR, FAC, and HYDRO).

14.A.6 EPA COMPLIANCE REVIEW

EPA reviewed Chapter 1.3 (pp. 1-12 to 1-14), Chapter 2 (pp. 2-1 to 2-6), Chapter 3 (pp. 3-1 to 3-14), Chapter 6.1 (pp. 6-13 to 6-35), and Chapter 7, the primary sources of information for the location of the disposal system. Various tables and figures, including Table 3-1, Figures 1-2, 2-18 and 3-1, provide general graphical information on the location of the disposal system. Other figures (e.g., Figures 2-38 and 7-9) in the CCA show the site in relation to geographical information. Chapter 2.1.4.2 (pp. 2-67 to 2-68) is the primary section in which the physical setting of the WIPP is described.

EPA examined the CCA to confirm the presence of adequate information about the location of the disposal system and control area, and also evaluated the accuracy and consistency of this information. EPA found that DOE provided the required disposal system and controlled area information, and that the information was technically adequate. Further information is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.A (EPA 1998a).

14.B.1 REQUIREMENT

"Any compliance application shall include:

(a)(2) A description of the geology, geophysics, hydrogeology, hydrology, and geochemistry of the disposal system and its vicinity and how these conditions are expected to change and interact over the regulatory time frame. Such description shall include, at a minimum:

> (i) Existing fluids and fluid hydraulic potential, including brine pockets, in and near the disposal system; and
>
> (ii) Existing higher permeability anhydrite interbeds located at or near the horizon of the waste."

14.B.2 ABSTRACT

The CCA must contain all the elements specified in Section 194.14(a)(2). EPA expected that the information provided in the CCA will support the conceptualization of the disposal system, and that major site-related characteristics will be included in PA modeling. DOE stated that the WIPP is located in the Delaware Basin of New Mexico and Texas. The Delaware Basin contains thick sedimentary deposits (15,000 - 20,000 feet) that overlay 1.1-1.5 billion year old metamorphic and igneous basement rock. Since the Permian age (~200-250 million year old) Salado was deposited, minimal structural deformation has occurred in the Delaware Basin. Reflecting the limited tectonic activity in the Delaware Basin, the sedimentary rocks of the Delaware Basin are nearly horizontal with a slight west to east dip of about 1 degree.

DOE stated that the major geomorphic process in the vicinity is dissolution. To the west, the slight dip in the beds has exposed the Salado to dissolution processes; however, DOE estimated that the dissolution front will not reach the WIPP site for hundreds of thousands of years. Near-surface dissolution of evaporitic rocks (e.g., gypsum) have created karst topography west of the WIPP site, but DOE contended that karst processes do not appear to have affected the rocks within the WIPP site itself. DOE stated that while deep dissolution has occurred in the Delaware Basin, the process of deep dissolution would not occur at such a rate at the WIPP that it would affect the waste containment capabilities of the WIPP during the regulatory time period.

DOE stated that some of the geologic formations below the repository area contain oil and gas, resources that are currently being exploited in the Delaware Basin. In addition, potash is found within the Salado Formation; however, the WIPP lies below an area of the Salado where there are no economically minable potash reserves. See Chapter 2.3.1 (p. 2-147) of the CCA for more information. According to DOE's analysis, most of the water in the vicinity of WIPP is highly saline, with the closest dependable potable aquifer associated with the Capitan Reef at the edge of the Basin.

DOE stated that the low permeability Salado has limited water (in the form of brine) available to dissolve the halite or to transport radionuclides. If fluid is available to move through the Salado and potentially transport radionuclides, DOE contended that the major pathway for flow and transport is believed to be the more permeable anhydrite interbeds. While more permeable than the halite, the Salado anhydrite interbeds are still very impermeable ($\sim 10^{-19}$ m^2 permeability for the anhydrite versus $\sim 10^{-21}$ m^2 permeability of the halite).

To assess the capability of the WIPP site to contain radionuclides over 10,000 years, DOE considered the primary geologic units of concern to be (from below the repository to the surface):

- Castile—consisting of anhydrite and halite with pressurized brine pockets found locally throughout the vicinity of the WIPP site.

- Salado—consisting primarily of halite with some anhydrite interbeds and accessory minerals and approximately 2,000 feet (600 meters) thick.

- Rustler— containing salt, anhydrite, clastics, and carbonates (primarily dolomite), with the Culebra member of the Rustler as the unit of greatest interest.

- Dewey Lake Red Beds Formation (Dewey Lake)—consisting of sandstone, siltstone and silty claystone.

DOE did not consider most of the geologic units above the Salado to be likely pathways for radionuclides. According to DOE, the ~8 meter thick Culebra is the major potential pathway for contaminants above the Salado.

EPA examined the CCA to determine whether it contained a technically adequate description of the geology, geophysics, hydrogeology, hydrology and geochemistry of the WIPP disposal system and its vicinity and how these conditions change over time.

14.B.3 COMPLIANCE REVIEW CRITERIA

To demonstrate compliance, DOE must provide all information specified in Section 194.14(a)(2). Specific studies, data, analyses, etc., performed by DOE must be accurate, technically sound, and supported by appropriate justifications. In addition, parameter values and data sources must be appropriate. Any technical conclusions drawn by DOE based upon the information presented in the CCA and supplemental information must be adequately justified, accurate, and relevant. EPA expected that information in the CCA would support the conceptualization of the disposal system, and that the PA would include major site-related characteristics.

EPA's Compliance Application Guidance for the Waste Isolation Pilot Plant (CAG, pp. 9-10) stated that the CCA should include a discussion of regional and site:

- Geologic history.
- Stratigraphy.
- Lithology.
- Structural geology and geotectonics (e.g., geologic structure, tectonichistory, lineaments, fault or fracture zones, earthquake occurrence, subsidence).
- Seismic history (e.g., earthquake activity, relation of epicenters with geologic structures and/or geologic setting).
- Geomorphology and topography (e.g, geomorphic units and processes, such as secondary topographic features caused by erosion).
- Soil characteristics in the controlled area that affect infiltration and runoff (e.g., hydraulic conductivity, infiltration capacity).
- Natural resources (e.g., type, occurrence, location, extent of minerals, hydrocarbons, and water, such as potash, oil, gas, irrigation water). **See also CARD 32—Scope of Performance Assessments, CARD 33—Consideration of Drilling Events in Performance Assessments, and CARD 45—Consideration of the Presence of Resources.**

EPA expected hydrologic, hydrogeologic, and geochemical descriptions to be included and the following general hydraulic characteristics to be addressed for all geologic units in the disposal system:

- Hydraulic conductivity.
- Storage coefficients.

- Transmissivity.
- Permeability.
- Thickness.
- Matrix and fracture characteristics.
- Hydraulic gradients.

For geological units that could be expected to transmit radionuclides to the accessible environment during the regulatory time frame, the CCA should include:

- Regional and site-specific recharge and discharge areas.
- Groundwater flow patterns, including horizontal flow (e.g., potentiometric surface, flow direction, effect of density on flow direction) and the estimated vertical flow into transmissive units.
- General physical characteristics (e.g., fracturing, porosity—total, effective, interstitial, and fracture—and saturated thickness).
- General transport characteristics (e.g., longitudinal and transverse dispersivity, tortuosity, matrix and fracture characteristics, retardation (physical and chemical) and a discussion of the characterization method(s) used).
- Flow boundaries, magnitudes and flow rates.
- Depth to water table (where applicable).
- Geochemistry and geochemical history (e.g., total dissolved solids, mineral content and distribution, fluid density, salinity).

In its description of the site's hydrogeology, hydrology, and geochemistry, the CCA should discuss the geological units that could be expected to transmit radionuclides to the accessible environment during the regulatory time frame. For those geological units that are not expected to transmit water, EPA recommended that the CCA discuss the basic hydrological properties that support this expectation.

14.B.4 DOE METHODOLOGY AND CONCLUSIONS

Geologic History

DOE provided information regarding the geologic history of the area around the WIPP site in the CCA in Chapter 2.1.2 (pp. 2-11 to 2-12), Appendix GCR.3.6 (pp. 3-83 to 3-108), GCR.4.5 (pp. 4-79 to 4-88), and HYDRO (pp. 10 to 22). DOE summarized the major geologic events that have occurred over time in a 200 mile radius (320 kilometer) surrounding the WIPP site. These events were organized according to the following geologic time periods:

- 1.5 to 1.1 billion years before the present, when the Precambrian age basement rocks, consisting of metamorphic and igneous rocks, were formed.
- 1.1 to 0.6 billion years before the present, a period of erosion when some of the Precambrian age rocks were removed in the WIPP region.
- 0.6 billion years ago to the present, a period of sedimentation that also includes shorter periods of erosion and dissolution. DOE's discussion focused on the major periods of deposition, erosion, tectonic activity and dissolution activity that has occurred from 0.6 billion years ago to the present (Figure 2-3, p. 2-15).

The WIPP is within the Delaware Basin, which is part of the larger Permian Basin, located within the south-central region of North America. During the Permian period, which began approximately 225 million years before present, ancient seas covered the basin and their later evaporation resulted in the deposition of a thick sequence of evaporite rocks. DOE stated that these evaporite rocks (which are primarily composed of halite) host the WIPP repository. See Appendix HYDRO (pp. 41 to 42), Chapter 2.1.3 (pp. 2-12 to 2-54), and Appendix GCR.4.3.2 (pp. 4-19 to 4-44) of the CCA.

Site Geology/Stratigraphy/Lithology

DOE provided information regarding the stratigraphy and lithology of the rock units surrounding the WIPP in Chapter 2.1.3 (pp. 2-12 to 2-64), as well as in Appendices GCR.4 (pp. 4-1 to 4-94), FAC, HYDRO (pp. 10 to 21), and other supporting references, including Appendix SUM.1.3 (pp. 6 to 10) and 6.3.5 (pp. 6-28 to 6-37). Figure IV-4 of EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a) shows the complete stratigraphic column in the WIPP area.

In Chapter 2.1.3 (pp. 2-12 to 2-64), DOE described stratigraphy that concentrated on the geologic formations above the Bell Canyon Formation. The Bell Canyon is the first laterally continuous transmissive unit below the WIPP repository, and this formation, as well as the formations above the Bell Canyon, was considered by DOE to comprise the WIPP disposal system. Chapter 2 briefly describes the stratigraphy of the units below the Bell Canyon and refers to Appendix GCR.4.3 (pp. 4-12 to 4-23) for additional information.

DOE stated in Appendix GCR.4.3.1 (pp. 4-12 to 4-13) that the Precambrian basement rocks below the Bell Canyon Formation are either granitic igneous rock or meta-granites and ryholites that occur approximately 18,200 feet (5.5 kilometers) below ground surface at the WIPP site. The Paleozoic rocks (from Cambrian to Pennsylvanian age) beneath the WIPP site were identified by DOE as being composed of mixed clastics and carbonates with an overall thickness ranging from 5,170 feet (1,575 meters) to 5,560 feet (1,696 meters) (Chapter 2.1.3, pp. 2-12 to 2-64).

DOE stated in Appendix GCR.4.3.2 (pp. 4-19 to 4-44) and Chapter 2.1.3 (p. 2-20) that the Permian age rocks are the thickest system in the northern Delaware Basin and are divided into four series from the base to the top: Wolfcampian, Leonardian, Guadalupian, and Ochoan. DOE stated that the overall thickness of the three lower series near the WIPP site were estimated as 8,684 feet (2.6 kilometers) and 8,500 feet (2.6 kilometers).

The Bell Canyon Formation is the youngest of the Permian age Guadalupian Series and was described by DOE as being 1,180 feet (360 meters) thick, consisting of mostly fine-grained sandstone with varying amounts of silty and shaley interbeds (Chapter 2.1.3.2, p. 2-23) and Appendix GCR.4.3.2 (pp. 4-22 to 4-23). As noted above, DOE stated that the Bell Canyon is the first laterally continuous transmissive unit below the WIPP repository and is composed of a series of sandstones deposited by density currents flowing from paleo-shelf regions to the north of the WIPP site. The Castile was deposited on top of the Bell Canyon Formation and consists primarily of anhydrite and halite. DOE recognized the potential for groundwater to migrate from the Bell Canyon and cause dissolution of the Castile below the repository, but contended that this will not occur to any significant degree within the 10,000 year regulatory period. See Appendix HYDRO (pp. 26 to 33) and Chapter 2.2.1 (pp. 2-97 to 2-108).

The Ochoan Series is comprised of the upper Paleozoic rocks and DOE stated that it includes perhaps the thickest and most extensive evaporative rock sequence in North America. See Appendix GCR.4.3.2 (pp. 4-23 to 4-44). The Ochoan Series rocks are nearly entirely of marine origin and are divided into a thick lower section of evaporates and a thin upper section of redbeds. The lower evaporates include the Castile, Salado, and Rustler, while the upper redbeds are represented by the Dewey Lake. At the WIPP site, the Ochoan rocks are about 3,900 to 4,000 feet (1,188 to 1,219 meters) thick, of which 3,600 to 3,800 feet (1,097 to 1,158 meters), or about 90 percent, are the evaporite sequences (see Chapter 2.1.3.3 through 2.1.3.6 (pp. 2-24 to 2-54).

DOE described the Castile in Chapter 2.1.3.3 (pp. 2-24 to 2-29) and Appendix GCR.4.3.2 (pp. 4-25 to 4-29) as an evaporite sequence consisting of approximately 989 feet (301 meters) of mostly interlaminated carbonate, anhydrite and high-purity halite, with no native sulfur near the WIPP site. DOE stated that in some locations near the WIPP, the Castile has been significantly deformed and there are pressurized brines associated with the deformed areas. The brine reservoirs are located in fracture systems within the upper part of the Castile, though DOE stated that not all wells drilled through the Castile may encounter fractures (or brine), probably due to fracture spacing in the deformed unit. According to DOE, deformation in the Castile (discussed in "Non-Tectonic Features" below) is due mainly to gravity foundering (Chapter 2.1.6, pp. 2-80 to 2-87).

The Salado is the host formation for the WIPP Repository. DOE stated in Chapter 2.1.3.4 (pp. 2-29 to 2-37) and Appendix GCR.4.3.2 (pp. 4-29 to 4-39) that the Salado consists of approximately 2,000 feet (609 meters) of bedded halite, with interbeds or seams of anhydrite, clay, and polyhalite. The Salado is divided into an unnamed upper member, the middle McNutt

Potash Zone, and an unnamed lower member. The WIPP is constructed in the lower member. DOE stated that there are 10 potash zones within the McNutt Member of potential significance in the vicinity of the WIPP. Potash is a potassium compound used in agriculture and industry. In addition, DOE stated that there are numerous thin sulfate marker beds (primarily anhydrite) within the Salado. The anhydrite marker beds have been numbered with MB 100 near the top of the formation and MB 144 near the base. The repository zone lies between MB 138 and MB 139 (Chapter 2.1.3.4, p. 2-30). See Chapter 2, Figure 2-8, for a stratigraphic column of the Salado.

DOE stated in Chapter 2.1.3.5 (pp. 2-37 to 2-53) and Appendix GCR.4.3.2 (pp. 4-39 to 4-42) that the Rustler overlies the Salado near the WIPP site and consists of evaporite units with interbedded siliciclastics and carbonates. DOE divided the Rustler into five members (from the base): Unnamed Lower member, Culebra member, Tamarisk member, Magenta Dolomite member, and Forty-niner member (CCA Figure 2-9). DOE stated that the Rustler is the last evaporite sequence of the Permian age Ochoan Series. The Rustler is 300 to 350 feet (91 to 107 meters) thick in the WIPP area and has been the subject of extensive characterization activities because it contains the most transmissive hydrologic units overlying the Salado (specifically, the Culebra). The Culebra member has an average thickness of approximately 25 feet (7.6 meters) across the WIPP site, and consists primarily of finely crystalline dolomite with vugular primary porosity and secondary fractures, both of which may have gypsum and/or anhydrite fill. A regionally extensive bed of organic, laminated carbonate, and clay occurs at the top of the Culebra at the WIPP site. The Culebra exhibits microporosity and vugular porosity. In the subsurface, vugs are partly filled or filled with anhydrite, gypsum, or clay. Culebra natural fractures can be filled with or partially lined by gypsum; gypsum infill within Culebra pore space increases to the east across the WIPP site. See Chapter 2.1.3.5.2 (pp. 2-45 to 2-49) for more information. The Magenta Dolomite member is 23 to 28 feet thick, and is gypsiferous. The Magenta Dolomite exhibits microporosity and vuggy porosity. For additional information regarding the hydrology of the Rustler, see EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.C (EPA 1998a).

DOE stated in Chapter 2.1.3.6 (pp. 2-53 to 2-54) and Appendix GCR.4.3.2 (p. 4-42) that the siliciclastic Dewey Lake is the uppermost Ochoan (late Permian) rock layer at the WIPP site. The Dewey Lake conformably overlays the Rustler and consists of approximately 498 feet (152 meters) of reddish-brown fine-grained sandstone to siltstone or silty claystone, with greenish-gray iron-reduction spots. DOE stated that there are mineral-filled fractures within the Dewey Lake. See Chapter 2.1.3.6 (p. 2-54) for more information.

The Mesozoic Era is represented at the WIPP site by the late Triassic age Santa Rosa Formation, deposited on top of the Dewey Lake. DOE described the Santa Rosa Formation in Chapter 2.1.3.7 (pp. 2-54 to 2-59) and Appendix GCR.4.3.2 (pp. 4-44 to 4-46) as an erosional wedge of varied-colored coarse-grained rocks approximately 2 feet (0.6 meters) thick that pinches out westward just beyond the center of the WIPP site. DOE stated that the Pleistocene to upper Miocene age Gatuña Formation, consisting of a light reddish-brown coarse conglomerate to claystone, with interbedded gypsiferous sections, lies unconformably over the Santa Rosa Formation. See Chapter 2.1.3.8 (p. 2-59) for more information. The Gatuña Formation is fluvial in origin and also includes low-energy deposits and evaporates; it is approximately 9 feet (2.7 meters) thick near the WIPP site. DOE stated that the Mescalero Caliche is an informal stratigraphic unit that overlies the Gatuña, which is early-to-middle Pleistocene in age (approximately 570,000 to 420,000 years old). The Mescalero Caliche is an approximately 10-foot (3-meter) thick caliche crust that formed with an upper dense laminar caprock, and an earthy-to-firm, nodular calcareous base. DOE concluded that where the Mescalero is flat-lying and not breached by erosion, it is an indicator of stability or integrity of the land surface over the last 500,000 years. The presence of the Mescalero Caliche also indicates that the past climate at the WIPP site has been relatively dry since past infiltration has not been sufficient to cause extensive dissolution of the Mescalero Caliche at the WIPP site. See Chapter 2.1.3.9 (p. 2-60) for more information.

Non-Tectonic Features

DOE stated that the most significant non-tectonic features in the vicinity of the WIPP site are related to Castile structures (i.e., disturbed zones) and evaporite dissolution. These processes are described in detail in Chapter 2.1.3.3 (p. 2-24) and 2.1.6 (pp. 2-80 to 2-93) and Appendices DEF.2 - DEF.3 (pp. DEF-1 to DEF-33).

DOE stated that the Castile has been known for many years to be deformed in parts of the Delaware Basin; see Appendix DEF.2 (pp. DEF-14 to DEF-17) and Chapter 2.1.6.1.1 (p. 2-80). Specifically along the northern margin of the Delaware Basin, the Castile thickens from the northwestern to the northern part of the basin, just inside the Capitan Reef. As part of the program to characterize an initial site for the WIPP, DOE drilled borehole ERDA-6 in 1975. The borehole is located approximately 5 miles (8 kilometers) northeast of the current center of the WIPP site. The borehole encountered pressurized brine and natural gas at a depth of 2,711 feet (826 meters) in the Castile. DOE stated that beds within the Castile were displaced upward by hundreds of feet, and “piercing” of upper Castile units by lower units is apparent. DOE concluded that the beds were too structurally deformed to reasonably mine along single horizons. DOE used the ERDA-6 well data to derive areas of less deformed Castile suitable for the WIPP site and relocated the WIPP to the current site in 1976. See Appendix DEF.2.1 (pp. DEF-1 to DEF-11) for more information.

Through 1977 and 1978, DOE collected seismic geophysical data to aid in mapping disturbed and non-disturbed zones of the Castile. The results of the survey stated an area of complex structure of the middle Castile strata 0.5 to 1 mile (0.8 to 1.6 kilometers) north of the WIPP storage facility. As a part of geophysical mapping, DOE drilled borehole WIPP-11 in 1978. Located approximately 3 miles (5 kilometers) north of the WIPP storage facility, the well encountered extensive deformation within the Castile, including strata extending into the overlying Salado. DOE stated, however, that it found no over-pressured brine (Chapter 2.1.6.1.1, p. 2-85).

DOE stated in Chapter 2.1.6.1.1 (p. 2-85) and Appendix DEF (pp. DEF-4 to DEF-11) that 1977 and 1978 seismic maps also suggested faulting in the Salado and the Rustler, possibly related to deformation in the Castile. To investigate the apparent structure, DOE drilled boreholes WIPP 18, 19, 21, and 22 within the WIPP site boundary and found no detectable offset on the contact between the Rustler and Salado. As a test of Castile fluid characteristics in relatively undisturbed Castile structure, DOE deepened WIPP-12 in 1981. DOE found fractured anhydrite in the upper Castile associated with pressurized brine. A time-domain electromagnetic survey (TDEM) conducted at the WIPP suggested the presence of brine under part of the WIPP facility, south of the disturbed zone (Chapter 2.2.1.2.2).

DOE stated in Chapter 2.1.6.1.3 (p. 2-87) and Appendix DEF.2.3 (pp. DEF-14 to DEF-16) that the principal hypotheses for the occurrence of deformational features in the Castile are gravity foundering, dissolution, gravity sliding, gypsum dehydration, and depositional processes. DOE summarized each of the hypotheses in Appendix DEF.2.3, but stated that gravity foundering is the most comprehensive and best-accepted hypothesis. DOE concluded that mathematical and centrifuge models of similar systems confirm the potential for such deformation and suggest a rate of deformation of about 0.02 inch per year (0.05 cm per year) (Appendix DEF.2.3, p. DEF-14). DOE stated that at this rate, the Castile disturbed zone could be inferred to develop over about 700,000 years. DOE stated that there is still some question regarding why the disturbed zones in the Castile (particularly those with pressurized brine and gas) only occur over a relatively small part of the Delaware Basin. See Appendices DEF.2.3 and DEF.2.4 (pp. DEF-14 to DEF-18) for more information.

DOE discussed three dissolution mechanisms potentially pertinent to WIPP in Chapter 2.1.6.2 (pp. 2-87 to 2-93) and Appendix DEF.3 (pp. DEF-18 to DEF-23). The mechanisms include: deep dissolution, including Bell-Canyon-Castile interface dissolution and breccia pipe development; lateral dissolution along the Rustler-Salado contact and within the Rustler; and shallow dissolution, including karst development. See Section 14.C of this CARD for further discussion of DOE’s assessment of the three dissolution mechanisms. DOE concluded that while these dissolution mechanisms may have occurred to varying degrees in the Delaware Basin, there is a high level of confidence that dissolution sufficient to affect the performance of the disposal system is physically unreasonable and will not occur over the regulatory time frame. See Appendix DEF.3.4 (p. DEF-33) for more information.

Tectonic Setting/Structural Features/Seismic History

DOE provided information regarding the tectonic setting and site structural features in Chapter 2.1.5 (pp. 2-68 to 2-80) and Appendix GCR.4.4 (pp. 4-53 to 4-79). DOE concluded that the WIPP site is located in an area with no evidence of significant tectonic activity and a low level of regional stress. DOE cited evidence demonstrating that the WIPP area has been tectonically stable since the Permian period. For example, the large structural features creating and surrounding the Delaware Basin are not directly reflected in the Mesozoic and Cenozoic rocks overlying these Paleozoic Era features, indicating that the structures are predominantly Paleozoic in age. Also, Late Permian Ochoan rocks and Triassic rocks do not stratigraphically or structurally reflect movements related to the formation of the Delaware Basin. The only major structural feature of post Paleozoic Formations identified by DOE was regional eastern slope, which appears to be a transitional expression of the Tertiary (approximately 12 million to 9 million years before present) Guadalupe Mountain uplift. See Chapter 2.1.5.1 (p. 2-73) for additional information.

DOE stated that there are known fault zones along the central Basin Platform east of the WIPP, and geophysical logs show that the faults displace Rustler rocks in this area. See Chapter

2.1.5.3 (p. 2-79) for more information. While the overlying Dewey Lake shows marked thinning along the same trend in this area, the structure contours of the top of the Dewey Lake were not clearly off-set, and no surface displacement or fault was reported along this trend. DOE stated that the nearest known Quaternary faults of tectonic origin to the WIPP have been mapped along the Salt Basin Graben west of both the Guadalupe and Delaware Mountains, which is over 50 miles west of the site. DOE concluded that there are no known Quaternary or Holocene faults of tectonic origin that offset rocks at the WIPP, and the closest occur along the western escarpment of the Guadalupe Mountains. See Chapter 2.1.5.3 (p. 2-79) for more information.

DOE provided information regarding the seismic history of the WIPP site within Chapter 2.6 (pp. 2-180 to 2-205) and stated that the current WIPP location was selected because of the absence of tectonic activity, faulting, and igneous activity. DOE stated that the most recent earthquake to be felt at the WIPP site was the April 14, 1995, quake in Marathon, Texas. The epicenter of the 5.7 magnitude event was 149 miles (240 kilometers) south of the site. DOE estimated that maximum accelaration at the WIPP site produced by this event would be less than 0.01 g. (Chapter 2.6.1, p. 2-193). DOE determined that igneous activity was limited to a single known feature, a series of lamprophyre dikes along a linear trace passing about 8 miles northwest of the WIPP site. The dikes have been radiometrically dated as being approximately 35 million years old (Chapter 2.1.5.4, pp. 2-79 to 2-80).

DOE also studied seismic activity to help predict ground motions that may affect the stability of the WIPP repository. Records of historic earthquakes, using anecdotal and seismic instrument data, formed the basis for the evaluation. The distribution of epicenters suggests three source zones representing the Central Basin Platform area, the combined Southern Basin and Range and Rio Grand Rift areas, and a WIPP site source zone representing background conditions. DOE established a Design Basis Earthquake (DBE), with a recurrence interval of 1,000 years. For the WIPP site, the DBE is considered equivalent to a Richter magnitude 5.5 earthquake at the site, a magnitude 6.0 earthquake on the Central Basin Platform, or a magnitude 7.8 earthquake in the Basin and Range-Rio Grande Rift area. The peak acceleration associated with the DBE is 0.075 g (g = the acceleration of gravity). DOE selected 0.1 g as the peak design acceleration to be used at the WIPP site for surface confinement structures and components. See Chapter 2.6 (pp. 2-180 to 2-205) for more information.

DOE provided an evaluation of stratigraphic loading and unloading in Chapter 2.1.5.2 (pp. 2-74 to 2-79). The evaluation focused on the geologic history since the Permian period deposition, because stress changes could have caused fracturing that would influence site hydrology. DOE developed two scenarios for the WIPP site: an extreme and a moderate deposition/erosion sequence. For the extreme situation, DOE theorized that up to 1,863 feet (586 meters) of rock may have been deposited above the Culebra by the end of the Triassic period, including rocks from the Dewey Lake and the Triassic age Dockum Group. The extreme sequence assumed that Jurassic period deposition at the WIPP site was unlikely and that erosion during the Jurassic period was insignificant. The extreme loading scenario also assumed the deposition of an additional 1,000 feet (300 meters) of Cretaceous age rocks above the Triassic age strata, and that Late Cretaceous period and Cenozoic period erosion removed both the Cretaceous period and Triassic period rocks from the site. Finally, during the extreme sequence, DOE determined that Miocene deposition and Pliocene-Pleistocene erosion of up to 330 feet possibly occurred at the site, based on the maximum known thickness in the area. See Chapter 2.1.5.2 (p. 2-76) for more information.

According to DOE, it is more likely that the moderate deposition and erosion rate scenario occurred (Chapter 2.1.5.2, pp. 2-74 to 2-79). This conclusion was based on evidence of relatively quiescent tectonics and fairly uniform rock structure around the WIPP site, suggesting a more modest loading and unloading history than required for the extreme scenario. The moderate loading scenario also assumed that up to 1,863 feet (586 meters) of the Dewey Lake and the Dockum Group rocks were deposited by the end of the Triassic period. In the moderate scenario, erosion of the Dockum Group rocks probably began in the Jurassic period, slowed or stopped during the Early Cretaceous period as the area was nearer or at base level, and then accelerated during the Cenozoic period. Erosion rates may have been relatively high over short periods, creating the greatest stress relief on the Culebra and underlying sediments. The moderate loading scenario assumed that virtually no Cretaceous period rocks were deposited in the vicinity of the WIPP site. DOE also assumed additional late Cenozoic loading and erosion occurred.

Geomorphology, Topography, and Soils

DOE provided information regarding the geomorphology and topography of the WIPP site in Chapter 2.1.4 (pp. 2-64 to 2-68). DOE concluded that the WIPP site is located in the Pecos Valley section of the southern Great Plains physiographic province. The Pecos Valley section is dominated by the Pecos River Valley, which is a long north-south trough that is from 5 to 30 miles (8.3 to 50 kilometers) wide and as much as 1,000 feet (305 meters) deep in the north. The Pecos River system receives almost all of the surface and subsurface drainage in the region, and most of its tributaries are intermittent due to the semi-arid climate. DOE described the physical setting of the land surface at the WIPP site as a semiarid, wind-blown plain sloping gently to the west and southwest, hummocky with sand ridges and dunes. The Mescalero Caliche underlies the sand blanket. Ground surface at the site ranges from 3,570 feet (1,088 meters) above mean sea level (amsl) in the east to 3,250 feet (990 meters) amsl in the west. The average east-to-west slope is 50 feet per mile (9.4 meters per kilometer). The CCA provides topographic maps in Chapter 2, Figure 2-18 (p. 2-69), and Appendix GCR, Figure 2.2-2.

DOE stated in Chapter 2.1.4.2 (p. 2-67) that the most prominent physiographic feature near the site is Livingston Ridge, which is a west facing escarpment located approximately 4 miles (6.4 kilometers) northwest of the center of the WIPP site. It marks the edge of Nash Draw, which is a shallow 5-mile-wide (8 kilometers), 200-300 feet (61 to 91 meters) deep feature caused, at least in part, by subsurface dissolution and the accompanying subsidence of overlying sediments. DOE stated that Livingston Ridge is the approximate eastern boundary of terrain that has undergone erosion and/or solution collapse. See Chapter 2.1.4.2 (p. 2-67) for more information.

DOE provided information regarding the soil characteristics in the vicinity of the WIPP in Chapter 2.1.3.10. DOE stated that there are three soil associations within 5 miles (8.3 kilometers) of the WIPP site: the Kermit-Berino, the Simona-Pajarito, and the Pyote-Maljamar-Kermit. The soils in the region were developed from Quaternary Mescalero caliche and Permian age parent material. DOE stated that only the Kermit-Berino soil association has been mapped at the WIPP site. The Berino Series soils cover about 50 percent of the site, include active dune areas, and consist of noncalcareous, yellow-red to red sandy soils. The Kermit Series soils consist of deep, non calcareous, excessively drained loose sands that are typically yellowish-red fine sands. The Kermit-Berino soils are susceptible to wind erosion if the vegetative cover is removed; see Chapter 2.1.3.10 (p. 2-63).

Natural Resources Identification

DOE provided information regarding natural resources in the vicinity of the WIPP site in Chapter 2.3 (pp. 2-145 to 2-161) and stated that the consideration of resources was an important part of the siting criteria for the WIPP. Several siting criteria emphasized the avoidance of resources that would impact the performance of the disposal system. DOE identified both economic (mineral and nonmineral) and cultural resources that may exist at or beneath the WIPP site. Due to the depth of the disposal horizon, only the mineral resources are of significance to predicting the long-term performance of the disposal system. (Note that while DOE assessed shallow drilling for water per Section 194.33 requirements, shallow drilling was screened from the PA based on low consequence. See Appendix SCR.3 (pp. SCR-91 to SCR-143) and **CARD 33—Consideration of Drilling Events in Performance Assessments** for additional information.) DOE concluded that the mineral resources of practical concern at the WIPP site were the potassium salts sylvite and langbenite in the McNutt Potash zone of the Salado, and oil, natural gas, and distillate liquids associated with natural gas that occur in strata below the Castile.

DOE stated that commercial quantities of potassium salts are restricted to the middle portion of the Salado, in the McNutt Potash zone. Based on information obtained from a 1995 re-evaluation of the mineral resources at and within 1 mile (1.6 kilometers) of the WIPP performed by the New Mexico Bureau of Mines and Mineral Resources, only the 4th and 10th of the eleven recognized potash zones contain economic potash reserves and neither of the economically minable reserves lies directly above the WIPP waste panels. DOE stated that in a reassessment of hydrocarbon resources in the vicinity of the WIPP, it calculated the amounts of probable oil and gas resources beneath the site by extrapolating currently productive oil and gas resources that are thought to extend beneath the study area. Chapter 2.3.1.2 (p. 2-148) refers to Appendix DEL.5 (pp. DEL-26 to DEL-46) and Appendix MASS.16 (pp. MASS-87 to MASS-99) for detailed information regarding modeling parameters related to hydrocarbon resources and their exploration.

General Hydrology

DOE provided information regarding the hydrogeologic characteristics of the geologic units in the disposal system in Chapter 2.2.1 (pp. 2-97 to 2-145), Appendix FAC.7 and FAC.8 (pp. 7-1 to 8-18), Appendix GCR.6 (pp. 6-1 to 6-62), and Appendix HYDRO (pp. 22 to 75). For each of the geologic units in the vicinity of the WIPP disposal system, DOE provided information regarding hydraulic conductivity, storage coefficients, transmissivity, permeability, thickness, matrix and fracture characteristics, and hydraulic gradients in a summary table provided to EPA in a letter dated February 14, 1997 (Docket A-93-02, Item II-I-08). This information was reproduced as Figure IV-10 in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a). The CCA also provides detailed groundwater hydrology information for geologic units that could be expected to transmit radionuclides to the accessible environment.

DOE determined that the Castile, Salado, Rustler and Dewey Lake hydrological systems are the most important to disposal system performance and modeling (Chapter 2.2.1, p. 2-97). The Castile provides a hydrologic barrier between the Bell Canyon and Salado and contains high-permeability zones with pressurized brine. DOE considered the Salado to be the most significant hydrologic barrier between the repository and more transmissive beds. At the WIPP site, the Rustler contains two transmissive members: the Culebra and the Magenta. DOE stated that the Dewey Lake is not an extensive aquifer at the WIPP site, though DOE reports groundwater movement in a fractured zone of the Dewey Lake off-site of the WIPP.

Castile and Salado Hydrology

DOE stated that the hydraulic characteristics of the Castile can be broken into two components: the Castile itself and the Castile brine reservoirs (Chapter 2.2.1.2.2, pp. 2-107 to 2-108). The Castile is dominated by low permeability anhydrite and halite zones. The Castile brine reservoirs are found in the upper portion of the Castile in areas of more permeable fractured anhydrite and are associated with Castile disturbed features. Fracturing in the upper anhydrite of the Castile generated isolated regions with much greater permeability than the surrounding intact anhydrite. These higher permeability areas of the Castile contain brine pressures greater than hydrostatic. In one example (borehole WIPP-12), DOE measured the fluid pressure at 12.7 megapascals, which was greater than the nominal hydrostatic pressure of 11.1 megapascals for that depth, indicating that brine could flow upward to the surface through a borehole. Using information from a time-domain electromagnetic survey (TDEM), DOE stated that similar brine occurrences may be present in the Castile under a portion of the waste disposal panels. On a geostatistical basis, DOE found the probability of a borehole encountering brine below a waste panel to be 8 percent (Powers et al. 1996). DOE stated that based on geochemical investigations, the brines originated from ancient sea water, and no evidence exists for fluid contribution from present meteoric waters (Popielak et al. 1983). Based on data from the ERDA-6 and WIPP-12 reservoirs, the brines are distinct from each other and from local groundwaters. In addition, DOE stated that the brines are saturated (or nearly so) with respect to halite and consequently have little potential to dissolve halite.

DOE stated that the Salado acts as a regional confining bed and does not contain circulating fluids (Chapter 2.2.1.3, pp. 2-108 to 2-113). For the purposes of hydrologic characterization, DOE considered the Salado to consist of impure halite, pure halite, anhydrite, and marker beds. DOE stated that fluid within the Salado is of two types: brine in isolated inclusions within the salt and fluid moving within interbeds, along clay boundaries, and in anhydrite fractures. Hydrologic information regarding the Salado is provided in Figure IV-10 of EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a). DOE estimated hydraulic properties of the Salado from field and laboratory experiments and information obtained from WIPP site boreholes. From data obtained during hydraulic tests in impure halite, DOE interpreted permeabilities of the Salado to vary from $1x10^{-23}$ to $4x10^{-18}$ square meters. Interpreted formation pore pressures vary from 0.3 to 9.7 megapascals, and DOE interpreted the lower pressure as affecting the Disturbed Rock Zone

(DRZ). See Section 14.E.4 of this CARD and **CARD 23—Models and Computer Codes** for further discussion of the DRZ. DOE stated that two hydraulic tests conducted in pure halite revealed no observable response, indicating either extremely low permeability ($<10^{-23}$ square meters) or no flow. From 14 tests in anhydrite, DOE interpreted Darcy model flow to vary from $2\text{x}10^{-20}$ to $7\text{x}10^{-18}$ square meters and interpreted formation pore pressures vary from atmospheric to 12.5 megapascals. DOE noted the lower pressure was caused by depressurization near the WIPP excavation. From testing of core samples from MB 139, the permeability varied from $1\text{x}10^{-18}$ to $4\text{x}10^{-21}$ square meters and the threshold capillary flow pressure was stated to be less than 1 megapascal. DOE collected qualitative data on brine flow to underground workings since 1985. Brine content of the Salado is estimated to be 1 to 2 percent by weight, and thin clay seams contain up to 25 percent brine by volume. Natural brine of the Salado will move toward areas of lower hydraulic potential. Flow to the WIPP DRZ was characterized by DOE as complex and discontinuous. See Chapter 2.2.1.3 (pp. 2-112 to 2-113) for more information.

Rustler, Dewey Lake, and Santa Rosa Formation Hydrology

DOE stated that the units above the Salado (i.e. the Rustler, the Dewey Lake and the Santa Rosa) are classified as a single hydrostratigraphic unit for conceptual and computer modeling (Chapter 2.2.1.4, pp. 2-114 to 2-132). DOE stated that the Rustler is of particular importance for WIPP because it contains the most transmissive units above the repository. In general, fluid flow in the Rustler is characterized by DOE as exhibiting very slow vertical leakage through confining layers and faster lateral flow in conductive units. Of the five members of the Rustler at the WIPP, the Culebra and the Magenta are considered conductive units, and the Unnamed Lower Member, the Tamarisk, and the Forty-niner are considered confining units. Specific hydrogeologic information regarding each member of the Rustler is provided in Figure IV-10 of EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a).

DOE stated that the Culebra is a fractured dolomite with non-uniform properties, both horizontally and vertically. The Culebra exhibits matrix (interparticle to vugular, and intercrystalline) and fracture (micro to macro) porosity. DOE stated that flow within the Culebra occurs primarily within fractures, although flow also occurs within vugs where they are connected by fractures and, to some extent, within interparticle porosity where this porosity is high. Flow in the Culebra is dominantly lateral and southward; see Chapter 6.0.2.3.6 (pp. 6-9 to 6-10) and Chapter 2.2.1.4.1.2 (p. 2-120).

DOE stated that the Culebra is the most transmissive hydrostratigraphic unit at the WIPP site and conceptually acts as a “drain” for the units around it. Transmissivity of the Culebra varies spatially over six orders of magnitude from east to west in the vicinity of WIPP (CCA Figure 2-30, p. 2-121). Over the site, the Culebra transmissivity varies by three to four orders of magnitude from about $1\text{x}10^{-3}$ square feet per day ($1\text{x}10^{-9}$ square meters per second) east of the WIPP site to about $1\text{x}10^{3}$ square feet per day ($1\text{x}10^{-3}$ square meters per second) in Nash Draw. Long-term hydraulic tests have also been performed by DOE; see Chapter 6.0.2.3.5 (pp. 6-8 to 6-9) and Chapter 2.2.1.4.1.2 (pp. 2-118 to 2-127).

Transmissivity, storativity, transport properties, and diffusion properties are affected by the nature of fractures and porosity. DOE obtained Culebra porosity measurements from cores and found values ranging from 3 percent to 30 percent in fractures, vugs, chalky dolomite, and interparticle porosity. Fracture spacing, as it affects transmissivity, is thought to vary as a function of the distribution of overburden above the Culebra, distribution of halite in the Rustler, dissolution of halite in the upper portion of the Salado, and distribution of Culebra gypsum fracture fillings. See Chapter 2.1.3.5.2 (pp. 2-45 to 2-50) and Appendix MASS.15 (pp. MASS-75 to MASS-81) for more information.

DOE stated in Chapter 2.4.2.1 (pp. 2-166 to 2-169) that there is considerable variation in the groundwater chemistry of the Culebra. DOE provided information supplemental to the CCA pertaining to groundwater flow and geochemistry within the Culebra member of the Rustler in a response, dated May 14, 1997 (Docket A-93-02, Item II-I-31), to EPA's March 19, 1997 letter (Docket A-93-02, Item II-I-17). In this letter, DOE explained that it modified the conceptualization of Culebra groundwater flow in the CCA relative to that supported by DOE in the past. Previously, DOE has had difficulty reconciling geochemical conditions within Culebra groundwater and current groundwater flow directions and velocities (see Chapter 2.2.1.4.1.2).

The new conceptualization, referred to as the groundwater basin model, offers a three dimensional approach to treatment of Supra-Salado rock units, and assumes vertical leakage (albeit very slow) between rock units of the Rustler exists (where hydraulic head is present). Flow in the Culebra is considered transient. This differs from previous interpretations, wherein no-flow was assumed between Rustler units. The model assumes that the groundwater system is dynamic and is responding to the drying of climate that has occurred since the late Pleistocene period. DOE assumed that recharge rates during the late Pleistocene period were sufficient to maintain the water table near land surface, but have since dropped significantly. Therefore, the impact of local topography on groundwater flow was greater during wetter periods, with discharge from the Rustler to the west; flow is dominated by more regional topographic effects during drier times, with flow to a more southerly direction.

DOE identified four hydrogeochemical facies within the Culebra in the WIPP area in Chapter 2.4.2.1 (p. 2-166) and Figure 2-40 (p. 2-167):

- Zone A - saline (2-3 molal) NaCl brines, Mg/Ca ratio of 1.2 to 2.
- Zone B - dilute (<0.1 molal) $CaSO_4$ - rich groundwater.
- Zone C - variable composition (0.3-1.6 molal); Mg/Ca ratio 0.3 to 1.2.
- Zone D - high salinities (3-7 molal); K/Na weight ratios (0.2).

DOE concluded that Facies A groundwater flow is slow, has not changed over the last 14,000 years, and probably recharged more than 600,000 years ago. Vertical leakage occurs to Facies A, and both lateral and vertical groundwater flow rates are extremely low. Facies B occurs in an area with greater vertical fracturing in the Culebra, and therefore exhibits more vertical infiltration and more rapid lateral flow in the Culebra. According to DOE, flow in Facies B is currently to the south (it may mix with Facies C water to the southeast) but was more toward the west during wetter climates; vertical infiltration from the Dewey Lake to the Culebra Facies B is assumed by DOE to have occurred during wetter climates in an area south of the WIPP site. DOE theorized that Facies C water was not diluted to create Facies B water. Facies C occurs “in between” Facies A and B, and groundwater flow entered the Culebra prior to the climate change (to drier conditions) 14,000 years ago. Facies C groundwater flow is to the south at WIPP, where DOE theorized that it joins with a small amount of Facies A solute being transported from the east. Groundwater flow rate in Facies C is faster than in A but slower than in B, and the proposed recharge area from the Dewey Lake to the Culebra was to the northeast of the WIPP site. DOE theorized that Facies C groundwater infiltrated into the Dewey Lake and then interacted with anhydrite and halite along its path to the Culebra, where it mixed with smaller amounts of Facies A water. Within information submitted in a letter dated May 14, 1997 (Docket A-93-02, Item II-I-31), DOE concluded that the presence of anhydrite within Rustler units does not preclude slow downward infiltration, as had been previously argued by DOE.

In the 1992 PA (DOE 1992), DOE stated that the geochemistry of Culebra groundwater was inconsistent with flow directions. This position was based on the premise that Facies C water must transform to facies B water (e.g. become “fresher”), which is inconsistent with the observed flow direction. According to the information submitted in a letter dated May 14, 1997 (Docket A-93-02, Item II-I-31), DOE now states that the observed geochemistry and flow directions can be explained with different recharge areas and Culebra travel paths.

DOE noted that anomalous water level rises are apparent in some Culebra wells and that the water level rises in the vicinity of the WIPP site are caused by recovery from drainage into the shafts. DOE also stated that water levels to the northwest of the site, in and near Nash Draw, appear to fluctuate in response to effluent discharge from potash mines, although this can not be proven due to a lack of specific data regarding the discharges. DOE conducted an analysis of oil and gas-related injection wells near the WIPP to determine whether any of these are malfunctioning and causing associated groundwater level anomalies. The resulting mechanical integrity tests (MITs) did not indicate well failure. The cause of water-level rises in the vicinity of the H-9 hydropad, about 6.5 miles (10.46 kilometers) south of the site, remains unexplained. DOE continues to monitor ground water levels throughout the region; see Chapter 2.2.1.4.1.2 (p. 2-124).

The Dewey Lake contains a productive zone of saturation, probably under water table conditions, in the southwestern to south-central portion of the WIPP site (Chapter 2.2.1.4.2.1, p. 2-131). The productive zone is approximately 180 to 265 feet (55 to 81 meters) below ground surface and appears to derive much of its transmissivity from open fractures. However, the Dewey Lake is not an aquifer in most areas near the WIPP site. Fractures below the productive zone tend to be completely filled with gypsum. DOE stated that the Dewey Lake is the uppermost important layer in the hydrological model and that changes in the water table in the Dewey Lake in the future, due to wetter conditions, were included in the conceptual model. DOE interpreted groundwater flow to be to the southwest at about 25 meters per mile (15.5 meters per kilometer). For modeling purposes, DOE estimated the saturated hydraulic conductivity of the Dewey Lake to be $3x10^{-3}$ feet per day (10^{-8} meters per second). DOE assumed that the Dewey Lake is an underground source of drinking water (USDW) in their bounding analysis in the compliance assessment. See Chapter 6.4.6.6 (pp. 6-148 to 6-149) and Appendix PAR, and Table PAR-26 (p. PAR-210) and Chapter 8 for more information. DOE's treatment of USDWs is further discussed in **CARD 53—Consideration of Underground Sources of Drinking Water**.

Capitan Aquifer and Rustler/Salado Contact

DOE stated in Chapter 2.2.1.5 (pp. 2-132 to 2-136) that there are two groundwater zones of regional importance that do not underlie the WIPP site: the Capitan Limestone aquifer and the Rustler/Salado Contact Zone in Nash Draw. DOE evaluated the Capitan Limestone because of its importance in processes such as the formation of breccia pipes. DOE stated that in the area north of the WIPP site, where the Capitan underlies the Salado, breccia pipes have formed in the Salado, most likely in response to the effects of dissolution by groundwater flowing in the Capitan along the base of the Salado. The Capitan aquifer forms a long narrow arcuate belt composed of very permeable rocks approximately 10-14 miles wide and approximately 10 miles north of the WIPP site at its closest point. DOE concluded there is a low probability that breccia pipes occur at the WIPP site because the Capitan is not present below the WIPP. See Appendix DEF.3.1 (pp. DEF-18 to DEF-25) and Chapter 2.2.1.5.2 (pp. 2-135 to 2-136) for more information.

The Rustler/Salado Contact Zone in Nash Draw, three miles (4.8 kilometers) west of the WIPP area, is a dissolution contact zone consisting of a residuum of gypsum, clay, and sandstone created by the dissolution of halite. The residuum ranges in thickness from 10.5 to 60 feet (3 to 18 meters), averages about 24 feet (7 meters) thick, and contains a brine aquifer. DOE stated that the Rustler/Salado residuum occurs to the west of the WIPP site, but is absent under the WIPP site. DOE described the location and hydraulic properties of the brine aquifer in Chapter 2.2.1.5.2 (p. 2-136).

14.B.5 EPA COMPLIANCE REVIEW

EPA reviewed the information provided in the CCA and the additional information submitted (see references in text below) to confirm the technical adequacy of the description of the geology, geophysics, hydrogeology and geochemistry of the disposal system and its vicinity, and how these conditions are expected to change.

Geologic History

EPA concluded that Chapter 2.1.2 (pp. 2-11 to 2-12) and associated Appendices GCR.3.6 (pp. 3-83 to 3-108), GCR.4.5 (pp. 4-79 to 4-88), HYDRO (pp. 10 to 22), and related references (e.g., Chapter 6.0.2.2 (pp. 6-2 to 6-5)) provide a technically adequate description of the geologic history of the WIPP area for purposes of the PA. EPA's initial review of the CCA raised questions regarding how DOE addressed the origin, nature, and distribution of fractures within supra-Salado rock units and Salado marker beds. These questions were sent to DOE in a letter dated December 19, 1996 (Docket A-93-02, Item II-I-01). EPA's December 19, 1996 letter (Enclosure 2, p. 7) noted that Anderson commented extensively on the development of karst dissolution and the link to climatic fluctuations (Docket A-93-02, Item II-D-22), and stated that "the Department needs to address Anderson's hypotheses specifically to discount them with more thorough analyses or data, or the results of modeling to show the proposed effects are bounded by the CCA assessments." EPA's December 19, 1996 letter (Enclosure 1, page 4, 194.14(a)(3)) also requested that "the CCA should be revised to include a more detailed discussion regarding the nature, extent, geologic characteristics, etc., of pre-existing fractures within Salado Formation marker beds." Supplemental information provided by DOE in a letter dated January 24, 1997 (Docket A-93-02, Item II-I-03), and independent analyses by EPA stated that DOE's treatment of these features is acceptable (see below). Further information on geologic history and other geologic, hydrogeologic, and geochemical issues is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV (EPA 1998a).

Site Geology/Stratigraphy

EPA found that although the CCA did not include a concise description of units below the Bell Canyon within the Volume 1, the necessary information was available in associated appendices and references (Appendix GCR, pp. 4-1 to 4-23). EPA concluded that the description of the Bell Canyon stratigraphy was technically adequate based on available lithologic information. Information regarding the general lithology and stratigraphy of the Castile contained in Chapter 2.1.3.3 (pp. 2-24 to 2-29) and its supporting documents, including Appendix GCR.4.3.2 (pp. 4-25 to 4-29), also was technically adequate. EPA found that DOE's geologic and geophysical basis for the distribution (i.e., 8 percent probability) of Castile disturbed zone structures below the WIPP appeared questionable, and therefore required this distribution to be revised (to a uniform distribution with a range of 0.01 to 0.6) in Performance Assessment Verification Testing (PAVT) (Docket A-93-02, Item II-I-25). The formation of Castile brine pockets as a result of Castile deformation was described in the CCA, and although DOE's discussion of the distribution and nature of fractures in the Castile was limited, modification of parameters to include larger Castile brine pockets in the PAVT sufficiently addressed this concern. Further information on this topic is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.C (EPA 1998a), EPA Technical Support Document for Section 194.23: Parameter Justification Report (EPA 1998e), and EPA Technical Support Document for Section 194.23: Review of TDEM Analysis of WIPP Brine Pockets (EPA 1998g).

EPA concluded that the description of the lithology and stratigraphy of the Salado, especially in the vicinity of the repository horizon, provided in Chapter 2.1.3.4 (pp. 2-29 to 2-37), Appendix GCR.4.3.2 (pp. 4-29 to 4-39), and supporting documentation, is appropriate for use in the PA. Although Salado Marker Bed characteristics were not detailed in the CCA, DOE submitted supplemental information in a letter dated April 15, 1997, regarding fracturing within anhydrites which clarified DOE's approach to anhydrite fracture properties pressurized conditions (Docket A-93-02, Item II-I-24).

EPA concluded that stratigraphic information pertaining to the Rustler (Chapter 2.1.3.5, pp. 2-37 to 2-53, and Appendix GCR.4.3.2, pp. 4-39 to 4-42) was technically adequate. Although EPA questioned DOE's interpretation of whether the origin of some of the Rustler stratigraphic characteristics was syndepositional, the origin of the Rustler characteristics is not as important as identifying whether dissolution processes are ongoing within the Rustler. EPA agrees that dissolution processes are not presently occurring within the Rustler, and that dissolution processes are not expected to recur and affect performance of the WIPP in the future (also see Non-Tectonic Features below). EPA concluded that stratigraphic information pertaining to the Dewey Lake is technically adequate, but that the Dewey Lake fracture characteristics could be better discussed within the CCA. However, the PAVT stated that little or no groundwater flow would occur from the repository to the Dewey Lake, thus removing the Dewey Lake as a potential pathway. In general, EPA concluded that stratigraphic information in the CCA pertaining to the Santa Rosa and Gatuna (Chapter 2.1.3.7 and 2.1.3.8, pp. 2-54 to 2-59) was technically adequate. The CCA addressed the occurrence and relative distribution of the Mescalero Caliche. Although a site-specific detailed map of the Mescalero Caliche distribution was not provided in the CCA, there was sufficient information to allow EPA to conclude that the stratigraphy of this unit was adequately discussed. Further discussion is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.B.3 (EPA 1998a).

Non-Tectonic Features

EPA agrees with DOE's conclusion that the mechanism most likely responsible for the Castile deformation is gravity foundering, although other mechanisms could occur to some degree. The distribution of these deformational features below the WIPP is uncertain, especially in terms of what DOE has chosen in PA modeling as the probability of encountering a brine pocket (Chapter 2.1.6.1.3, p. 2-87, and Appendix DEF.2, pp. DEF-1 to DEF-18). EPA addressed this uncertainty by requiring DOE to vary the brine pocket probability in the PAVT between 0.01 and 0.6 (DOE 1997b and 1997c). EPA concluded that DOE's assertions regarding timing of deformation feature formation or brine movement within these features were not unreasonable but could be better referenced in the CCA and more fully discussed in associated appendices and references. Information in the CCA was sufficient to conclude that creation of these features is beyond the regulatory time period (see Chapter 2.1.6.1.3, p. 2-87, and Appendix DEF.2, pp. DEF-1 to DEF-18).

EPA concluded that deep-seated dissolution has occurred in the Delaware Basin; however, there is little evidence to show this mechanism is active below the WIPP. Even if it is occurring, it would not be of sufficient magnitude to compromise the containment capabilities of the disposal system during the 10,000 year regulatory time frame. DOE contended that lateral dissolution of halite within the Rustler or along the Rustler-Salado contact is not a process of concern during the regulatory time frame (Appendix DEF.3.4, p. DEF-33). EPA concluded that, while limited dissolution at the Rustler-Salado contact and within the Rustler halites could be ongoing, the process is very slow and would take hundreds of thousands of years to reach the repository. Further discussion on lateral dissolution is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.B.3.t (EPA 1998a).

EPA acknowledges that karst terrain is present in the vicinity of the WIPP site boundary (Chapter 2.1.3.4 and Chapter 2.1.6.2, pp. 2-87 to 2-93, and Appendix DEF 3.3). Nash Draw, which is approximately one mile west of the WIPP site, is attributed to shallow dissolution and contains karst features. EPA recognized the potential importance of karst development on fluid migration. Karst terrain typically exhibits cavernous flow, blind streams, and potential for channel development that would enhance fluid and contaminant migration.

EPA reviewed information and comments submitted by DOE (Chapter 2.1.6.2, pp. 2-87 to 2-93, and Appendix DEF3.3, pp. DEF-29 to DEF-30) and stakeholders (Docket A-93-02, Item II-D-102 and comment 236 A-61.3) regarding the occurrence and development of karst at the WIPP. EPA agrees that karst features occur in the WIPP area but concluded that karst features are not pervasive over the disposal system itself. Available data suggest that dissolution-related features occur in the immediate WIPP area (e.g., WIPP-33), but these features are not pervasive and are not associated with any identified preferential groundwater flow paths or anomalies.[1] Data from Sandia National Laboratories tracer tests do not indicate the presence of anomalous cavernous-type flow; for example, the interpretation of the H2 hydropad, located just west of the waste panel area, is one of single (matrix) porosity, not channeling (Jones et al., 1992).

EPA reviewed information pertinent to the potential development of karst in the WIPP area. The relative pervasiveness of the Mescalero Caliche and its occurrence in relatively dry climates (which supports climatic variation conclusions drawn by DOE), combined with DOE's near-future precipitation assumptions, led EPA to conclude that karst feature development will neither be pervasive nor impact the containment capabilities of the WIPP during the 10,000 year regulatory period.

Numerous questions about karst were posed by commenters during the public comment period on the proposed rule. EPA's responses to the comments may be found in the Response to Comments Document for the final certification decision (EPA 1998j). EPA believes it important to clarify what is meant by "karst" and the importance of timing relative to karst development. Karst is generally defined as a type of topography formed over limestone, dolomite, or gypsum by dissolution that is characterized by sinkholes, caves, and underground caverns. This topographic modification can happen at any point in geologic time, and "karst" features can then be covered by sediments that lithify to rocks. Also, these *paleo*karst features can continue to change as the rock column undergoes consolidation, lithification, or other geologic modifications through time. If a modern karst system is currently developing at WIPP, all rocks from the ground surface downward, would be affected by the dissolution process, whether it be from dissolution of soluble intervals or from collapse of non-soluble rocks due to removal of soluble material.

Numerous geologic investigations have been conducted in the vicinity and across the WIPP site to assess the occurrence of dissolution (karst) including, for example, Anderson (CCA Reference #12), Bachman (CCA References #22 and #27), and Borns et al. (CCA Reference #79). Detailed geologic analysis of subsurface strata to assess the presence of dissolution-related features has been conducted (e.g., Holt and Powers 1988 and Appendix FAC). The presence of active karst features at the WIPP site has also been investigated by EPA. EPA conducted a field investigation during the summer of 1990 to assess the occurrence of karst features as part of its

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[1] The Environmental Evaluation Group (EEG) stated that "while the WIPP site is located in a karst region, the groudwater is not abundant and is of poor quality and while pathways of higher permeability may be present, solution channels as potential pathways for fast movement of water do not appear to be [present]." EEG further statef that "the karst phenomena do not appear to warrant a rejection of the WIPP site" (Docket A-93-02, Item II-D-102).

WIPP Test Phase No Migration Variance determination. As a result of that field investigation and detailed examination of site geologic and hydrologic information, including core data and hydrologic (i.e. water level) information, EPA concluded that "karst is not now an issue at the WIPP, and is unlikely to become one for many thousands of years, if ever" (55 FR47714).

Commenters stated that brecciated rock units are evidence of karst. DOE stated that many brecciated units present in the Rustler Formation can be attributed to syndepositional (i.e., accompanying deposition of the sediment) and immediate post-depositional processes, such as slumping of sedimentary strata, as well dissolution that occurred immediately post-depositionally (Appendix FAC, summarized in pages iii-v). DOE does not believe that salt/soluble bed distribution need be attributed to more recent dissolution. EPA examined geologic and/or hydrologic data for H1, H3, H6, and WIPP wells 13, 18, 19, 21, 22, 23, and 25, available through geologic borehole logs and associated records, available core data, and geologic interpretive reports (e.g. Appendix FAC) and concluded that the syndepositional and post-depositional processes (including dissolution soon after deposition) could account for some of the observed sedimentary fabrics. For example, the exhaust shaft includes a brecciated zone that could have been formed due to post-depositional slumping and/or dissolution, but this unit is immediately covered by undisrupted strata (CCA Reference #309, Figure 11). The contact between this brecciated zone and underlying/overlying units is gradational (indicating that no large time or sedimentologic "breaks" between depositional and brecciation events is apparent), which supports the conclusion that the brecciated feature formed at the same time (or immediately after) the rock units immediately surrounding the brecciated zone were deposited. EPA does not agree with DOE's assertion that the distribution of salt in the Rustler is only a depositional feature because Rustler transmissivity (which is related to fracture occurrence in the Rustler; see Chapter 2, Figure 2-30) generally corresponds to the occurrence of salt in the Rustler (Appendix HYDRO, Figure 13). This implies that some post-Rustler dissolution has occurred that affects the fracturing in Rustler rocks. However, the sum evidence observed by EPA and described above indicate that a complex history of deposition and dissolution has occurred in the WIPP area, but many Rustler features (e.g., the breccia zone in the exhaust shaft, or at WIPP-18, where anhydrite/clay-rich strata may be halite dissolution residues) were formed during unit deposition or immediately post-depositionally over 200 million years ago. Other Rustler features (e.g., salt distribution in the Rustler) could have occurred sometime after the Rustler was deposited, but there is no evidence to indicate that ongoing dissolution of soluble material in the Rustler or at the Rustler-Salado contact will modify the existing transmissivity to the extent that the PA would be affected.

Commenters also stated that poor core recovery is indicative of karst terrain. "Washout" zones are developed when the rock strength of strata differs from that of surrounding units, thereby allowing the weaker material to be more readily removed via drilling fluid circulation. The presence of a caliper response is in no way definitive "proof" of caverns, but instead indicates lithologic/rock strength differs between adjacent strata. Core recovery is related to rock strength, and does not necessarily have an association with local hydrologic conditions. In the case of WIPP, cores that were attempted through fractured material, including the Culebra, exhibited poor recoveries. EPA agrees that fractured Rustler is present at H-3. However, EPA does not believe that the presence of fractured material in the Rustler indicates that karst processes are active. In fact, the development of fractures can occur for various reasons unrelated to dissolution (i.e. geologic unloading). DOE has long recognized the presence of fractures within the Culebra and has included this dual porosity system in the PA (Chapter 6.4.6.2).

Commenters questioned whether the presence of fractures in the Rustler is indicative of karst development. DOE has long recognized a complex history of site loading and unloading that resulted in "variable removal of strata" and the potential development of fractures (Chapter 2.1.5.2). DOE also believes that the presence of salt in the Culebra is attributable to syn or near post-depositional processes, but EPA concluded that a more complex set of processes contributed to both halite and fracture distribution. EPA agrees that fracture formation is likely a result of Rustler halite dissolution and subsequent overlying unit fracturing loading/unloading, as well as the syn and post-depositional processes posited by DOE. Some of the clay horizons within the Rustler could well be the result of dissolutional processes that occurred possibly over many thousands of years after the beds were deposited. EPA also agrees that limited lateral dissolution at the Rustler/Salado contact and within Rustler halites could be ongoing, but the process is very slow and will not affect the containment capabilities of the WIPP disposal system.

Commenters expressed concern about the origin of fractures at hydro pad H-3 and in the WIPP exhaust shaft. EPA agrees that fractured Rustler is present at H-3. However, the presence of fractures does not necessarily indicate that karst features (i.e. features formed from surface-down dissolution) are present. EPA also notes that there is no hydrologic evidence to indicate that Rustler units are interconnected at this location, which would be the case if pervasive, ground surface-downward karst feature development were apparent. For example, at H-3, the hydraulic head in the Culebra is 150 feet below that of the Magenta and 480 feet higher than the hydraulic head in the underlying Rustler-Salado contact residuum, which supports the concept of hydraulic isolation between these water bearing members of the Rustler (Appendix HYDRO, p. 60). Not only is there a significant difference in hydraulic heads between the Culebra and Magenta Dolomites, but the potentiometric surfaces of these units infer substantially different ground water flow direction, which is also indicative of hydrologic isolation (CCA Figure 2-31, page 2-125, 2-32, and 2-129). Water level data indicate that the potentiometric surface in the Culebra decreases from north to south, whereas the potentiometric surface in the Magenta generally decreases from east to west, as shown in Figures 7-3 and 7-4 (pp. 7-8 and 7-9) of Appendix SER of the CCA. If surface-down karst features had developed through the entire Rustler Formation, hydrologic isolation of the units could not persist. In addition, DOE and EPA have long recognized that a higher hydraulic conductivity zone in the Culebra is present near H-3 due to fractures in this area (CCA Figure 2-20), and the modeling of this zone is included in the PA. DOE performed numerous aquifer tests in the Rustler Formation (e.g., hydropads H-3, H-11, and H-19), as well as tracer tests at six locations (H-2, H-3, H-4, H-6, H-11 and H-19 hydropads) (Chapter 2.2.1.4.1.2 and Appendix MASS 15). DOE's data indicate that the Rustler is a fractured dolomite (which is accounted for in the PA), but no data acquired to date suggest that there is pervasive, cavernous, karst porosity. Based on this information, EPA concluded that, while fractured rock is present at H-3, it does not indicate the presence of pervasive karst systems that interconnect Rustler rock units.

Dissolution in the major drainage features of the site region is related to the infiltration of ground water into the sub-channel regions of perennial through-flowing streams, which formerly occupied the second and third order tributaries of the Pecos River. The only remaining active member of this ancient regional drainage system is the Pecos River, which is marginal in this arid region and owes its persistence to its headwater in the well-watered high mountains of the southern-most Rocky Mountains. Some dissolution continues in these relict stream valleys because of their tendency to capture local runoff and the chaotic fracture permeability caused by the extensive paleo-dissolution from an earlier humid phase of climate (more than 500,000 years before present). None of the incised and collapsed members of the relict drainage system of the region occurs on the WIPP site, and present climatic conditions cannot create any new features of this kind since the arid climate at the site results in high evapotranspiration rates. Given the high evapotranspiration rates, rainfall that does percolate into the Mescalero Caliche is drawn up again by capillary forces and plant root processes, but does not regularly infiltrate into the deep subsurface. The lack of rainwater infiltration into the deep subsurface limits the potential for dissolution processes to occur at the WIPP site.

Tectonic Setting and Structural Features

Based upon geologic data presented within the CCA and from a general geologic text (Slemmons et al. 1991) concerning the structural history of the Delaware Basin, EPA concluded that DOE's argument that the tectonic setting should remain stable within the 10,000 year period (Chapter 2.1.5, pp. 2-68 to 2-80) is acceptable. The timing, location, orientation and nature of structural features in the WIPP area were discussed in detail and were adequately supported by references.

EPA also concluded that DOE's choice of a more moderate loading and unloading history at the WIPP site was technically adequate, based on a review of the various depositional and erosional interpretations (scenarios) presented in Chapter 2.1.5.2 (pp. 2-74 to 2-79). The CCA, however, did not specify which loading and unloading event(s) most likely influenced the hydrology of the Permian units, as well as other units, at the WIPP site and does not link this information with observed fracturing in the Rustler. Nonetheless, EPA concluded that it is unlikely that loading/unloading will be of sufficient magnitude to significantly impact the Rustler unit's characteristics over the regulatory time period. EPA's detailed review of the loading and unloading history is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.B.4 (EPA 1998a).

Geomorphology, Topography, and Soils

EPA concluded that DOE's description of the physiography, geomorphology, and topography presented in Chapters 2.1.4 and 2.1.3.10 (pp. 2-64 to 2-68 and 2-63) was technically adequate, as was DOE's description of soil series at the WIPP. This subject is discussed in greater detail in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, sections IV.B.5 and IV.B.6 (EPA 1998a).

Natural Resources Identification

DOE concluded that the most important extractable resources in the WIPP are hydrocarbons, potassium salts, and water. EPA agrees that this conclusion is reasonable. Chapter 2.3 (pp. 2-145 to 2-161), Appendices DEL.4 (pp. DEL 9 to DEL 25), DEL.5 (pp. DEL-

26 to DEL-46), and an evaluation by the New Mexico Bureau of Mines and Mineral Resources (NMBMMR 1995) discuss estimates of these resources in detail, including current and future mining and oil and gas extraction technologies. With respect to potash, the CCA states that only the 4th and 10th horizons are economic reserves, although remaining ore zones are considered resources that would be mined with advances in thin-seam extraction technologies. This map was similar to that identified in an EPA technical memorandum (Docket A-92-56, Item IV-B-07). EPA concluded that DOE's presentation was sufficient, given the requirement to assess resources relative to those currently being mined. See **CARD 32—Scope of Performance Assessments**, especially Section 32.B, for further discussion.

EPA concluded that neither DOE's nor Department of Interior's estimate shows the area above the WIPP waste panels as containing mineable reserves. EPA also found that Chapter 2.5 focused on extractable resources of most apparent immediate import but did not address other resource removal activities, such as the extraction of salt-bearing waters for use in oil-extraction or potash solution mining. DOE provided supplemental information in a letter dated May 14, 1997, indicating that potash solution mining and brine extraction do not need to be considered for the PA, based on low consequence to the containment capability of the repository (Docket A-93-02, Item II-I-31). EPA reviewed the supplemental data and concurs with DOE's conclusion. See **CARD 32—Scope of Performance Assessments**, Section 32.B, for further discussion.

DOE addressed groundwater resources and calculated the rate of shallow drilling (including that for water resources) in the WIPP area, as required under Section 194.33. See **CARD 33—Consideration of Drilling Events in Performance Assessments**, Section 33.A.5, for further discussion. DOE concluded that shallow drilling will have little consequence on the repository containment capabilities and so screened shallow drilling from the PA; see Appendix SCR.3.2.1 (pp. SCR-101 to SCR-104) and SCR.3.3.1 (pp. SCR-108 to SCR-135). EPA concurred with this assessment and noted that most of the water in the vicinity of WIPP is highly saline, with the exception of the Capitan aquifer (which is the aquifer most commonly tapped for domestic use) that occurs near the edge of the Delaware Basin, about 20 miles from the WIPP (see **CARD 32—Scope of Performance Assessments**, Section 32.F).

General Hydrology

The CCA provided information regarding groundwater hydrology of the geologic units in the vicinity of the WIPP site in Chapter 2.2.1 (pp. 2-97 to 2-145), Appendices GCR.6 (pp. 6-1 to 6-62) and HYDRO (pp. 22 to 75), and numerous references cited throughout Chapter 2.2.1, e.g., Appendix MASS.2 (pp. MASS-1 to MASS-11). In general, EPA concluded that information regarding the groundwater hydrology for the various geologic and hydrostratigraphic units at the WIPP site identified the important characteristics of the disposal system for the PA and was therefore technically sufficient. EPA noted that the primary hydrogeologic units of concern relative to containment capability of the WIPP are the Castile, Salado, Rustler, and the Dewey Lake.

Technical issues relative to Castile brine, Salado marker bed permeability, and Culebra hydraulic properties (e.g., transmissivity variation) were initially raised by EPA in a letter dated December 19, 1996 (Docket A-93-02, Item II-I-01). DOE provided additional information regarding these issues in letters dated January 24, 1997, February 7, 1997, April 15, 1997, June 13, 1997, June 27, 1997, and July 3, 1997 (Docket A-93-02, Items II-I-03, II-I-07, II-I-24, II-H-44, II-H-45, and II-H-46, respectively). EPA found that this supplemental information adequately addressed EPA's initial concerns. The December 19, 1996 letter (Enclosure 1) also requested that DOE provide general hydraulic characteristic information for all geologic units within the disposal system by revising a partially complete table included in the letter. For each of the geologic units in the WIPP disposal system, DOE provided the required information regarding hydraulic conductivity, storage coefficients, transmissivity, permeability, thickness, matrix and fracture characteristics, and hydraulic gradients in a Summary Table in a letter dated February 14, 1997 (Docket A-93-02, Item II-I-08). See EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.C.1 for further discussion (EPA 1998a).

During the public comment period on the proposed rule, commenters questioned the effect that the Mesacalero Caliche at WIPP would have on surface water infiltration and groundwater recharge. EPA did not find that the Mescalero Caliche is a 100% continuous, impenetrable surface. However, EPA believes that the near continuous presence of the more than half-million year old Mescalero Caliche over the WIPP site is an indicator of an arid climate at the site. Caliche is the precipitate of trace minerals contained in rainwater with some minor additional constituents leached from shallow soils. It develops in an environment in which evapotranspiration greatly exceeds the average rainfall and where the upper part of the soil column exhibits relatively low permeability. Caliche also only develops in environments in which there is little recharge. Infiltration carries these minerals downward to the saturated zone where they cannot accumulate. In regions having actively forming caliche, virtually all rainfall either runs off or is removed from the shallow soil by evapotranspiration. CCA Appendix CLI (p. 3) indicates that the present annual freshwater pan evaporation rate at the WIPP is approximately 108 inches (274 cm) per year, the average annual rainfall is approximately 12.6 inches (32 cm) per year, and that an average of 96% of precipitation is lost to evapotranspiration. Further, since caliche is an evaporative precipitate, it is very soluble. For caliche to persist over a long period of geologic history, as in the case of the Mescalero Caliche, the relationship between evapotranspiration, runoff, and precipitation must have remained in favor of evaporation. Rainfall percolates into the caliche and is drawn up again by capillary forces and plant root processes, but does not regularly infiltrate into the deep subsurface. The caliche may locally retard infiltration and abet runoff, but its principal significance is that it is an indicator of an arid climate and very low recharge conditions over a very long period at the WIPP site.

Commenters noted that DOE is uncertain of the source of the water flowing into Laguna Grande de la Sal, and that ground water flow to the spring may be via conduit-type flow due to the presence of karst features. In the CCA's description of ground water flow in units above the Salado provided in Section 2.2.1.4 (p. 2-114), DOE acknowledged that Nash Draw and the Pecos River are areas where discharge of ground water to ground surface occurs. DOE specifically identified Surprise Springs and the saline lakes in Nash Draw. Surprise Springs discharges into Laguna Grande de la Sal. In the discussion of the Culebra hydrology provided in Chapter 2.2.1.4.1.2 (p. 2-120), DOE stated that flow in the Culebra is dominantly lateral and southward except in discharge areas along the west or south boundaries of the ground water basin. In Appendix HYDRO (pp. 47 to 55) regarding the"brine aquifer," which occurs within the

Rustler-Salado Contact Zone residuum west of the WIPP area in Nash Draw, DOE documented that the sources of water in Laguna Grande de la Sal were precipitation, surface drainage, ground water inflow from upper units above the brine aquifer and possibly inflow from mining activities that take place further north in Nash Draw. DOE further stated that discharge of ground water into Laguna Grande de la Sal is by flow of seeps and springs, particularly along the northern end of the lake, and Surprise Spring is specifically identified by DOE as a potential ground water discharge point.

However, in Appendix HYDRO (p. 49), DOE noted that because sodium and chloride concentrations in samples from Surprise Spring and samples of Culebra and Rustler-Salado contact residuum water collected from test-hole WIPP-29 (located near Surprise Spring) are different, the Culebra and the Rustler-Salado contact residuum are not the source of water in Surprise Spring. Appendix HYDRO (pp. 53 and 61) also stated that the discharge point for the ground water within the Culebra and the Rustler-Salado contact residuum is located south of Laguna de la Sal, near Malaga Bend. DOE acknowledged that sources of water in Laguna Grande de la Sal include discharge of ground water from the units above the Salado, but DOE does not necessarily agree that the Culebra is the sole source of this discharge.

In addition, DOE's model domain includes Laguna Grande de la Sal (Chapter 2, Figure 2-29) and the model boundary extends well beyond the WIPP site boundary. EPA evaluated DOE's ground water basin model and concluded that it uses appropriate and realistic boundary conditions to simulate ground water flow within the Culebra in the WIPP area. See **CARD 23 – Models and Computer Codes** and EPA Technical Support Document for Section 23: Ground Water Flow and Contaminant Transport Modeling at WIPP (EPA 1998i) for further discussion of the ground water basin model. EPA also examined information regarding the hydrology of the units above the Salado Formation and DOE's conceptualization of the ground water flow model, including supplementary information submitted in letters dated May 2, 1997 (Docket A-93-02, Item V-B-6) and May 14, 1997 (Docket A-93-02, Item II-I-17). EPA concluded that the information is adequate.

In summary, DOE recognized that sources of water in Laguna Grande de la Sal included discharge of ground water from the units above the Salado. EPA believes that the presence of springs and seeps along the northern end of Laguna de la Sal is not by itself an indication of the presence of karst topography or channelized flow through an aquifer. Rather, the seeps and springs represent the locations where the ground water table/potentiometric surface intercepts the ground surface. Based on WIPP field observations and site-specific hydrologic information, EPA concluded that there is no indication that any cavernous or other karst-related flow is present at the WIPP. EPA concurs with DOE's conceptualization of ground water flow in the Culebra, which includes the presence of fractures within the Culebra and recharge and discharge areas for ground water that are more consistent with potential discharge to areas west of the WIPP.

Castile and Salado Hydrology

EPA found that DOE's discussion of the size, orientation, and repressurization potential of the Castile brine reservoirs was not well supported in the CCA (see Chapter 2.2.1.2.2, pp. 2-107 to 2-108, and Appendices DEF.2, pp. DEF-1 to DEF-18, and DEL.7.5, pp. DEL-81 to DEL-

87). The probability value for encountering a brine pocket also was poorly supported, since other DOE data imply this probability could be as high as about 60 percent (Chapter 2.2.1.2.2, pp. 2-107 to 2-108). Therefore, in a letter dated April 25, 1997 (Docket A-93-02, Item II-I-27), EPA required this parameter to be sampled between a range of 1 and 60 percent in the PAVT[2] (DOE 1997b and 1997c). In addition, EPA modified the values for parameters such as bulk compressibility of Castile rock so that the brine reservoir used in the PA would be sampled more representatively relative to larger, higher-end possible brine volumes. Further information on EPA's review of these parameters may be found in **CARD 23—Models and Computer Codes**, EPA Technical Support Document for Section 23: Models and Computer Codes (EPA 1998g), and EPA Technical Support Document for Section 23: Ground Water Flow and Contaminant Transport Modeling at WIPP (EPA 1998i). The PAVT used modified Castile brine reservoir characteristics and showed that the WIPP still meets the containment requirements (DOE 1997b, Figure 7-2). As a result, EPA found that the original brine reservoir characteristics were, in fact, acceptable.

In the PAVT, EPA assigned a range of values from 1 to 60% for the probability of hitting a brine pocket (ID No. 3493, parameter PBRINE). Using data from the TDEM study, EPA developed probability distributions for four cases; see CCA Reference #229 and EPA Technical Support Document for 194.23: Review of TDEM Analysis of WIPP Brine Pockets (EPA 1998h). These cases involved either the random or block models for correlation between adjacent TDEM measurements and assumed either the base of the Castile or the base of the Anhydrite III layer in the Castile as the cutoff point above which brine pockets may exist. Since the TDEM measurements showed no discernable spatial correlation in any direction at distances larger than the unit of the measurement grid (250 m), two bounding analyses were performed to reflect the uncertainty in the depth to the first conducting surface: the random model and the block model. In the random model, all points in the disposal region have the same likelihood of being underlain by brine regardless of the proximity to any specific TDEM measurement locations with higher or lower than average elevation measurements. In the block model, the best estimate of the elevation of the first conducting layer is the elevation of the nearest TDEM data point. EPA found that it made little difference whether the random model or the block model was used to characterize correlation between the TDEM measurements.

The simulated probability distributions for encountering brine were highly sensitive to the assumption of whether or not brine pockets exist below the bottom of the Anhydrite III layer (EPA 1998h). Using the base of the Castile Anhydrite Layer III as the lowermost stratigraphic layer below which no brine pockets occur, the simulations show that the area of the WIPP repository underlain by a brine pocket varies from 1 to 6% of the excavated WIPP repository area. However, using the base of the Castile as the lowermost stratigraphic layer below which no brine pockets occur, the area of the excavated repository underlain by brine pockets increases to

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[2] The Performance Assessment Verification Test (PAVT) was conducted by DOE at the direction of EPA in order to verify that the cumulative effect of both changes in parameter values identified by EPA and changes to computer codes would not require an additional PA. The PAVT calculations were conducted like the CCA calculations, with the exception of changes to parameters and modified computer codes. DOE demonstrated that the computer code changes were insignificant and that, even with EPA's directed changes in parameters, the disposal system still complied with the containment requirements.

about 35 to 58%. According to the 1992 WIPP PA (CCA Reference #563, Vol. 3, p. 5-4), Castile Formation brines are generally found in fracture zones in the anticlinal structures in the uppermost anhydrite layer (generally Anhydrite III). If it is assumed that brine is confined to the Anhydrite III layer, which is the more probable assumption based on available geologic information, the maximum fraction of the repository area underlain by brine is 6%. If it is assumed that brine pockets can occur all the way to the base of the Castile (which is a conservative assumption, since most brine pockets occur in the Anhydrite III layer), then a 58% probability would be the maximum to assume (EPA 1998h). EPA selected 1% as the lower limit and 60% as the upper limit for the fraction of the excavated repository area underlain by brine in the PAVT. The upper value of 60% rounds up the highest value from the TDEM data, providing a more conservative range. The lower limit was selected by the Agency to represent a reasonable minimum that bounded the 1992 PA and the geostatistical study. A uniform distribution was mandated because the range of this parameter spans slightly more than an order of magnitude and the use of a uniform distribution will conservatively bias the sampling toward the high end. EPA believes that this range adequately reflects the uncertainty in the parameter PBRINE and is a more appropriate representation of the concept of reasonable expectation than the fixed value of 8% used by DOE in the CCA.

EPA found that DOE's compressibility parameters for the Castile brine reservoir and representation of brine pocket size/volume in the PA were not consistent with available information. EPA believes, however, that the parameters of the Castile brine reservoirs are highly uncertain, particularly the rock compressibility and related brine pocket volume. In situations where the actual value of a parameter is not known, it is appropriate to sample it statistically from a range of parameter values. EPA directed DOE to conduct new PA modeling that included modified parameter values in letters dated March 19, 1997 (Docket A-93-02, Item II-I-01, Enclosure 3), and April 25, 1997 (Docket A-93-02, Item II-I-27, Enclosure 2). EPA required that the parameters regarding rock compressibility and porosity (e.g. Castile COMP_RCK), as well as how the brine pocket volume is sampled, be modified in the PAVT (Docket A-93-02, Items II-G-26 and II-G-28). This approach effectively modified the sampled brine pocket volume to include, more representatively, the possibility of higher brine pocket volumes like that at WIPP-12. EPA found that modification of these parameters did not result in PAVT CCDFs that exceed EPA's containment standards. As a result of the PAVT, EPA found that the original brine reservoir characteristics were acceptable. For further discussion of this topic, see Sections IV.B.3.t and IV.C.1.f.ii of EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a) and Section 3.11, 3.12, 3.13, 4.4, 4.5, 5.2, and 5.3 of the Technical Support Document for Section 194.23: Parameter Justification Report (EPA 1998e).

Hydrology of the Salado relative to the distribution of fractures within marker beds and how it affects fluid flow to/out of the repository was the subject of numerous DOE studies, as well as an EPA study concerning fluid injection (see EPA Technical Support Document for Section 194.32: Fluid Injection Analysis (EPA 1998f). DOE's initial information on anhydrite characteristics and response to high pressure was unclear. EPA identified information needed to clarify the anhydrite characteristics in letters to DOE dated December 19, 1996 (Docket A-93-02, Item II-I-01), and March 19, 1997 (Docket A-93-02, Item II-I-17). In supplemental information provided in letters dated January 24, 1997 (Docket A-93-02, Item II-I-03) and April 15, 1997

(Docket A-93-02, Item II-I-24), DOE provided information on anhydrite characterization and modeling implementation. EPA concluded that while fracture distribution and subsequent fluid flow in the Salado marker beds cannot be detailed, the general application of fracturing and subsequent fluid flow appears to be an adequate representation of overall site conditions. EPA also concluded that DOE's modeling of fractures within Salado anhydrite marker beds is acceptable; see **CARD 23—Models and Computer Codes**, Section 1.3.2, for further discussion.

Rustler, Dewey Lake, and Santa Rosa Hydrology

EPA concluded that DOE's description of the hydrology of the Rustler (Chapter 2.2.1.4, pp. 2-114 to 2-132) was technically adequate because it addressed the major elements required for use in the PA. DOE stated that most anomalous water level increases in some Culebra wells (e.g., related to shaft installation activities and subsequent rebound of Culebra heads) can be explained but some remain unexplained. EPA reviewed these data and concluded that despite these unexplained water level rises, the current anomalous heads lead to water level variations that are already incorporated into PA modeling. See **CARD 23—Models and Computer Codes**, Section 7.3, for further discussion.

The CCA stated that transmissivity variations within the Culebra are due to both primary and secondary features. The CCA also stated that the significant spatial variability in transmissivity was accounted for in TFIELD model runs (Appendix TFIELD.2, pp. TFIELD-1 to TFIELD-23). EPA found that Chapter 2.2.1.4.1.2 (pp. 2-118 to 2-127) did not provide a detailed discussion of the origin of these variations relative to fracture infill/dissolution, integration of climatic change, and loading/unloading events, which are important to understanding not only current transmissivity differences but also potential future transmissivity variations that could affect PA calculations. However, EPA's review stated that determination of the specific origin of these fractures was not necessary because conditions are not expected to change during the regulatory period. DOE provided supplemental information in letters dating January 24, 1997, March 12, 1997, May 14, 1997, June 13, 1997, and July 3, 1997 (Docket A-93-02, Items II-I-03, II-H-24, II-I-31, II-H-44, and II-H-46, respectively) indicating that a significant mechanism that could alter fracture permeability—dissolution of fracture fill—will not likely have a significant impact on transmissivity. EPA accepted DOE's argument that infiltrating waters would most likely become saturated with calcium sulfate and consequently would not dissolve anhydrite or gypsum fracture fill. Further information on EPA's review of anhydrite and gypsum fracture fill dissolution is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.C (EPA 1998a).

Hydrochemical facies within the Culebra were not adequately described with respect to origin in the CCA. In a letter dated May 14, 1997 (Docket A-93-02, Item II-I-31, No. 1), DOE submitted additional information that described the Culebra hydrochemical facies with respect to potential groundwater infiltration rates, Culebra flow velocities, and geochemical facies. EPA reviewed this information and concluded that it was sufficient to explain Culebra geochemical facies within the WIPP area.

The CCA stated that there were no contributions to total releases from the ground-water pathway. This was due, in large part, to the fact that radionuclides are adsorbed onto the Culebra and do not move with the ground water flow. That is, the movement of the radionuclides were retarded with respect to the ground water flow. The estimate of retardation involved laboratory tests using crushed rocks and small columns of rock.[3]

EPA concluded that the laboratory tests in Appendix MASS 15-1 were conducted appropriately and that they provide approximate representations of actinide solid/liquid partitioning in the Culebra. EPA further concluded that the range of K_d values that DOE derived from this laboratory testing is reasonable given the experimental evidence. Moreover, EPA concluded that the uniform distribution is not an appropriate representation of the data provided in Appendix MASS. EPA believes that a lognormal distribution is a more appropriate representation of the data distribution, and required the use of a lognormal distribution in the PAVT (Docket A-93-02, Item II-I-17). In addition, confirmatory modeling by EPA stated that low values of K_ds (such as less than the 20 ml/g used in the CCA in the case of plutonium and americium) highly retard the movement of the radionuclides in the Culebra. EPA did not find field tests using sorbing tracers to be necessary because: 1) the batch tests and the column tests produce similar results that indicate retardation takes place in the Culebra, and 2) these results are consistent with other similar types of tests, and 3) calculations indicate that even very low K_ds significantly retard radionuclides so that if DOE's range of K_d estimates is too high, there is a large margin for error. See EPA Technical Support Document for Section 194.14: Assessment of K_ds Used in the CCA (EPA 1998b).

The Environmental Evaluation Group's (EEG) Report No. 35 (CCA Reference #118) states that available isotopic data at the WIPP site are similar to verifiably young ground water found elsewhere in the WIPP area. The report also states that available data cannot indicate ages for water in the various aquifers, but can point to isotopic similarities. The report concludes that the age of water in the Rustler Formation and the presence or absence of modern recharge cannot be determined on the basis of stable isotopic composition alone. EPA believes that the use of data outside of the Delaware Basin acquired in different hydrologic systems, recharge/discharge points, etc., cannot be extended without reservation to the WIPP site. Similarities of ground water quality and isotopic composition do not definitively indicate similar ground water "age." Ground water data obtained near WIPP are not universally "similar" to that elsewhere in southeastern New Mexico, and in fact numerous data points fall well outside of the meteoric water line, implying that the characteristics of this ground water, including its "age," are in fact dissimilar to that of those units in southeastern New Mexico. EPA also notes that later reports (e.g., Lambert and Harvey 1987) conclude that tritium samples from WIPP area wells indicate little meteoric input in the last 40 years. EPA concludes that the extension of regional data to site-specific WIPP conditions is not an absolute "measure" of ground water "age" at the WIPP, and that it has found no data that directly indicate that WIPP area ground water is less than 46 years in age. The 46-year time frame represents the approximate amount of time since the start of atmospheric thermonuclear weapons tests.

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[3] In Appendix MASS 15-1, DOE stated that if actinide speciation is unaffected by the organic ligands, then the K_ds are unlikely to be affected as well. Results from additional speciation calculations are generally consistent with this hypothesis, in that the percentages of organically complexed actinides are decreased under expected repository conditions relative to the experimental solutions presented in Appendix MASS 15-1. (See EPA Technical Support Document for Section 194.14: Assessment of K_ds Used in the Compliance Certification Application (EPA 1998b).

EEG Report No. 39 (CCA Reference #119) states that general geochemical data imply more recent or different recharge events than DOE was advocating at that the time the EEG report was written. DOE has since modified its description of the hydrologic system at WIPP to include downward infiltration events, although such events are not modeled to occur rapidly (i.e., tens of years). DOE developed a ground water basin model (Docket A-93-02, Item II-I-31) that examines ground water flow within the Rustler and identifies potential recharge locations. This model takes into account the geochemical characteristics of Culebra ground water and recognizes four different ground water geochemical zones that differ in geochemical characteristics, recharge rates, and recharge locations. This new interpretation allows for very slow vertical infiltration to the Culebra through overlying beds, although the primary "source" of ground water will be lateral flow from the north of the site. EPA reviewed DOE's conceptualization of ground water flow and recharge, and believes that it provides a realistic representation of site conditions because it conceptualizes slow, downward infiltration of meteoric water. EPA agrees that the absence of tritium in ground water only indicates that ground water has not been recharged in the last 50 years. EPA also recognizes that age dating techniques provide data that have been interpreted differently by others. However, EPA examined all available data pertaining to ground water flow in the Rustler and concluded that DOE's total conceptualization adequately described system behavior for the purposes of the PA (Docket A-93-02, Items V-B-3 and V-B-7).

DOE stated ,and EPA agreed, that ^{14}C dates from samples taken in wells not contaminated by organic additives in drilling fluids supported minimum ground water ages of around 13,000 years (WPO 26144). Vertical recharge to the Culebra from any source of younger water might be capable of reducing minimum age dates but can not cause anomalous older waters to occur. The consistently old ^{14}C ages, the very low probability of significant recharge from the site surface (EEG-32, Docket A-93-02, Item II-A-41) and the absence of point sources of local recharge in the hydrologic testing results strongly refute arguments that Culebra water is "young." DOE's site flow model includes flow within the Rustler Formation. The numerical site flow model accepted by the Conceptual Models Peer Review Panel (July 1996) is based on abundant in-situ hydrologic data and does not imply or permit the presence of strong local sources of recharge of young meteoric water through the parts of the Rustler that overlay the Culebra.

Capitan Aquifer and Rustler/Salado Contact

EPA found that the information pertaining to the Capitan aquifer in Chapter 2.2.1.5 (pp. 2-132 to 2-136) and Appendix HYDRO adequately described the relevant hydrological and geochemical properties of the aquifer. EPA's initial review of the CCA found the discussion of the Rustler/Salado contact to be confusing, particularly with respect to the possibility of the continued development and characteristics of a dissolution front along this contact, and the impact that continued dissolution within the brine aquifer residuum would have on the overlying units of the Rustler. DOE discussed the rate and extent of dissolution processes further in supplemental information provided in a letter dated June 13, 1997 (Docket A-93-02, II-H-44). Based upon this information, EPA concluded that, while dissolution may occur along the Rustler Salado contact, it would not affect the WIPP's containment capabilities during the regulatory time period. Further discussion of this topic is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.C.3.o (EPA 1998a).

14.C.1 REQUIREMENT

"Any compliance application shall include:

(a) a current description of the natural and engineered features that may affect the performance of the disposal system. The description of the disposal system shall include, at a minimum, the following information:

(3) The presence and characteristics of potential pathways for transport of waste from the disposal system to the accessible environment including, but not limited to: existing boreholes, solution features, breccia pipes, and other potentially permeable features, such as interbeds."

14.C.2 ABSTRACT

In reviewing compliance with Section 194.14(a)(3), EPA sought information supporting the conceptualization of the disposal system and the major site-related characteristics included in the PA modeling. DOE described the presence and characteristics of potential pathways for the transport of waste from the disposal system to the accessible environment in Chapter 2 and Appendix DEF. The potential pathways identified by DOE were: breccia pipes and deep dissolution along the Bell Canyon-Castile interface; lateral dissolution along the Rustler-Salado contact and within the Rustler; and shallow dissolution, including the development of karst and dissolution of fracture fill in Salado marker beds and the Rustler.

DOE identified and described numerous potential pathways and concluded that the potential for significant fluid migration to occur through most of these pathways is low. However, DOE also concluded that fluid migration could occur within the Rustler and Salado marker beds and included this possibility in PA calculations.

EPA agreed with DOE's conclusion that karst features and breccia pipes are not potential pathways. EPA also concluded that deep, lateral, and shallow dissolution pathways will not serve as significant potential radionuclide pathways and that the potential for significant fracture-fill dissolution during the regulatory time period is low.

EPA noted that the potential for fluid migration through Salado marker beds and the Culebra member of the Rustler were acknowledged by DOE and included in the PA calculations. While the Dewey Lake is a potential underground source of drinking water (Chapter 8.2.2), DOE's modeling identified that radionuclides will not reach the Dewey Lake, thus removing the formation as a unit needing consideration as a pathway (DOE 1997b and 1997c). EPA concluded that Salado marker beds and the Culebra were adequately identified and characterized to the level necessary for PA calculations.

14.C.3 COMPLIANCE REVIEW CRITERIA

EPA expected the CCA to provide information that supported the conceptualization of the disposal system and the major site-related characteristics included in the PA modeling. EPA also examined the CCA to determine whether DOE included all of the required information and fulfilled clarifying questions or information requests. In addition, EPA evaluated DOE's specific studies, data, analysis, etc., for accuracy, sound technical basis, and appropriateness of associated justifications. EPA also assessed DOE's technical conclusions based on the supportability, reasonableness, accuracy, applicability, and relative importance to the PA of information presented in the CCA and supplements to the CCA.

14.C.4 DOE METHODOLOGY AND CONCLUSIONS

DOE described the presence and characteristics of potential pathways for transport of waste from the disposal system to the accessible environment in Chapter 2 and Appendix DEF. The potential pathways identified by DOE included: breccia pipes and Bell Canyon-Castile interface dissolution as a result of deep dissolution; lateral dissolution along the Rustler-Salado contact and within the Rustler; and shallow dissolution, including the development of karst and dissolution of fracture fill in Salado marker beds and the Rustler. The Culebra and other members of the Rustler are other potential pathways identified by DOE. In addition, DOE addressed potential transport through shaft seals (Chapter 8.1.1, pp. 8-2 to 8-3).

DOE provided information regarding the presence and characteristics of evaporite dissolution features, which are potential pathways, in Chapter 2.1.6.2 (pp. 2-86 to 2-87) and Appendix DEF.3 (pp. DEF-18 to DEF-33). DOE stated that because evaporates are known to be much more soluble than most other rocks, it was important to understand the dissolution processes and rates that occur at the WIPP and the surrounding area. DOE also stated that there are three dissolution processes possible or identified at the WIPP: deep dissolution (including breccia pipes), lateral dissolution, and shallow dissolution (including karst).

DOE stated that breccia pipes are deep dissolution features that are vertical or near vertical cylindrical features filled with collapse debris and typically extending from near the ground surface down to the Castile; see Appendix DEF.3.1(pp. DEF-18 to DEF-25). DOE stated that breccia pipes were known to be present in the northern part of Nash Draw, approximately 12 miles (19 kilometers) northwest of the WIPP repository. During a resistivity field program that covered about 37 square miles (93.25 square kilometers), DOE identified several potential anomalies but no breccia was encountered in the boreholes drilled to investigate the anomalies.

DOE also conducted studies of known breccia pipes to develop an understanding of the mechanisms leading to their formation. DOE stated that deep dissolution is a possible mechanism for the formation of breccia pipes and introduced the concept of brine density flow, which allows upward flow of water through an overlying fractured/permeable unit, dissolution of evaporates, and subsequent downward flow of the ensuing, more dense brine. The overlying rocks may then collapse into the resulting solution cavity. DOE stated that there are no known breccia pipes that are not underlain by the Capitan Limestone or Bell Canyon (where the Bell Canyon is not overlain by the Castile). Breccia pipes can form above these two formations because the hydraulic conductivity of the formations is sufficiently high to allow significant groundwater flow and transport of dissolved material, thereby allowing the formation of solution cavities. The Capitan Limestone does not occur below WIPP, and the Bell Canyon below is of low transmissivity and is overlain by the Castile.

More generalized dissolution of deeper units such as the Castile, due to the flow of unsaturated groundwater within the Bell Canyon Formation and subsequent dissolution salt along the fresher-water interface, represents another potential deep dissolution feature. DOE drilled a borehole within a feature where structural depressions in the Salado suggested slow removal of salt at depth. DOE's interpretation of the resulting data stated that the feature was the result of deformation rather than dissolution. DOE concluded that there is no unequivocal information that supports the possibility of deep dissolution occurring anywhere other than the edges of the Capitan Reef (Appendix DEF.3.1, p. DEF-25).

DOE stated that lateral dissolution results from groundwater movement within units that lead to lateral variations in porosity and permeability. The CCA stated that lateral dissolution of the upper Salado and within the Rustler in the Region of the WIPP has been recognized and studied since at least 1970 (Appendix DEF.3.2, p. DEF-25). DOE stated that lateral dissolution of the upper Salado (and the subsequent collapse of the overlying Rustler) formed Nash Draw, located approximately 1 to 5 miles (1.6 to 8 kilometers) west of the WIPP site. DOE stated that the maximum eastward lateral extent of dissolution at the top of the Salado is east of Livingston Ridge. DOE concluded that the edge of halite dissolution at the top of the Salado will not reach the repository until well after the period of regulatory concern (Appendix DEF.3.2, p. DEF-29).

DOE stated that dissolution within the Rustler also led to further development of Nash Draw and that in the vicinity of Nash Draw, halite is absent from all the units of the Rustler (Chapter 2.1.3.5, pp. 2-37 to 2-38). Further east, toward the WIPP site, halite progressively appears in younger units, which has led many investigators to conclude that halite has been dissolved from the Rustler by groundwater in a process similar to the lateral dissolution at the top of the Salado. DOE presented an alternative interpretation, based on shaft mapping and core logging, stating that the Rustler was formed in variable depositional environments and that the current distribution of halite in the Rustler is similar to that when the unit was deposited. DOE concluded, however, that neither interpretation of the Rustler would appear to threaten the integrity of the disposal system during the regulatory time period (Appendix DEF.3.2, p. DEF-29).

DOE also discussed shallow dissolution, including karst development and dissolution of Culebra fracture fills. Karst topography is developed through dissolution of soluble rock units. DOE stated that karst features such as dolines, collapse sinks, karst valleys, blind valleys, and other solution/subsidence-related features are present in Nash Draw, which is a dissolution feature approximately one mile west of the LWA boundary. DOE stated that east of Nash Draw, "only a few small clusters of shallow dolines on the Mescalero caliche have been identified" (Appendix DEF.3.3, p. DEF-30). DOE stated that dissolution of fracture fill within the Culebra would significantly impact the transmissivity of this unit. DOE stated that "there is no evidence for progressive change in this pattern [of fracture fill] across the area although some dissolution and precipitation of gypsum as fracture infills will inevitably occur in the next 10,000 years." DOE submitted supplemental information in letters dated June 13, 1997, May 14, 1997, March 12, 1997, February 26, 1997, February 7, 1997, and January 24, 1997 (Docket A-93-02, Items II-H-44, II-I-31, II-H-22, II-I-10, II-I-07 and II-I-03, respectively) concerning fracture fill dissolution. These letters were sent in response to both questions raised in EPA's December 19, 1996 letter (Docket A-93-02, Item II-I-01) requesting additional information and public comments on EPA's

Advance Notice of Proposed Rulemaking for the certification decision. DOE concluded that the possibility of fracture fill dissolution is very low because infiltrating waters that would cause the dissolution would be saturated with respect to calcium sulfate. Because infiltrating water is saturated with fracture fill mineral, the likelihood that these waters could dissolve and remove existing fracture fill is remote.

DOE concluded that, while these dissolution mechanisms may have occurred to varying degrees in the Delaware Basin, “there is a high level of confidence that dissolution sufficient to affect the performance of the disposal system is physically unreasonable and will not occur over the regulatory time frame” (Appendix DEF, p. DEF-33). Appendix SCR.1.1.5.1 provides a summary of the screening of these dissolution mechanisms with respect to the PA.

DOE also considered actinide movement through marker beds in the undisturbed case and presented an overview of results in Chapter 8.1.1 (pp. 8-2 to 8-3). DOE assigned porosity and gas-pressure sensitive permeability to the Salado marker beds and modeled actinide movement through the beds. Of the 300 CCA PA model realizations, nine showed releases of actinides at the LWA boundary through lateral movement in Salado marker beds. However, DOE noted that the release concentrations were well below the limits of regulatory concern. In addition, DOE screened fluid injection from the PA based on low consequence. DOE concluded that it addressed and described actinide transport in Salado marker beds, and that little, if any, transport would occur along these beds. See Appendix SCR.2 and SCR.3 (pp. SCR-33 to SCR-144) for more information regarding fluid injection.

DOE also recognized the importance of the Rustler (i.e., Culebra member) as an important potential pathway. The presence and characteristics of this pathway were discussed in Chapter 2.1.3.5.2 (pp. 2-45 to 2-49) and 2.2.1.4.1 (pp. 2-117 to 2-127), and Appendix HYDRO (pp. 55 to 62).

In summary, DOE identified and described numerous potential pathways within the CCA. DOE concluded that the potential for significant fluid migration to occur through most of these pathways is low. However, DOE also concluded that fluid migration could occur within the Rustler and Salado marker beds and so included this possibility in PA calculations.

14.C.5 EPA COMPLIANCE REVIEW

The CCA discusses numerous potential radionuclide transport pathways, including: deep dissolution resulting in either movement through breccia pipes, or through conduits developed through deep seated dissolution; shallow dissolution horizontal pathways; dissolution-enhanced transmissivity through supra-Salado units; karst features; and brine movement through anhydrite marker beds in the Salado (see, for example, Chapters 2.2.1, 6.0.2, and 6.3.2). EPA concurred with DOE’s conclusion that karst features and breccia pipes are not potential pathways at the WIPP. However, EPA’s preliminary review found that DOE could not reasonably conclude that the mechanism for breccia pipe formation presented in the CCA is the only breccia pipe formation mechanism that could be present within the WIPP area without additional discussion of potential non-Capitan related breccia pipes.

EPA's review identified questions about karst, shallow dissolution, and breccia pipe development. These questions were transmitted to DOE in an EPA letter dated December 19, 1996 (Docket A-93-02, Item II-I-01) and are discussed in greater detail in Section IV.B.3 of EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application (EPA 1998a). DOE submitted supplemental information in a letter dated January 24, 1997 (Enclosure 2, p. 7, Docket A-93-02, Item II-I-03) regarding non-Capitan related breccia pipes (i.e., those associated with the Bell Canyon where it is relatively shallow). EPA reviewed this information and concurred that the geologic evidence indicates that the breccia pipes are not likely to occur under the repository. EPA also concluded that the marker beds of the Salado contain brine that has limited ability to dissolve additional halite, and these marker beds, while more permeable than the halite, exhibit very low permeabilities. EPA also concluded that deep, lateral, and shallow dissolution pathways will not serve as significant potential radionuclide pathways and that the potential for significant fracture fill dissolution during the regulatory time period is low.

EPA found that the potential for fluid migration through Salado marker beds and the Culebra member of the Rustler was acknowledged by DOE (Chapter 6.4.5.2, pp. 6-116 to 6-118, Chapter 6.4.6.2, pp. 6-123 to 6-136, Chapter 6.5, pp. 6-214 to 6-234) and included in PA calculations. The characteristics (e.g., hydraulic conductivity) of the different geologic units (see Chapter 2 and Docket A-93-02, Item II-I-08) indicate that most of the geologic units cannot transmit water and that DOE appropriately identified the geologic units to the level necessary for PA calculations.

14.D.1 REQUIREMENT

"Any compliance application shall include:

(a) a current description of the natural and engineered features that may affect the performance of the disposal system. The description of the disposal system shall include, at a minimum, the following information:

(4) The projected geophysical, hydrogeologic and geochemical conditions of the disposal system due to the presence of waste including, but not limited to, the effects of production of heat or gases from the waste."

14.D.2 ABSTRACT

EPA expected the CCA to identify the projected geophysical, hydrogeological, and geochemical conditions due to the presence of wastes. DOE discussed how it considered the effects of waste presence (including heat and gas generation on geophysical, hydrological, and geochemical conditions of the repository) in Chapters 4 and 6 and Appendices SCR, SOTERM, WCA, and BRAGFLO. DOE considered and screened out the impact that radioactive decay-related heat generation would have on the disposal system because the generated heat is of low consequence. In addition, heat generated via nuclear criticality was also screened out based on the low probability that a criticality event would occur.

DOE acknowledged that the presence of waste within the WIPP affects the geochemistry of the disposal system and so included the presence of waste in the PA. The oxidation conditions within the repository are altered by the corrosion of steel waste containers, and DOE linked the changing oxidation conditions to the oxidation state of actinides considered in solubility analysis. Furthermore, degradation of cellulosic, plastic, and rubber waste could result in carbon dioxide generation, which decreases brine pH and hence increases actinide solubility. DOE stated that MgO emplaced with transuranic waste would mitigate the solubility-enhancing effects of carbon dioxide generated from waste degradation.

In addition to considering the generation of carbon dioxide's impact on the disposal system, DOE stated that gas generation would be a critical factor to consider in the PA. Gas will be generated through two primary processes: corrosion of steel to generate hydrogen gas, and degradation of organic material to create carbon dioxide and methane. DOE modeled the cumulative impact of gas generation on repository pressure throughout the 10,000 year regulatory period and included this estimate in modeled room closure rates, porosity surface calculations, pressure-sensitive permeability calculations for Salado marker beds, and spallings particle releases estimates.

EPA reviewed the information provided in the CCA and concluded that DOE's exclusion of heat-generating mechanisms from the PA was appropriate, since the impact that heat generation would have on the disposal system hydrogeology and geochemistry would be minimal. DOE identified the waste components and characteristics that impact repository performance. EPA also concluded that DOE integrated gas generation into PA models.

14.D.3 COMPLIANCE REVIEW CRITERIA

For this requirement, EPA expected the CCA to identify the projected geophysical, hydrogeological and geochemical conditions due to the presence of wastes. See **CARD 23—Model and Computer Codes**, Section 1, and **CARD 32—Scope of Performance Assessments**, Section 32.C, for additional criteria.

14.D.4 DOE METHODOLOGY AND CONCLUSIONS

DOE discussed how it considered the effects of waste presence (including heat and gas generation on geophysical, hydrological, and geochemical conditions of the repository) in Chapters 4 and 6 and Appendices SCR, SOTERM, WCA, and BRAGFLO. Related discussions of DOE's analysis are included in **CARD 23—Models and Computer Codes, , section 1, CARD 24—Waste Characterization, section 24.B.5, and CARD 32—Scope of Performance Assessments, section 32.C.**. Within Appendix SCR.2.2.2 (p. SCR-40), DOE considered and screened out the impact that radioactive decay-related heat generation would have on the disposal system as a result of the low consequence of the generated heat. Heat generated via nuclear criticality was also screened out in Appendix SCR.2.2.3 (p. SCR-43) based on the low probability that a criticality event would occur. Based on the low probability of occurrence, DOE also screened out the following: thermal effects on materials and waste properties; thermally induced stress changes; thermal expansion of WIPP geologic material; and exothermic reactions, including concrete and backfill hydration and aluminum corrosion. For additional discussion regarding

DOE's consideration of heat on geophysical, hydrological, and geochemical conditions within the WIPP repository, see Appendices SCR.2.3.6 (p. SCR-50), SCR.2.4.3 (p. SCR-56), SCR.2.5.7 (p. SCR-76), and SCR.2.7.3 (p. SCR-84).

DOE acknowledged that the presence of waste within the WIPP affects the geochemistry of the WIPP disposal system (Chapter 6.4.3, pp.6-92 to 6-111, and Appendix SCR.2, pp. SCR-33 to SCR-90). For this reason, DOE included the presence of waste in the PA. The oxidation conditions within the repository are altered by the corrosion of steel waste containers, and DOE linked the changing oxidation conditions to the oxidation state of actinides considered in solubility analysis. The presence of complexants in waste, including colloids and organic ligands, affects solubility of actinides as well. Furthermore, degradation of cellulosic, plastic, and rubber waste could result in carbon dioxide generation that decreases brine pH and hence increases actinide solubility. DOE stated that MgO emplaced among WIPP transuranic waste would mitigate the solubility-enhancing effects of carbon dioxide from waste degradation. DOE's analysis of geochemical conditions due to the presence of waste was discussed in Appendices WCA and SOTERM, as well as in supplementary information submitted by DOE (DOE 1997a).

In addition to considering the impact of carbon dioxide generation on the disposal system, DOE stated that gas generation would be a critical factor to consider in the PA. For example, gas generation would increase pressure within the WIPP repository, and this increased pressure could impact creep closure, permeability of fractured units, brine inflow, spallings releases, etc. DOE considered that gas will be generated through two primary processes: corrosion of steel to generate hydrogen gas and degradation of organic material to create carbon dioxide and methane. DOE calculated steel corrosion rates under humid and inundated conditions, and assumed the inundated conditions' rates for PAs. DOE determined that inundated gas generation rates are higher than humid corrosion rates. DOE modeled the cumulative impact of gas generation on repository pressure throughout the 10,000 year regulatory period and included this estimate in modeled room closure, porosity surface calculations, pressure-sensitive permeability calculations for Salado marker beds, and spallings particle releases. DOE discusses the modeling of gas generation and repository response in Chapter 6 and Appendices MASS, WCA, SOTERM, PORSURF, and BRAGFLO. For a detailed discussion of DOE's gas generation studies, refer to **CARD 24—Waste Characterization**, Section 194.24(b). For discussion of DOE's modeling approach for inclusion of gas generation in the PA, refer to **CARD 23—Models and Computer Codes**, Section 2.3.2.

14.D.5 EPA COMPLIANCE REVIEW

EPA reviewed DOE's consideration of waste-related impacts on WIPP geophysical, geochemical, and hydrogeological conditions (Chapter 6.4.3, pp.6-92 to 6-111, and Appendix SCR.2, pp. SCR-33 to SCR-90). EPA concluded that DOE's exclusion of heat-generating mechanisms from the PA was appropriate since the impact that heat generation would have on the disposal system hydrogeology and geochemistry is minimal. EPA determined that DOE identified the waste components and characteristics that impact repository performance and integrated them into the PA appropriately. For EPA's review of waste-related conditions in the WIPP repository as they pertain to gas generation and actinide solubility, see **CARD 24—Waste Characterization, Section 24.B**. EPA concluded that DOE appropriately integrated gas generation into PA models. For further discussion of integrating gas generation into PA models, refer to **CARD 23—Models and Computer Codes**.

14.E.1 REQUIREMENT

"Any compliance application shall include:

(b) a description of the design of the disposal system including:

(1) Information on materials of construction including, but not limited to: geologic media, structural materials, engineered barriers, general arrangement, and approximate dimensions.

14.E.2 ABSTRACT

The CCA contained a general description of the entire WIPP facility and a detailed description of the disposal system (including the engineered barriers in the repository and shaft system as well as the geologic units). Chapter 3.1.3 briefly described the various support structures located at the ground surface and offered a detailed description of the four vertical shafts connecting the ground surface with the underground waste disposal area. Chapters 2.1.3.4 and 2.2.1.3 described the Salado, which DOE stated is the primary natural containment for potential radionuclide releases from the WIPP. Chapter 3.3 described the design and materials of construction of the three types of engineered barriers that DOE incorporated into the disposal system design (shaft seals, panel closures, and borehole plugs) and the additional engineered barrier of backfill around the waste that DOE incorporated for the purpose of assurance.

DOE provided information on the design and materials of construction of the disposal system. DOE identified the compacted salt column as the most critical element in the long-term performance of the shaft seal system and likewise identified the moisture content of the compacted salt as the single greatest challenge to its ability to perform as required. DOE therefore focused its shaft seal design efforts on keeping moisture out of the compacted salt column**.** DOE provided four options for panel seal closures but did not specify which panel closure option would be used at WIPP.

To assess compliance with Section 194.14 (b)(1), EPA determined whether the CCA contained the required information and that the construction material and general design descriptions were consistent and technically adequate throughout the CCA.

14.E.3 COMPLIANCE REVIEW CRITERIA

EPA expected that the compliance application would provide a complete description of the disposal system design. The information provided in the CCA must support the conceptualization of the disposal system and the major site-related characteristics included in the PA modeling. EPA examined the accuracy, technical basis, and appropriateness of studies, data, and analyses described in the CCA, including whether DOE adequately answered clarifying questions and fulfilled information requests. EPA also assessed the reasonableness, accuracy, and importance to the PA of the technical conclusions drawn by DOE.

14.E.4 DOE METHODOLOGY AND CONCLUSIONS

DOE described the design and materials of construction of the disposal system in the CCA in Chapter 3, Chapters 2.1.3 (pp. 2-12 to 2-63) and 2.2.1 (pp. 2-97 to 2-136), Chapter 7.4 (pp. 7-89 to 7-96), and Appendices BACK, DEL, PCS, and SEAL.

DOE provided a general description of the WIPP facility and the waste disposal system, including the general arrangement and approximate dimensions, in Chapters 3.0, 3.1, and 3.2 (pp. 3-1 to 3-14). DOE stated that the ground surface area of the WIPP facility has been divided into the following four areas:

- The WIPP Land Withdrawal Area, a 16-section (41.4-square-kilometer) Federal land area under DOE’s jurisdiction and bounded by the WIPP site boundary. The Land Withdrawal Area is the controlled area for purposes of demonstrating compliance to 40 CFR Part 191.

- The off-limits area—approximately 1,454 acres (5.9 square kilometers)—which is posted and managed as off-limits by DOE.

- The exclusive use area—approximately 277 acres (112 hectares)—which is restricted exclusively for the use of DOE and its contractors and subcontractors and is posted against trespass by the general public.

- The property protection area—approximately 34 acres (13.7 hectares)—which is enclosed by a chain-link security fence that protects all major surface structures.

The surface facilities at the WIPP accommodate personnel, equipment, and support services required for the safe receipt and transfer of TRU waste from the surface to the underground. These facilities are all located within the property protection area. The principal surface structure is the Waste Handling Building. Other structures include hoist houses, the exhaust filter building, the support building, office trailers, and the guard and security building. DOE stated that the surface structures will be in service during the operation of the WIPP and are not considered part of the disposal system. See Chapter 3.1 (pp. 3-7 to 3-11) for more information.

The WIPP facility design includes four vertical shafts to connect the waste disposal area with the ground surface: the waste shaft, the salt handling shaft, the air intake shaft, and the exhaust shaft. All but the exhaust shaft have permanently installed hoists capable of moving personnel, equipment, and materials between the surface and the repository. Each shaft includes a shaft collar, a shaft lining, and a shaft key section. The shaft collars are constructed of reinforced concrete and serve to retain unconsolidated materials and prevent surface water runoff from entering the shaft. The shaft linings extend from the base of the collar to the top of the Salado and serve to retain loose rock and inhibit water seepage from water-bearing formations. The shaft lining is concrete except in the salt handling shaft, where it is made of steel. The shaft key section is a circular reinforced concrete section below the lining of each shaft that extends approximately 100 feet into the Salado. The shaft key section supports the weight of the lining and contains water seal rings to prevent water from seeping into the shaft. All of the shafts will eventually be sealed using the seal design described below; see Chapters 3.1.3 (pp. 3-11 to 3-12) and 3.2 (p. 3-13).

The waste disposal area of the WIPP repository is located 2,150 feet (655 meters) below ground surface (bgs) (Chapter 3.2, pp. 3-12 to 3-14). The waste disposal area consists of eight panels, each of which contains seven rooms, and the access drifts and crosscuts adjacent to the disposal panels. The access drifts and crosscuts have been labeled Panels 9 and 10. See Figure 3-2 (p. 3-5) of the CCA for a plan view of the WIPP underground facility. Each of the disposal rooms in Panels 1 through 8 will have nominal dimensions of 300 feet (91 meters) long, 33 feet (10 meters) wide, and 13 feet (4 meters) high. The pillars between each room will be 100 feet wide. The access drifts and crosscuts designated as Panels 9 and 10 will typically have smaller cross-sections than the disposal rooms and will range from 14 to 25 feet (4.25 to 7.6 meters) wide and 12 to 13 feet high (3.6 to 4 meters) high. The overall size of the waste disposal area is approximately 1,970 feet (600 meters) by 2,625 feet (800 meters) and is designed to hold a combined total of 6.2 million cubic feet (175,600 cubic meters) of contact-handled and remote-handled transuranic (TRU) waste. Only Panel 1 and portions of drifts have been constructed to date. See Chapters 3 (pp. 3-1 and 3-2), 3.2 (pp. 3-12 to 3-14), and Figure 3-2 for more information.

DOE provided information regarding the geologic media in Chapter 2.1.3.4 (pp. 2-29 to 2-37) and 2.2.1.3 (pp. 2-108 to 2-113). DOE stated that the Salado, a regionally extensive evaporite, provides the primary natural containment for potential radionuclide releases from the WIPP. According to DOE, the existence of a large salt deposit such as the Salado demonstrates isolation from circulating groundwater for long periods of time. In addition, creep closure of the salt in the Salado will encapsulate the emplaced waste after closure.

The Salado is part of the Permian age Ochoan Series, is approximately 2,000 feet (609 meters) thick in the WIPP area, and is divided into an unnamed upper member, the middle McNutt Potash Zone, and an unnamed lower member. There are 10 potash zones within the McNutt Member, of which the 4th and 10th zones are of potential significance in the vicinity of the WIPP. Also, there are numerous sulfate beds (primarily anhydrite) within the Salado. The anhydrite layers are designated as marker beds (MB) and have been numbered MB100 (near the top of the formation) to MB 144 (near the base). DOE provided information regarding the characteristics of the geologic media above and below the Salado in Chapter 2.1.3 and 2.2.1 (pp. 2-97 to 2-136).

DOE provided information regarding the design and materials of construction for engineered barriers incorporated into the disposal system design in Chapter 3.3 (pp. 3-14 to 3-45) and Appendices SEAL, PCS, BACK, and DEL. DOE incorporated three types of engineered barriers into the design of the disposal system: shaft seals, panel closures, and borehole plugs.

DOE described the seals to be used in each of the four shafts in Chapter 3.3.1 (pp. 3-15 to 3-27). Appendix SEAL included the design plans and the material and construction specifications for the seals. The purpose of the shaft seal system is to limit fluid flow within the shafts after the WIPP is decommissioned and to ensure that the shafts will not become pathways for radionuclide release. The shaft seal system has 13 elements that fill the shaft with engineered materials possessing high density and low permeability, including concrete, clay, compacted salt, cementitious grout, and earthen fill. The compacted salt column component of the system within the Salado is intended to serve as the primary long-term barrier by limiting fluid transport along the shaft during the 10,000-year regulatory period. The other components of the shaft seal within the Salado are intended to prevent migration of radionuclides in the short term and protect the compacted salt column until it becomes effective as a long-term barrier. Components of the seal system within the Rustler are intended to limit the commingling of groundwater between the water bearing members. The seal system overlying the Rustler will consist of compacted earthen fill (Chapter 3.3.1 and Appendix SEAL).

Chapter 3.3.2 (pp. 3-27 to 3-33) and Appendix PCS provide a description of the types of panel closure system that DOE could emplace in the panel access drifts of the waste disposal panels after waste in emplaced in each panel. The CCA (Figure 3-5, p. 3-29, and Appendix PCS) provides four panel closure system design options, identified as Options A through D. Each of the design options consists of a two component composite system. The first component consists of a rigid concrete component emplaced either with removal of the DRZ (Options C and D), or without removal of the DRZ (Options A and B). The second component is either an explosion-isolation wall (Options B and D) or a construction-isolation wall (Options A and C). The concrete barrier component is intended as the primary barrier for the flow of air, volatile organic compounds and brine through the panel access drift after closure of the waste disposal panel. DOE proposed (Appendix PCS, p. 2-29) that the concrete barrier be composed of standard concrete with a plain cement mix. The CCA stated (Appendix PCS, pp. ES-8 and 3-4) that the construction isolation wall is intended to comply with Mine Safety and Health Administration regulations to safely isolate abandoned areas from active workings using barricades of substantial construction and will be constructed of concrete block keyed into the salt. The CCA (Appendix PCS, p. ES-8) indicates that the explosion-isolation wall will be used for those panel closures where there is a potential for the occurrence of an explosive mixture of methane within the closed panel. The explosion-isolation wall is also constructed of concrete block, but will be thicker than the construction isolation wall to mitigate the effects of a postulated methane explosion.

Chapter 3.3.2 (p. 3-27) indicates that the original intention of the panel closure system was to support Resource Conservation and Recovery Act (RCRA) closure of the waste disposal panels and to prevent the release of potentially unacceptable levels of volatile organic compounds from the filled waste disposal panels during waste management operations in the remainder of the repository (up to 35 years). The CCA stated (p. 3-33) that although the design of the panel closure system was based on its need to protect human health and the environment during the operations period, the use of these systems will also influence fluid connections between panels during the post-closure phase. The CCA also indicates (p. 3-23) that although the panel closures are neither intended nor designed for long-term repository compliance, they provide a solid barrier within the panel access drifts to prevent the preexisting DRZ from increasing in permeability after closure system installation.

DOE described the borehole plug materials that will be installed in existing unplugged borings within the controlled area in Chapter 3.3.4 (pp. 3-39 through 3-45). Appendix DEL.6.2.4 (pp. DEL-72 to DEL-73) lists the applicable State oil and gas well plugging requirements. The purpose of the borehole plugs is to mitigate the potential for migration of contaminants toward the accessible environment. DOE also stated that the plugs are 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. DOE stated that shallow unplugged boreholes within the controlled area will be plugged in accordance with current State or Federal regulations. Existing deep unplugged boreholes within the controlled area will be plugged in according to the State of New Mexico, Oil Conservation Division, Order R-111-P. DOE concluded that boreholes within the controlled area, which were previously plugged in accordance with appropriate State and Federal regulations in effect at the time of plugging, will mitigate the potential for migration of fluids to the accessible environment.

DOE also plans to employ the additional engineered barrier of MgO backfill around the waste for the purpose of meeting the assurance requirements at Section 194.44. The purpose of the MgO backfill is to buffer the chemical composition of brine that may enter the waste disposal area over the 10,000-year regulatory period. For a detailed discussion of MgO backfill as an engineered barrier, see **CARD 44—Engineered Barriers**, Section 44.A. For information concerning how MgO was incorporated into PA calculations, refer to the discussion of the Chemical Conditions model in **CARD 23—Models and Computer Codes**.

14.E.5 EPA COMPLIANCE REVIEW

EPA verified whether the information required at Section 194.14(b)(1) was provided and the descriptions of construction material and general design were accurate, appropriate, and consistent throughout the CCA. Most of the information referenced by DOE as demonstrating compliance with Section 194.14(b)(1) was principally used to demonstrate compliance with other sections of the Compliance Criteria. By comparing the references for Section 194.14(b)(1) with parts of the CCA dealing with other Compliance Criteria sections (e.g., Section 194.23 and Section 194.44), EPA found that the CCA did not provide a separate description of the materials for construction of the disposal system. EPA reviewed all of the disposal system information to verify that there were no inconsistent, extraneous, or contradictory descriptions of materials or dimensions.

Based on a review of the information in Chapter 3, Chapters 2.1.3 (pp. 2-12 to 2-63) and 2.2.1 (pp. 2-97 through 2-136), Chapter 7.4 (pp. 7-89 through 7-96), and Appendices BACK, DEL, PCS, and SEAL, EPA concluded that the documentation provided by DOE to describe the design and materials of construction of the disposal system and to demonstrate that they can be implemented and will function in the intended manner was consistent and technically sufficient.

The purpose of borehole plugs is to mitigate the potential for migration of contaminants toward the accessible environment. DOE stated that it will abide by the applicable State oil and gas well plugging requirements listed in Appendix DEL 6.2.4 (State of New Mexico, Oil Conservation Division, Order R-111-P). While there are four deep research wells drilled in the disposal system, DOE stated that "the ERDA-9 exploratory hole was the only hole within the underground development area which was permitted to penetrate the Salado to the underground facility horizon" (Appendix DVR.12.2.3). ERDA-9 did not penetrate what will be a waste panel area, and DOE stated that abandoned boreholes less than a meter away from the waste can be screened out due to low consequence (Appendix SCR.3.3.1.4.2). EPA agrees with DOE's assessment that these boreholes are not significant to performance of the disposal system and can be screened out of PA.

EPA concurred with DOE's predictions regarding the consolidation and subsequent decrease in permeability of the compacted salt components of the proposed shaft seals. The compacted salt component will serve as the "primary" long-term shaft seal component, since it will be the largest single component (approximately 560 feet in vertical length) and has an inherent compatibility with the host rock material. The salt will be compacted during seal construction to 90 percent of the density of undisturbed halite. Moreover, approximately 100 to 200 years after construction, the pressure from overlying materials and inward creep of the surrounding Salado should further consolidate the salt plug and reduce its permeability to within an order of magnitude of undisturbed halite. The shaft seal design in Appendix SEAL of the CCA received extensive technical review by DOE and also was subjected to an independent design review. EPA concluded that the shaft seal design is adequate because the system can be built and is expected to function as intended.

EPA was concerned about the potential for seepage of brine into the shafts from the surrounding Salado in the zone to be occupied by the compacted salt plug. DOE has been unable to quantify the brine seepage, although seepage locations have been observed and documented (Appendix SEAL, Table 2-1). This is essentially an operational problem because seepage zones would be plugged before emplacement of shaft seal materials.

EPA investigated the seepage of brine in the salt column interval by reviewing the original shaft stratigraphic mapping reports, viewing bore logs, reviewing the interim shaft geologic inspection report, interviewing the lead geologist (Dr. Dennis Powers) who prepared the shaft mapping and inspection reports, and performing an independent inspection of the air intake shaft. On January 28, 1997, EPA inspected the shaft from Marker Bed 101 to the repository level by stopping the lift cage repeatedly at intervening marker beds, observing the shaft face with the assistance of video lighting equipment, and correlating these observations with previous records of brine seepage. Dr. Powers was available for questioning and clarification during the inspection. EPA's inspection stated that there is no apparent brine seepage between Marker Beds 117 and 135. See EPA's Air Intake Shaft Inspection Trip Report in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Attachment 1 (EPA 1998a) and additional DOE references ("Geologic Mapping of the Air Intake Shaft at the WIPP" (Holt and Powers 1990) and "Summary of Brine Investigation at the WIPP" (DOE 1995c)) for additional information regarding brine seepage in the air intake shaft.

EPA's review of the panel closure system stated that the original purpose of the panel closure system was to reduce VOC emissions from the repository during the operational period and control possible explosions. The primary long-term effect of the seal will be to block the flow of brine between panels. Gas flow between panels would be unaffected by the design choice. DOE stated that the panel closure system is designed so that components can be added or removed, or their shapes adjusted, based on the particular ground conditions (stability of the roof, walls, and floor of the excavation) at the time of installation.

DOE provided four options for panel seal closures in the CCA but did not specify which panel closure option would be used at WIPP. This lack of a specificity was pointed out in public comments (e.g., Docket A-93-02, Item II-H-10). EPA reviewed the four panel closure system options proposed by DOE and considered the intended purpose of the panel closure system in preventing the existing DRZ in the panel access drifts from increasing in permeability after panel closure. EPA considers the panel closure system design identified as "Option D" in Figure 3-5 of the CCA (p. 3-29) to be the most robust panel closure design. Option D involves removal of the DRZ prior to construction of the concrete barrier portion of the panel closure system, thereby ensuring consistency in the initial characteristics of the interface between the Salado host rock and the concrete barrier component of the panel closure system and the resulting permeability of the DRZ surrounding the panel closure system. The consistency between the initial characteristics of the interface between the Salado host rock and the concrete barrier component of the panel closure system serves to support DOE's assumption that DRZ permeability remained fixed as modeled in the PA.

EPA determined that implementation of Option D is adequate to achieve the long-term performance modeled in PA, since DOE provides information in Appendix PCS that shows that the use of a concrete barrier component is capable of providing resistance to inward deformation of the surrounding salt and prohibiting growth of the DRZ from its initial state. However, DOE would have to replace the fresh water concrete proposed in Option D with Salado mass concrete. EPA requires the use of Salado mass concrete for construction of the concrete barrier component of the panel closure due to the potential for degradation and decomposition of fresh water concrete. The degradation of the freshwater concrete barrier component could occur because of infiltration of brine into the block of concrete or along the interface between the salt and the concrete. These processes could potentially reduce the strength of the concrete and potentially increase the permeability of the concrete.

Although EPA's sensitivity analysis indicates that the panel seal permeability is not a sensitive parameter (see EPA Technical Support Document for Section 194.23: Sensitivity Analysis, Section PD-17 (EPA 1998c)), especially with the disturbed rock zone at the same or higher permeability, the Agency believes it is important to ensure that the proposed design on which compliance was based is actually implemented at the site. Therefore, EPA is requiring that DOE implement panel closure seal design Option D, with Salado mass concrete replacing fresh water concrete. The waste storage panels within WIPP must be sealed with a strong concrete barrier engineered to contain hazardous gases. The panel seals will also impede the transport of radioactive materials.

EPA received numerous comments pertaining to panel and shaft seals during the public comment period following the proposed rule. EPA has clarified its analysis of these technical elements in the Response to Comments Document, Section 14 (EPA 1998j).

14.F.1 REQUIREMENT

"Any compliance application shall include:

(b) a description of the design of the disposal system including:

(2) Computer codes and standards that have been applied to the design and construction of the disposal system."

14.F.2 ABSTRACT

The CCA must contain documentation of the computer codes and standards applied to the design and construction of the disposal system. The actual computer codes need not be submitted as part of the CCA. DOE described the design standards and identified the computer codes applied to the design and construction of the disposal system within the CCA in Chapters 3.1, 3.3.3, and Appendices DVR, PCS, and SEAL. EPA reviewed DOE's identification of the codes and standards used and its description of how they were applied to the design.

14.F.3 COMPLIANCE REVIEW CRITERIA

To meet the requirements of Section 194.14(b)(2), EPA expected the compliance application to contain a complete description of the computer codes and standards applied to the design and construction of the disposal system.

14.F.4 DOE METHODOLOGY AND CONCLUSIONS

DOE stated in Chapter 3.1.1 (p. 3-7) of the CCA that Federal facility acquisition policies were applied to the design and construction of the WIPP facility and that WIPP structures were designed to meet DOE design and QA requirements as documented in the Final Safety and Analysis Report (DOE 1995a). The Final Safety and Analysis Report provided identification of the design criteria and QA requirements used for the design and construction of the WIPP facility. Chapter 3.1.1 (p. 3-7) also stated that structures, systems, and components were designed to meet the requirements applicable to Design Class II structures, systems, and components for nonreactor nuclear facilities. Chapter 3.2 (pp. 3-12 to 3-14) stated that the Site and Preliminary Design Validation (SPDV) program was implemented in 1981 to validate the WIPP site geology and provide preliminary validation of the underground excavation. The data obtained during the SPDV program were analyzed to determine the suitability of the design criteria and the design bases and to provide confirmation of the underground opening reference design. DOE states in the CCA (p. 3-13) that "Information in Appendix DVR (Section DVR.6.4.2) meets the criterion specified in Section 194.14(b)(2)" for demonstrating that the designs can implemented and that they will function in the manner for which they were designed.

Chapter 3.1.2 (p. 3-8) describes how the design standards for the WIPP are documented and maintained through a Configuration Control System. Under this system, any changes to the current design must be fully reviewed and approved to avoid compromising the Safety Analysis Report for the facility. DOE stated that the primary standards used in design and construction of the WIPP are the ASME NQA-1 nuclear facility quality assurance standards (Chapter 3.1.2, p. 3-8).

DOE identified computer codes used in design of the disposal system in Chapter 3.3.3 and Appendices DVR, PCS, and SEAL. Chapter 3.3.3 (p. 3-39) stated that DOE estimated the chemical effects of MgO backfill using a commercially available code named EQ3/EQ6. The 1986 WIPP Design Validation Report in Appendices DVR.2.6.3 (p. 2-15), 5.4 (pp. 5-13 through 5-16), and 7.3.3 (pp. 7-47 to 7-67) described the Model Simulation activities used to assess structural behavior around the disposal rooms and shafts. DOE provided descriptions of a model for air flow through a panel closure in Appendix A of Appendix PCS. Appendix C of Appendix PCS discusses another model (FLAC) for analyzing stress of the panel closure, while a third model developed for determining the heat transfer effects resulting from (potential) methane explosions within a panel after closure is contained in Appendix F of Appendix PCS. Appendix SEAL describes three models (SPECTROM-32, SPECTROM-41, and SALT_SUBSID used in evaluating the structural performance of the shaft seals and surrounding rock mass. Two additional models (SWIFT II and TOUGH28W) were used in a total of four different configurations to evaluate the fluid-flow performance of the shaft seal design; see Appendix SEAL, Section 8.2 (p. 63) and Appendix C.

14.F.5 EPA COMPLIANCE REVIEW

EPA verified whether the information required at Section 194.14(b)(2), including the descriptions of design standards and computer codes that have been applied to the design and construction of the disposal system, were provided. Based on the review of the information in Chapter 3, Appendix DVR, and the Final Safety and Analysis Report (DOE 1995a), EPA determined that the identification of the design standards used in the design and construction of the disposal system provided by DOE was appropriate since the regulation did not specify that a detailed description of the individual design standards was required. Based on the review of information provided in Chapter 3.3.3, and Appendices DVR, PCS, and SEAL, EPA determined that DOE's identification of the computer codes and standards that have been applied to the design and construction of the disposal system is adequate since the regulation does not specify that a detailed description of the individual computer codes was required.

14.G.1 REQUIREMENT

"Any compliance application shall include:

(c) Results of assessments conducted pursuant to the disposal regulations."

14.G.2 ABSTRACT

DOE was required to present the results of assessments of the WIPP's performance, given human intrusion into the disposal system (PA) and undisturbed conditions (compliance assessment), that were conducted in accordance with the disposal regulations at 40 CFR Part 191, Section 13 and Subpart C. Despite the large quantity in the CCA of information pertaining to results of assessments, EPA identified numerous issues concerning the technical validity and completeness of information in the CCA. EPA's requests for clarification led to the provision by DOE of supplementary information related to the results of assessments. The technical adequacy of this information, as well as EPA's requests for additional information, are discussed fully in the following CARDs: **CARD 23—Models and Computer Codes, CARD 24—Waste Characterization, CARD 32—Scope of Performance Assessments, CARD 34—Results of Performance Assessments, CARD 42—Monitoring, CARD 44—Engineered Barriers, CARD 54—Scope of Compliance Assessments, and CARD 55—Results of Compliance Assessments**.

14.G.3 COMPLIANCE REVIEW CRITERIA

To demonstrate compliance with this provision, EPA expected the compliance application to include the results of the PA and compliance assessments (CA) conducted pursuant to the disposal regulations. EPA examined the CCA to determine if performance and compliance assessments were sufficiently documented.

14.G.4 DOE METHODOLOGY AND CONCLUSIONS

Chapter 6 summarizes the results of the PA and Chapter 8 summarizes the results of the CA. Major Appendices that support conclusions drawn in these chapters include, but are not limited to, Appendix MASS and modeling and computer code-related Appendices such as CCDFGF, SOTERM, GTMP, and WCA.

DOE presented the results of performance and compliance assessment activities in accordance with the disposal regulations (Chapter 6.5, pp. 6-214 to 6-234, and Chapter 8, pp. 8-1 to 8-19). DOE concluded that the results of the PA indicate that the cumulative releases via all mechanisms over the 10,000 year regulatory period are well below EPA release standards. DOE concluded that the results of the CA indicate that the maximum potential dose will be one-thirtieth of the individual protection standard and that radionuclide concentrations in a hypothetical underground source of drinking water would be less than half of the EPA groundwater protection standard.

14.G.5 EPA COMPLIANCE REVIEW

EPA reviewed Chapter 6, Chapter 8, and numerous supporting appendices and references to determine DOE's compliance with Section 194.14(c). EPA raised questions in letters to DOE dated December 19, 1996, March 19, 1997, April 17, 1997, and April 25, 1997 (Docket A-93-02, Items II-I-10, II-I-17, II-I-25, and II-I-27, respectively) regarding the technical validity of the information, which DOE addressed by providing supplementary information in letters dated July

3, 1997, June 27, 1997, June 13, 1997, May14, 1997, April 15, 1997, March 12, 1997, February 26, 1997, February 14, 1997, February 7, 1997, and January 24, 1997 (Docket A-93-02, Items II-H-46, II-H-45, II-H-44, II-I-31, II-I-24, II-H-22, II-I-10, and II-I-08, II-I-07, and II-I-03, respectively). EPA's requests for additional information and the technical adequacy of DOE's supplements are fully discussed in the following CARDs: **CARD 23—Models and Computer Codes, CARD 24—Waste Characterization, CARD 32—Scope of Performance Assessments, CARD 34 —Results of Performance Assessment, CARD 42—Monitoring, CARD 44—Engineered Barriers, CARD 54—Scope of Compliance Assessments, and CARD 55—Results of Compliance Assessments.**

EPA concluded that, with the provision of supplementary information, DOE had provided sufficient information regarding the results of the PA and CA. The CCA documentation included the evaluations necessary to support PA calculations pursuant to the disposal regulations. The CCDFs in Chapter 6.5 portrays the results as required in Section 194.34. In addition, the PAVT (DOE 1997b and 1997c) verified the original CCA PA results.

EPA concluded that, with the provision of supplementary information, DOE provided sufficient information regarding the results of its CA, which included evaluations necessary to support the bounding calculations used by DOE to address the disposal regulations. Radioactive releases in the undisturbed scenario are essentially zero; any releases reported were more likely due to numerical dispersion in the modeling than to measurable radionuclide activities.

14.H.1 REQUIREMENT

"Any compliance application shall include:

(d) A description of input parameters associated with assessments conducted pursuant to this part and the basis for selecting those input parameters."

14.H.2 ABSTRACT

Section 194.14(d) requires DOE to describe the input parameters to the PA and discuss the basis for their selection. DOE provided descriptions of input parameters to the PA in Chapter 6.1 (pp. 6-13 to 6-35) and Appendix PAR. EPA reviewed DOE's justification of parameter selection in the CCA and found that the traceability and supportability of the parameters needed improvement (e.g., better database compilation, improvements in data road maps, and more extensive documentation of legacy parameters). EPA also found that the CCA lacked supporting data for the parameters. EPA requested supplementary information from DOE on the description of input parameters and concluded that it sufficiently addressed EPA's concerns. EPA's review of DOE's input parameters is discussed in **CARD 23—Models and Computer Codes**, Section 12, and EPA Technical Support Documents for Section 194.23: Parameter Report (EPA 1998d) and Parameter Justification Report (EPA 1998e).

EPA conducted a detailed technical evaluation of parameters used in the PA and concluded that several parameters required modification (see Table 1 below). EPA required that revised parameters be used in Performance Assessment Verification Test (PAVT) in lieu of the parameter values used by DOE in the PA.

14.H.3 COMPLIANCE REVIEW CRITERIA

To demonstrate compliance with this provision, EPA expected the compliance application to include a description of the input parameters and a basis for selecting the parameters associated with PAs. EPA sought descriptions of input parameters linked to the appropriate models and data as required in Sections 194.23, 194.34, and 194.55. See **CARD 23—Models and Computer Codes**, Section 12, for an evaluation of the technical adequacy of the input parameters.

14.H.4 DOE METHODOLOGY AND CONCLUSIONS

DOE presented descriptions of input parameters to the PA within Appendix PAR and associated references (see Chapter 6.5, pp. 6-214 to 6-235). The 57 Latin Hypercube Sampled (LHS) parameters were discussed individually, while the remaining 1,400+ parameters were presented in tabular format. Appendix PAR included, for each LHS parameter, a parameter description, material/parameter names, related computational codes, mean, median, min, max and standard deviation, units, distribution type, experimental data (as applicable), discussion, Sandia National Laboratories Records Center WPO record number(s), and additional references. The LHS parameters include parameters such as inundated steel corrosion rate, Castile brine reservoir initial pressure, and waste particle diameter for the computer code CUTTINGS_S. See **CARD 23—Models and Computer Codes** and EPA Technical Support Documents for Section 23: Models and Computer Codes (EPA 1998h), Parameter Report (EPA 1998d), and Parameter Justification Report (EPA 1998e), for a complete discussion of parameters.

14.H.5 EPA COMPLIANCE REVIEW

EPA thoroughly reviewed DOE’s parameter selection and justification as presented in Appendix PAR and conducted a detailed independent analysis of the parameter selection process. EPA assessed over 300 parameters for traceability of data and availability of documentation supporting parameters selected; see **CARD 23—Models and Computer Codes** and EPA Technical Support Documents for Section 194.23: Parameter Report (EPA 1998d) and Parameter Justification Report (EPA 1998e). EPA found that parameter traceability and support in the CCA required some clarification, including better data base compilation, improvements in data “road maps,” documentation of legacy parameters, and documentation as to why parameters based on professional judgement do not require use of the expert elicitation process. EPA requested in letters dated December 19, 1996 (Docket A-93-02, Item II-I-01, Enclosure 1), and March 19, 1997 (Docket A-93-02, Item II-I-17, Enclosure 1), that DOE provide additional information, which DOE sent with letters dated February 26, 1997 (Docket A-93-02, Item II-I-10), April 15, 1997 (Docket A-93-02, Item II-I-24, p. 11), and May 14, 1997 (Docket A-93-02, Item II-I-31,p. 24). DOE also responded by adding to records in the Sandia National Laboratories (SNL) Record Center. EPA found that this supplementary information adequately addressed EPA’s concerns, as discussed in the Technical Support Documents for **CARD 23—Models and Computer Codes**, Section 12.4.

Additionally, EPA required DOE to convene an expert judgement panel to derive the particle size diameter value. See EPA Technical Support Document for Section 194.23: Parameter Justification Report (EPA 1998e) for a complete discussion of this parameter. See also **CARD 26—Expert Judgment** for a discussion of the procedure by which the expert judgment was conducted.

EPA also conducted a technical evaluation of the parameter values used in the PA. EPA's technical review of parameter values stated that several parameters required modification (see Table 1 below). EPA required that modifications of these parameter values be used in PAVT in lieu of the parameter values used by DOE. Table 1 lists the parameters and values that EPA directed DOE to use in the PAVT. See **CARD 23—Models and Computer Codes**, Section 12.4, for a complete discussion information of modified parameters and values.

Table 1. EPA Mandated Performance Assessment Verification Testing Parameters

ID No.	Material	Parameter	Distribution Type/Unit	Min	Max	Med	Mean	Standard Dev.
198	DRZ_1	PRMX_LOG	Loguniform/m^2	3.98×10^{-20}	3.16×10^{-13}	1.12×10^{-16}	1.99×10^{-14}	5.24×10^{-14}
3184	BH_SAND	PRMX_LOG	Loguniform/m^2	5.01×10^{-17}	1.00×10^{-11}	2.24×10^{-14}	8.19×10^{-13}	7.85×10^{-12}
8001	CONC_PLG	PRMX	Uniform/m^2	1.0×10^{-19}	1.0×10^{-17}	5.05×10^{-18}	--	--
663	WAS_AREA	PRMX_LOG	Constant/m^2	2.4×10^{-13}	2.4×10^{-13}	2.4×10^{-13}	2.4×10^{-13}	0.00
2131	REPOSIT	PRMX_LOG	Constant/m^2	2.4×10^{-13}	2.4×10^{-13}	2.4×10^{-13}	2.4×10^{-13}	0.00
2907	STEEL	CORRMCO2	Uniform/M/S	0.00	3.17×10^{-14}	1.585×10^{-14}	1.585×10^{-14}	9.151×10^{-15}
61	CASTILER	COMP_RCK	Triangular/log (Pa-^{1})	2.00×10^{-11}	1.00×10^{-10}	4.00×10^{-11}	5.333×10^{-11}	1.6997×10^{-11}
3493	GLOBAL	PBRINE	Uniform/None	0.01	0.60	0.305	0.305	0.1703
27	BOREHOLE	DOMEGA	Cumulative/rad/s	4.20	23.0	7.77	8.63	3.16
3482	AM+3	MKD_AM	Loguniform/m^3/kg	0.020	0.500	0.100	0.1491	0.1286
3480	PU+3	MKD_PU	Loguniform/m^3/kg	0.020	0.500	0.100	0.1491	0.1286
3481	PU+4	MKD_PU	Loguniform/m^3/kg	0.900	20.0	4.243	6.1591	5.141
3479	U+4	MKD_U	Loguniform/m^3/kg	0.900	20.0	4.243	6.1591	5.141
3475	U+6	MKD_U	Loguniform/m^3/kg	3.00×10^{-5}	3.00×10^{-2}	9.487×10^{-4}	4.339×10^{-3}	6.808×10^{-3}
3406	SOLMOD3	SOLSIM	Constant/moles/liter	1.2×10^{-7}	1.2×10^{-7}	1.2×10^{-7}	1.2×10^{-7}	0.00
3402	SOLMOD3	SOLCIM	Constant/moles/liter	1.3×10^{-8}	1.3×10^{-8}	1.3×10^{-8}	1.3×10^{-8}	0.00
3407	SOLMOD4	SOLSIM	Constant/moles/liter	1.3×10^{-8}	1.3×10^{-8}	1.3×10^{-8}	1.3×10^{-8}	0.00
3403	SOLMOD4	SOLCIM	Constant/moles/liter	4.1×10^{-8}	4.1×10^{-8}	4.1×10^{-8}	4.1×10^{-8}	0.00
3408	SOLMOD5	SOLSIM	Constant/moles/liter	2.4×10^{-7}	2.4×10^{-7}	2.4×10^{-7}	2.4×10^{-7}	0.00
3404	SOLMOD5	SOLCIM	Constant/moles/liter	4.8×10^{-7}	4.8×10^{-7}	4.8×10^{-7}	4.8×10^{-7}	0.00

ID No.	Material	Parameter	Distribution Type/Unit	Min	Max	Med	Mean	Standard Dev.
3478	TH+4	MKD_TH	Loguniform/m3/kg	0.900	20.0	4.243	6.1591	5.141
2254	BOREHOLE	TAUFAIL	Loguniform/Pa	0.05	77	--	--	--
8004	WAS-AREA	VOL SPALL	Uniform/m^3	0.50	4.00	2.25	2.25	1.01

14.I.1 REQUIREMENT

"Any compliance application shall include:

(e) Documentation of measures taken to meet the assurance requirements of this part."

14.I.2 ABSTRACT

Section 194.14(e) required DOE to submit documentation of measures taken to meet the assurance requirements of this part. Assurance requirements constitute qualitative requirements that are intended to provide confidence that the radioactive waste disposal repository will comply with the disposal regulations. They are intended to compensate for the inherent uncertainties in protecting the behavior of natural and engineered components of the repository for many thousands of years.

The six assurance topics that DOE must address are: active institutional controls (Section 194.41), monitoring (Section 194.42), passive institutional controls (Section 194.43), engineered barriers (Section 194.44), consideration of the presence of resources (Section 194.45), and removal of waste (Section 194.46). DOE documented the measures taken to meet these assurance requirements in Chapter 7 and numerous appendices. As stated in the CAG, EPA did not expect documentation for Section 194.14(e) to exceed that required to comply with the assurance requirements (CAG, p. 11).

14.I.3 COMPLIANCE REVIEW CRITERIA

To demonstrate compliance with this provision, EPA expected the compliance application to include documentation of measures taken to meet the assurance requirements. EPA considered DOE to have complied with Section 194.14(e) if it provided the information required in Sections 194.41 through 194.46. For a complete discussion of each of the assurance requirements, see **CARD 41—Active Institutional Controls, CARD 42—Monitoring, CARD 43—Passive Institutional Controls, CARD 44—Engineered Barriers, CARD 45—Consideration of the Presence of Resources, and CARD 46—Removal of Waste**.

14.I.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided documentation of the assurance requirements in Chapter 7 and numerous appendices. A complete discussion of DOE's compliance with the assurance requirements can be found in the following CARDs: **CARD 41—Active Institutional Controls, CARD 42—Monitoring, CARD 43—Passive Institutional Controls, CARD 44—Engineered Barriers, CARD 45—Consideration of the Presence of Resources, and CARD 46—Removal of Waste.**

14.I.5 EPA COMPLIANCE REVIEW

EPA thoroughly reviewed DOE's documentation of assurance requirements in the CCA. In certain cases EPA requested additional information from DOE, which DOE provided. See the following CARDs for a complete discussion of EPA's requests for additional information and an evaluation of the technical adequacy of the CCA and supplementary materials: **CARD 41—Active Institutional Controls, CARD 42—Monitoring, CARD 43—Passive Institutional Controls, CARD 44—Engineered Barriers, CARD 45—Consideration of the Presence of Resources, and CARD 46—Removal of Waste.**

14.J.1 REQUIREMENT

"Any compliance application shall include:

(f) a description of waste acceptance criteria and actions taken to assure adherence to such criteria."

14.J.2 ABSTRACT

DOE described waste acceptance criteria in a document entitled "Waste Acceptance Criteria for the WIPP." Appendix WAP and the Transuranic Waste Characterization Quality Assurance Program Plan describe procedures to ensure that the waste acceptance criteria are met. EPA reviewed these documents to determine whether DOE provided satisfactory waste analysis methodologies to ensure adherence to these criteria.

14.J.3 COMPLIANCE REVIEW CRITERIA

Section 194.14(f) required DOE to describe the waste acceptance criteria and the actions taken to ensure adherence to those criteria. EPA examined the CCA to determine whether it contained waste acceptance criteria and procedures to ensure adherence to these criteria.

14.J.4 DOE METHODOLOGY AND CONCLUSIONS

To demonstrate compliance, DOE provided the current Waste Acceptance Criteria for the WIPP (DOE 1996), Appendix WAP, and the Transuranic Waste Characterization Quality Assurance Program Plan (DOE 1995b). The latter two documents describe procedures that DOE will follow to ensure that the waste acceptance criteria are met. DOE's methodologies include those for generator site waste characterization (non-destructive examination and assay, real-time radiography, and acceptable knowledge), data transfer mechanisms (e.g., WIPP Waste Information System), and waste verification and emplacement activities.

DOE also identified waste limits that must be met by the WIPP. Appendix WCL specified, for example, the minimum quantity of steel to be emplaced in the WIPP. Steel promotes reducing conditions and provides metals (via corrosion) that will preferentially combine with organic ligands or colloids, thus reducing actinide mobility. In addition, DOE identified a maximum allowable quantity of cellulosics to ensure that the quantity of MgO emplaced around waste containers as an engineered barrier is sufficient to mitigate carbon dioxide generation due to degradation of cellulosics.

14.J.5 EPA COMPLIANCE REVIEW

EPA reviewed the documentation provided by DOE and concluded that DOE provided satisfactory descriptions of actions that will be followed to ensure adherence to the waste acceptance criteria. In addition, EPA audited generator sites, examined performance demonstration programs, and attended WWIS demonstrations, from which it concluded that overall procedures are in place to ensure that waste acceptance criteria and waste limits will be met. See Section 194.24(c)(4) in **CARD 24—Waste Characterization** for further discussion of waste acceptance criteria.

14.K.1 REQUIREMENT

"Any compliance application shall include:

(g) a description of background radiation in air, soil and water in the vicinity of the disposal system and the procedures employed to determine such radiation."

14.K.2 ABSTRACT

EPA expected the CCA to discuss the background radiation levels in air, soil, and water, as well as the procedures employed to determine these levels. DOE provided information regarding background levels of radiation in air, soil, surface water, sediments, groundwater and biota and how they were determined in Chapter 2.4.4 and Appendices EMP, RBP and SER. DOE initiated the WIPP Radiological Baseline Program in July 1975 to describe background levels of radiation and radionuclides in the WIPP environment prior to the emplacement of radioactive waste. DOE established a radiation baseline under five programs: atmospheric, ambient radiation, terrestrial (soils), hydrologic (surface water, sediments and groundwater) and biotic. EPA reviewed information in the CCA on background radiation in air, soil, and water, as well as procedures to monitor these media for radiation.

14.K.3 COMPLIANCE REVIEW CRITERIA

The CCA must discuss the background radiation levels in air, soil, and water, as well as the procedures employed to determine these levels. As stated in the CAG (p. 12), EPA expected that the CCA would identify:

- Locations in which the measurements were made.
- Dates on which the measurements were made.
- Standard statistics, such as mean and standard deviation.
- Discussion of problems (if any) encountered in the measurement process.
- Identification of the instrument used and lower limit of detection for the instrumentation.

- Documentation that the measurements were quality assured.

The analyses performed by DOE must be accurate, technically sound, and adequately justified.

14.K.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided information regarding the levels of background radiation in air, soil, surface water, sediments, groundwater, and biota in Chapter 2.4.4 (pp. 2-170 to 2-175), Appendix RBP, and Appendix EMP.5.3 (pp. 5-5 to 5-10), 6 (pp. 6-1 to 6-3), 7 (pp. 7-1 through 7-4) and 8 (pp. 8-1 through 8-7). DOE also described the procedures used to determine the background radiation in Appendix RBP (Section 2). DOE stated in Chapter 2.4.4 (p. 2-170) and Appendix RBP that background radiation in the vicinity of the WIPP site is influenced by natural sources of radiation, fallout from nuclear tests, and one local research project, Project Gnome, which involved the underground detonation of a nuclear device on December 10, 1961, at a site approximately 8 miles (13 kilometers) southwest of the WIPP site.

The WIPP Radiological Baseline Program (RBP) was initiated in July 1975 to describe background levels of radiation and radionuclides in the WIPP environment prior to the emplacement of radioactive waste. The RBP consisted of five baseline subprograms: atmospheric, ambient radiation, terrestrial (soils), hydrologic (surface water, sediments, and groundwater), and biotic. The RBP was succeeded by the Environmental Monitoring Plan (EMP). The final report on the RBP was provided as Appendix RBP and the Environmental Monitoring Plan was provided as Appendix EMP. See Appendices EMP.5.3 (pp. 5-5 to 5-10), EMP.6 (pp. 6-1 to 6-3), EMP.7 (pp. 7-1 through 7-4) and EMP.8 (pp. 8-1 through 8-7) for more information.

Chapter 2.4.4 (pp. 2-170 to 2-175) summarizes the results of the radiological monitoring. Appendices RBP, EMP and SER, Sections 1.3, (pp. 1-6 to 1-8), 5 (pp. 5-1 to 5-24), 8 (pp. 8-1 to 8-9), and Appendix A, contained information regarding the locations and dates at or on which the measurements were made, standard statistical information, identification of the instrument used and the lower detection limit for the instrumentation, and documentation that the measurements were quality assured. The reports containing background radiation information provided as Appendix RBP and Appendix SER did not provide specific sections describing whether any problems were encountered during the measurement process, but problems encountered were discussed within the body of each report (e.g., the description of the impact of the Chernobyl accident on gross alpha results for airborne particulate samples in Appendix RBP.3.1, p. 3-1).

14.K.5 EPA COMPLIANCE REVIEW

EPA reviewed the background radiation conditions in the vicinity of the WIPP as discussed in Chapter 2.4.4, including DOE’s description of background radiation in air, soil, and water and the procedures employed to determine such radiation. DOE programs established to monitor environmental radioactivity in the vicinity of the WIPP are the RBP and the EMP. EPA found that DOE provided sufficient discussion of these background levels and associated procedures to monitor these media for radiation. Further discussion of EPA’s review is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.L (EPA 1998a).

14.L.1 REQUIREMENT

“Any compliance application shall include:

(h) One or more topographic map(s) of the vicinity of the disposal system. The contour interval shall be sufficient to show clearly the pattern of surface water flow in the vicinity of the disposal system. The map(s) shall include standard map notations and symbols, and, in addition, shall show boundaries of the controlled area and the location of any active, inactive, and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system.”

14.L.2 ABSTRACT

The CCA must include topographic maps with a contour interval sufficient to show clearly the pattern of surface water flow in the vicinity of the disposal system. DOE provided four topographic maps that show the pattern of surface water flow in the vicinity of the WIPP. The CCA included three figures showing the locations of the controlled area within the U.S. Public Land Survey coordinate system, as well as a map showing the location of active, inactive, and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system. EPA reviewed the topographic maps provided in the CCA to determine their sufficiency.

14.L.3 COMPLIANCE REVIEW CRITERIA

To comply with this section, EPA expected the CCA to include topographic maps with a contour interval sufficient to show clearly the pattern of surface water flow in the vicinity of the disposal system. In addition, the maps must include: standard map notations and symbols; boundaries of the controlled area; and the location of any active, inactive, and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system. The CCA also should include sufficient topographic and/or other maps and should clearly discuss the information on the maps within the text of the application.

14.L.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided topographic maps in Chapter 2 and Appendix DEL, and also at the end of Volume I of the CCA (as attachments). The four topographic maps showing the pattern of surface water flow in the vicinity of the WIPP were:

- Figure 2-18 (p. 2-69), which shows an area 60 miles by 44 miles (96.5 kilometers by 70.8 kilometers) at a contour interval of 100 feet.

- Figure 2-25 (p. 2-99), which shows an area 36 miles by 42 miles (58 kilometers by 65.6 kilometers) at a contour interval of 50 feet.

- Two USGS 15 minute quadrangle topographic maps of Livingston Ridge and Los Medanos (attached to Volume I of the CCA), each of which covers an area of 7.5 miles by 8.5 miles (12 kilometers by 13.7 kilometers) at a contour interval of 10 feet.

DOE provided maps in the CCA Figures 2-1 (p. 2-7), 2-25 (p. 2-99) and 3-1 (p. 3-3) to show the locations of the controlled area within the U.S. Public Land Survey coordinate system. DOE also provided a map showing the location of active, inactive and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system in Appendix DEL, Plate DEL-6.

14.L.5 EPA COMPLIANCE REVIEW

EPA reviewed the topographic maps provided in the CCA. Figure 2-18 (p. 2-69) and the topographic maps included at the end of Volume 1 illustrate the surface water drainage pattern in the vicinity of the disposal system. The topographic maps provided in the CCA also included: standard map notations and symbols; boundaries of the controlled area; and the location of active, inactive, and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system. A complete discussion of EPA's review of topographic maps is contained in EPA Technical Support Document for Section 194.14: Content of Compliance Certification Application, Section IV.B.5 (EPA 1998a).

14.M.1 REQUIREMENT

"Any compliance application shall include:

(i) a description of past and current climatologic and meteorologic conditions in the vicinity of the disposal system and how these conditions are expected to change over the regulatory time frame."

14.M.2 ABSTRACT

DOE was required to describe past and current climatologic and meteorologic conditions at the WIPP site and estimate how those conditions might change over 10,000 years. EPA recommended that DOE list recent estimates in tabular form, using existing written records. DOE described past glaciation events, climatic changes, and precipitation and temperature averages in Chapter 2.5.1 and Appendix CLI. DOE then discussed how historic climatic conditions were used to anticipate climatic conditions 10,000 years in the future. DOE concluded that it is unlikely that the WIPP site will experience future climatic extremes in excess of those occurring between the late Pleistocene (1.4 million years ago) and the present.

Chapter 2.5.2 described current climatic conditions in the WIPP area, including summaries of recent rainfall, temperature, and wind data. DOE discussed how climate changes were incorporated in conceptual models in Chapter 6.4.9.

EPA reviewed specific studies, data and analysis provided by DOE for accuracy, technical basis, and appropriateness of associated justifications. EPA also assessed technical conclusions drawn by DOE in the CCA and supplemental information based upon their reasonableness, accuracy, applicability, and relative importance to the PA.

14.M.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 13), EPA expected the CCA to include recent estimates, using existing written records, of climatologic and meteorologic conditions in the vicinity of the disposal system in tabular form, and to discuss the following:

- Record of annual and monthly precipitation averages.
- Record of monthly temperature averages and extremes.
- Wind speed and direction information that forms the basis for the exposure pathway modeling.
- Estimated evapotranspiration.

In addition, the CCA must discuss the past climatologic and meteorologic conditions for the vicinity of the disposal system including climate changes (e.g., past glaciation events) and past precipitation and temperature averages and variability, estimated from the geologic record or other means.

The CCA should discuss how climatologic and meteorologic conditions are expected to change during the 10,000-year regulatory time period. EPA further expected the CCA to state how climatologic and meteorologic changes were incorporated into the conceptual models used, and how they were used in the performance and compliance assessments, including:

- Potential changes and rates of change in precipitation, air temperatures, and resulting changes in potential evapotranspiration from the present.
- Potential precipitation patterns that may evolve in the future as a result of climatic and geologic changes.
- Potential increased/decreased recharge to the disposal system.

The information provided in the CCA should support the conceptualization of the disposal system and the major site-related characteristics included in the PA modeling.

14.M.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided information regarding the past climatologic and meteorologic conditions in the vicinity of the WIPP in Chapter 2.5.1 (pp. 2-176 to 2-178) and Appendix CLI. DOE provided a discussion of past glaciation events and climatic changes and included information on past precipitation and temperature averages. Appendix CLI included graphics to show global climate variation, as deduced through isotopic studies. Chapter 2.5.1 described the historic climatic conditions that were assessed by DOE to understand how climatic conditions can influence the WIPP site 10,000 years in the future. Although a precise prediction is not possible, DOE stated that it is unlikely the WIPP site will experience future climatic extremes that will exceed those occurring from the late Pleistocene, 1.4 million years ago, to the present. DOE stated that periodicity of glacial conditions suggests that a return to the cooler, wetter periods characteristic of the late Pleistocene is unlikely within the next 10,000 years.

After studying multiple lines of physical and biological evidence, DOE reached the following conclusions regarding climate in the WIPP region (Chapter 2.5.1, p. 2-178):

- Maximum precipitation coincided with the maximum advance of the North American ice sheet (22,000 to 18,000 years ago), and minimum precipitation occurred after the ice sheet had retreated to its present limits.
- Past maximum long-term average precipitation was roughly twice the present level, and past minimum precipitation may have been 90 percent of the present level.
- Short-term fluctuations in precipitation have occurred during the present relatively dry, interglacial period (from 18,000 years ago), though the long-term average precipitation has not exceeded upper limits of the glacial maximum (22,000 to 18,000 years ago).

DOE described recent climatic conditions in the WIPP area in Chapter 2.5.2 (pp. 2-178 to 2-191) and various supporting documents, including Appendix SER and the WIPP Site Environmental Reports for 1990 through 1994 (WEC 1991, WEC 1992, WEC 1993, WEC 1994, WEC 1995). Summaries of recent rainfall, temperature, and wind data were presented in Chapter 2.5.2 (pp. 2-178 to 2-191). DOE provided an estimate of evapotranspiration in Appendix CLI.2, p. 3). DOE described how the climate changes were incorporated in conceptual models in Chapter 6.4.9 (pp. 6-165 to 6-168).

14.M.5 EPA COMPLIANCE REVIEW

EPA reviewed Chapter 2 of the CCA, related supporting references, and Appendix CLI and determined that the discussion of how climatologic and meterologic conditions at the WIPP site are expected to change during the 10,000-year regulatory time period is adequate. EPA also reviewed the information provided in Chapter 6.4.9 of the CCA and determined that the method used by DOE to incorporate climatologic and meterologic changes into the conceptual models was appropriate, and that the climate index parameter presented in Appendix PAR and derived from historic meteorological climatic condition data was sufficiently justified. EPA concluded that DOE's assumption in the PA that the range of precipitation levels in the future would be no less than current levels was adequate and conservative, and that the description of past and present climatic changes and their associated impacts on the WIPP disposal system were adequately addressed. For further discussion of the potential for increased/decreased recharge to the disposal system, see **CARD 25—Future State Assumptions**, Section 25.D, and Section 14.B of this CARD.

EPA reviewed Chapter 2.5.2 (pp. 2-178 to 2-191), Appendix SER, and CCA Reference Nos. 191, 192, 690, 691, and 692 and determined that the information provided regarding records of recent annual and monthly precipitation averages, monthly temperature averages and extremes, wind speed and wind direction, and estimates of evapotranspirations were adequately detailed.

14.N.1 REQUIREMENT

“Any compliance application shall include:

(j) The information required elsewhere in this part or any additional information, analyses, tests, or records determined by the Administrator or the Administrator's authorized representative to be necessary for determining compliance with this part.”

14.N.2 ABSTRACT

After receipt of the CCA, EPA formally requested additional information from DOE in seven letters. The information requested by these letters was necessary for EPA’s completeness determination and technical review. EPA staff and contractors also reviewed records maintained by DOE or DOE’s contractors (e.g., records kept at the Sandia National Laboratories Records Center in Albuquerque, New Mexico). No additional laboratory or field tests were conducted by DOE at EPA’s specific direction; however, DOE did conduct and document laboratory tests after October 29, 1996, in order to present additional data to the Conceptual Model Peer Review Panel. EPA did not issue a formal written request for additional information from DOE after publication of the proposed rule, but did informally ask DOE and Sandia National Laboratory for information and other assistance.

14.N.3 COMPLIANCE REVIEW CRITERIA

EPA expected DOE to provide the information required by the other sections of 40 CFR Part 194, as well as any additional information that EPA determined to be necessary for determining compliance.

14.N.4 DOE METHODOLOGY AND CONCLUSIONS

DOE provided supplementary information to EPA in response to seven formal requests, as listed in Section 14.N.5 below. DOE’s responses contain clarifications of information in the CCA and the results of analyses and tests conducted subsequent to the preparation of the final CCA. At EPA’s request, DOE provided information and other assistance in calculations related to the Hartman scenario, drilling into fractured anhydrite, and the CCDFGF code and quasi-static spreadsheet with regard to air drilling (Docket A-93-02, Items IV-E-24, IV-E-25, IV-E-26, and IV-E-27, respectively). In addition, DOE voluntarily submitted information on the proposed rule that EPA treated as public comments.

Additional supplementary documentation that was not formally sent to EPA but was reviewed by the Agency is available in the Sandia National Laboratories Records Center in Albuquerque, New Mexico (e.g., calculations of actinide solubility for americium, plutonium, thorium and uranium). DOE also conducted peer review exercises after submittal of the CCA.

14.N.5 EPA COMPLIANCE REVIEW

In regard to information required by sections other than Section 194.14, EPA did not conduct a separate evaluation of compliance with Section 194.14(j). Rather, EPA's consideration of DOE's compliance is addressed in the CARDs for those sections.

The CARDs for other sections of the compliance criteria discuss in greater detail DOE's responses to EPA's formal requests for additional information and any other supplementary information submitted to EPA after receipt of the CCA. EPA formally requested additional information from DOE in seven letters dated December 19, 1996 (Docket A-93-02, Item II-I-01), February 18, 1997 (Docket A-93-02, Item II-I-09), March 19, 1997 (Docket A-93-02, Item II-I-17), April 17, 1997 (Docket A-93-02, Item II-I-25), April 25, 1997 (Docket A-93-02, Item II-I-27), June 6, 1997 (Docket A-93-02, Item II-I-33), and July 2, 1997 (Docket A-93-02, Item II-I-37).

The information requested by these letters and other supplementary information provided by DOE was necessary for EPA's completeness determination and technical review. A complete list of the additional information EPA received from DOE is attached **(Attachment A)**.

EPA staff and contractors also reviewed records maintained by DOE or DOE's contractors (e.g., records kept at the Sandia National Laboratories Records Center in Albuquerque, New Mexico). No additional laboratory or field tests were conducted by DOE at EPA's specific direction; however, DOE did conduct and document laboratory tests after October 29, 1996, in order to present additional data to the Conceptual Model Peer Review Panel (Docket A-93-02, Item II-A-39).

EPA did not issue a written request for additional information from DOE after publication of the proposed rule. In order to respond to public comments, however, EPA did informally ask DOE and Sandia National Laboratory for information and other assistance in calculations related to the Hartman scenario, drilling into fractured anhydrite, and the CCDFGF code and quasi-static spreadsheet with regard to air drilling (Docket A-93-02, Items IV-E-24, IV-E-25, IV-E-26, and IV-E-27). In addition, DOE voluntarily submitted information on the proposed rule that was considered as comments.

All documents sent to EPA regarding certification of the WIPP are available in EPA Air Docket A-93-02. Additional information relevant to EPA's certification evaluation that was reviewed by the Agency (e.g., DOE data records packages, quality assurance records, and calculations of actinide solubility for americium, plutonium, thorium and uranium) is also publicly available. Documentation of peer review panel meetings conducted after receipt of the CCA has been placed in the EPA docket. See EPA's Response to Comments Document (EPA 1998j) for further information on the location of all documentation reviewed by EPA.

14.O REFERENCES

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DOE 1995a. U.S. Department of Energy. Waste Isolation Pilot Plant Safety Analysis Report. DOE/WIPP/95-2065, Revision 0. November 1995. (CCA Reference #202)

DOE 1995b. U.S. Department of Energy. Transuranic Waste Characterization Quality Assurance Program Plan, Revision 0, DOE/CAO-94-1010. April 30, 1995. (CCA Reference #201)

DOE 1995c. U.S. Department of Energy. Summary of Brine Investigation at the Waste Isolation Pilot Plant, Southeastern New Mexico, DOE/WIPP 96-2161. 1995.

DOE 1996. U.S. Department of Energy. Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Revision 5, DOE/WIPP-96-069. April 1996. (CCA Reference #208)

DOE 1997a. U.S. Department of Energy. Chemical Conditions Model: Results of the MgO Backfill Efficacy Investigation. Prepared for the U.S. DOE Carlsbad Area Office by Sandia National Laboratories. April 23, 1997. (Docket A-93-02, Item II-A-39)

DOE 1997b. U.S. Department of Energy. Summary of EPA-Mandated Performance Assessment Verification Test (Replicate 1) and Comparison with Compliance Certification Application Calculations. July 25, 1997. (Docket A-93-02, Item II-G-26)

DOE 1997c. U.S. Department of Energy. Summary of EPA-Mandated Performance Assessment Verification Test (All Replicates) and Comparison with Compliance Certification Application Calculations, WPO# 46702. August 8, 1997. (Docket A-93-02, Item II-G-28)

Environmental Evaluation Group (EEG). Stable Isotopes in Southeastern New Mexico Groundwater: Implications for Dating Recharge in the WIPP Area, EEG-35. (CCA Reference #118)

Environmental Evaluation Group (EEG). Chemical and Radiochemical Characteristics of Groundwater in the Culebra Dolomite, Southeastern New Mexico, EEG-39. (CCA Reference #119)

EPA 1998a. U.S. Environmental Protection Agency. Technical Support Document for 40 CFR 194.14: Content of Compliance Certification Application. 1997. (Docket A-93-02, Item V-B-3)

EPA 1998b. U.S. Environmental Protection Agency. Technical Support Document for 40 CFR 194.14: Assessment of K_ds used in the CCA. 1997. (Docket A-93-02, Item V-B-4).

EPA 1998c. U.S. Environmental Protection Agency. Technical Support Document for 40 CFR 194.23: Sensitivity Analysis Report. (Docket A-93-02, Item V-B-13)

EPA 1998d. U.S. Environmental Protection Agency. Technical Support Document for Section 194.23: Parameter Report. 1997. (Docket A-93-02, Item V-B-12)

EPA 1998e. U.S. Environmental Protection Agency. Technical Support Document for Section 194.23: Parameter Justification Report. 1997. (Docket A-93-02, Item V-B-14)

EPA 1998f. U.S. Environmental Protection Agency. Technical Support Document for Section 194.32: Fluid Injection Analysis. 1997. (Docket A-93-02, Item V-B-22)

EPA 1998g. U.S. Environmental Protection Agency. Technical Support Document for Section 194.23: Models and Computer Codes. (Docket A-93-02, Item V-B-6)

EPA 1998h. U.S. Environmental Protection Agency. Technical Support Document for Section 194.23: Review of TDEM Analysis of WIPP Brine Pockets. (Docket A-93-02, Item V-B-30)

EPA 1998i. U.S. Environmental Protection Agency. Technical Support Document for Section 194.23: Ground-Water Flow and Contaminant Transport Modeling at WIPP (Docket A-93-02, Item V-B-7)

EPA 1998j. U.S. Environmental Protection Agency. Response to Comments Document for the Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 91 Disposal Regulations: Certification Decision. (Docket A-93-02, Item V-C-1)

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Slemmons, D. B., E.R. Engdahl, Mark D. Zoback, and David D. Blackwell, Eds. Neotectonics of North America. Geological Society of America. 1991. (CCA Reference #595)

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WEC 1992. Westinghouse Electric Corporation. Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1991, DOE/WIPP 92-007. 1992. (CCA Reference #191)

WEC 1993. Westinghouse Electric Corporation. Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1992, DOE/WIPP 93-017. 1993. (CCA Reference #192)

WEC 1994. Westinghouse Electric Corporation. Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1993, DOE/WIPP 94-2033. 1994. (CCA Reference #691)

WEC 1995. Westinghouse Electric Corporation. Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994, DOE/WIPP 95-2094. 1995. (CCA Reference #692)

ATTACHMENT A

Section 194.14(j) Additional Information

EPA received the following additional information from DOE:

- DOE response to EPA's letter of December 19, 1996 requesting additional CCA documentation. Dated January 17, 1997. Docket A-93-02, Item II-I-02. Supplemental information for the Compliance Certification Application (CCA) includes the following:

  Response to EPA Comments, Enclosure 1:
  a. 194.23(a)(1) Models and Computer Codes
  b. 194.23(a)(2) Models and Computer Codes
  c. 194.32(c)Scope of Performance

  Response to EPA Comments, Enclosure 2
  a. 194.32(a) Scope of Performance

- DOE second response package to EPA's letter of December 19, 1996. Dated January 24, 1997. Docket A-93-02, Item II-I-03. Supplemental Information for the CCA includes the following:

  Response to EPA Comments Enclosure 1
  a. 194.14(a)(3) Content of Compliance Certification Application
  b. 194.22(a)(2)(iii) Quality Assurance
  c. 194.23(a)(3)(i) Models and Computer Codes

  Response to EPA Comments Enclosure 2
  a. 194.23(a)(1) Models and Computer Codes
  b. 194.32(e)(3) Scope of Performance
  c. 194.33(c)(1) Consideration for drilling events in PA
  d. 194.53 Consideration of underground sources of drinking water

- DOE letter dated January 21, 1997 (Docket A-93-02, Item II-I-05) transmitting a supplement to Appendix EPIC to the CCA. The supplement is entitled, "*DOE report on Effectiveness of Passive Institutional Controls in Reducing Inadvertent Human Intrusion into the WIPP*," WIPP/CAO-96-3168, Revision 1, November 14, 1996 with Addendum of December 6, 1996 (Docket A-93-02, Item II-G-16).

- DOE third response package to EPA's letter of December 19, 1996. Dated February 7, 1997. Docket A-93-02, Item II-I-07. Supplemental Information for the CCA includes the following:

Response to EPA Comments, Enclosure 1
a. 194.23(a)(2) Models and Computer Codes
b. 194.24(a) Waste Characterization
c. 194.41(a) Active Institutional Control

Response to EPA Comments, Enclosure 2
a. 194.23(a)(1) & 194.23(a)(2)

- DOE fourth response package to EPA's letter December 19, 1996. Dated February 14, 1997. Docket A-93-02, Item II-I-08. Supplemental information for the CCA includes the following:

  Response to EPA Comments , Enclosure 1:
  a. 194.14(a)(2) Content of Compliance Certification
  b. 194.23(c) Models and Computer Codes
  c. 194.23(c)(2) Models and Computer Codes
  d. 194.23(c)(3) Models and Computer Codes
  e. 194.23(c)(6) Models and Computer Codes
  f. 194.32(a) Scope of Performance Assessment
  g. 194.32(e) Scope of Performance Assessment
  h. 194.34(b) Results of Performance Assessment
  i. 194.42(a) Monitoring

- DOE fifth response package to EPA's letter of December 19, 1996. Dated February 26, 1997. Docket A-93-02, Item II-I-10. Supplemental Information for the CCA includes the following:

  Response to EPA Comments , Enclosure 1:
  a. 194.14(a)(2) Content of CCA
  b. 194.22(a)(2)(iii) Quality Assurance (Models and Computer Codes)
  c. 194.23(a)(3)(ii) Models and Computer Codes
  d. 194.23(a)(3)(iii) Models and Computer Codes
  e. 194.23(a)(3)(iv) Models and Computer Codes
  f. 194.24(c) and 194.24(c)(1) Waste Characterization
  g. 194.24(c)(4) Waste Characterization
  h. 194.24(g) Waste Characterization
  i . 194.25(b)(i) Future State Assumptions
  j. 194.53 Consideration of Underground Sources of Drinking Water

  Response to EPA Comments, Enclosure 2
  a. 194.14(a)(2) Content of CCA
  b. 194.23(a)(3)(i) Models and Computer Codes
  c. 194.23(a)(3)(i) Models and Computer Codes
  d. 194.23(a)(3)(iv) Models and Computer Codes
  e. 194.23(c)(2) Models and Computer Codes
  f. 194.34(c) Results of Performance Assessments

g 194.44 Engineered Barriers
h. 194.51 Consideration of Protected Individual

- DOE response to EPA letter of February 18, 1997 requesting data record packages. Dated February 27, 1997. Docket A-93-02, Item II-I-12.

- DOE supplemental response to Enclosure 2, page 2 for 40 CFR 194.12(a)(3)(1) of EPA's letter of December 19, 1996. Dated March 13, 1997. Docket A-93-02, Item II-I-15. This supplemental information for DOE's CCA is an attached paper entitled "*Implementation of Chemical Controls Through a Backfill System for the Waste Isolation Pilot Plant (WIPP).*"

- DOE supplemental response dated March 13, 1997 (Docket A-93-02, Item II-I-16) to Enclosure 1, page 8, 40 CFR 194.23(a)(3)(iv) of EPA's letter of December 19, 1997. This supplemental information is a DOE Analysis Package for the BRAGFLO Sensitivity Study (WPO#43593, Revision #1, dated March 11, 1997) entitled "*Sensitivity of Flow, Transport, and Direct Brine Release to Grid Refinement Using the BRAFGFLO and NUTS Computer Models*." (Docket A-93-02, Item II-G-17).

- DOE supplemental response dated March 14, 1997 (Docket A-93-02, Item II-I-19) to Enclosure 2, Page 5, 40 CFR 194.23(c)(2) to EPA's letter of Dec. 19, 1996, transmitting the "*Analysis of Ground Water Travel Times through Calibrated Transmissivity Fields Generated by GRASP-INV* "(WPO#44199 (Version 2.01) Revision O, March 1997), with Appendix A - TCSTRIP UTILITY CODE VERIFICATION (Rev. O, March 1997), and Appendix B - HDSTRIP UTILITY CODE VERIFICATION (Rev O, March 1997). This document is filed at A-93-02, II-G-18.

- DOE response to March 19, 1997 letter regarding CCA issues/ comments. Dated April 15, 1997. Docket A-93-02, Item II-I-24.

Comment No. 2	Data Quality Characteristics
Comment No. 3	E2 After E2 Scenarios
Comment No. 9	More Information on Permeability and Porosity Versus Pressure Curves
Comment No. 12	Does DOE want to Include Other than BIR Data?
Comment No. 13	Adsorption of Actinides for Cuttings/Caving
Comment No. 14	Details on HYDRAQL code
Comment No. 15	Uncertainties on Upper and Lower Limits
Comment No. 16	Detail on Methods of NDA
Comment No. 17	Support an EPA Audit of WWIS
Comment No. 19	Contaminant Transport from Brine Flow from a Single Hole

- DOE's Plan to Respond to Issues Raised in EPA's letter of March 19, 1997. Dated April 11, 1997. Docket A-93-02, Item II-I-26.

- DOE second Response to EPA's letter of March 19, 1997 requesting additional information the WIPP CCA. Dated May 2, 1997. Docket A-93-02, Item II-I-28.

  Response to Comment #10 (Models and Computer Codes)
  Response to Comments #14, #15, #18(Waste Characterization)
  Response to EPA findings from EPA Audit of CAO, 12/9-13/96
  Response to EPA findings from EPA Audit of SNL, 1/13-24/97
  Response to EPA findings/observations from EPA Audit of CAO Peer Review, 2/10-12/97

- DOE letter transmitting report of DOE's Expert Elicitation on Waste Particle Diameter (Draft Report dated May 12, 1997). Dated May 15, 1997. Docket A-93-02, Item II-I-30.

- DOE third response to EPA's letter of March 19, 1997, regarding CCA issues/ comments. Dated May 14, 1997. Docket A-93-02, Item II-I-31. Supplemental information includes responses to Enclosures 1 of the March 19, 1997 letter as follows:

  Comment No. 1 - Origin of Hydrochemicals Facies and Modeled Paleoflow Directions
  Comment No. 4 - SECOTP2D - Test with a Heterogeneous T-Field
  Comment No. 5 - SECOTP2D - Mass Balance Comment No. 6 - Quantity Impacts of Code Errors
  Comment No. 7 - SECOTP3D Code Test Results
  Comment No. 8 - Benchmark NUTS with SWIFT
  Comment No. 11 - Traceability of Development of Legacy Parameters
  Comment No. 20 - Solution Mining and 22

- DOE letter dated June 4, 1997 (Docket A-93-02, Item II-I-34) transmitting the final report on "*Expert Elicitation on WIPP Waste Particle Size Distribution(s) During the 10,000-Year Regulatory Post-Closure Period*" (Report filed in Docket A-93-02, Item II-G-24. Dated June 3, 1997).

- DOE letter dated June 2, 1997 (Docket A-93-02, Item II-I-35) transmitting draft reports on "*Results of the MgO Backfill Efficacy Investigation*" (Filed at Docket A-93-02, Item II-A-39) and "*Description and Evaluation of a Mechanistically Based Conceptual Model for Spall*" (Filed at Docket A-93-02, Item II-G-23. Dated May 1, 1997).

- DOE letter dated June 17, 1997 (Docket A-93-02, Item II-I-36) responding to EPA's letter of March 19, 1997 requesting additional information regarding water flooding. This supplemental information includes the following:

  a. Response to Enclosure 1, page 7, 40 CFR 194.32(e)- Scope of PA
  b. Sandia National Laboratories - WIPP - Expedited CCA Activity - WPO #44158 Supplementary Analyses of the Effect of Salt Water Disposal and Waterflooding on the WIPP. (This document is filed at Docket A-93-02, Item II-G-25)

Attachment 1: Injection Methods: Current Practices and Failure Rates in the Delaware Basin DOE/WIPP-97-2240, June 1997;
Attachment 2: Technical Review by Swift, et al of the HARTMAN Scenario: Implications for the WIPP by John Bredehoeft, June 13, 1997.

- DOE letter dated July 25, 1997 (Docket A-93-02, Item II-I-38) transmitting intermediate results of the EPA-Mandated Performance Assessment Verification Test (PAVT) (Replicate 1) and Comparison with the CCA Calculations. (This document is filed at A-93-02, Item II-G-26).

- DOE letter dated August 11, 1997 (Docket A-93-02, Item II-I-49) transmitting final results of the EPA-mandated Performance Assessment Verification Test (PAVT) (All Replicates) and Comparison with the CCA Calculations. WPO# 46702, Dated August 8, 1997. (This document is filed at Docket A-93-02, Item II-G-28).

- DOE letter dated June 3, 1997 (Docket A-93-02, Item II-I-51) with enclosure 1 for the approved Performance Demonstration Program Plan for Nondestructive Assay for the TRU Waste Characterization Program, CAO-94-1045, Rev. 1 dated May, 1997. (This document is filed Docket A-93-02, Item II-G-31).

- DOE letter transmitting two papers. Dated August 15, 1997. Docket A-93-02, Item II-I-52.

  a. *Data Quality Characteristics in the WIPP CCA.*
  b. *The WIPP Project Approach to the Assessment of Quality Characteristics.*

- DOE letter dated August 25, 1997 (Docket A-93-02, Item II-I-53) transmitting DOE Information Sheet - *How to Obtain Records at the U.S. Department of Energy's Carlsbad Area Office for the Waste Isolation Pilot Plant Compliance Certification Application*, 97-006 (Docket A-93-02, Item II-G-32. Dated August 1997.).

- DOE letter regarding the evaluation of the equivalency of the CCA PA and the EPA Mandated Performance Assessment Verification Test. Dated August 27, 1997. Docket A-93-02, Item II-I-55.

  Attachment 1 - Executive Summary
  Attachment 2 - C. Whipple's Assessment

- DOE transmitted "*Analysis of 40 CFR 194.24 Waste Characterization Requirements*," during staff attorney's telephone conversation with DOE August 27, 1997.Docket A-93-02, Item II-I-57.

- DOE letter dated August 27, 1997 (Docket A-93-02, Item II-I-60) transmitting the following documents:

  - DOE WPO 46124 - Memorandum from Craig F. Novak to R. Vann Bynum "*Calculation of Actinide Solubilities in WIPP SPC and ERDA6 Brines Under MgO Backfill Scenarios Containing Nesquehonite or Hydromagnesite as the* $MgO\text{-}CO_3$ *Solubility-limiting Phase.*" Dated April 21, 1997. Docket A-93-02, Item II-G-33.

  - DOE WPO 46646 - Memorandum from Yifeng Wang and Kurt Larson to Margaret Chu "*Estimate Waste Critical Shear Stress for WIPP PA Caving Model.*" Dated June 27, 1997. Docket A-93-02, Item II-G-34.

  - DOE WPO 46411 - Memorandum from S. Howarth and Palmer Vaughn to Margaret Chu "*Changes in Classification of Data Category' Column in the EPA Parameter Database.*" Dated July 21, 1997. Docket A-93-02, Item II-G-35.

  - DOE WPO 46936 -Memorandum from Yifeng Wang to Margaret CCU "*Estimate WIPP Waste Particle Sizes on Expert Elicitation Results: Revision 1.*" Dated August 5, 1997. Docket A-93-02, Item II-G-36.

- DOE Compliance Application Guidance (CAG) Checklist for the WIPP. Dated November, 1996. Docket A-93-02, Item II-G-02.

- DOE QA packages for 13 PA Codes (supplemental information supporting the DOE/WIPP CCA). Dated November, 1996. Docket A-93-02, Item II-G-03.

- DOE Analysis of Generation of Transmissivity Fields for the Culebra Dolomite, WPO #40517 Supporting the DOE/WIPP CCA. Dated December 6, 1996. Docket A-93-02, Item II-G-04.

- DOE analysis package for BRAGFLO-WPO#40520, Supporting the DOE/WIPP CCA. Dated December, 1996. Docket A-93-02, Item II-G-05.

- DOE analysis package for the Cuttings and Spalling Calculations - WPO #40527, Supporting the DOE/WIPP CCA (WPO #CORRECTION). Dated December 13, 1996. Docket A-93-02, Item II-G-06.

- DOE preliminary summary of Uncertainty and Sensitivity Analysis Results Obtained in Support of the 1996 Compliance Certification for the WIPP. Dated December 23, 1996. Docket A-93-02, Item II-G-07.

- DOE analysis package for the Salado Transport Calculations (Task 1) of the PA - WPO #40514, Supporting the CCA. Dated December 20, 1996. Docket A-93-02, Item II-G-08.

- DOE analysis package for the Salado Transport Calculations (Task 2) of the PA - WPO #40515, Supporting the CCA. Dated December 23, 1996. Docket A-93-02, Item II-G-09.

- DOE analysis package for the CCDF Construction (Task 7) of the PA Analysis - WPO #40524, Supporting the CCA. Dated December 20, 1996. Docket A-93-02, Item II-G-10.

- DOE analysis package of the Culebra Flow and Transport Calculations (Task 3) of the PA Analysis - WPO #40516, Supporting the CCA Analysis - Plan 019. Dated December 11, 1996. Docket A-93-02, Item II-G-11.

- DOE WIPP Conceptual Models Supplementary Peer Review Report. Dated December, 1996. Docket A-93-02, Item II-G-12.

- DOE WIPP Engineered Systems Data Qualification Supplementary Peer Review Report. Dated December, 1996. Docket A-93-02, Item II-G-13.

- DOE WIPP Waste Characterization Analysis Supplementary Peer Review Report. Dated December, 1996. Docket A-93-02, Item II-G-14.

- DOE WIPP Passive Institutional Controls Supplementary Peer Review Report. Dated December, 1996. Docket A-93-02, Item II-G-15.

- DOE Amendments to CAO Peer Review Management Plan and Peer Review Plans for: Engineered Systems, Rev. 1, 6/25/96; Passive Institutional Controls, Rev. 0, 5/28/96; Conceptual Models, Rev. 0, 3/3/96; and, Waste Characterization, Rev. 0, 6/27/96. Dated October 30, 1996. Docket A-93-02, Item II-G-19.

- DOE/CAO Team Procedure, Revision 1 (TP No 10.5) for Peer Review. Dated November 5, 1996. Docket A-93-02, Item II-G-20.

- DOE WIPP Conceptual Models Second Supplementary Peer Review Report. Dated January, 1997. Docket A-93-02, Item II-G-21.

- DOE letter transmitting the Final Report, WIPP, Conceptual Models Third Supplementary Peer Review Report, April 1997. Dated May 8, 1997. Docket A-93-02, Item II-G-22.

- Memorandum to Docket No. A-93-02, Sandia National Laboratories - WIPP Records Center, with attachment entitled, "*Process for Obtaining Additional WIPP Records that are Available through Sandia National Laboratories*." Not dated. Docket A-93-02, Item II-G-27.

- DOE Summary of Uncertainty and Sensitivity Analysis Results for the EPA-Mandated Performance Assessment Verification Test - WPO #46912. Dated August 22, 1997. Docket A-93-02, Item II-G-30.

- DOE WPA 45115, *U(VI) Solubility Calculation, Performance of Uranium (VI) Solubility Predictions for EPA*, R.V. Bynum and Yifeng Wang. (Additional calculations). Dated May 6, 1997. (Docket A-93-02, Item II-G-44).

- On July 22, 1997, DOE submitted to EPA the following information. This information is included in EPA Technical Support Documents for Section 194.23 entitled "Parameter Report" (Docket A-93-02, Item III-B-12) and "Parameter Justification Report" (Docket A-93-02, Item III-B-14).

  - Worksheet 1) Footnotes for Attachment 2, Main Database

  - Worksheet 2) Main Database

  - Worksheet 3) Parameters based on Empirical Data

  - Worksheet 4) Model Cross-reference

  - Worksheet 5) Source Cross-reference

  - Worksheet 6) Additional Sources

  - Worksheet 7) Enhanced Resources

- During the RFETS PDP Inspection in November 1996, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Waste Characterization Status of INEL, LANL, RFETS (Docket A-93-02, Item III-B-18).

  - EG&G Rocky Flats Plant, E&W Waste Operations, Analytical Test Procedure Manual, Manual Number 5 22320 ALP, Procedure Number W 5228 REV 0, Procedure Title: Passive Active Drum Counter, Building 371, Effective Date 01/25/93.

- During the LANL Audit Inspection in May 1997, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Waste Characterization Status of INEL, LANL, RFETS (Docket A-93-02, Item III-B-18).

  - Los Alamos National Laboratory, Memorandum, Audits and Assessments Office, Internal Assessments Group, To: Marjorie Gavett, From: Carl Frostenson, Subject: Final Report - TWCP Audit (AA2-97-07), May 12, 1997.

  - TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: TWCP Training Procedure, Procedure Number TWCP-QP-1.1-003, R.1, Effective Date 04/17/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Records Management, Procedure Number TWCP-QP-1.1004, R.1, Effective Date 04/16/97.

-- TRU Waste Characterization/Characterization Program, TWCP Quality Procedure, Procedure Title: Project Level Data Validation and Verification, Procedure Number TWCP-QP-1.1-010, R.1, Effective Date 04/07/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Data Generation Level Review, Procedure Number TWCP-QP-1.1-011, R.2, Effective Date 04/07/97.

-- TRU Waste Characterization Program, TWCP Quality Procedure, Procedure Title: Determination of Sufficient Data for Waste Stream Characterization and Reconciliation with Data Quality Objectives, Procedure Number TWCP-QP-1.1-023, R.1, Effective Date 04/29/96.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Equipment Calibration and Maintenance, Procedure Number TWCP-QP-1.1-018, R.2 Effective Date 04/07/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Acceptable Knowledge Documentation, Procedure Number TWCP-QP-1.1-021, R.1, Effective Date 05/08/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: PAP Blind Audit Sample Analysis and Reporting, Procedure Number TWCP-QP-1.1-022, R.0, Effective Date 04/30/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Reporting Summarized Characterization Data and Waste Stream Summaries to CAO, Procedure Number TWCP-QP-1.1-024, R.0, Effective Date 05/09/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Audits, Procedure Number TWCP-QP-1.1-027, R.1, Effective Date 04/07/97.

-- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Reconciliation of Waste Stream Information, Procedure Number TWCP-QP-1.1-028, R.0, Dated 05/07/97.

-- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: WCRRF Visual and Drum Packaging Process Procedure for the TWCP, Procedure Number TWCP-DTP-1.2-001, R.1, Effective Date 01/24/97.

- -- TRU Waste Characterization Program, TWCP Detailed Operating Procedure, Procedure Title: Qualification of Radiography Operators, Procedure Number TWCP-DPT-1.2-003, R.1, Effective Date 04/17/96.

- -- Transuranic Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Qualifications of Visual Examination Personnel, Procedure Number TWCP-DTP-1.2-004, R.1, Effective Date 01/29/97.

- -- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Calculation of UCL90 Values for Headspace Gas VOC, Total VOC, SVOC, and Metals Data, Procedure Number TWCP-DTP-1.2-006, R.1, Effective Date 04/15/97.

- -- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Detailed Technical Procedure for Performing Nondestructive Testing Using the Mobile Real-time Radiography System, Procedure Number TWCP-DTP-1.2-008, R.2, Effective Date 04/24/97.

- -- TRU Waste Characterization Program, TWCP Detailed Operating Procedure, Procedure Title: Calculation for Determining the Number of Containers to Sample in a Waste Stream, Procedure Number TWCP-DTP-1.2-013, R.0, Effective Date 04/15/97.

- -- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Random Selection of Containers and Sampling Locations for the TRU Waste Characterization Activities, Procedure Number TWCP-DTP-1.2-014, R.3, Effective Date 04/14/97.

- -- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Calculation for Determining the Number of Containers for Visual Examination, Procedure Number TWCP-DTP-1.2-015, R.0, Effective Date 04/15/97.

- -- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Waste Container Tracking, Procedure Number TWCP-DTP-1.2-020, R.0, Effective Date 04/17/97.

- During the WWIS Demonstration in June 1997, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Evaluation of DOE’s WIPP Waste Information System (WWIS) (Docket A-93-02, Item III-B-16).

  - -- WWIS Software Configuration Management Process

  - -- WWIS Software Version Control Process

- WIPP Waste Information System Software Modifications
- WIPP Network Management Relateive to WWIS
- WWIS Quality Assurance
- WIPP Waste Information System
- WIPP Disposal Decision Plan
- Risk Analysis Report - WIPP Wide-Area Network (WIPPnet), April 1997
- Contingency Plan - WIPP Wide-Area Network (WIPPnet), April 1997
- Screen Prints of WWIS Interface
- Sample Nuclide Report
- Sample Shipment Summary Report
- Sample Waste Container Data Report
- Sample Waste Emplacement Report
- WWIS Reference Tables
- WIPP TRU Waste Data Management Plan (WP 05-WA.01, rev. 0, February 28, 1997)
- WIPP Waste Information System Program (WP 05-WA.02, rev. 0, April 15, 1997)
- Waste Stream Profile Form Review and Approval Program (WP 05-WA.03, Rev. 0, May 1, 1997)
- WIPP Waste Information System Software Quality Assurance Program (WP 05-WA.04, Rev. 0, May 9, 1997)
- WIPP Waste Information System Configuration Management Plan (WP 05-WA.08, Rev. 0, June 18, 1997)
- WIPP Waste Information System Software Verification and Validation Plan (WP 05-WA.05, Rev. 0, June 17, 1997)
- WIPP Waste Information System Software Requirements Specification (WP 05-WA.06, Rev. 0, June 17, 1997)

- WIPP Waste Information System Software Design Description (WP 05-WA.07, Rev. 0,June 19, 1997)

- WIPP Waste Information System Configuration Management Plan (WP 05-WA.08, Rev.0, June 18, 1997)

- During the RFETS Audit Inspection in July 1997, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Waste Characterization Status of INEL, LANL, RFETS (Docket A-93-02, Item III-B-18).

  - ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, (RFETS) Transuranic Waste Program, Presented By Alan Parker, Kaiser- Hill and Joe Legare, DOE-RFFO, Dated July 14, 1997.

  - Carlsbad Area Office, Audit A-97-03 of the Rocky Flats Environmental Technology Site (RFETS), TRU Waste Characterization, Transportation and Certification, Post Audit Conference, Dated July 18, 1997.

  - Canberra Ind., Procedure Title: IQ3 Waste Assay Trailer Operating Procedure, Procedure Number SQM-007, Dated 07/09/97.

  - Canberra Ind., Procedure Title: Operating and Calibrating Canberra Passive Neutron Counter, Procedure Number SQM-008, Dated 07/09/97.

  - Canberra Ind., Procedure Title: Review Validation and Reporting Nondestructive Assay (NDA) Data and Results, Procedure Number SQM-010, Dated 07/09/97.

  - Canberra Ind., Procedure Title: Operating and Calibrating Canberra Segmented Gamma Scanner, Procedure Number SQM-009, Dated 07/09/97.

  - Canberra Ind., Procedure Title: Transmittal of Documents, Procedure Number SQM-013, Dated 07/09/97.

  - Rocky Flats Environmental Technology Site, Procedure Title: Real-Time Radiography Testing of Transuranic and Low-Level Waste, Rev. 1, Procedure Number 4-I19-NDT-00569, Effective Date 06/30/97.

  - Rocky Flats Environmental Technology Site, Procedure Title: Real-Time Radiography Testing of Transuranic and Low-Level Waste, Rev. 0, Procedure Number 4-W30-NDT-00664, Effective Date 06/13/96.

  - Rocky Flats Environmental Technology Site, Procedure Title: Preparation of Quality Assurance Program Plans, Rev. 1, Procedure Number 1-C40-QAP-02.01, Effective Date 02/01/96.

- During the LANL Follow-up Audit in August 1997, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Waste Characterization Status of INEL, LANL, RFETS (Docket A-93-02, Item III-B-18).

  -- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Acceptable Knowledge Documentation, Procedure Number TWCP-QP-1.1-021, R.2, Effective Date 07/17/97.

  -- Los Alamos National Laboratory, Transuranic Waste Characterization Project, Procedure Title Acceptable Knowledge Summary Report, Procedure Number TA-55-20A, Dated 08/15/97.

  -- TRU Waste Characterization/Certification Program, Procedure Title: PDP Blind Audit Management, Analysis, and Reporting, Procedure Number TWCP-QP1.1-022, R.1, Effective Date 07/11/97.

  -- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title Reporting Summarized Characterization Data and Waste Stream Summaries to CAO, Procedure Number TWCP-QP-1.1-024, R.0, Effective Date 05/09/97.

  -- Los Alamos National Laboratory, Controlled Document, Procedure Title: Reconciliation of Waste Stream Information, Procedure Number TWCP-QP-1.1-028, R.1, Effective Date 08/15/97.

  -- TRU Waste Characterization/Certification Program, Procedure Title: Waste Container Tracking, Procedure Number TWCP-QP-1.1-032, R.1, Effective Date 07/15/97.

  -- TRU Waste Characterization/Certification Program, Quality Procedure, Procedure Title: WWIS Data Entry, Procedure Number TWCP-QP-1.1-034, R.0, Effective Date 08/16/97.

  -- TRU Waste Characterization/Certification Program, TWCP Quality Procedure, Procedure Title: Random Selection of Containers and Sampling Locations for the TRU Waste Characterization Activities, Procedure Number TWCP-DPT-1.2-014, R.3, Effective Date 04/14/97.

  -- TRU Waste Characterization/Certification Program, TWCP Detailed Technical Procedure, Procedure Title: Detailed Technical Procedure for the Determining Isotopic Ratios in Waste Containers Using the RANT PC FRAM Assay System, Procedure Number TWCP-DTP-1.2-029, R.0, Dated 07/18/97.

  - Carlsbad Area Office, Audit A-07 of the Los Alamos National Laboratory (LANL), Procedure Title: TRU Waste Characterization, Transportation and Certification, Post Audit Conference, Dated 08/22/97.

- During the WWIS Test and LANL Follow-up Audit in September 1997, DOE provided EPA with the following information. This information is included in EPA Technical Support Document for Section 194.24: Waste Characterization Status of INEL, LANL, RFETS (Docket A-93-02, Item III-B-18).

  - Test Data, WIPP Waste Information System Program, Procedure Number WP 05-WA.02. Rev.0, Chg.1, Attachment 4- Shipping Review of Cellulose, Plastics and Rubber, Dated 09/11/97.

  - WIPP Waste Information System Software Quality Assurance Program, Rev. 0, Procedure Number WP 05-WA.04, Effective Date 05/09/97.

  - Attachment 1- Engineering Change Order, Rev.0, Chg.11, WWIS Software Modification, ECO No. 8688, Dated 07/15/97.

  - WIPP Waste Information System Software Verification and Validation Plan, Rev. 0, Procedure Number WP 05-WA.05, Effective Date 06/17/97.

  - WIPP Waste Information System Software Requirements Specifications, Rev.0, Procedure WP 05-WA.06, Effective Date 06/17/97.

  - WIPP Waste Information System User's Manual, For Use by Shippers/Generators, Procedure Number DOE/CAO-97-2273, Dated 09/04/97.

  - WIPP Waste Information System Software Design Description, Attachment 1-Change Notice, Dated 06/21/97.

  - WIPP Waste Information System Configuration Management Plan, Rev. 0, Procedure Number WP 05-WA.08, Effective Date 06/18/97.

  - WIPP Waste Information System, Test Data, Nuclide Report, Dated 09/11/97.

  - WIPP Waste Information System, Waste Container Data Report, Dated 09/11/97.

  - WIPP Waste Information System Program, Rev. 0, Procedure Number WP 05-WA.02, Effective Date 04/15/97.

- DOE forwarded to EPA on September 15, 1997, a memorandum dated September 10, 1997, to M.S.Y. Chu, Org from L.C. Sanchez, entitled, “Recalculation of Waste Unit Factor With the Corrected Radionuclide Inventory.” (Docket A-93-02, Item II-G-42).

- DOE WPO 046766. DOE forwarded to EPA August 8, 1997, a memorandum dated August 8, 1997, from Sayan Chakraborti to Margaret Chu, entitled, "*Assumptions and Methodology Involved in the Estimation of the WIPP Disposal Radionuclde Inventory in the CCA*." (Docket A-93-02, Item II-G-43).

- Letter dated September 15, 1997 (Docket A-93-02, Item II-I-61) from DOE to EPA transmitting Transcripts for Sessions 1-7, Public Meetings held in Carlsbad, New Mexico, May 5 - 7, 1997, regarding "*Expert Elicitation on WIPP Waste Particle Diameter Size Distribution(s) During the 10,000-Year Regulatory Post-Closure Period*." Transcripts filed A-93-02, Item II-G-37.

- Letter from DOE to EPA responding to John Brederhoeft's memorandum of July 28, 1997, titled "*Rebuttal Tehnical Review of the HARTMAN Scenario: Implications for WIPP*" WPO #46999, SNL memorandum dated August 28, 1997. Dated September 5, 1997. Docket A-93-02, Item II-I-63.

- DOE/CAO-95-2119 - "*Generator Site Certification Guide*," Revision 1. Dated August 1997. Docket A-93-02, Item II-G-38.

- DOE forwarded to EPA on September 15, 1997, *Summary of the EPA-Mandated Performance Assessment Verification Test Resuslts for the Individual and Groundwater Protection Requirements*, WPO#47258. Dated September 12, 1997. Docket A-93-02, Item II-G-39. (The transmittal letter is filed A-93-02, Item II-I-65).

- DOE forwarded to EPA on September 29, 1997, *Summary of the EPA-Mandated Performance Assessment Verifiction Test Results for Individual Prtoection Requirements: Estimated Doses to Internal Organs and Total Body from Groundwater Ingestion and to the Total Body from Beef Consumption, Vegetable Consumption and Inhalation of Soil*, WPO#47309. Dated September 22, 1997. Docket A-93-02, Item II-G-40. (The transmittal letter is filed A-93-02, Item II-I-68).

- DOE forwarded to EPA on September 29, 1997, *Analysis Report of an Evaluation of the Dose Contributions from Beta, Electron and Photon Emissions to Critical Organs Related to Drinking Water Consumed for the Undisturbed Performance supporting the Compliance Certification Appliction*, WPO#47308. Dated September 22, 1997. Docket A-93-02, Item II-G-41. (The transmittal letter is filed A-93-02, Item II-I-68).

- On September 18, 1997 DOE/OGC transmitted document titled, "*Information in the Compliance Certification Application that Demonstrates compliance with Section 194.24*". Docket A-93-02, Item II-I-69.

- DOE provided EPA a copy of its September 12, 1997 memorandum to G. Thomas Todd, Area Manager, LAAO, regarding: *Site Certification of Los Alamos National Laboratory*. Docket A-93-02, Item II-I-70. The following attachments were included:

Attachment 1 - LANL Certification Program Status
Attachment 2 - Elements Audited during CAO Certification Audits of LANL (A-97-01, A-97-07 and A-97-16)

- Summary of EPA contractor/SC&A interactions with Sandia National Laboratories staff concerning EPA modeling of fluid injection using BRAGFLO (April 23, 1998, Memo to file) (Docket A-93-02, Item IV-E-24)

- Summary of EPA contractor/TechLaw/Charles Wilson's interactions with Sandia National Laboratories staff on fractured interbed calculations (April 23, 1998, Memo to file) (Docket A-93-02, Item IV-E-25)

- Summary of EPA contractor/TechLaw Charles Wilson's interactions with SNL staff on documentation of CCDFGF changes for air drilling (supplemental information to Docket A-93-02, Item IV-E-21) April 23, 1998, Memo to file:(Docket A-93-02, Item IV-E-26)

- Summary of EPA contractor SC&A interactions with Carlsbad Area Office Technical Assistance Contract staff concerning air drilling modeling (April 23, 1998, Memo to file) (Docket A-93-02, Item IV-E-27)