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

Scope of Performance Assessments
(40 CFR § 194.32)

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

Scope of Performance Assessments
(40 CFR § 194.32)

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Acronyms and Abbreviations

CCA	Compliance Certification Application
CRA	Compliance Recertification Application
DOE	U.S. Department of Energy
DP	disturbed performance
EPA	U.S. Environmental Protection Agency
EP	event and process
FEP	feature, event, and process
HCN	Historic, Current, and Near-Future
mi	mile
PA	Performance Assessment
QA	quality assurance
SKI	Statens Kärnkraftinspektion (Swedish Nuclear Inspectorate)
SO-C	screened out-consequence
SO-P	screened out-probability
SO-R	screened out-regulation
UP	undisturbed performance
WIPP	Waste Isolation Pilot Plant

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32.0 Scope of Performance Assessments

32.1 Requirements

§ 194.32 Scope of Performance Assessment

(a) Performance assessments shall consider natural processes and events, mining, deep drilling, and shallow drilling that may affect the disposal system during the regulatory time frame.

(b) Assessments of mining effects may be limited to changes in the hydraulic conductivity of the hydrogeologic units of the disposal system from excavation mining for natural resources. Mining shall be assumed to occur with a one in 100 probability in each century of the regulatory time frame. Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area during the century in which such mining is randomly calculated to occur. Complete removal of such mineral resources shall be assumed to occur only once during the regulatory time frame.

(c) Performance assessments shall include an analysis of the effects on the disposal system of any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after disposal. Such activities shall include, but shall not be limited to, existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities.

(d) Performance assessments need not consider processes and events that have less than one chance in 10,000 of occurring over 10,000 years.

(e) Any compliance application(s) shall include information which:

(1) Identifies all potential processes, events or sequences and combinations of processes and events that may occur during the regulatory time frame and may affect the disposal system;

(2) Identifies the processes, events or sequences and combinations of processes and events included in performance assessments; and

(3) Documents why any processes, events or sequences and combinations of processes and events identified pursuant to paragraph (e)(1) of this section were not included in performance assessment results provided in any compliance application.

32.2 Background

Performance Assessment (PA) is a process that assesses the likelihood that the Waste Isolation Pilot Plant (WIPP) will meet the release limits specified by 40 CFR § 191.13 (U.S. Environmental Protection Agency 1993) for 10,000 years after disposal. The PA process must consider both natural and man-made processes and events that have an effect on this disposal system.

40 CFR § 194.32 (U.S. Environmental Protection Agency 1996) requires that PAs include the effects of excavation mining, drilling, fluid injection, and future development of leases. In addition, PA must also include the effects of current activities such as secondary oil recovery methods (waterflooding), disposal of natural brine, and solution mining to extract brine in the vicinity of the repository. Section 194.32 requires identification of all features, events, and processes (FEPs), or sequences or combinations of processes and events, that could occur during the regulatory time frame that may affect the repository.

Therefore, the PA methodology for the WIPP includes compiling and screening a comprehensive list of FEPs relevant to disposal system performance. Those FEPs with the potential to affect performance are represented in scenarios and quantitative calculations using a system of linked

computer models. These models describe the interaction of the repository with the natural system, both with and without human intrusion. For the Compliance Certification Application (CCA) (U.S. Department of Energy 1996), the U.S. Department of Energy (DOE) compiled a comprehensive list of FEPs, which was subjected to a screening process leading to the set of relevant FEPs used in PA to demonstrate the WIPP's compliance with the long-term disposal standards.

The screening criteria shown below were used to determine whether to include FEPs in conceptual models and performance scenarios:

- Screened Out-Regulation (SO-R): For example, future human-initiated events and processes (EPs) may be excluded from consideration for regulatory reasons (e.g., deliberate drilling intrusions). 40 CFR § 194.25(a) requires 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.

- Screened Out-Probability (SO-P): 40 CFR § 194.32(d) states that PA need not consider processes and events that have less than 1 in 10,000 chance of occurring over 10,000 years.

- Screened Out-Consequence (SO-C): The DOE eliminated some FEPs based on their consequences according to the following two criteria:

  – Insignificant Consequences. The DOE eliminated FEPs where there was a reasonable expectation that the remaining probability distribution of cumulative releases would not be significantly changed by such omissions. These FEPs are designated SO-C.

  – Beneficial FEPs. FEPs that are potentially beneficial to disposal system or subsystem performance were eliminated to simplify the analysis. This argument may be used when there is uncertainty as to exactly how the FEP should be incorporated into assessment calculations, or when incorporation would incur unreasonable difficulties. This is considered a conservative decision. These FEPS are designated SO-C Beneficial (e.g., the accumulation of radioactive contaminants in soils).

The FEPs retained in the PA were accounted for under calculations of either the undisturbed performance (UP) or disturbed performance (DP) (see the CCA, Chapter 6.0, Sections 6.2.2.2 and 6.2.2.3).

- UP includes the predicted behavior of the disposal system assuming it is not disrupted by human intrusion or the occurrence of unlikely natural events.

- DP includes the predicted behavior of the disposal system assuming disruption by human intrusion or other actions, including future drilling and mining activities.

32.3 1998 Certification Decision

32.3.1 40 CFR § 194.32(a)

In the CCA, the DOE discusses the origin and development of the WIPP FEPs list, as well as well-defined screening criteria in the CCA, Appendix SCR. A list of the WIPP-relevant FEPs is also provided in the CCA, Chapter 6.0, Section 6.2. The DOE identified approximately 237 FEPs in three major categories: natural (N), waste- and repository-induced (W), and human-initiated (H). Of particular importance to the performance of the disposal system were those FEPs dealing with mining, deep drilling, and shallow drilling. The CCA and supporting documents illustrated the process used by the DOE to implement the FEPs in scenarios relevant to PA.

The U.S. Environmental Protection Agency (EPA) evaluated the adequacy of the natural FEPs appropriate to the disposal system and how these were considered in the PA. The EPA also evaluated the DOE's consideration of mining and drilling in the PA. The EPA performed a critical review of each step in the DOE FEP selection process for the CCA, including identification and listing of the potentially disruptive FEPs, screening of these FEPs, combination of FEPs to form scenarios, screening of scenarios, and the final formation of scenarios for use in the CCA PA.

The EPA concluded that the initial FEP list assembled by the DOE was sufficiently comprehensive. This list appropriately screened out EPs on the basis of probability, consequence, or regulatory requirements. The EPA concluded that the DOE considered and incorporated into PA numerous natural EPs, mining, and deep drilling. The EPA concluded that the DOE considered shallow drilling and appropriately screened it out on the basis of low consequence. The DOE also appropriately followed regulatory requirements when it did not consider future fluid injection activities (U.S. Environmental Protection Agency 1998a).

32.3.2 40 CFR § 194.32(b)

The CCA describes how mining is incorporated into the PA, including information on mining rates and probabilities, the application of institutional controls, hydraulic conductivity variations as a result of mining, and the extent of minable reserves (see the CCA, Chapter 6.0, Section 6.4.6.2.3). The DOE identified potash as the only natural resource currently being mined near the WIPP. The DOE used the EPA-specified frequency of mining and probability when considering changes in hydraulic conductivity up to 1,000 times the base hydraulic conductivity of the Culebra Dolomite Member of the Rustler Formation (hereafter referred to as Culebra). In its calculation of the potash area to be mined, the DOE considered minable reserves inside and outside the controlled area (the CCA, Appendix DEL, Section DEL.4.2.4).

In reviewing the DOE's compliance with 40 CFR § 194.32(b), the EPA considered whether the CCA included a detailed, accurate, and comprehensive analysis of mined resources in the WIPP area and sufficient information to demonstrate how mining probability was determined. Specifically, the EPA examined the validity of the DOE's potash reserve estimates, including the DOE's assumptions regarding potash reserve location, quality, and minable horizons. The EPA also examined the CCA to determine how hydraulic conductivity in the supra-Salado units was

modified to address changes that could be caused by mining over the 10,000-year regulatory period (U.S. Environmental Protection Agency 1998a).

The EPA's review of minable reserves found that the DOE identified current minable thicknesses and horizons near the WIPP. The DOE's estimate roughly corresponds to that identified in an EPA technical memorandum (Peake 1996). The EPA recognized that this is not necessarily representative of the entire Delaware Basin, and it is conceivable that additional reserves could be mined in the WIPP area. However, speculation of this nature would extend to other horizons or reserves, which is beyond the intent of section 194.32(b). The EPA therefore concurred with the DOE's approach.

The EPA also found that the DOE assumed mined resources will be completely removed from the controlled area within the century in which mining occurs, and complete removal of mineral resources was assumed to occur only once over the regulatory time frame, in accordance with section 194.32(b). The DOE assumed that mining will be done via room and pillar or other conventional methods, and solution mining of potash will not take place because of mineralogical and economic constraints.

Finally, the EPA determined that mining was properly incorporated in PA through the application of the 1 to 1,000 multiplier for hydraulic conductivity in the calculated transmissivity field for the Culebra. The CCA, Appendix TFIELD and related documentation include information pertinent to this application of the transmissivity multiplier.

32.3.3 40 CFR § 194.32(c)

In the CCA, the DOE identified appropriate events and analyses of their effects on the disposal system, as well as the effects of existing boreholes. The EPA considered how these events affected the disposal system and whether the DOE addressed the potential for slant drilling. The EPA also examined whether the DOE addressed potentially exploitable existing leases.

The DOE concluded that oil and gas exploration and exploitation and water and potash exploration are the only human-initiated activities that need to be considered for PA (see the CCA, Chapter 6.0, Section 6.3.2). The DOE divided human-initiated activities into two categories: (1) those that have been Historic, Current, and Near-Future (HCN); and (2) those that may happen in the future after disposal (Future). Human-initiated activities included three different drilling-related intrusion scenarios used in PA based on the screening analysis, designated by the DOE as E1, E2, and E1E2 (see the CCA, Chapter 6.0, Section 6.3.2). The E1 scenario assumed penetration of a panel by a borehole drilled through the repository, which then strikes a brine pocket present in the underlying Castile. The E2 scenario included all future boreholes that penetrate a panel but do not strike an underlying brine pocket within the Castile. The E1E2 scenario was defined as the occurrence of multiple boreholes that intersect a single waste panel, with at least one of the events being an E1 occurrence.

The EPA evaluated the DOE's compliance with 40 CFR § 194.32(c) and determined that the DOE had used a reasonable approach to screen human-initiated activities that might impact the repository. The EPA concluded that, based on the discussion in the CCA, Appendix SCR, the DOE considered the appropriate issues, and the technical conclusions reached by the DOE

regarding screening of oil and gas exploration and extraction activities were valid (U.S. Environmental Protection Agency 1998a).

32.3.4 40 CFR § 194.32(d)

The DOE listed FEPs eliminated from PA based on probability, and described why they were not included. The DOE used this requirement to screen out FEPs such as nuclear criticality, galvanic coupling, formation of new faults, glaciation, and impact of large meteorites.

The EPA examined the screening arguments and information in the CCA, Appendix SCR to assess the traceability of assumptions, approximations, and measures of uncertainties. The EPA examined the DOE's approach to determine whether it was well documented and adequately justified. The EPA examined assigned probabilities to determine whether they were appropriate, documented, and in accordance with EPA regulatory requirements, and examined the sufficiency of all data in terms of quantity and adequacy. In conclusion, the EPA concurred with the events and processes that were screened out by the DOE using the low-probability criterion (U.S Environmental Protection Agency 1998a).

32.3.5 40 CFR § 194.32(e)

32.3.5.1 40 CFR § 194.32(e)(1)

40 CFR § 194.32(e)(1) specifies that all potential FEPs that may occur during the regulatory time period be identified and considered. In this criterion, a time frame of interest is applied to FEPs that may affect the disposal system. This criterion specifies "the regulatory time frame," which begins at repository closure and continues for 10,000 years in the future. This is in contrast to that specified in section 194.32(c), where the time period of interest is HCN.[1]

The CCA, Appendix SCR, identified the processes and events, or sequences and combinations of processes and events, included in PA, including natural and human-initiated processes and events. The CCA, Appendix SCR provided a comprehensive analysis of all FEPs that may affect WIPP performance. In addition, the CCA, Appendix SCR and its attachments document the development of the WIPP FEPs list and describe its origin from over 1,200 FEPs identified through various international repository programs. The broad and comprehensive beginning of the WIPP FEPs list helps to assure that all potential WIPP-relevant FEPs can be properly identified. After refinement of the initial list, the DOE's FEPs identification process resulted in approximately 237 FEPs that were retained for screening.

The EPA reviewed the DOE's initial FEPs listings at each stage of development and review to determine whether it was comprehensive. In addition, the EPA examined information sources used by the DOE to compile the FEPs lists for completeness and accuracy of technical information. The EPA concluded that the DOE identified those events and processes, and sequences or combinations of events and processes, that may occur during the regulatory time period and affect the repository. The EPA concluded that these FEPs represented those most

[1] Human-initiated FEPs are screened for both the HCN and Future time periods (i.e., sections 194.32(c) and 194.32(e)(1)).

critical in terms of affecting the disposal repository (U.S. Environmental Protection Agency 1998a).

32.3.5.2 40 CFR § 194.32(e)(2)

40 CFR § 194.32(e)(2) states that combinations of events and processes must be included in PA. To accomplish this, the DOE formulated conceptual models and scenarios that incorporated each of the FEPs screened in during the screening processes detailed in the CCA, Appendix SCR. The DOE developed scenarios to represent both undisturbed and disturbed system performance. FEPs were included into scenarios ranging from the effects of deep and shallow drilling and mining to undisturbed disposal system performance. In the CCA, Chapter 6.0, Section 6.2, Table 6-6, the DOE identifies the specific locations in the CCA where information on the modeling of the individual FEP can be found.

The EPA reviewed the CCA to determine whether FEPs and subsequent scenarios were appropriately screened, adequately justified, and completely supported. In addition, the EPA examined combinations of FEPs and scenarios included in PA. The EPA concluded that DOE used a process (i.e., the Statens Kärnkraftinspektion (SKI) [Stenhouse, Chapman, and Sumerling 1993] list modified to suit conditions at the WIPP site) that identified the processes, events, or sequences or combinations of processes and events. As part of this process, the DOE adequately addressed and evaluated the effects of mining, deep drilling, and shallow drilling. The DOE evaluated the FEPs and sequences of FEPs through calculations, estimates of probability, and comparisons to regulatory requirements. The EPA concluded that the DOE appropriately identified, listed, and discussed the FEPs and the effects of the sequences and combinations of FEPs that result in modeled scenarios (U.S. Environmental Protection Agency 1998a).

32.3.5.3 40 CFR § 194.32(e)(3)

40 CFR § 194.32(e)(3) requires that FEPs not included in PA calculations be adequately documented and justified. The DOE identified approximately 237 FEPs in the CCA, Appendix SCR and the CCA, Chapter 6.0, Section 6.3. For each FEP, DOE provided a description and a generalized rationale for screening classifications. Of the 237 FEPs analyzed, 154 were screened out on the basis of regulations (SO-R), low consequence (SO-C), or probability (SO-P). The CCA, Appendix SCR included the DOE's screening rationale for each of the 237 CCA FEPs.

To verify the DOE's compliance with this section, the EPA reviewed the information in the CCA, Appendix SCR and also conducted audits to verify the proper execution of quality assurance (QA) programs for all items and activities important to the containment of waste in the repository, including items and activities related to FEPs. As a result of these EPA audits, the EPA concluded that QA programs were properly executed for FEP-related items and activities, and that the DOE had demonstrated compliance with the requirements of section 194.32 (U.S. Environmental Protection Agency 1998a).

32.4 Changes in the CRA-2004

For the Compliance Recertification Application of 2004 (CRA-2004) (U.S. Department of Energy 2004) and the subsequent Performance Assessment Baseline Calculation, the DOE

revaluated all WIPP FEPs to determine if any had changed or if new FEPs needed to be added. The DOE's reevaluation resulted in only a few changes to the FEPs analysis. Wagner, Kirkes, and Martell (2003) concluded that of the original 237 FEPs included in the CCA, 106 did not change, 120 required updates to their FEP descriptions and/or screening arguments, and 7 of the original baseline FEPs screening decisions required a change from their original screening decision. Four of the original baseline FEPs were deleted or combined with other closely related FEPs, and two new FEPs were added to the baseline. These two FEPs were previously addressed in an existing FEP; they were separated for clarity. Therefore, for the CRA-2004, reevaluation resulted in a new FEPs baseline consisting of 235 FEPs, but did not change the CCA conceptual models or the scenarios developed for PA.

32.5 The EPA's Evaluation of Compliance for the 2004 Recertification

For the CRA-2004, the DOE applied the same approach used for the CCA to develop and screen the list of FEPs that may have an effect on the disposal system as that used for the CCA. Since the WIPP FEPs were previously evaluated and approved in the initial certification process, the EPA focused its recertification review on the FEPs that had changed since the 1998 Certification Decision (U.S Environmental Protection Agency 1998b). The EPA verified that the DOE's FEP-development and review process was fundamentally the same as the CCA process, and verified that the DOE's reevaluation properly considered changes since the original certification decision in 1998. The EPA verified that any changes to FEP-screening arguments or FEPs-related discussions were reasonable, appropriate, and complete.

The EPA received one public comment related to the scope of PA. Some stakeholders proposed that karst (FEP N20) should be included in the PA conceptual model development. The EPA reevaluated karst issues raised by stakeholders from the CCA as well as new information made available since the original certification decision. The EPA's review is discussed in *Technical Support Document for Section 194.14/15: Evaluation of Karst at the WIPP Site* (U.S. Environmental Protection Agency 2006a). After a thorough review, the EPA determined that karst should not be screened into the PA process.

Based on a review and evaluation of the CRA-2004 and supplemental information provided by the DOE, the EPA determined that the DOE continued to comply with the requirements for section 194.32 (U.S. Environmental Protection Agency 2006b).

32.6 Changes or New Information since the 2004 Recertification

For the CRA-2009, the DOE has identified PA changes implemented since the CRA-2004 and determined their impacts on the FEPs baseline. Changes that affect the FEPs basis are detailed in Appendix SCR-2009. As a result of the reevaluation, 35 FEPs were updated with new information, 1 screening argument has been changed to correct errors discovered during review, and the screening decision for one FEP was changed from SO-R to SO-C. This latter change has no impact on PA calculations because the FEP continues to be excluded from PA, albeit using a different screening rationale. Finally, 10 FEPs have been split into 20 similar, but more specific, FEPs. The following sections present information that demonstrates compliance with the requirements of section 194.32.

32.6.1 40 CFR § 194.32(a)

Changes to the WIPP baseline since the CRA-2004 have been identified and evaluated to determine their impact upon the WIPP FEPs baseline. This reevaluation process is very similar to the process used for the CRA-2004. The FEPs baseline is maintained according to Sandia National Laboratories Specific Procedure 9-4, *Performing FEPS Baseline Impact Assessments for Planned and Unplanned Changes* (Kirkes 2006). For the CRA-2009, there are 70 natural FEPs, 61 human-initiated EPs, and 114 waste and repository FEPs, resulting in 245 WIPP FEPs. The current FEPs baseline is presented in Appendix SCR-2009. Table 32-1 lists the CRA-2009 FEPs and their screening decisions, and summarizes any changes to related information since the CRA-2004.

Table 32-1. CRA-2009 FEPs Summary

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
N1	Stratigraphy	No	No change.	UP
N2	Brine Reservoirs	No	No change.	DP
N3	Changes in Regional Stress	No	No change.	SO-C
N4	Regional Tectonics	No	No change.	SO-C
N5	Regional Uplift and Subsidence	No	No change.	SO-C
N6	Salt Deformation	No	No change.	SO-P
N7	Diapirism	No	No change.	SO-P
N8	Formation of Fractures	No	No change.	SO-P UP (Repository)
N9	Changes in Fracture Properties	No	No change.	SO-C UP (Near Repository)
N10	Formation of New Faults	No	No change.	SO-P
N11	Fault Movement	No	No change.	SO-P
N12	Seismic Activity	No	Updated with new seismic data.	UP
N13	Volcanic Activity	No	No change.	SO-P
N14	Magmatic Activity	No	No change.	SO-C
N15	Metamorphic Activity	No	No change.	SO-P
N16	Shallow Dissolution	No	No change.	UP
N18	Deep Dissolution	No	No change.	SO-P
N20	Breccia Pipes	No	No change.	SO-P
N21	Collapse Breccias	No	No change.	SO-P
N22	Fracture Infills	No	No change.	SO-C - Beneficial

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
N23	Saturated Groundwater Flow	No	No change.	UP
N24	Unsaturated Groundwater Flow	No	No change.	UP
N25	Fracture Flow	No	No change.	UP
N27	Effects of Preferential Pathways	No	No change.	UP
N26	Density effects on Groundwater Flow	No	No change.	SO-C
N28	Thermal effects on Groundwater Flow	No	No change.	SO-C
N29	Saline Intrusion [Hydrogeological Effects]	No	No change.	SO-P
N30	Freshwater Intrusion [Hydrogeological effects]	No	No change.	SO-P
N31	Hydrological Response to Earthquakes	No	No change.	SO-C
N32	Natural Gas Intrusion	No	No change.	SO-P
N33	Groundwater Geochemistry	No	No change.	UP
N34	Saline Intrusion (Geochemical Effects)	No	No change.	SO-C
N38	Effects of Dissolution	No	No change.	SO-C
N35	Freshwater Intrusion (Geochemical Effects)	No	No change.	SO-C
N36	Changes in Groundwater Eh	No	No change.	SO-C
N37	Changes in Groundwater pH	No	No change.	SO-C
N39	Physiography	No	No change.	UP
N40	Impact of a Large Meteorite	No	Errors identified in screening argument corrected; no change in screening decision.	SO-P
N41	Mechanical Weathering	No	No change.	SO-C
N42	Chemical Weathering	No	No change.	SO-C
N43	Aeolian Erosion	No	No change.	SO-C
N44	Fluvial Erosion	No	No change.	SO-C
N45	Mass Wasting [Erosion]	No	No change.	SO-C
N46	Aeolian Deposition	No	No change.	SO-C
N47	Fluvial Deposition	No	No change.	SO-C

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
N48	Lacustrine Deposition	No	No change.	SO-C
N49	Mass Wasting [Deposition]	No	No change.	SO-C
N50	Soil Development	No	No change.	SO-C
N51	Stream and River Flow	No	No change.	SO-C
N52	Surface Water Bodies	No	No change.	SO-C
N53	Groundwater Discharge	No	No change.	UP
N54	Groundwater Recharge	No	No change.	UP
N55	Infiltration	No	No change.	UP
N56	Changes in Groundwater Recharge and Discharge	No	No change.	UP
N57	Lake Formation	No	No change.	SO-C
N58	River Flooding	No	No change.	SO-C
N59	Precipitation (e.g. Rainfall)	No	No change.	UP
N60	Temperature	No	No change.	UP
N61	Climate Change	No	No change.	UP
N62	Glaciation	No	No change.	SO-P
N63	Permafrost	No	No change.	SO-P
N64	Seas and Oceans	No	No change.	SO-C
N65	Estuaries	No	No change.	SO-C
N66	Coastal Erosion	No	No change.	SO-C
N67	Marine Sediment Transport and Deposition	No	No change.	SO-C
N68	Sea Level Changes	No	No change.	SO-C
N69	Plants	No	No change.	SO-C
N70	Animals	No	No change.	SO-C
N71	Microbes	No	No change.	SO-C (UP - for colloidal effects and gas generation)
N72	Natural Ecological Development	No	No change.	SO-C
H1	Oil and Gas Exploration	No	No change.	SO-C (HCN) DP (Future)
H2	Potash Exploration	No	No change.	SO-C (HCN) DP (Future)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
H4	Oil and Gas Exploitation	No	No change.	SO-C (HCN) DP (Future)
H8	Other Resources	No	No change.	SO-C (HCN) DP (Future)
H9	Enhanced Oil and Gas Recovery	No	No change.	SO-C (HCN) DP (Future)
H3	Water Resources Exploration	No	Updated with most recent monitoring information.	SO-C (HCN) SO-C (Future)
H5	Groundwater Exploitation	No	Updated with most recent monitoring information.	SO-C (HCN) SO-C (Future)
H6	Archaeological Investigations	No	No change.	SO-R (HCN) SO-R (Future)
H7	Geothermal	No	No change.	SO-R (HCN) SO-R (Future)
H10	Liquid Waste Disposal	No	No change.	SO-R (HCN) SO-R (Future)
H11	Hydrocarbon Storage	No	No change.	SO-R (HCN) SO-R (Future)
H12	Deliberate Drilling Intrusion	No	No change.	SO-R (HCN) SO-R (Future)
H13	Conventional Underground Potash Mining	No	No change.	UP (HCN) DP (Future)
H14	Other Resources (mining for)	No	No change.	SO-C (HCN) SO-R (Future)
H15	Tunneling	No	No change.	SO-R (HCN) SO-R (Future)
H16	Construction of Underground Facilities (for Example Storage, Disposal, Accommodation)	No	No change.	SO-R (HCN) SO-R (Future)
H17	Archaeological Excavations	No	No change.	SO-C (HCN) SO-R (Future)
H18	Deliberate Mining Intrusion	No	No change.	SO-R (HCN) SO-R (Future)
H19	Explosions for Resource Recovery	No	No change.	SO-C (HCN) SO-R (Future)
H20	Underground Nuclear Device Testing	No	No change.	SO-C (HCN) SO-R (Future)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
H21	Drilling Fluid Flow	No	Screening argument revised.	SO-C (HCN) DP (Future)
H22	Drilling Fluid Loss	No	Screening argument revised.	SO-C (HCN) DP (Future)
H23	Blowouts	No	No change.	SO-C (HCN) DP (Future)
H24	Drilling-Induced Geochemical Changes	No	No change.	UP (HCN) DP (Future)
H25	Oil and Gas Extraction	No	Screening argument updated.	SO-C (HCN) SO-R (Future)
H26	Groundwater Extraction	No	Screening argument updated.	SO-C (HCN) SO-R (Future)
H27	Liquid Waste Disposal–OB	No	FEP title has been modified to show that this event or process specifically applies to activities outside the WIPP boundary. Screening argument has also been updated with new information.	SO-C (HCN) SO-C (Future)
H28	Enhanced Oil and Gas Production–OB	No	FEP title has been modified to show that this event or process specifically applies to activities outside the WIPP boundary. Screening argument has also been updated with new information.	SO-C (HCN) SO-C (Future)
H29	Hydrocarbon Storage–OB	No	FEP title has been modified to show that this event or process specifically applies to activities outside the WIPP boundary. Screening argument has also been updated with new information.	SO-C (HCN) SO-C (Future)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
H60	Liquid Waste Disposal–IB	N/A – new FEP	This is a new FEP that is similar to H27, except that it specifically applies to activities inside the WIPP boundary.	SO-R (HCN) SO-R (Future)
H61	Enhanced Oil and Gas Production–IB	N/A – new FEP	This is a new FEP that is similar to H28, except that it specifically applies to activities inside the WIPP boundary.	SO-R (HCN) SO-R (Future)
H62	Hydrocarbon Storage–IB	N/A – new FEP	This is a new FEP that is similar to H29, except that it specifically applies to activities inside the WIPP boundary.	SO-R (HCN) SO-R (Future)
H30	Fluid-injection Induced Geochemical Changes	No	No change.	UP (HCN) SO-R (Future)
H31	Natural Borehole Fluid Flow	No	No change.	SO-C (HCN) SO-C (Future, holes not penetrating waste panels) DP (Future, holes penetrating panels)
H32	Waste-Induced Borehole Flow	No	No change.	SO-R (HCN) DP (Future)
H34	Borehole-Induced Solution and Subsidence	No	No change.	SO-C (HCN) SO-C (Future)
H35	Borehole-Induced Mineralization	No	No change.	SO-C (HCN) SO-C (Future)
H36	Borehole-Induced Geochemical Changes	No	No change.	UP (HCN) DP (Future) SO-C (for units other than the Culebra)
H37	Changes in Groundwater Flow Due to Mining	No	No change.	UP (HCN) DP (Future)
H38	Changes in Geochemistry Due to Mining	No	No change.	SO-C (HCN) SO-R (Future)
H39	Changes in Groundwater Flow Due to Explosions	No	No change.	SO-C (HCN) SO-R (Future)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
H40	Land Use Changes	No	No change.	SO-R (HCN) SO-R (Future)
H41	Surface Disruptions	Yes	Screening decision changed from SO-R to SO-C to remove inconsistency with rationale.	UP (HCN) SO-C (Future)
H42	Damming of Streams or Rivers	No	No change.	SO-C (HCN) SO-R (Future)
H43	Reservoirs	No	No change.	SO-C (HCN) SO-R (Future)
H44	Irrigation	No	No change.	SO-C (HCN) SO-R (Future)
H45	Lake Usage	No	No change.	SO-R (HCN) SO-R (Future)
H46	Altered Soil or Surface Water Chemistry by Human Activities	No	No change.	SO-C (HCN) SO-R (Future)
H47	Greenhouse Gas Effects	No	No change.	SO-R (HCN) SO-R (Future)
H48	Acid Rain	No	No change.	SO-R (HCN) SO-R (Future)
H49	Damage to the Ozone Layer	No	No change.	SO-R (HCN) SO-R (Future)
H50	Coastal Water Use	No	No change.	SO-R (HCN) SO-R (Future)
H51	Sea water Use	No	No change.	SO-R (HCN) SO-R (Future)
H52	Estuarine Water Use	No	No change.	SO-R (HCN) SO-R (Future)
H53	Arable Farming	No	No change.	SO-C (HCN) SO-R (Future)
H54	Ranching	No	No change.	SO-C (HCN) SO-R (Future)
H55	Fish Farming	No	No change.	SO-R (HCN) SO-R (Future)
H56	Demographic Change and Urban Development	No	No change.	SO-R (HCN) SO-R (Future)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
H57	Loss of Records	No	No change.	NA (HCN) DP (Future)
H58	Solution Mining for Potash	No	Updated with information regarding solution activities and plans in the region.	SO-R (HCN) SO-R (Future)
H59	Solution Mining for Other Resources	No	Updated with new information regarding brine wells in the region.	SO-C (HCN) SO-C (Future)
W1	Disposal Geometry	No	No change.	UP
W2	Waste Inventory	No	Updated to reflect the inventory data sources used for the CRA-2009 PA.	UP
W3	Heterogeneity of Waste Forms	No	Updated to reflect the inventory data sources used for the CRA-2009 PA.	DP
W4	Container Form	No	Updated to reflect the inventory data sources used for the CRA-2009 PA.	SO-C – Beneficial
W5	Container Material Inventory	No	No change.	UP
W6	Shaft Seal Geometry	No	Title changed to be specific to shaft seals.	UP
W7	Shaft Seal Physical Properties	No	Title changed to be specific to shaft seals.	UP
W109	Panel Closure Geometry	N/A – new FEP.	Split from W6 to be specific to panel closures.	UP
W110	Panel Closure Physical Properties	N/A – new FEP	Split from W7 to be specific to panel closures.	UP
W8	Shaft Seal Chemical Composition	No	Title changed to be specific to shaft seals.	SO-C Beneficial
W111	Panel Closure Chemical Composition	N/A – new FEP	Split from W8 to be specific to panel closures.	SO-C Beneficial
W9	Backfill Physical Properties	No	No change.	SO-C

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W10	Backfill Chemical Composition	No	No change.	UP
W11	Post-Closure Monitoring	No	No change.	SO-C
W12	Radionuclide Decay and In-Growth	No	No change.	UP
W13	Heat from Radioactive Decay	No	Updated to reflect the inventory used for the CRA-2009 PA.	SO-C
W14	Nuclear Criticality: Heat	No	Updated to reflect the inventory used for the CRA-2009 PA.	SO-P
W15	Radiological Effects on Waste	No	Updated to reflect the inventory used for the CRA.	SO-C
W16	Radiological Effects on Containers	No	Updated to reflect the inventory used for the CRA.	SO-C
W17	Radiological Effects on Shaft Seals	No	FEP title changed to be specific to shaft seals; screening argument updated to reflect the inventory used for the CRA.	SO-C
W112	Radionuclide Effects on Panel Closures	N/A – new FEP	Split from W17 to be specific to panel closures.	SO-C
W18	Disturbed Rock Zone (DRZ)	No	No change.	UP
W19	Excavation-Induced Changes in Stress	No	No change.	UP
W20	Salt Creep	No	No change.	UP
W21	Changes in the Stress Field	No	No change.	UP
W22	Roof Falls	No	No change.	UP
W23	Subsidence	No	Source of subsidence monitoring data added.	SO-C
W24	Large Scale Rock Fracturing	No	Source of subsidence monitoring data added.	SO-P
W25	Disruption Due to Gas Effects	No	No change.	UP
W26	Pressurization	No	No change.	UP
W27	Gas Explosions	No	No change.	UP

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W28	Nuclear Explosions	No	Updated to reflect the inventory used for the CRA-2009 PA.	SO-P
W29	Thermal Effects on Material Properties	No	Updated to reflect the inventory used for the CRA. New thermal calculations added.	SO-C
W30	Thermally-Induced Stress Changes	No	Updated to reflect the inventory used for the CRA. New thermal calculations added.	SO-C
W31	Differing Thermal Expansion of Repository Components	No	Updated to reflect the inventory used for the CRA. New thermal calculations added.	SO-C
W72	Exothermic Reactions	No	Updated to reflect the inventory used for the CRA. New thermal calculations added.	SO-C
W73	Concrete Hydration	No	Updated to reflect the inventory used for the CRA. New thermal calculations added.	SO-C
W32	Consolidation of Waste	No	No change.	UP
W36	Consolidation of Shaft Seals	No	Title changed to be specific to shaft seals.	UP
W37	Mechanical Degradation of Shaft Seals	No	Title changed to be specific to shaft seals.	UP
W39	Underground Boreholes	No	No change.	UP
W113	Consolidation of Panel Closures	N/A – new FEP	Split from W36 to be specific to panel closures.	UP
W114	Mechanical Degradation of Panel Closures	N/A – new FEP	Split from W37 to be specific to panel closures.	UP
W33	Movement of Containers	No	Updated to reference new inventory data.	SO-C
W34	Container Integrity	No	No change.	SO-C Beneficial
W35	Mechanical Effects of Backfill	No	Screening argument updated to reflect reduction in MgO.	SO-C

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W40	Brine Inflow	No	No change.	UP
W41	Wicking	No	No change.	UP
W42	Fluid Flow Due to Gas Production	No	No change.	UP
W43	Convection	No	No change.	SO-C
W44	Degradation of Organic Material	No	New thermal rise calculations referenced.	UP
W45	Effects of Temperature on Microbial Gas Generation	No	New thermal rise calculations referenced.	UP
W48	Effects of Biofilms on Microbial Gas Generation	No	New thermal rise calculations referenced.	UP
W46	Effects of Pressure on Microbial Gas Generation	No	No change.	SO-C
W47	Effects of Radiation on Microbial Gas Generation	No	Screening argument updated with new radionuclide inventory.	SO-C
W49	Gases from Metal Corrosion	No	No change.	UP
W51	Chemical Effects of Corrosion	No	No change.	UP
W50	Galvanic Coupling (Within the Repository)	No	No change.	SO-C
W52	Radiolysis of Brine	No	No change.	SO-C
W53	Radiolysis of Cellulose	No	Screening argument updated with new radionuclide inventory.	SO-C
W54	Helium Gas Production	No	Screening argument updated with new radionuclide inventory.	SO-C
W55	Radioactive Gases	No	Reference made to CRA-2009 inventory data.	SO-C
W56	Speciation	No	No change.	UP in disposal rooms and Culebra. SO-C elsewhere, and SO-C Beneficial in cementitious seals

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W57	Kinetics of Speciation	No	No change.	SO-C
W58	Dissolution of Waste	No	No change.	UP
W59	Precipitation of Secondary Minerals	No	No change.	SO-C Beneficial
W60	Kinetics of Precipitation and Dissolution	No	No change.	SO-C
W61	Actinide Sorption	No	No change.	UP in the Culebra and Dewey Lake; SO-C—Beneficial in the disposal room, shaft seals, panel closures, and other geologic units.
W62	Kinetics of Sorption	No	No change.	UP in the Culebra and Dewey Lake; SO-C—Beneficial in the disposal room, shaft seals, panel closures, and other geologic units.
W63	Changes in Sorptive Surfaces	No	No change.	UP
W64	Effects of Metal Corrosion	No	No change.	UP
W66	Reduction-Oxidation Kinetics	No	No change.	UP
W65	Reduction-Oxidation Fronts	No	No change.	SO-P
W67	Localized Reducing Zones	No	No change.	SO-C
W68	Organic Complexation	No	No change.	UP
W69	Organic Ligands	No	No change.	UP
W71	Kinetics of Organic Complexation	No	No change.	SO-C
W70	Humic and Fulvic Acids	No	No change.	UP
W74	Chemical Degradation of Shaft Seals	No	Title changed to be specific to shaft seals.	UP
W76	Microbial Growth on Concrete	No	No change.	UP
W115	Chemical Degradation of Panel Closures	N/A – new FEP	Split from W74 to be specific to panel closures.	UP

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W75	Chemical Degradation of Backfill	No	No change.	SO-C
W77	Solute Transport	No	No change.	UP
W78	Colloid Transport	No	No change.	UP
W79	Colloid Formation and Stability	No	No change.	UP
W80	Colloid Filtration	No	No change.	UP
W81	Colloid Sorption	No	No change.	UP
W82	Suspensions of Particles	No	No change.	DP
W83	Rinse	No	No change.	SO-C
W84	Cuttings	No	No change.	DP
W85	Cavings	No	No change.	DP
W86	Spallings	No	No change.	DP
W87	Microbial Transport	No	No change.	UP
W88	Biofilms	No	No change.	SO-C Beneficial
W89	Transport of Radioactive Gases	No	Screening argument updated with CRA-2009 inventory data.	SO-C
W90	Advection	No	No change.	UP
W91	Diffusion	No	No change.	UP
W92	Matrix Diffusion	No	No change.	UP
W93	Soret Effect	No	New thermal values added for aluminum corrosion.	SO-C
W94	Electrochemical Effects	No	No change.	SO-C
W95	Galvanic Coupling (Outside the Repository)	No	No change.	SO-P
W96	Electrophoresis	No	No change.	SO-C
W97	Chemical Gradients	No	No change.	SO-C
W98	Osmotic Processes	No	No change.	SO-C
W99	Alpha Recoil	No	No change.	SO-C
W100	Enhanced Diffusion	No	No change.	SO-C
W101	Plant Uptake	No	No change.	SO-R (for section 191.13) SO-C (for section 191.15)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-Induced FEP

Table 32-1. CRA-2009 FEPs Summary (Continued)

EPA FEP I.D.[a,b,c]	FEP Name	Screening Decision Changed	Change Summary	Screening Classification
W102	Animal Uptake	No	No change.	SO-R (for section 191.13) SO-C (for section 191.15)
W103	Accumulation in Soils	No	No change.	SO-C Beneficial (for section 191.13) SO-C (for section 191.15)
W104	Ingestion	No	No change.	SO-R SO-C (for section 191.15)
W105	Inhalation	No	No change.	SO-R SO-C (for section 191.15)
W106	Irradiation	No	No change.	SO-R SO-C (for section 191.15)
W107	Dermal Sorption	No	No change.	SO-R SO-C (for section 191.15)
W108	Injection	No	No change.	SO-R SO-C (for section 191.15)

[a] N = Natural FEP
[b] H = Human-induced EP
[c] W = Waste- and Repository-induced FEP

Those FEPs not separated by gridlines in the first column of Table 32-1 have been addressed by group, due to close similarity with other FEPs within that group.

32.6.2 40 CFR § 194.32(b)

The requirements of section 194.32(b) specify assumptions regarding the implementation of mining in PA calculations. The PA modeling system used for the mining scenario is similar to that developed for the undisturbed repository scenario, but with a modified Culebra transmissivity field in the controlled area to account for the mining effects. Minor changes were made in the way mining is implemented in PA due to comments by the EPA in their review of the CRA-2004 (Cotsworth 2004). These changes include redefining the mined area to include 0.8-kilometer- (0.5-mile [mi]) diameter exclusion zones around oil and gas wells (see Section 2.7 of Leigh et al. [2005]). The result of including the 0.8 kilometer- (0.5-mi) diameter exclusion zone around oil and gas wells was to increase travels times in the Culebra (Lowry 2004). Details regarding how mining processes are represented in PA models are described in Appendix PA-2009, Section PA-2.3.2.2.1 and Appendix MASS-2009, Section MASS-15.1. FEPs related to the presence of resources are described and considered in Appendix SCR-2009, Section SCR-5.0.

32.6.3 40 CFR § 194.32(c)

Section 194.32(c) provides specific time frames to evaluate activities that may affect the disposal system. This requirement focuses on activities that have occurred in the past, are occurring, or are expected to occur in the near future. The DOE classifies this time frame as HCN. Because section 194.32(e)(1) requires the evaluation of human-initiated EPs during the regulatory time period, the DOE also evaluates human-initiated FEPs for the period of time from closure of the repository to 10,000 years into the future (Future) (see human-initiated EPs in Table 32-1). Human-initiated EPs are described and screened for both the HCN and Future time frames in Appendix SCR-2009, Section SCR-5.0. Therefore, the DOE is in compliance with the requirements of section 194.32(c).

32.6.4 40 CFR § 194.32(d)

Low-probability events can be excluded on the basis of the criterion provided in 40 CFR § 194.32(d), which states, "performance assessments need not consider processes and events that have less than one chance in 10,000 of occurring over 10,000 years." In practice, for most SO-P FEPs, it has not been possible to estimate a meaningful quantitative probability. In the absence of quantitative probability estimates, a qualitative argument was used. SO-P FEPs are listed in Table 32-2.

32.6.5 40 CFR § 194.32(e)

The requirements in 40 CFR § 194.32(e) are met by the analyses of FEPs as documented in Appendix SCR-2009. Table 32-1 lists the CRA-2009 FEPs and summarizes any changes to screening decisions and arguments.

Section 194.32, "Scope of Performance Assessment" requires the identification, selection, screening, and incorporation of all significant processes and events into PA. The DOE has taken a comprehensive approach in meeting the requirements of the section as documented here and in Appendix SCR-2009 of this CRA. The process used is consistent with evaluations of WIPP FEPs in past compliance applications. Any new information that relates to WIPP FEPs is identified and incorporated into PA as appropriate. Therefore, the DOE has met the requirements of section 194.32.

Table 32-2. CRA-2009 FEPs Screened Out for Low Probability (SO-P)

FEP I.D.	FEP Name
N6	Salt Deformation
N7	Diapirism
N8	Formation of Fractures
N10	Formation of New Faults
N11	Fault Movement
N13	Volcanic Activity
N15	Metamorphic Activity
N18	Deep Dissolution
N20	Breccia Pipes
N21	Collapse Breccias
N29	Saline Intrusion (Hydrogeological Effects)
N30	Freshwater Intrusion (Hydrogeological Effects)
N32	Natural Gas Intrusion
N40	Impact of a Large Meteorite
N62	Glaciation
N63	Permafrost
W14	Nuclear Criticality: Heat
W24	Large Scale Rock Fracturing
W28	Nuclear Explosions
W65	Reduction-Oxidation Fronts
W95	Galvanic Coupling (Outside the Repository)

32.7 References

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