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. 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, the DOE applied a bounding-analysis approach using unrealistic assumptions that result in the over estimation 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 currently exists near the boundary. Using this very conservative approach, the calculated maximum potential dose to an individual would be about one-thirtieth 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. (See Table 1-8 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 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 UP

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, the DOE has found that contaminated brine may migrate away from the waste-disposal panels if pressure within the panels is elevated by the generation of gas 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 (hereafter referred to as the Salado), or;

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, then contaminated brine may migrate up the shafts. As a result, radionuclides may be transported directly to the ground surface, or they may be transported 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 6-8. 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 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.

The DOE has used the modeling system applied to the performance assessment, as described in Chapter 6.0, to make this determination. Scenario screening for the UP is described in Appendix SCR. As specified by 40 CFR § 194.54(b)(2), Appendix 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 SCR-4 in Appendix SCR identifies FEPs included in the UP modeling. Appendix 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 PAR. Section 8.1.5 identifies sampled parameters used in the compliance assessment.

Three hundred realizations of the modeling system were generated to evaluate UP. These 300 realizations are comprised of three sets of 100 realizations each, generated using the Latin hypercube sampling (LHS) method. Of the 300 realizations, none show any radionuclides reaching the top of the Salado through the sealed shafts.

Nine of the 300 realizations show concentrations of radionuclides greater than zero reaching the accessible environment through the anhydrite interbeds. All of the remaining 291 realizations show that no radionuclides reach the accessible environment during 10,000 years through the anhydrite interbeds. A receptor in the accessible environment could not come in contact with the anhydrite interbeds located at a depth greater than 2,000 feet (606 meters). Table 8-1 shows the maximum concentrations of radionuclides calculated by the modeling evaluation as reaching the accessible environment in the nine nonzero realizations. The full range of estimated values for radionuclide concentrations 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.

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 from radionuclide releases from the disposal system (40 CFR § 194.51). Also as stated earlier, 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 which intersects the contaminant plume in the accessible environment. Consistent with assumptions described in Section 6.4.7.2 and the information provided in 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 (hereafter referred to as the Rustler). 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 Redbeds (hereafter referred to as the Culebra and the Dewey Lake, respectively). 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.

As specified in 40 CFR § 194.54(b), this pathway considers the presence of an existing borehole. As discussed in Section 6.2.5.1, the influence of other existing boreholes has been evaluated in the FEPs screening for UP.

8.1.2.2 Bounding Analysis

As stated earlier, 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 has elected to perform a bounding analysis using assumptions that do not represent reality, but that

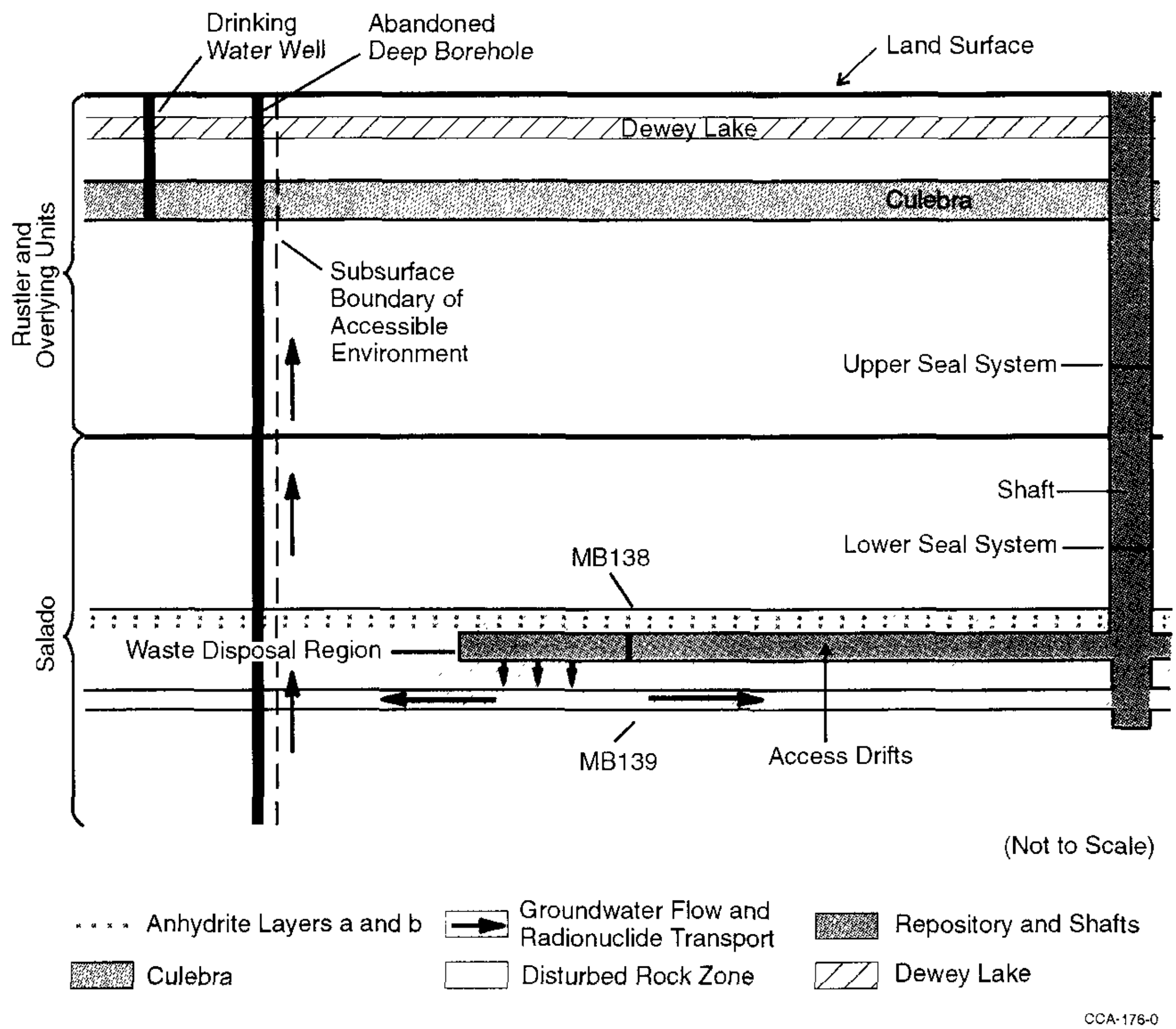

Figure 8-1. Conceptual Transport Pathway

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

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

[1] Parameter values applied to each vector may be found in Appendix IRES (Tables IRES-2, IRES-3, and IRES-4).

[2] Values less than 10^{-18} curies per liter are considered to be negligible relative to the other values and are not reported.

would result instead in a bounding estimate that is 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.

The bounding analysis used for this assessment is based on the following factors and assumptions:

1. No specific transport mechanism is 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) are assumed to be available to a receptor.

2. Brine derived from the anhydrite interbeds has 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 is calculated based on a 50-year dose commitment. A 50-year dose commitment is 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 is 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 that 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 location of the receptor. The well from which the receptor drinks is assumed to be located such that the contaminants reaching the anhydrite interbeds are delivered directly to the well.

The bounding analysis dose calculation was performed using the GENII-A code. 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 to result from the releases listed in Table 8-1, after applying the factors and assumptions listed above, are shown in Table 8-2. By definition, the bounding doses are greater than any realistic doses that could be delivered to a receptor. The calculated bounding doses are well below the regulatory standard, which is an annual committed effective dose of 15 millirems. The full range of estimated radiation doses is from zero to some value less than the bounding values shown in Table 8-2.

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

Table 8-2. Calculated Maximum Annual Committed Effective Doses

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	-	N[2]

[1] Parameter values applied to each vector may be found in 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 are considered to be negligible and are not reported.

percentile is by definition 0.99. This means that only 1 in 100 estimates would have a value exceeding the 99th percentile, or conversely, the estimate would 99 times out of 100 have a value below the 99th percentile. Additionally, it follows that for two independent events, the probability that both estimates have 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 compliment ($1 - 0.99^n$) 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

$$1 - 0.99^n = 0.95 \text{ or } n\log(0.99) = \log(0.05) \text{, which implies } n > 298 \qquad (1)$$

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 4.7×10^{-1} millirems, as reported in Table 8-2. All other potential doses resulting from the 300 realizations of the modeling system 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 4.7×10^{-1} millirem value.

8.1.5 Parameter Values

Appendix PAR provides tables listing the parameters used in the performance assessment and compliance assessment modeling program. As provided by 40 CFR § 194.55(b), Appendix 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. Of the listed parameters, the Appendix PAR tables listed in Table 8-3 identify parameters used in the compliance assessment.

8.1.6 Summary of Compliance with the Individual Protection Standard

In performing the compliance assessment, the DOE applied a bounding-analysis approach using unrealistic assumptions that result in the over estimation of 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 would be about one-thirtieth of the individual protection standard.

Table 8-3. Parameter Values Listed in Appendix PAR

Title	Table
Earthen Fill Shaft Material Parameters	PAR-16
Rustler Compacted Clay Shaft Material Parameters	PAR-17
Asphalt Shaft Material Parameters	PAR-18
Concrete Shaft Material Parameters	PAR-19
Compacted Salt Shaft Material Parameter	PAR-20
Upper Clay Shaft Material Parameters	PAR-21
Lower Clay Shaft Material Parameters	PAR-22
Bottom Clay Shaft Material Parameters	PAR-23
Concrete Monolith Shaft Material Parameters	PAR-24
Santa Rosa Formation Parameters	PAR-25
Dewey Lake Formation Parameters	PAR-26
Forty-Niner Member of the Rustler Formation Parameters	PAR-27
Magenta Member of the Rustler Formation Parameters	PAR-28
Tamarisk Member of the Rustler Formation Parameters	PAR-29
Culebra Member of the Rustler Formation Parameters	PAR-30
Unnamed Lower Member of the Rustler Formation Parameters	PAR-31
Salado Formation Intact Halite Parameters	PAR-32
Salado Formation Brine Parameters	PAR-33
Salado Formation Marker Bed 138 Parameters	PAR-34
Salado Formation Marker Bed 139 Parameters	PAR-35
Salado Formation anhydrite Beds a and b, Intact and Fractured Parameters	PAR-36
Disturbed Rock Zone Parameters	PAR-37
Waste Area and Waste Material Parameters	PAR-38
Waste Chemistry Parameters	PAR-39
Radionuclide Parameters	PAR-40
Isotope Inventory	PAR-41
Waste Container Parameters	PAR-42
Stoichiometric Gas Generation Model Parameters	PAR-43
Repository (Outside of Panel Region) Parameters	PAR-44
Predisposal Cavities (Waste Area) Parameters	PAR-45
Panel Closure Parameters	PAR-46
Operations Region Parameters	PAR-47
Experimental Area Parameters	PAR-48
Reference Constants	PAR-52
Listing of Parameters Used in BRAGFLO which Differ from the WIPP 1996 CCA Parameter Database	PAR-54
Listing of Parameters Used in PANEL which Differ from the WIPP 1996 CCA Parameter Database	PAR-55

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 Appendix USDW and is summarized in Section 8.2.2.

8.2.1 Criteria for USDW Determination

In performing the evaluation of the presence of any USDW, it is necessary to establish criteria to be applied 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 applied to the assessment of 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.

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 be conservative in the definition of a USDW, the lower of these two values is assigned by the DOE to the first subcriterion. Based on calculations presented in Appendix USDW, a quantity of five gallons per minute is assigned as the first subcriterion.

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 milligrams per liter 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 be producing water that meets the quality criterion for a USDW. Any aquifer or its portion producing water having TDS concentrations at or above this level is determined to be producing water that does not meet the quality criterion and the regulatory definition of a USDW.

8.2.2 Comparison with USDW Determination Criteria

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 Appendix USDW.

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

- the Capitan Aquifer of the Guadalupian reef complex,
- the Culebra,
- the Magenta Dolomite Member of the Rustler Formation,
- the Dewey Lake,and
- the Santa Rosa Sandstone of the Dockum Group (hereafter referred to as the Santa Rosa).

Investigations conducted in the vicinity of the WIPP to characterize the hydrology of these formations are described in 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, 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 3, 9, and 6.5 miles (4.8, 14.5, and 10.5 kilometers) to the south/southwest of the controlled area boundary, respectively. Possible USDWs may occur in the Dewey Lake, about 1 mile (1.6 kilometers) south of the controlled area boundary, and the Santa Rosa, 7.7 to 9 miles (12.4 to 14.5 kilometers) to the east of the controlled area boundary, where private wells (used predominantly for supplying water to livestock) have generated no 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.

8.2.3 Comparison with the National Primary Drinking Water Standards

To provide additional assurance of the safety of the WIPP, the DOE has 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 was the case 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, are presented to 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 for the evaluation of 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 such that 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 that specifies 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 WCA). 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 tracer exercise of the NUTS code 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 kilogram per cubic meter results in a concentration at the accessible environment boundary of 2.5×10^{-7} kilograms per cubic meter. By applying this scaling factor determined by the tracer exercise 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 2 picocuries per liter, 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, shown in Table 8-2. The calculation uses the mass and activity loads for ^{226}Ra and ^{228}Ra in the radionuclide inventory at decommissioning and at 10,000 years. These values are provided in Table 8-4. The ORIGEN 2 code is used to calculate the activity loads at 10,000 years; these loads are 94.98 curies of ^{226}Ra in CH and RH waste and 1.01 curies of ^{228}Ra in CH and RH waste. The calculated concentration is based on the volume of brine, 441,375 cubic feet (12,500 cubic meters), projected to flow across the accessible environment boundary at 10,000 years in the BRAGFLO flow field.

Table 8-4. Total Inventory and Mass Loading of ^{226}Ra and ^{228}Ra

Radionuclide	Waste Type	Total Inventory at Decommissioning [1] (curies)	Total Inventory at 10,000 Years [2] (curies)	Mass Loading [1] (kilograms)
^{226}Ra	CH	1.16×10^{1}	9.21×10^{1}	1.17×10^{-2}
^{226}Ra	RH	3.58×10^{-5}	2.88×10^{0}	3.62×10^{-8}
^{228}Ra	CH	7.47×10^{-1}	9.14 xx10^{-1}	3.19×10^{-6}
^{228}Ra	RH	7.77×10^{-2}	9.26×10^{-2}	3.32×10^{-7}

[1] Values for activity at decommissioning are from Table 4 of Appendix WCA, Attachment WCA.8.2. Values for mass loading at decommissioning are from Table 6 of Appendix WCA, Attachment WCA.8.2.

[2] Values for activity at 10,000 years are from Table 5.4-10 of Sanchez et al. 1996, *EPAUNI: Estimating Probability Distribution of EPA Unit Loading in the WIPP Repository for Performance Assessment Calculations*, in SWCF-A:1.2.07.1.1:WA; QA: EPAUNI, WPO No. 39259.

The total concentration (CH and RH) of either ^{226}Ra or ^{228}Ra at 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.

The 2 picocuries per liter maximum concentration occurs in the anhydrite interbeds within the Salado and not in a zone that could realistically be expected to be a source of drinking water.

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

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 expected to be a source of drinking water.

8.2.3.4 <u>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</u>

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 from any of these radionuclides is 0.47 millirems, which is the value reported in Table 8-2 for transport through MB139 and is an order-of-magnitude below the regulatory standard. The 0.47 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.

8.3 Compliance Summary

In performing the compliance assessment, the DOE applied a bounding-analysis approach using unrealistic assumptions that result in the over estimation of 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 would be about one-thirtieth of the individual protection standard. The maximum concentrations of contamination in the hypothetical USDW would be 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 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 underground sources of drinking water.

REFERENCES

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