40 CFR Part 191
Subparts B and C
Compliance Recertification Application 2026
for the
Waste Isolation Pilot Plant

Appendix IGP-2026
Individual and Groundwater
Protection Requirements

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

Compliance Recertification Application 2026
Appendix IGP-2026
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TABLE OF CONTENTS

IGP-1.0 INTRODUCTION 1

IGP-2.0 INDIVIDUAL PROTECTION REQUIREMENTS 1
IGP-2.1 Compliance Assessment of Undisturbed Performance 3
IGP-2.2 Dose Calculation 5
IGP-2.3 Statistical Assessment 7
IGP-2.4 Summary of Compliance with the Individual Protection Standard 7

IGP-3.0 GROUNDWATER PROTECTION REQUIREMENTS 8
IGP-3.1 Criteria for USDW Determination 8
IGP-3.1.1 Groundwater Quantity 8
IGP-3.1.2 Groundwater Quality 10
IGP-3.2 Comparison with the National Primary Drinking Water Regulations 10
IGP-3.2.1 Combined ^{226}Ra and ^{228}Ra 10
IGP-3.2.2 Gross Alpha Particle Activity Including ^{226}Ra but Excluding Rn and U 11
IGP-3.2.3 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 11

IGP-4.0 COMPLIANCE SUMMARY 12

IGP-5.0 REFERENCES 12

LIST OF FIGURES

Figure IGP-1. Conceptual Transport Pathway 6

LIST OF TABLES

Table IGP-1. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for Initial Bounding Case in the CCA PA. 4
Table IGP-2. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for the CRA-2026 PA. 5
Table IGP-3. Calculated Maximum Annual Committed Effective Doses for CRA-2026. 7
Table IGP-4. Per Person Household and Water Consumption Values Evaluated in the CRA-2019 and CRA-2026. 9

ACRONYMS AND ABBREVIATIONS

CCA	Compliance Certification Application
CFR	Code of Federal Regulations
Ci/L	curies per liter
CRA	Compliance Recertification Application
DOE	U.S. Department of Energy
FEPs	features, events, and processes
gpm	gallons per minute
LWB	Land Withdrawal Boundary
mg/L	milligrams per liter
mrem	millirem
NUTS	Nuclide Transport System
PA	performance assessment
pCi/L	picocuries per liter
TDS	total dissolved solids
UP	undisturbed performance
USDW	underground source of drinking water
WIPP	Waste Isolation Pilot Plant

ELEMENTS AND CHEMICAL COMPOUNDS

Am	americium
Pu	plutonium
Ra	radium
Rn	radon
Th	thorium
U	uranium

IGP-1.0 INTRODUCTION

Title 40 CFR 191 sets the fundamental quantitative performance standards (e.g., specific radionuclide release limits and dose limits) that must be met, along with overarching qualitative environmental protection goals. Title 40 CFR 194 provides the detailed framework and criteria, which are largely quantitative in their application, for demonstrating and assessing compliance with the standards of 40 CFR 191. It outlines the methodologies, data, and analyses required to prove, in a quantitative manner, that the Waste Isolation Pilot Plant (WIPP) meets the 40 CFR 191 limits. This appendix demonstrates the U.S. Department of Energy's (DOE) compliance with both the individual and groundwater protection requirements in relation to the WIPP disposal system.

In conducting performance assessment (PA) calculations, a bounding analysis based on conservative assumptions that overestimate potential radiation doses and radionuclide concentrations is used. To provide added assurance, the presence of an underground source of drinking water (USDW) within the WIPP Land Withdrawal Boundary (LWB) is assumed, even though the quality and quantity of available water indicates that none exists within the boundary. The bounding analysis also assumes that all radionuclides reaching the accessible environment[1] are directly available to a receptor. The analysis bounds potential impacts of underground interconnections among bodies of surface water, groundwater, and any potential USDW.

In support of the 2026 Compliance Recertification Application (CRA-2026), radionuclide concentrations that could potentially reach the accessible environment from an undisturbed disposal system have been re-examined. Compliance with both individual protection requirements (Appendix IGP-2.0) and groundwater protection requirements (Appendix IGP-3.0) are documented in this appendix.

IGP-2.0 INDIVIDUAL PROTECTION REQUIREMENTS

The individual protection requirements are contained in 40 CFR 191.15 of the long-term disposal regulations. Title 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

[1] Per 40 CFR 191.12, the accessible environment means the atmosphere, land surfaces, surface waters, oceans, and all the lithosphere that is beyond the controlled area. At WIPP, the controlled area is defined by the LWB. For PA calculations, disturbed-case releases reach the accessible environment at the land surface, while undisturbed-case releases reach the accessible environment when they extend beyond the LWB in the subsurface.

> 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, Subpart B as "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" (U.S. EPA 1993). Appendix SCR and Scope of Performance Assessment, Section 32, describe UP, the conceptual models associated with UP, and the screening of features, events, and processes (FEPs) important to UP.

The method used to evaluate compliance with the individual protection requirements is similar to that used to assess compliance with the containment requirements. This method has not changed since the Compliance Certification Application (CCA). If the evaluation of the UP scenario considered for the containment requirements indicates that radionuclides will reach the accessible environment, the resulting dose to exposed individuals must be calculated and compared with the 15 millirem (mrem) annual committed effective dose specified in 40 CFR 191.15.

Further guidance on implementing the individual protection requirements is found in 40 CFR 194. Title 40 CFR 194.51 (U.S. EPA 1996) states:

> 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.

Title 40 CFR 194.52 (U.S. EPA 1996) states:

> In compliance assessments 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) (U.S. EPA 1996) provides criteria related to the assumptions that should be made when undertaking dose calculations as follows:

> 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.

IGP-2.1 Compliance Assessment of Undisturbed Performance

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

- Existing boreholes, as required by 40 CFR 194.54(b)(1) (U.S. EPA 1996)
- Potential boreholes, including those that may be used for fluid injection, as required by 40 CFR 194.32(c) (U.S. EPA 1996) and 40 CFR 194.54(b)(2) (U.S. EPA 1996)

After considering these pathways, it was found that contaminated brine may migrate away from the waste-disposal panels if pressure within the panels is elevated by gas generated from corrosion, microbial degradation, or radiolysis. Two credible pathways by which radionuclides could reach the accessible environment are illustrated in Appendix PA-2026, Figure PA-3, and include the following:

1. Radionuclide transport may occur laterally, through the anhydrite interbeds, toward the subsurface projection of the LWB in the Salado Formation (hereafter referred to as the Salado).

2. Transport may occur through access drifts or anhydrite interbeds (primarily Marker Bed 139) to the base of the shafts. If the pressure in the panels exceeds the lithostatic pressure of the overlying strata, 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 Dolomite Member of the Rustler Formation (hereafter referred to as the Culebra), toward the subsurface projection of the LWB.

Although both pathways are possible, the PA modeling indicates that under undisturbed conditions, only the first is a potential pathway during the 10,000-year regulatory period (see Appendix PA-7.2). The modeling system applied to the PA has been used to make this determination.

Scenario screening for the UP is described in Appendix SCR-2026. As specified by 40 CFR 194.54(b)(2), Appendix SCR-2026 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. The FEPs represented in the UP modeling are listed in Appendix SCR-2026, Table SCR-1.

As specified by 40 CFR 194.55(a), uncertainty in the performance of the compliance assessment is documented in CRA-2004, Chapter 6.0, Section 6.1.2 (U.S. DOE 2004). Probability distributions for uncertain disposal system parameter values used in the compliance assessment were developed and documented in Feng and Kicker (2025), which identifies sampled parameters used in the compliance assessment for the CRA-2026.

The maximum concentrations of radionuclides that reach the accessible environment calculated in the initial bounding case and in the CRA-2026 evaluations are shown in Tables IGP-1 and IGP-2, respectively[2]. For CRA-2026, no vectors in the undisturbed scenario passed the PA screening criteria, and all had zero actinide concentrations in the anhydrite interbeds at the accessible environment (Docherty and Kim 2025).

Table IGP-1. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for Initial Bounding Case in the CCA PA.

Realization No.	Vector No.	^{241}Am (Ci/L)	^{239}Pu (Ci/L)	^{238}Pu (Ci/L)	^{234}U (Ci/L)	^{230}Th (Ci/L)	Total Excluding ^{234}U (pCi/L) [b]
1	Replicate 1 Vector 46	1.36×10^{-17}	4.33×10^{-12}	Negligible [a]	5.82×10^{-13}	2.10×10^{-14}	4.35
2	Replicate 2 Vector 16	Negligible	5.13×10^{-14}	Negligible	6.77×10^{-15}	1.89×10^{-17}	0.05
3	Replicate 2 Vector 25	Negligible	1.35×10^{-15}	Negligible	1.65×10^{-16}	7.00×10^{-18}	0.00
4	Replicate 2 Vector 33	1.32×10^{-17}	7.18×10^{-14}	Negligible	9.76×10^{-15}	9.36×10^{-16}	0.07
5	Replicate 2 Vector 81	Negligible	6.23×10^{-18}	Negligible	Negligible	Negligible	0.00
6	Replicate 2 Vector 90	Negligible	5.20×10^{-16}	Negligible	7.40×10^{-17}	Negligible	0.00
7	Replicate 3 Vector 3	3.50×10^{-18}	3.08×10^{-13}	Negligible	4.32×10^{-14}	1.07×10^{-16}	0.31
8	Replicate 3 Vector 60	5.98×10^{-17}	7.41×10^{-14}	Negligible	9.09×10^{-15}	2.30×10^{-15}	0.08
9	Replicate 3 Vector 64	5.42×10^{-17}	5.85×10^{-12}	Negligible	7.61×10^{-13}	4.68×10^{-15}	5.85
10-300	—	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

[a] Values less than 10^{-18} curies per liter (Ci/L) are considered negligible relative to the other values and are not reported.

[b] The total concentration excluding uranium is provided for comparison to the gross alpha particle activity limit of 15 pCi/L (see Appendix IGP-3.2.2).

[2] The releases reported in Tables IGP-1 and IGP-2 fall below the effective numerical precision of the transport calculations. The nonzero values are attributed to numerical dispersion in the Nuclide Transport System (NUTS) finite-difference solution method and result from coarse grid spacing, not contaminant transport.

Table IGP-2. Maximum Concentrations of Radionuclides Within the Salado Interbeds at the Disposal System Boundary for the CRA-2026 PA.

Realization No.	Vector No.	^{241}Am (Ci/L)	^{239}Pu (Ci/L)	^{238}Pu (Ci/L)	^{234}U (Ci/L)	^{230}Th (Ci/L)
1-300	—	0	0	0	0	0

IGP-2.2 Dose Calculation

Per 40 CFR 194.51, the dose must be estimated for the individual in the accessible environment expected to receive the highest exposure. Under 40 CFR 194.52, all exposure pathways associated with the UP of the repository must be assessed (U.S. EPA 1996).

To perform the required dose calculation for the CCA, it was necessary to identify possible pathways for radionuclide transport from the anhydrite interbeds to a receptor. The only credible pathway identified is an abandoned deep borehole that intersects the contaminant plume in the accessible environment. Contaminants would then be available to a receptor through a water well used to supply drinking water. This conceptual transport pathway is illustrated in Figure IGP-1. As specified in 40 CFR 194.54(b), this pathway considers the presence of an existing borehole.

The description of uncertainty in calculating radionuclide concentrations in the anhydrite interbeds is described in the CRA-2004, Chapter 6.0, Section 6.1.2 (U.S. DOE 2004). Epistemic uncertainty represents a lack of knowledge about parameters or models and is implemented in WIPP PA via the probabilistic treatment of parameters, which has been updated for the CRA-2026 by Feng and Kicker (2025). Additional uncertainty is introduced in calculating doses resulting from the specified exposure pathway, which is an aleatory uncertainty associated with randomness in future states of the WIPP system. Considering this uncertainty, a bounding analysis with conservative assumptions is used that yields dose estimates well above any reasonably expected receptor exposure. Briefly, the bounding analysis is based on the following assumptions (U.S. DOE 1996):

1. Transport assumption — Contaminants present in the anhydrite interbeds at year 10,000 are available to the receptor, without specifying a transport mechanism.

2. Brine dilution assumption — Brine with a total dissolved solids (TDS) concentration of 324,000 parts per million is diluted by a factor of 32.4 to 10,000 parts per million for dose calculations.

3. Dose commitment period — Annual committed effective dose is calculated using a 50-year dose commitment, which is a stochastic effect representing the total risk of developing cancer or genetic effects over a lifetime.

4. Water intake rate — The receptor is assumed to consume two liters of water each day for one year.

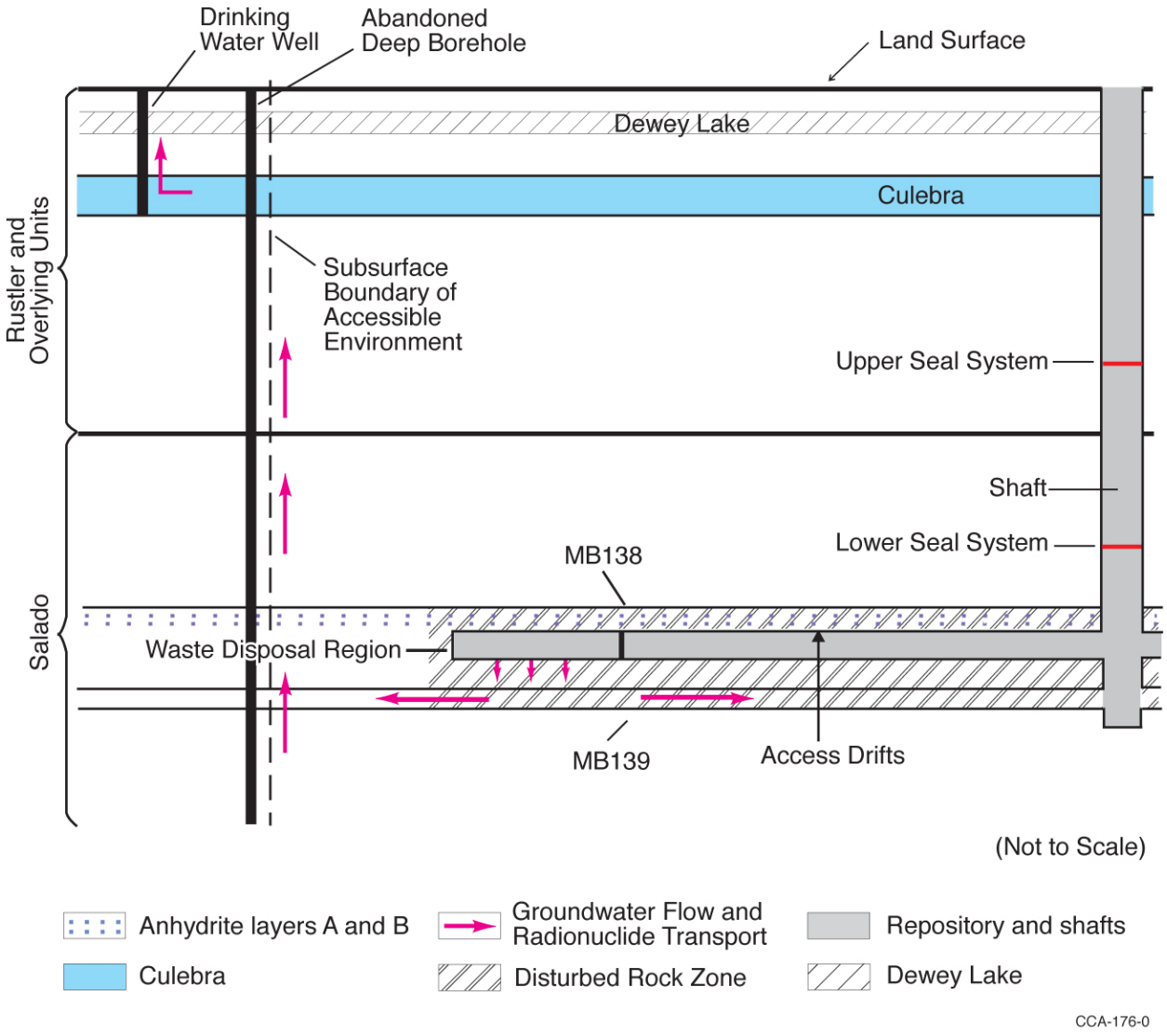


Figure IGP-1. Conceptual Transport Pathway

In compliance with 40 CFR 194.51, all 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. That is, contaminants reaching the anhydrite interbeds are delivered directly to the receptor's drinking well.

The maximum calculated doses calculated for CRA-2026 are shown in Table IGP-3. These doses, which are based on the initial bounding analysis (U.S. DOE 1996), are greater than any realistic doses that could be delivered to a receptor. The initial bounding analysis was extended to account for exposure pathways other than 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. The contribution of these pathways added 0.46 mrem per year (Dials 1997a, Enclosure 2) to the calculated groundwater dose of 0.47 mrem per year (Table IGP-3). Thus, the

maximum total dose calculated from all pathways is 0.93 mrem per year, well below the 15-mrem-per-year standard. The bounding analysis provides the basis for determining compliance. If the calculated dose is below the regulatory limit, compliance is demonstrated. Because the initial concentrations for the CRA-2026 calculations (Table IGP-2) are below those used in the initial bounding case (Table IGP-1), and that case produced doses below the regulatory limit of an annual committed effective dose of 15 mrem, no recalculation of dose was required. The original bounding analysis demonstrates compliance.

Table IGP-3. Calculated Maximum Annual Committed Effective Doses for CRA-2026

Realization No.	Vector No.	Maximum Annual Committed Effective Dose (mrem)
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 [a]

[a] Doses derived from concentrations less than 10^{-18} Ci/L are considered negligible and are not reported.

IGP-2.3 Statistical Assessment

Under 40 CFR 194.55(d), the number of simulations must be large enough to ensure, with 95% confidence, that the results include a value above the 99th percentile. In practical terms, this means running a sufficiently large number of simulations so that one of them is very likely to capture an extreme, high result. In addition, 40 CFR 194.55(f) requires the DOE to show, with the same 95% level of confidence, that the mean and median of the estimated doses and concentrations meet the limits in 40 CFR 191.15 and 40 CFR Part 191, Subpart C. Together, these provisions ensure that both the typical results and the extreme high-end results are evaluated. The detailed statistical basis for these requirements is explained in U.S. DOE (1996), resulting in the selection of 300 simulations for the modeling system to meet the 95% confidence level. A bounding analysis that exceeds the mean and median doses has been developed, providing greater than 95% confidence that all potential doses will be below the annual committed effective dose of 15 mrem.

IGP-2.4 Summary of Compliance with the Individual Protection Standard

A bounding analysis with conservative assumptions is used to intentionally overestimate potential doses. Even under these assumptions, the maximum dose was only about one-sixteenth of the regulatory limit. Because the CRA-2026 analysis resulted in even lower

concentrations, the original analysis remains bounding and CRA-2026 demonstrates compliance.

IGP-3.0 GROUNDWATER PROTECTION REQUIREMENTS

The groundwater protection evaluation follows the requirements in 40 CFR Part 191, Subpart C by assessing whether predicted radionuclide concentrations remain below federal drinking water limits throughout 10,000 years of undisturbed performance. These limits, established in 40 CFR 141, include standards for combined radium, gross alpha particle activity, and dose from man-made beta and photo emitters. Consistent with 40 CFR 194.53, the evaluation considers all underground sources of drinking water in the accessible environment that could be affected, including potential hydrologic connections among surface water, groundwater, and USDWs. To assess compliance with these provisions of the regulations, it is first necessary to determine whether any USDWs are located near the WIPP disposal system.

IGP-3.1 Criteria for USDW Determination

To evaluate the presence of any USDW, it is necessary to establish criteria for water quality and quantity data from wells in the vicinity of the WIPP disposal system. The criteria are based on the regulatory definition of a USDW, as provided in 40 CFR 191.22 (U.S. EPA 1993). 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.

Criteria based on these definitions were developed and are used to assess the presence of any USDW near the WIPP disposal system. These criteria are defined in the sections that follow.

IGP-3.1.1 Groundwater Quantity

Since there are no public water systems in the WIPP vicinity, any possible USDW must meet the 40 CFR 191.22(2)(i) or (ii) requirements. The following three sub-criteria have been identified and applied to these USDW requirements:

(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.

(3) An aquifer must contain fewer than 10,000 milligrams per liter (mg/L) of TDS.

Water-consumption information was evaluated to define the first sub-criterion (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 define a USDW, the lower of these two values is assigned to the first sub-criterion. At WIPP, a USDW is defined based on a quantity of 5 gallons per minute (gpm) (U.S. DOE 1996, Appendix USDW). In updating these calculations for the CRA-2026, data relating to the sub-criteria rate were reviewed to ensure new information was consistent with the previous calculations. These data are shown in Table IGP-4.

For CRA-2026, the rate derived based on 15 service connections is much larger than the rate of that derived from 25 individuals. This is because 15 service connections with 2.71 persons per household (Table IGP-4) gives a rate based on 41 individuals. Therefore, only the rate based on 25 individuals is necessary. Multiplying 262 gallons per capita per day times 25 people and converting to gallons per minute yields a rate of 4.54 gpm. Based on this information, it is concluded that applying the 5-gpm sub-criterion is still valid for a bounding analysis. No change in this sub-criterion is warranted as a result of applying the most current census and water consumption data.

Table IGP-4. Per Person Household and Water Consumption Values Evaluated in the CRA-2019 and CRA-2026.

Community	Persons Per Household, 2023[a] (CRA-2026)	Persons Per Household, 2016[b] (CRA-2019)	Gallons Per Capita Per Day[c]
Artesia	2.56	2.29	347
Carlsbad	2.49	2.24	254
Hobbs	2.71	2.76	57
Lovington	3.21	2.83	399
Roswell	2.58	2.42	251
Average	2.71	2.51	262

Sources: [a] U.S. Census Bureau 2024; [b] U.S. DOE 2019, Appendix IGP, Table IGP-1; [c] Valdez et al. 2024, Appendix B, Table 7, which is based on New Mexico water use data for the 2020 calendar year.

The definition of the second quantity sub-criterion (the acceptable production duration of 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 continues 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 to fund new rural water supply systems. The loan periods are generally 40 years in duration. Based on this, a duration of 40 years is applied to the second quantity sub-criterion. This is the same assumption that has been used since the CCA.

IGP-3.1.2 Groundwater Quality

A criterion of 10,000 mg/L of TDS is specified in 40 CFR 191.22. Any aquifer or its water-producing portion with TDS concentrations below this level is determined to produce water that meets the quality criterion for a USDW. Any aquifer or its water-producing portion with 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.

Previous analyses of water quality in the WIPP site characterization and groundwater investigation wells have determined that there are wells with groundwater TDS below 10,000 mg/L in the WIPP vicinity. The WIPP vicinity is the area where these WIPP wells are located outside of the WIPP LWB. The WIPP LWB is the regulatory compliance point for individual and groundwater protection. Although for conservatism a USDW at the WIPP LWB is assumed, analyses of available data concluded that no wells within the WIPP and at the boundary meet the criteria or definition of a USDW. For CRA-2019, and for this recertification period, there were no new wells drilled at new locations in the WIPP vicinity, only replacement wells (information on these wells is provided in Appendix HYDRO-5.0). As such, there is no new information to assess for a USDW determination. No additional USDW investigations were performed as part of the CRA-2026. Based on this review, no modification of the USDW determinations reported in the CCA, Appendix USDW, is warranted. No USDWs are present within the WIPP LWB. However, USDWs are present in the Culebra and may occur in the Dewey Lake and the Santa Rosa Formations near the disposal system.

IGP-3.2 Comparison with the National Primary Drinking Water Regulations

To provide additional assurance of the safety of the WIPP disposal system, a bounding assessment of the concentrations of contaminants that could occur in the hypothetical USDW at the WIPP LWB as discussed in Appendix IGP-2.2 was prepared. Doses to a receptor consuming water from the USDW were calculated. As with the dose calculations, maximum concentrations were summed to develop concentrations for comparison with the limits established in 40 CFR 141. The transport pathway described in Appendix IGP-2.2 is assessed to evaluate compliance with the groundwater protection standard.

IGP-3.2.1 Combined ^{226}Ra and ^{228}Ra

In addition to the key radionuclides tracked by the NUTS PA computer code (Table IGP-1), the transport ^{226}Ra or ^{228}Ra was also tracked to the accessible environment. Groundwater protection standards limit the combined concentration of ^{226}Ra and ^{228}Ra to 5 picocuries per liter (pCi/L). Therefore, analyses are required to evaluate compliance with the groundwater protection standard for releases from the undisturbed repository through the interbed.

A bounding analysis that applied a scaling factor to the quantity of ^{226}Ra and ^{228}Ra projected to be emplaced in the repository determined that the maximum concentration of these radionuclides in the accessible environment is 0.07 pCi/L (Wagner 2003), which is below the 5 pCi/L standard. Naturally occurring radium in Culebra groundwater is higher, but the PA considers only incremental releases from the repository.

The CRA-2026 predicted zero radium concentration reaching the accessible environment, as no vectors passed the NUTS screening. These results confirm continued compliance with the combined ^{226}Ra and ^{228}Ra standard.

IGP-3.2.2 Gross Alpha Particle Activity Including ^{226}Ra but Excluding Rn and U

Compliance with the groundwater protection standard was assessed by summing the maximum concentration values provided in Table IGP-1 for ^{241}Am, ^{239}Pu, ^{238}Pu, and ^{230}Th and adding the value for ^{226}Ra to confirm that the total is below the 15 pCi/L standard. The value of 226Ra is 0.14 pCi/L for the initial bounding case in the CCA (Dials 1997b).

For the CRA-2026, no radionuclide concentrations reached the accessible environment over the regulatory time frame for the undisturbed scenario. As such, no additional analyses were performed. The gross alpha particle activity, including ^{226}Ra and excluding Rn and U, is zero, demonstrating continued compliance with the 40 CFR 141 standard.

IGP-3.2.3 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

To assess compliance with the total Annual Dose to the Total Body or Any Internal Organ standard, an annual dose equivalent of 4 mrem per year, the transport of ^{239}Pu, ^{238}Pu, ^{234}U, and ^{230}Th was evaluated. The maximum annual committed effective dose calculated for the bounding analysis from any of these radionuclides was 0.93 mrem (Appendix IGP-2.2). The 0.93-mrem value includes alpha particle radioactivity, as well as beta particle and photon radioactivity. The alpha particle radioactivity represents about 99.7% of the 0.93-mrem value (ICRP 2008, Table A.1). Thus, the value is very conservative, as the 4-mrem annual dose equivalent limit is only for beta particle and photon radioactivity.

For the CRA-2026, no radionuclide concentrations reached the accessible environment in the undisturbed scenario over the 10,000-year regulatory time period. As such, the annual dose equivalent to the total body or any internal organ from the average annual concentration of beta particle and photon radioactivity is zero, demonstrating continued compliance with the 40 CFR 141 standard.

IGP-4.0 COMPLIANCE SUMMARY

Groundwater protection has been evaluated using a conservative bounding-analysis approach that intentionally overestimates potential doses and contaminant concentrations. This analysis includes a hypothetical USDW at the WIPP LWB for added protection, even though none is known to exist. The assessment further assumes that any contaminants reaching the accessible environment could be available to a receptor and accounts for possible hydrologic connections among groundwater, surface water, and USDWs. Under these conservative conditions, the maximum dose was about one-sixteenth of the regulatory limit.

For the CRA-2026, potential concentrations and receptor doses in the hypothetical USDW remain bounded by the original analysis. The predicted dose from releases through the Salado interbeds is zero, confirming continued compliance.

IGP-5.0 REFERENCES

(*Indicates a reference that has not been previously submitted.)

Dials, G.E. 1997a. Letter (with attachments) to R. Trovato, Director, EPA Office of Radiation Programs. February 26, 1997. U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM.

Dials, G.E. 1997b. Letter (with attachment) to L. Weinstock, EPA Office of Radiation and Indoor Air. Subject: Summary of the EPA-Mandated Performance Assessment Verification Test Results for the Individual and Groundwater Protection Requirements. September 15,1997. U.S. Department of Energy, Carlsbad Area Office.

Docherty, P.C., and S. Kim. 2025. Analysis Report for Actinide Mobilization and Salado Transport in the 2026 Compliance Recertification Application Performance Assessment: Interim State Repository, Revision 0. Carlsbad, NM: Sandia National Laboratories.*

Feng, L.M., and D.C. Kicker. 2025. Input Parameter Report for the 2026 Compliance Recertification Application Performance Assessment: Interim State Repository, Revision 0. Carlsbad, NM: Sandia National Laboratories.*

International Commission on Radiological Protection (ICRP) 2008. Nuclear Decay Data for Dosimetric Calculations, ICRP Publication 107. *Annals of the ICRP*, Vol. 38, No. 3.*

U.S. Census Bureau. 2024. 2019-2023 American Community Survey 5-Year Estimates. <census.gov/quickfacts/fact/table/US/HSD310223>, accessed on February 11, 2025.*

U.S. Department of Energy (U.S. DOE). 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant (October). Carlsbad, NM: Carlsbad Area Office. DOE/CAO 1994-2184.

U.S. DOE. 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant (March). Carlsbad, NM: Carlsbad Field Office. DOE/WIPP 2004-3231.

U.S. DOE. 2019. Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application for the Waste Isolation Pilot Plant. Carlsbad, NM: Carlsbad Field Office. DOE/WIPP 2019-3609.*

U.S. Environmental Protection Agency (U.S. EPA). 1993. 40 CFR Part 191: Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: Final Rule. *Federal Register*, vol. 58 (December 20, 1993): 66398–66416.

U.S. EPA. 1996. 40 CFR Part 194: Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations; Final Rule. *Federal Register*, vol. 61 (February 9, 1996): 5223–5245.

Valdez, J., P. Harms, M. Nelson, and A. Gagnon. 2024. New Mexico Water Use by Categories 2020. New Mexico Office of the State Engineer, Technical Report 56, November 2024.*

Wagner, S.W. 2003. Memorandum to Cliff Hansen, November 6, 2003. Calculation of Combined ^{226}Ra and ^{228}Ra Concentrations at Boundary for Chapter 8 Compliance Assessment. Carlsbad, NM: Sandia National Laboratories. ERMS 532804.