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8.0 INDIVIDUAL AND GROUNDWATER PROTECTION REQUIREMENTS

The quantitative release limits set forth in the Containment Requirements provisions of Title 40 of the Code of Federal Regulations (CFR) § 191.13 are one of three long-term numerical performance requirements contained in 40 CFR Part 191 Subparts B and C. The Waste Isolation Pilot Plant (WIPP) must also comply with two other numerical performance standards that are contained in the individual (40 CFR § 191.15) and groundwater (40 CFR Part 191, Subpart C) protection requirements. This section describes the U.S. Department of Energy's (DOE's) demonstration of compliance for the WIPP with both the individual and groundwater protection requirements.

In performing the compliance assessment for the CCA, the DOE applied a bounding-analysis approach using unrealistic assumptions that resulted in an overestimation of potential doses and contaminant concentrations. To provide added assurance, the DOE assumed the presence of an underground source of drinking water (USDW) in close proximity to the WIPP Land Withdrawal Area boundary, even though available data indicate that none exists near the boundary. Using this very conservative approach, the calculated maximum potential dose to an individual was found for the CCA evaluation to be about one-sixteenth of the individual protection standard. Concentrations of contamination in the hypothetical USDW would be less than half of the U.S. Environmental Protection Agency (EPA) groundwater protection limits and potential doses to a receptor who drinks from the hypothetical USDW would be an order of magnitude less.

This conservative approach also assumes that all contaminants reaching the accessible environment are directly available to a receptor. The analysis bounds any potential impacts of underground interconnections among bodies of surface water, groundwater, and any USDW.

In support of its recertification effort, the DOE has reexamined concentrations of radionuclides that could potentially reach the accessible environment under undisturbed conditions. This evaluation shows that the maximum concentration of radionuclides reaching the boundary is now projected to be six orders of magnitude less than the maximum concentration projected in the CCA. Based on this and additional updated information presented in the remainder of this chapter, the DOE concludes that the project continues to comply with the individual and groundwater protection provisions of Part 191, Subparts B and C. (See Table 1-1 in Chapter 1.0 for a list of appendices that provide additional information supporting this chapter.)

8.1 Individual Protection Requirements

The individual protection requirements are contained in 40 CFR § 191.15 of the long-term disposal regulations. 40 CFR § 191.15(a) requires that

> Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that, for 10,000 years after disposal, undisturbed performance of the disposal system shall not cause the annual committed effective dose, received through all potential pathways from the disposal system to any member of the public in the accessible environment, to exceed 15 millirems (150 microsieverts).

Undisturbed performance (UP) is defined in Subpart B of 40 CFR Part 191 to mean "the predicted behavior of a disposal system, including consideration of the uncertainties in predicted behavior, if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events" (40 CFR § 191.12). Section 6.3.1 provides a description of UP, the conceptual models associated with UP, and the screening of features, events, and processes (FEPs) that are important to UP.

The method used to evaluate compliance with the individual protection requirements is related to that developed for assessing compliance with the containment requirements. If the evaluation of the UP scenario considered for the containment requirements shows contaminants will reach the accessible environment, the resulting dose to exposed individuals must be calculated and compared to the 15-millirem annual committed effective dose specified in 40 CFR § 191.15.

Further guidance on the implementation of the individual protection requirements is found in 40 CFR Part 194. 40 CFR § 194.51 states that

> Compliance assessments that analyze compliance with § 191.15 of this chapter shall assume that an individual resides at the single geographic point on the surface of the accessible environment where that individual would be expected to receive the highest dose from radionuclide releases from the disposal system.

40 CFR § 194.52 states that

> In compliance assessment that analyze compliance with § 191.15 of this chapter, all potential exposure pathways from the disposal system to individuals shall be considered. Compliance assessments with part 191, subpart C and § 191.15 of this chapter shall assume that individuals consume 2 liters per day of drinking water from any underground sources of drinking water in the accessible environment.

In addition, 40 CFR § 194.25(a) provides criteria related to the assumptions that should be made when undertaking dose calculations:

> Unless otherwise specified in this part or in the disposal regulations, performance assessments and compliance assessments conducted pursuant to the provisions of this part to demonstrate compliance with § 191.13, § 191.15 and part 191, subpart C shall assume that characteristics of the future remain what they are at the time the compliance application is prepared, provided that such characteristics are not related to hydrogeologic, geologic or climatic conditions.

8.1.1 Compliance Assessment of Undisturbed Performance

40 CFR § 194.52 specifies that compliance assessments consider "all potential pathways from the disposal system to individuals." The DOE has considered the following potential pathways for groundwater flow and radionuclide transport:

- existing boreholes, as required by 40 CFR § 194.55(b)(1); and
- potential boreholes, including those that may be used for fluid injection as required, by 40 CFR § 194.32(c) and 40 CFR § 194.54(b)(2).

After considering all of these *pathways***,** the DOE found that contaminated brine may migrate away from the waste-disposal panels if pressure within the panels is elevated by gas generated from corrosion or microbial degradation. Two credible pathways by which radionuclides could reach the accessible environment have been identified.

1. Radionuclide transport may occur laterally, through the anhydrite interbeds toward the subsurface boundary of the accessible environment in the Salado Formation.

2. Transport may occur through access drifts or anhydrite interbeds (primarily Marker Bed [MB] 139) to the base of the shafts. In this case, if the pressure gradient between the panels and overlying strata is sufficient, contaminated brine may migrate up the shafts. As a result, radionuclides may be transported directly to the ground surface, or laterally away from the shafts, through permeable strata such as the Culebra, toward the subsurface boundary of the accessible environment.

These conceptual release pathways for UP are illustrated in Figure 6-9. The modeling system described in Section 6.4 does not preclude potential radionuclide transport along other pathways, such as migration through Salado halite. However, the natural properties of the undisturbed system make radionuclide transport to the accessible environment via these other pathways unlikely.

Although both pathways are possible, the performance assessment (PA) modeling indicates that under undisturbed conditions, only the first is a potential pathway during the 10,000-year period of interest specified in the regulation (see Appendix PA, Section PA-7.2).

The DOE has used the modeling system applied to the PA, as described in Chapter 6.0, to make this determination. Scenario screening for the UP is described in Appendix PA, Attachment SCR. As specified by 40 CFR § 194.54(b)(2), Appendix PA, Attachment SCR identifies activities that may occur in the vicinity of the disposal system prior to or soon after disposal and documents which of these are included in the compliance assessment calculations. Table 6-8 in Section 6.2 identifies FEPs included in the UP modeling. Appendix PA, Attachment SCR also identifies FEPs that were considered, but are not included, in the modeling evaluation and the reasons for their elimination.

As specified by 40 CFR § 194.55(a), uncertainty in the performance of the compliance assessment is documented in Section 6.1.2. Probability distributions for uncertain disposal system parameter values used in the compliance assessment were developed and are documented in Appendix PA, Attachment PAR. Section 8.1.5 identifies sampled parameters used in the compliance assessment.

For both the CCA compliance assessment and the CRA compliance assessment, 300 realizations of the modeling system were generated to evaluate UP. These 300 realizations are composed of three sets of 100 realizations each generated using the Latin hypercube sampling (LHS) method. In both the CCA and CRA evaluations, none of the 300 realizations show any radionuclides reaching the top of the Salado through the sealed shafts.

In the CCA evaluation, nine of the 300 realizations show concentrations of radionuclides greater than zero reaching the accessible environment through the anhydrite interbeds. None of the remaining 291 realizations show radionuclides reaching the accessible environment through the anhydrite interbeds during 10,000 years. Table 8-1 shows the maximum concentrations of radionuclides calculated by the modeling evaluation as reaching the accessible environment in the nine nonzero CCA realizations. The full range of estimated values for radionuclide concentrations for the CCA evaluation is from zero to the values shown in Table 8-1. The maximum concentration values shown in Table 8-1 occur 10,000 years after the time of decommissioning.

Table 8-1. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for the CCA Analysis

CCA Realization No.	Maximum Concentrations (curies/liter)					
	Vector No.[1]	^{241}Am	^{239}Pu	^{238}Pu	^{234}U	^{230}Th
1	Replicate 1 Vector 46	1.36×10^{-17}	4.33×10^{-12}	Negligible[2]	5.82×10^{-13}	2.10×10^{-14}
2	Replicate 2 Vector 16	Negligible	5.13×10^{-14}	Negligible	6.77×10^{-15}	1.89×10^{-17}
3	Replicate 2 Vector 25	Negligible	1.35×10^{-15}	Negligible	1.65×10^{-16}	7.00×10^{-18}
4	Replicate 2 Vector 33	1.32×10^{-17}	7.18×10^{-14}	Negligible	9.76×10^{-15}	9.36×10^{-16}
5	Replicate 2 Vector 81	Negligible	6.23×10^{-18}	Negligible	Negligible	Negligible
6	Replicate 2 Vector 90	Negligible	5.20×10^{-16}	Negligible	7.40×10^{-17}	Negligible
7	Replicate 3 Vector 3	3.50×10^{-18}	3.08×10^{-13}	Negligible	4.32×10^{-14}	1.07×10^{-16}
8	Replicate 3 Vector 60	5.98×10^{-17}	7.41×10^{-14}	Negligible	9.09×10^{-15}	2.30×10^{-15}
9	Replicate 3 Vector 64	5.42×10^{-17}	5.85×10^{-12}	Negligible	7.61×10^{-13}	4.68×10^{-15}
10-300		Negligible	Negligible	Negligible	Negligible	Negligible

1 Parameter values applied to each vector may be found in CCA (Appendix IRES, Tables IRES-2, IRES-3, and IRES-4).
2 Values less than 10^{-18} curies per liter are considered negligible relative to the other values and are not reported.

The maximum concentrations of radionuclides calculated by the CRA evaluation to reach the accessible environment are shown in Table 8-2. In the CRA evaluation, only one of the 300 realizations shows concentrations of radionuclides greater than zero reaching the accessible environment through the anhydrite interbeds (see Appendix PA, Section PA-7.2). The remaining 299 realizations show no radionuclides reaching the accessible environment during the 10,000-year period. The reduction in the number of realizations showing radionuclides reaching the accessible environment is due to changes in the BRAGFLO grid and enhancements to the PA modeling system that have increased model accuracy and decreased numerical dispersion.

Table 8-2. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for the CRA Analysis

CRA Realization No.	Vector No.[1]	Maximum Concentrations (curies/liter)				
		^{241}Am	^{239}Pu	^{238}Pu	^{234}U	^{230}Th
1	Replicate 1 Vector 82	Negligible	2.53×10^{-18}	Negligible	Negligible	Negligible
2-300	—	Negligible	Negligible	Negligible	Negligible	Negligible

[1] Parameter values applied to each vector may be found in Appendix PA, Attachment PAR.
[2] Values less than 10^{-18} curies per liter are considered negligible relative to the other values and are not reported.

In this single CRA realization, only one radionuclide has a non-zero concentration reaching the accessible environment. The radionuclide plutonium-239 (^{239}Pu) has a concentration of 2.53×10^{-18} curies per liter (Garner 2003). This compares with the maximum concentration of ^{239}Pu calculated for the CCA evaluation of 5.85×10^{-12} curies per liter. The concentration of ^{239}Pu in the CRA evaluation is six orders of magnitude lower than that shown for the CCA evaluation. In the CRA evaluation, no other radionuclides are calculated in concentrations greater than the 10^{-18} cut-off, where americium-241 (^{241}Am), uranium-234 (^{234}U), and thorium-230 (^{230}Th) all had concentrations exceeding the cut-off in the CCA. Since the CRA evaluation shows only one radionuclide contributing to a potential dose, and the concentration is six orders of magnitude lower than that shown for the CCA evaluation, the CCA dose estimates are bounding. No new dose calculations are necessary**.**

8.1.2 Dose Calculation

As quoted earlier, 40 CFR Part 194 states that doses must be estimated for an individual who resides at the location in the accessible environment where that individual would be expected to receive the highest exposure to radionuclide releases from the disposal system (40 CFR § 194.51). All potential pathways for exposure associated with the UP of the repository must be assessed (40 CFR § 194.52).

8.1.2.1 Transport Pathway

To perform the required dose calculation, it is necessary to specify possible pathways for the transport of the contaminants from the anhydrite interbeds to a receptor. The specified pathway is an abandoned, deep borehole that intersects the contaminant plume in the accessible environment. Consistent with assumptions described in Section 6.4.7.2 and the information provided in CCA Appendix DEL, the hole is assumed to have the permeability of an uncased hole filled with silty sand after the degradation of a borehole plug in the Rustler Formation. A pressure gradient is assumed to exist because of the pressures in the anhydrite resulting from gas generation in the repository. The pressures are assumed to be sufficient to force contaminants up the abandoned hole to the Culebra Formation or the Dewey Lake Formation. The contaminants would then be available to a receptor through a well used to supply drinking water. This conceptual transport pathway is shown in Figure 8-1. This is the only credible pathway that the DOE has been able to identify. As such, no inhalation or direct radiation exposures are anticipated.

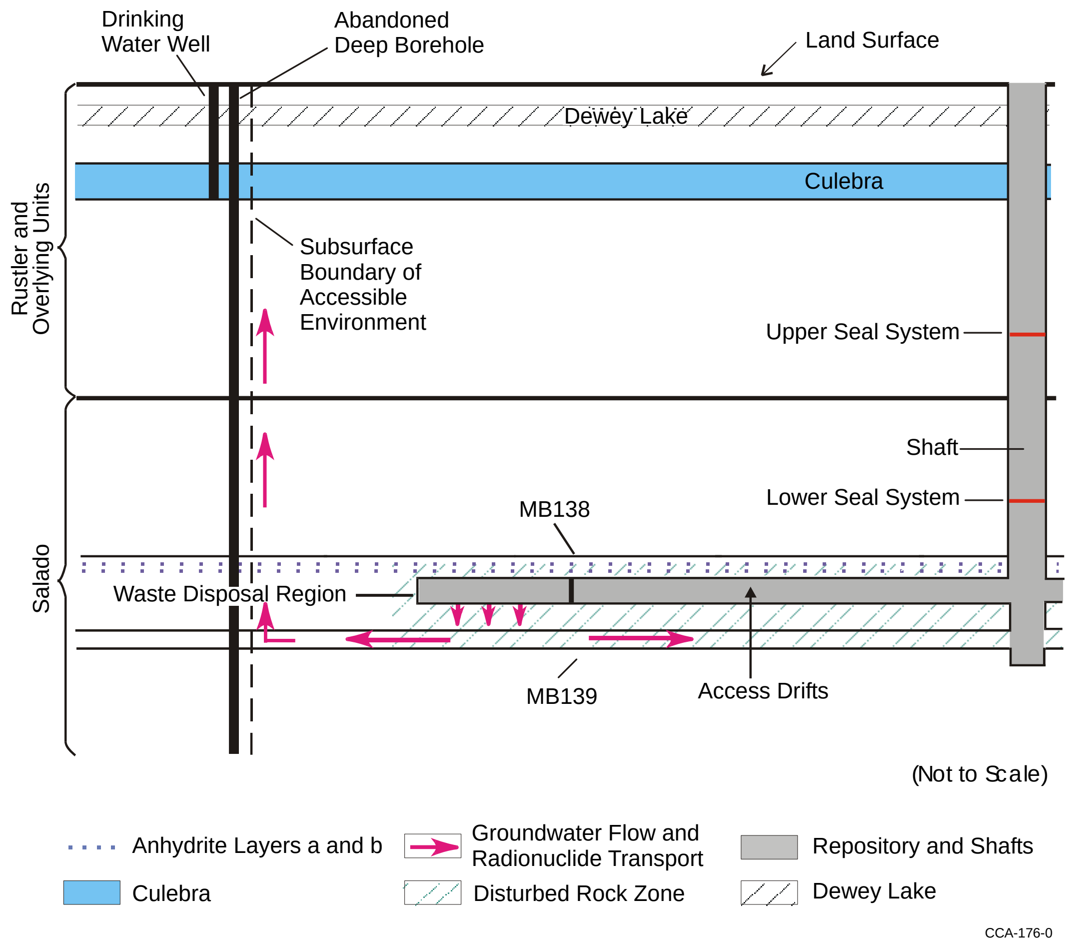

Figure 8-1. Conceptual Transport Pathway

As specified in 40 CFR § 194.54(b), this pathway considers the presence of an existing borehole. As discussed in Section 6.2.5, the influence of other existing boreholes has been evaluated in the FEPs screening for UP.

8.1.2.2 Bounding Analysis

Uncertainty in the calculation of radionuclide concentrations in the anhydrite interbeds is described in Section 6.1.2. Additional uncertainty is involved in the calculation of doses resulting from the specified exposure pathway. Given this uncertainty, the DOE elected for the CCA evaluation to perform a bounding analysis using assumptions that do not represent reality, but that would result instead in a bounding estimate much greater than any reasonably expected dose to a receptor. If this unrealistic, yet bounding, analysis results in calculated doses to the receptor that are below the regulatory limit, compliance with the standard is demonstrated. If subsequent analyses, such as those performed to support this application, have lower initial concentrations than the bounding CCA analysis, recalculation of the doses is unnecessary because the original bounding analysis is conservative and shows results below regulatory limits.

The bounding analysis used for the CCA assessment was based on the following factors and assumptions.

1. No specific transport mechanism was postulated. Instead, all of the contaminants reaching the accessible environment within the anhydrite interbeds during the year of maximum releases (that is, year 10,000) were assumed to be available to a receptor.

2. Brine derived from the anhydrite interbeds had total dissolved solids (TDS) concentrations of about 324,000 parts per million; this represents a concentration that could not be consumed by humans. For the bounding analysis, the calculation includes the dilution of this brine by a factor of 32.4 to a TDS concentration of 10,000 parts per million, which is the upper limit for potable water.

3. The resulting annual committed effective dose was calculated based on a 50-year dose commitment. A 50-year dose commitment was selected because this period is specified in Appendix B of 40 CFR Part 191 and because it is the duration for which published external dose-rate conversion factors are readily available in the literature (DOE 1988).

4. The individual receptor was assumed to drink two liters of water each day (as specified in 40 CFR § 194.52) for one year (in accordance with the specification of an annual committed effective dose in Appendix B of 40 CFR Part 191).

40 CFR § 194.51 states that DOE shall assume an individual resides at the single geographic point where that individual would receive the highest dose. With the bounding analysis, the DOE complies with the intent of this criterion but the specific location of the receptor is not identified, because all of the contaminants reaching the accessible environment within the anhydrite interbeds during the year of maximum releases are assumed to be directly available to the receptor, regardless of the receptor's location. The well from which the receptor drinks is assumed to be located where the contaminants reaching the anhydrite interbeds are delivered directly to the well.

The bounding analysis dose calculation was performed using the GENII-A code. CCA Appendix GENII describes the modeling method. GENII-A incorporates dose-calculation guidance provided in Appendix B of 40 CFR Part 191.

8.1.3 Dose Calculation Results

The maximum doses calculated from the releases listed in Table 8-1, after applying the factors and assumptions listed above, are shown in Table 8-3. These doses are greater than any realistic doses that could be delivered to a receptor. The calculated doses are well below the regulatory standard, which is an annual committed effective dose of 15 millirems.

Table 8-3. Calculated Maximum Annual Committed Effective Doses for the CCA Evaluation

Realization No.	Vector No.[1]	Maximum Annual Committed Effective Dose (millirems)
1	Replicate 1 Vector 46	3.4×10^{-1}
2	Replicate 2 Vector 16	4.3×10^{-3}
3	Replicate 2 Vector 25	1.1×10^{-4}
4	Replicate 2 Vector 33	5.8×10^{-3}
5	Replicate 2 Vector 81	5.1×10^{-7}
6	Replicate 2 Vector 90	4.3×10^{-5}
7	Replicate 3 Vector 3	2.5×10^{-2}
8	Replicate 3 Vector 60	6.2×10^{-3}
9	Replicate 3 Vector 64	4.7×10^{-1}
10-300	—	Negligible[2]

[1] Parameter values applied to each vector may be found in CCA Appendix IRES, Tables IRES-2, IRES-3, and IRES-4.
[2] Doses derived from Table 8-1 concentration values of less than 10^{-18} curies per liter are considered negligible and are not reported.

On February 26, 1997, DOE submitted supplementary information to EPA in response to an EPA request for additional information (Docket A-93-02, Item II-I-10, Enclosure 2h). The supplementary information describes how DOE extended its initial bounding analysis to account for exposure pathways besides direct ingestion of contaminated water by humans. Specifically, the analysis was expanded to include consumption of contaminated water by cattle (leading to the receptor's consumption of contaminated milk and beef), consumption of crops irrigated with contaminated water, and inhalation of airborne dust from soil contaminated by irrigation. DOE found that the contribution of these pathways added 0.46 millirem per year to the calculated dose associated with the realization showing the highest concentration of radionuclides reaching the boundary of the accessible environment under undisturbed conditions. The maximum total dose calculated from all pathways was 0.93 millirem per year, well below the 15-millirem-per-year regulatory standard.

Given that the maximum concentration of radionuclides shown to reach the accessible environment for the CRA analysis is six orders of magnitude less than the maximum value calculated for the CCA evaluation, resulting potential doses to the receptor would also be well below the 15-millirem standard. As such, the CCA dose calculation bounds any possible dose to a receptor for the CRA evaluation and new dose calculations are not needed to demonstrate compliance. The CCA results are bounding, and continued compliance with the individual protection standard is demonstrated.

8.1.4 Statistical Assessment

EPA criterion 40 CFR § 194.55(d) specifies that the "number of estimates generated pursuant to paragraph (c) of this section shall be large enough such that the maximum estimates of doses and concentrations generated exceed the 99th percentile of the population of estimates with at least a 0.95 probability." The probability that an individual estimate is below the 99th percentile is, by definition, 0.99. This means that only 1 in 100 estimates would have a value exceeding the 99th percentile, or conversely, 99 times out of 100, the estimate would have a value below the 99th percentile. It follows that for two independent events, the probability of both estimates having a value below the 99th percentile is equal to the product (0.99)(0.99), or $(0.99)^2$, and that for n events, the probability that all estimates have a value below the 99th percentile is equal to $(0.99)^n$. To ensure a value exceeds the 99th percentile with a specified probability, the complement $(1 - 0.99^n)$ is used to calculate the number of estimates required.

The probability specified by 40 CFR § 194.55(d) is 0.95, or 95-percent confidence, that the maximum estimates of doses and concentrations generated exceed the 99th percentile of the population of estimates. Therefore, the following equation can be solved for n, and the number of estimates required is

$$1 - 0.99^n = 0.95 \text{ or } n\log(0.99) = \log(0.05), \tag{8.1}$$

which implies n > 298.

The solution requires n to be greater than 298 and was used to determine that 300 realizations of the modeling system is a sufficient number to meet the confidence level specified in 40 CFR § 194.55(d).

The 300 realizations of the modeling system (as described in Section 8.1.1) report concentrations of radionuclides reaching the accessible environment within the Salado anhydrite interbeds and not doses to a receptor, as specified by 40 CFR § 194.55(d). Nevertheless, the maximum possible resulting dose to an individual is 0.93 millirems, the sum of 0.47 millirems, as reported in Table 8-3, plus the additional value of 0.46 millirems, determined to be contributed through additional dose pathways. All other potential doses resulting from the 300 realizations of the modeling system for both the CCA and CRA evaluations are below this value.

EPA criterion 40 CFR § 194.55(f) specifies that DOE shall

> document that there is at least a 95 percent level of statistical confidence that the mean and the median of the range of estimated radiation doses and the range of estimated radionuclide concentrations meet the requirements of § 191.15 and part 191, subpart C of this chapter, respectively.

Because the DOE has developed a bounding analysis, it is not meaningful to calculate and present mean and median dose values. Instead, the bounding analysis provides 100 percent confidence that all potential doses will be below the 0.93 millirem value.

8.1.5 Parameter Values

Parameter values applied to the CCA modeling assessment for UP are described in CCA Appendix PAR and Section 8.1.5. Parameters used in the PA and compliance assessment modeling program for the CRA are described in Appendix PA, Attachment PAR. As provided by 40 CFR § 194.55(b), Appendix PA, Attachment PAR also identifies the probability distributions for these parameters, their units, the models and codes in which the parameters are used, the functional form of the probability distributions used for the sampled parameters, and associated input data.

8.1.6 Summary of Compliance with the Individual Protection Standard

In performing the compliance assessment, DOE applied a bounding-analysis approach using unrealistic assumptions that over-estimate potential doses and contaminant concentrations. This conservative approach assumes that all contaminants reaching the accessible environment are directly available to a receptor. Using this very conservative approach, the calculated maximum potential dose to an individual from the CCA evaluation would be about one-sixteenth of the individual protection standard. Given that modeled maximum radionuclide concentrations in the accessible environment for the CRA evaluation are well below those of the CCA evaluation, the CCA results are bounding and continued compliance with the individual protection standard is demonstrated.

8.2 Groundwater Protection Requirements

The groundwater protection requirements are contained in Subpart C of 40 CFR Part 191. In particular, 40 CFR § 191.24(a)(1) requires that

> *General*. Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that 10,000 years of undisturbed performance after disposal shall not cause the levels of radioactivity in any underground source of drinking water, in the accessible environment, to exceed the limits specified in 40 CFR Part 141 as they exist on January 19, 1994.

EPA rule 40 CFR Part 141 specifies the National Primary Drinking Water Standards. The levels of radioactivity (and dose equivalent in the case of 40 CFR § 141.16[a]) specified in 40 CFR Part 141, as of January 19, 1994 were:

1. Combined ^{226}Ra and ^{228}Ra(40 CFR § 141.15[a]): 5 picocuries per liter;

2. Gross alpha particle activity, including ^{226}Ra but excluding radon and uranium (40 CFR § 141.15[b]): 15 picocuries per liter;

3. Annual dose equivalent to the total body or any internal organ from the average annual concentration of beta particle and photon radioactivity from man-made radionuclides (40 CFR § 141.16[a]): 4 millirem per year.

In addition, Section 194.53 applies to DOE's consideration of USDWs. The criterion specifies that

> In compliance assessments that analyze compliance with part 191, subpart C of this chapter, all underground sources of drinking water in the accessible environment that are expected to be affected by the disposal system over the regulatory time frame shall be considered. In determining whether underground sources of drinking water are expected to be affected by the disposal system, underground interconnections among bodies of surface water, groundwater, and underground sources of drinking water shall be considered.

To assess compliance with these provisions of the regulations, it is first necessary to identify any USDW that may be located near the WIPP. DOE's evaluation of whether any USDW is located near the WIPP is provided as CCA Appendix USDW and is summarized in Section 8.2.2. In developing the CRA, DOE reevaluated the presence of USDWs near the WIPP and supplemented the information presented in CCA Appendix USDW. The supplemental information is also provided in Section 8.2.2. Based on this review, DOE believes that no deviation from the findings and conclusions of the 1996 evaluation is warranted.

8.2.1 Criteria for USDW Determination

In evaluating the presence of any USDW, it is necessary to establish criteria to apply to water quality and quantity data from wells in the vicinity of the WIPP. The criteria must be based on the regulatory definition of a USDW, as provided in 40 CFR § 191.22. A USDW is defined in 40 CFR § 191.22 to mean an aquifer or its portion that

> (1) Supplies any public water system; or
>
> (2) Contains a sufficient quantity of groundwater to supply a public water system; and
>
> (I) Currently supplies drinking water for human consumption; or
>
> (ii) Contains fewer than 10,000 milligrams of total dissolved solids per liter.
>
> "Public water system" means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. Such term includes:
>
> (1) Any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system; and
>
> (2) Any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.
>
> "Total dissolved solids" means the total dissolved (filterable) solids in water as determined by use of the method specified in 40 CFR Part 136.

Criteria based on these definitions were developed by the DOE and are used to assess the presence of any USDW near the WIPP. These criteria are defined in the following subsections.

8.2.1.1 Groundwater Quantity

Two subcriteria have been identified by the DOE and applied to the groundwater quantity definition:

1. An aquifer or its portion must be capable of producing water at an adequate rate, and

2. An aquifer or its portion must be capable of producing water for a sufficient duration.

Water-consumption information was evaluated by the DOE to define the first subcriterion (the ability to produce at an adequate rate). The value to be applied is determined by obtaining the following information.

1. The rate, over a 24-hour period, at which water is consumed by 15 service connections.

2. The rate, over a 24-hour period, at which water is consumed by 25 individuals.

To conservatively define a USDW, the lower of these two values is assigned by the DOE to the first subcriterion. Based on calculations presented in CCA Appendix USDW and updated in support of the CRA, a quantity of five gallons per minute is assigned as the first subcriterion. Details on the derivation of the five-gallon-per-minute value are provided below.

For the CCA evaluation, the rate of consumption by 15 service connections was calculated using the data provided in Table 8-4. These are 1990 U.S. Bureau of the Census data for the number of persons per household in southeastern New Mexico communities and water-consumption data for the same communities. The water-consumption data were obtained from the New Mexico State Engineer's Office (Wilson 1992).

Table 8-4. Persons Per Household and Water Consumption Values Used in the CCA

Community	Persons Per Household, 1990	Gallons Per Capita Per Day
Artesia	2.69	285
Carlsbad	2.63	307
Hobbs	2.81	267
Lovington	2.96	264
Roswell	2.66	285
Average	2.75	282

Sources: U.S. Bureau of the Census (1990); Wilson (1992).

As reported in Wilson (1992), the average water usage in these communities was 282 gallons per person per day. The 1990 census statistics for these communities show an average of 2.75 people per household. One household equals one service connection.

Therefore:

2.75 people × 282 gallons per person per day = 775.5 gallons per service connection per day,

775.5 gallons per day per service connection × 15 connections = 11,633 gallons per day, and

11,633 gallons per day/1,440 minutes per day = 8.08 gallons per minute.

The rate of consumption by 15 service connections, based on the 1990 and 1992 statistics, is calculated to be 8.08 gallons per minute.

The rate over a 24-hour period at which water would be consumed by 25 individuals may be calculated using these same data. The average water usage was 282 gallons per person per day in area communities. The consumption of water by 25 people equals:

282 gallons per person per day × 25 people = 7050 gallons per day, and

7050 gallons per day/1,440 minutes per day = 4.89 gallons per minute.

Based on these two calculations, the quantity consumed by 25 individuals (4.89 gallons per minute; nominally 5 gallons per minute) is smaller than the quantity consumed by 15 service connections (8.08 gallons per minute). To conservatively determine the quantity derived from a well that meets this DOE quantity criterion, the five-gallons-per-minute value was applied to the CCA evaluations.

In updating this calculation for the CRA, more current census data and water consumption data were obtained. These more current data are provided in Table 8-5. The updated calculations are provided below.

Table 8-5. Persons Per Household and Water Consumption Values Used in the CRA

Community	Persons Per Household, 2000[1]	Gallons Per Capita Per Day, 2000[2]
Artesia	2.61	390
Carlsbad	2.51	277
Hobbs	2.72	284
Lovington	2.80	289
Roswell	2.58	283
Average	2.64	305

Sources: 1. U.S. Bureau of the Census (2000); 2. New Mexico Office of the State Engineer (2002).

The average water usage in these communities is 305 gallons per person per day. The 2000 census statistics for these communities show an average of 2.64 people per household. One household equals one service connection.

Therefore:

2.64 people × 305 gallons per person per day = 805.2 gallons per service connection per day,

805.2 gallons per day per service connection × 15 connections = 12,078 gallons per day, and

12,078 gallons per day/1,440 minutes per day = 8.39 gallons per minute.

Using updated data, the rate of consumption by 15 service connections is calculated to be 8.39 gallons per minute.

The rate over a 24-hour period at which water would be consumed by 25 individuals may be calculated using these same data. The current average water usage is 305 gallons per person per day in area communities. The consumption of water by 25 people equals:

305 gallons per person per day × 25 people = 7625 gallons per day, and

7625 gallons per day/1,440 minutes per day = 5.30 gallons per minute.

Based on these two calculations, the quantity consumed by 25 individuals (5.30 gallons per minute; nominally 5 gallons per minute) is smaller than the quantity consumed by 15 service connections (8.39 gallons per minute). To conservatively determine the quantity derived from a well that meets the quantity subcriterion, the five-gallons-per-minute value is applied. No change in this subcriterion is warranted as a result of applying current census and water consumption data to the calculation.

The definition of the second quantity subcriterion (the acceptable production duration from a well) is more subjective. Because the creation of a public water supply system involves considerable capital expense, it is reasonable to assume that such a water system would not be constructed unless the water source would continue to be available for some time, at least long enough to recover the capital expense. The Rural Utility Service of the U.S. Department of Agriculture provides loans for funding new rural water supply systems. The loan periods are generally 40 years in duration. Based on this, a duration of 40 years is applied by the DOE to the second quantity subcriterion.

8.2.1.2 Groundwater Quality

A criterion of 10,000 mg/L of TDS is specified in 40 CFR § 191.22. Any aquifer or its portion producing water having TDS concentrations below this level is determined to produce water that meets the quality criterion for a USDW. Any aquifer or its portion producing water TDS concentrations at or above this level is determined to produce water that does not meet the quality criterion and the regulatory definition of a USDW.

8.2.2 Comparison with Underground Source of Drinking Water Determination Criteria

For the CCA evaluation, current conditions and available hydrogeologic data were reviewed by the DOE to assess the presence of USDWs near the WIPP. This assessment compares current conditions and available data to the groundwater quantity and quality criteria described above. The results of this comparison are summarized below and provided in detail in CCA Appendix USDW. In addition, relevant updated information is provided here to support the CRA.

Five geologic units within the vicinity of the WIPP could potentially meet the definition of a USDW under Subpart C of 40 CFR Part 191. These include:

1. the Capitan Aquifer of the Guadalupian reef complex,
2. the Culebra,
3. the Magenta Dolomite Member of the Rustler Formation,

4. the Dewey Lake, and

5. the Santa Rosa Sandstone of the Dockum Group.

Investigations conducted in the vicinity of the WIPP to characterize the hydrology of these formations are described in CCA Appendix USDW. Important sources of relevant information are identified and findings or conclusions related to the presence of USDWs are provided. Based on this work and the recent update performed to support the CRA, the DOE has concluded that USDWs are present in the Culebra, and, because of inconclusive groundwater production data, possible USDWs are present in the Dewey Lake and the Santa Rosa. USDWs in the Culebra are located at WIPP water quality sampling program (WQSP) wells H-07b1, H-08b, and H-09b about 4.8, 14.5, and 10.5 km (3, 9, and 6.5 mi) to the south/southwest of the controlled area boundary, respectively. Possible USDWs may occur in the Dewey Lake, about 1.6 km (1 mi) south of the controlled area boundary, and the Santa Rosa, 12.4 to 14.5 km (7.7 to 9 mi) to the east of the controlled area boundary, where private wells (used predominantly for supplying water to livestock) have not generated available groundwater production data to assess their potential to yield a sufficient quantity to meet 40 CFR § 191.22 requirements. In the absence of such data, and to be conservative, these wells are designated as being located in possible USDWs.

In reevaluating the conclusions presented in CCA Appendix USDW, DOE reviewed available groundwater quality and quantity data for the wells identified in the appendix to determine if any data collected since 1996 are available. No new TDS or groundwater quantity data were obtained by WIPP WQSP personnel after 1996. The WQSP is a detection monitoring program operated under the provisions of the WIPP Hazardous Waste Facility Permit. Data for a variety of parameters are collected through the WIPP WQSP, but not TDS concentrations or water quantity data.

In addition, a review was performed to determine if any wells not reported in CCA Appendix USDW were drilled that may provide groundwater quality (i.e., TDS concentrations) and groundwater quantity data. One new well, identified as well C-2737, was developed at the WIPP site. This well was drilled during February and March of 2001 to replace well H-1, which was plugged and abandoned. In February of 2001, a water sample from the upper Dewey Lake Formation was obtained from this well. Laboratory analysis of this sample showed a TDS concentration of 2,590 ppm (Powers 2002).

Additional wells were installed across the WIPP site to investigate the extent of groundwater at the contact of the Santa Rosa and Dewey Lake Formations. Four monitoring wells and 12 piezometer wells were emplaced. The results of multiple rounds of sampling and analyses from these holes are reported in DES (1997). Samples from several of these holes show TDS concentrations both below and above 10,000 ppm, although it was not possible to pump water from any of these holes at rates of five gallons per minute or more.

In addition, State of New Mexico records indicate that several new wells were drilled in the southwestern portion of the study area evaluated in CCA Appendix USDW. These records, however, include no TDS or production data.

Based on this review, no modification of the USDW determinations reported in CCA Appendix USDW is warranted. The DOE continues to conclude that USDWs are present in the Culebra, and, because of inconclusive groundwater production data, possible USDWs are present in the Dewey Lake and the Santa Rosa Formations.

During its review of the CCA, EPA requested that DOE provide a map or maps showing the location of USDWs. The DOE responded to this request with supplementary information dated February 26, 1997 (Air Docket A-93-02, Item II-I-10, Enclosure 1j). The supplementary information includes a map showing the boundaries of potential USDWs nearest the WIPP in the Culebra, Santa Rosa, and Dewey Lake Formations. The EPA found the map to be sufficient for purposes of compliance assessment because it identifies potential USDWs near the WIPP. No change to this map is deemed appropriate at this time.

8.2.3 Comparison with the National Primary Drinking Water Standards

To provide additional assurance of the safety of the WIPP, the DOE prepared a bounding assessment of the concentrations of contaminants that could occur in a nearby USDW. Bounding doses that could be received by drinking from the USDW are also calculated. As was done to assess compliance with the individual protection standard, the analysis is bounding; the results do not represent reality, but rather illustrate the maximum yet unrealistic concentrations of contaminants in a hypothetical USDW and the maximum yet unrealistic resulting doses. As with the dose calculations, maximum concentrations were summed to develop concentrations for comparison with the National Primary Drinking Water Standards. The conclusions of this work, provided in the following subsections, illustrate that the consequences of the undisturbed repository are negligible, even when unrealistic assumptions are applied to the performance evaluation. The results of the bounding analysis support the position that additional characterization of groundwater near the WIPP to make a more definitive USDW determination is not warranted.

8.2.3.1 Transport Pathway

Section 8.1.2.1 describes the transport pathway assumed for the bounding analysis performed to evaluate compliance with the individual protection standard. This same transport pathway is assessed for the evaluation of compliance with the groundwater protection standard.

This pathway assumes that a USDW is located where the maximum possible concentration of radionuclides could be realized in the USDW and the maximum possible dose to an individual who drinks from the USDW could be delivered to the individual. As such, the analysis bounds the 40 CFR § 194.53 criterion specifying that DOE must consider underground interconnections among bodies of surface water, groundwater, and USDWs.

8.2.3.2 Combined ^{226}Ra and ^{228}Ra

The modeling system employed to simulate the performance of the undisturbed repository tracks the transport of the radionuclides of greatest importance to releases to the accessible environment (see Appendix TRU WASTE). These radionuclides of interest, listed in Table 8-1, are ^{241}Am, ^{239}Pu, ^{238}Pu, ^{234}U, and ^{230}Th. They do not include ^{226}Ra or ^{228}Ra because these radionuclides are not a prevalent component of the projected inventory of the repository. However, an analysis of ^{226}Ra and ^{228}Ra is required to evaluate compliance with the groundwater protection standard.

To perform the bounding analysis, the results of a NUTS code tracer exercise were used to scale the anticipated releases of ^{226}Ra and ^{228}Ra. The tracer exercise shows that an initial concentration of radionuclides in the repository of 1 kg/m^3 results in a concentration at the accessible environment boundary of 1.025×10^{-7} kg/m^3. By applying this scaling factor to the quantity of ^{226}Ra and ^{228}Ra projected to be emplaced in the repository, it is determined that the maximum concentration of these radionuclides in the accessible environment is 0.07 picocuries per liter (Wagner 2003), which is below the 40 CFR § 141.15(a) standard of 5 picocuries per liter.

This concentration is calculated by transporting the passive tracer in the flow field generated using the BRAGFLO code for Realization 1 (Replicate 1, Vector 82), shown in Table 8-2. The calculation uses the mass and activity loads for ^{226}Ra and ^{228}Ra in the radionuclide inventory at closure and at 10,000 years. These values are provided in Table 8-6. The ORIGEN 2.2 code is used to calculate the activity loads at 10,000 years; these loads are 51.43 curies of ^{226}Ra in contact-handled (CH-) and remote-handled (RH-) transuranic (TRU) waste and 7.95 curies of ^{228}Ra in CH- and RH-TRU waste. The calculated concentration is

Table 8-6. Total Inventory and Mass Loading of ^{226}Ra and ^{228}Ra

Radionuclide	Waste Type	Total Inventory at Closure (Ci)	Total Inventory at 10,000 Years (Ci)	Mass Loading (kilograms)
^{226}Ra	CH	6.28×10^{0}	4.98×10^{1}	6.35×10^{-3}
^{226}Ra	RH	4.99×10^{-5}	1.63×10^{0}	5.05×10^{-8}
^{228}Ra	CH	7.63×10^{0}	7.70×10^{0}	2.81×10^{-5}
^{228}Ra	RH	2.51×10^{-1}	2.54×10^{-1}	9.23×10^{-7}

Source: Leigh (2003)

based on the volume of brine, 5577 m^3 (169,924 ft^3), in the repository at time zero in the BRAGFLO calculation.

The total concentration (CH- and RH-TRU) of either ^{226}Ra or ^{228}Ra 10,000 years at the accessible environment boundary is calculated accordingly.

1. Calculate the total mass load at 10,000 years by multiplying the total mass load at decommissioning by the ratio of activity loadings at 10,000 years and decommissioning, respectively.

2. Calculate the total mass concentration at the accessible environment boundary by dividing by the value of brine from the BRAGFLO simulation and multiplying by the scaling factor.

3. Convert to total concentration of activity at the accessible environment boundary by multiplying by the ratio of activity loading to mass loading at decommissioning.

4. Divide the concentration by the dilution factor 32.4 (See Section 8.1.2.2).

The 0.07 picocurie per liter maximum concentration occurs in the anhydrite interbeds within the Salado and not in a zone that could realistically be a source of drinking water.

In the CCA, this value is reported as 2 picocuries per liter. During the performance of the Performance Assessment Verification Test (PAVT) (SNL 1997), it was determined that the CCA calculation used an inappropriate brine volume value and failed to account for the dilution factor. Accordingly, the PAVT analysis shows that the correct value that should have been reported in the CCA is 0.14 picocuries per liter.

8.2.3.3 Gross Alpha Particle Activity Including ^{226}Ra But Excluding Radon and Uranium

For the CCA evaluation, compliance with the 40 CFR § 141.15(b) standard was assessed by summing the maximum concentration values provided in Table 8-1 for ^{241}Am, ^{239}Pu, ^{238}Pu, and ^{230}Th and adding the value for ^{226}Ra obtained to perform the 40 CFR § 141.15(a) assessment. The value obtained by this method is 7.81 picocuries per liter, which is below the 40 CFR § 141.15(b) standard of 15 picocuries per liter. This concentration occurs in the anhydrite interbeds within the Salado and not in a zone that could realistically be a source of drinking water.

For the CRA evaluation, the only contributing radionuclide is ^{239}Pu with a concentration of 2.53 $\times 10^{-18}$ picocuries per liter (Table 8-2). This value, summed with the 0.07-picocurie-per-liter value derived for the 40 CFR § 141.15(a) assessment, is essentially 0.07 picocuries per liter, well below the 15-picocuries-per-liter standard.

8.2.3.4 Annual Dose Equivalent to the Total Body or Any Internal Organ from the Average Annual Concentration of Beta Particle and Photon Radioactivity from Man-Made Radionuclides

To assess compliance with the 40 CFR § 141.16(a) standard, an annual dose equivalent of 4 millirem per year, the transport of the following radionuclides was evaluated: ^{239}Pu, ^{238}Pu, ^{234}U, and ^{230}Th. The maximum annual committed effective dose calculated for the CCA evaluation from any of these radionuclides is 0.93 millirems, which is the value reported for transport through MB139 and is well below the regulatory standard. The 0.93 millirem value includes alpha particle radioactivity, as well as beta particle and photon radioactivity. Thus, the value is very conservative in that the 4 millirem annual dose equivalent limit is only for beta particle and photon radioactivity.

By comparison, the maximum radionuclide concentration in the accessible environment calculated for the CRA evaluation is six orders of magnitude less than the maximum bounding value calculated for the CCA (see Section 8.1.1). Resulting doses for the CRA case would be correspondingly lower, as well.

8.3 Compliance Summary

In performing the compliance assessment, the DOE applied a bounding-analysis approach using unrealistic assumptions that overestimate potential doses and contaminant concentrations. To provide added assurance, the DOE assumed the presence of a USDW in close proximity to the WIPP Land Withdrawal Area boundary, even though available data indicate that none currently exists near the boundary. Using this very conservative approach, the calculated maximum potential dose to an individual determined for the CCA evaluation would be about one-sixteenth of the individual protection standard.

For the CRA evaluation, this concentration is well below the CCA value. In addition, the maximum concentrations of contamination in the hypothetical USDW would be much less than half of the EPA groundwater protection limits and the maximum potential dose to a receptor who drinks from the hypothetical USDW would be well below one-quarter of the standard.

This conservative approach also assumes that all contaminants reaching the accessible environment are directly available to a receptor. The analysis bounds any potential impacts of underground interconnections among bodies of surface water, groundwater, and underground sources of drinking water.

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