CARD No. 32
Scope of Performance Assessments

32.A.1 BACKGROUND

The radioactive waste disposal regulations at 40 CFR Part 191 include requirements for containment of radionuclides. The containment requirements specify that releases from a disposal system to the accessible environment must not exceed the release limits set forth in Appendix A, Table 1 of 40 CFR 191.13. Assessment of the likelihood that the Waste Isolation Pilot Plant (WIPP) will meet EPA's release limits is conducted through the use of a process known as a "performance assessment" (PA). The WIPP PA essentially consists of a series of computer simulations that attempt to describe the physical attributes of the repository (site, geology, waste forms and quantities, engineered features) in a manner that captures the behaviors and interactions among its various components. The results of the simulations show the potential releases of radioactive materials from the disposal system to the accessible environment over the 10,000-year regulatory time frame. The PA must include both natural and man-made processes and events that have an effect on the disposal system (61 FR 5228). Section 194.32, "Scope of Performance Assessment," stipulates that the PA must include both natural and man-made processes and events that may affect the disposal system over the regulatory time period.

Section 194.32 requires that the PA include the effects of excavation mining, drilling, fluid injection and future development of leases. The PA also must include the effects of current activities such as secondary oil recovery methods (waterflooding), disposal of natural brine, solution mining to extract brine, etc., in the vicinity of the repository. Section 194.32 requires identification of all processes, events, or sequences, and combinations of processes and events that may occur during the regulatory time frame that may affect the repository. Also, DOE must document why any events or processes, or sequences so identified are not included in the PA.

32.A.2 REQUIREMENT

(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."

32.A.3 ABSTRACT

EPA reviewed the CCA to evaluate the adequacy and comprehensiveness of the events and processes selected and used by DOE to develop PA scenarios, as required by Section 194.32. The CCA and supporting documents illustrated the process used by DOE to select the features, events and processes (FEPs) and subsequent scenarios relevant to PA. DOE's methodology for demonstrating compliance with Section 194.32(a) was based on the general requirements for FEP and scenario identification stated in the Section 194.32(e). These requirements include the following:

- Identifying FEPs relevant to the WIPP.
- Classifying FEPs.
- Screening FEPs.
- Combining FEPs to form scenarios.
- Screening scenarios
- Selecting scenarios for implementation in the PA.

DOE presented a brief discussion of the screening process for FEPs in Chapter 6.2 of the CCA. DOE identified approximately 236 FEPs, divided into three major categories: natural, waste- and repository-induced, and human-initiated. Of particular importance were those FEPs dealing with mining, deep drilling, and shallow drilling. FEPs were combined by DOE to create scenarios with concurrent conceptual model development; scenarios selected for implementation were the basis for PA model development. EPA performed a critical review of each step of the DOE FEP selection process, including: 1) identification and listing of the potentially disruptive FEPs; 2) screening of these FEPs; and 3) combination of FEPs to form scenarios, screening of scenarios, and the final formation of scenarios formulated for use in the PA.

EPA's main criterion in determining compliance was the comprehensiveness and completeness of the FEP source list used by DOE. EPA evaluated the adequacy of the natural events and processes appropriate to the disposal system, and how these were considered in the PA. EPA also evaluated DOE's consideration of mining and drilling in the PA.

32.A.4 Compliance Review Criteria

EPA expected the CCA to identify all features, events and processes that were considered in the performance assessment. The CCA should identify all sources used to identify FEPs and reference all relevant information pertaining to the identification and evaluation of FEPs. The CCA should document the progression from development of a FEPs list through screening of FEPs and the subsequent formulation of scenarios for use in the performance assessment.

EPA recognizes that PAs and/or other modeling may indicate that some items are not necessary to demonstrate compliance. In those instances, the compliance application should include justification as to why the particular items are not important to a reasonable expectation of compliance (Compliance Application Guidance for the Waste Isolation Pilot Plant: A Companion Guide to 40 CFR Part 194 (CAG), p. 42). See Section 194.32(e)(1) for additional relevant guidance.

32.A.5 DOE Methodology and Conclusions

DOE presented information pertaining to Section 194.32(a) primarily within Chapter 6.2-6.4 of the CCA, as well as Appendices DEL, SCR, CCDFGF, SA, and MASS. DOE's methodology for demonstrating compliance with Section 194.32(a) was based on the general requirements stated in Section 194.32(e). This methodology included the following:

- ♦ Identifying FEPs relevant to the WIPP.
- ♦ Classifying FEPs.
- ♦ Screening FEPs.
- ♦ Combining FEPs to form scenarios.
- ♦ Screening scenarios
- ♦ Selecting scenarios for implementation in the PA.

DOE identified approximately 236 FEPs divided into three major categories: 1) natural FEPs, 2) waste- and repository-induced FEPs, and 3) human-initiated FEPs. Screening out FEPs from the list of 236 by DOE was based on regulatory, probability, and consequence criteria (Chapter 6.2.1). Refer to the discussion of Section 194.32(e)(1) through (3) in this CARD for more information regarding the FEP identification and screening process. Refer to the discussion of Section 194.32(b) for information on mining, and to the discussion of Section 194.32(c) for information on deep and shallow drilling.

DOE retained FEPs in PA calculations for either undisturbed performance (UP) or disturbed performance (DP). UP included the predicted behavior of the disposal system, assuming the disposal system in the controlled area was not disrupted by human intrusion or the occurrence of unlikely natural events. DP included the predicted behavior of the disposal system assuming disruption of the system by human intrusion or other actions, including future drilling and mining activities.

A logic diagram developed within the framework of 40 CFR 191.13, 191.15 and 191.24, illustrates the development of scenarios from those FEPs accounted for in PA calculations (Chapter 6.3, Figure 6-7, p. 6-63). DOE used the retained FEPs in conceptual models, mathematical models (equations), and codes (initial and boundary conditions, geometry and material property parameters) or computational models.

DOE concluded that:

- ♦ The requirements at Section 194.32(e) for identification, screening, and documentation, were fulfilled by Appendix SCR and Chapter 6 of the CCA.
- ♦ DOE met all requirements of Section 194.32(a) (Chapter 6, pp. 6-36 to 6-84).

32.A.6 EPA COMPLIANCE REVIEW

EPA examined the CCA to determine how DOE identified, screened, and combined FEPs to form scenarios used in PA. EPA evaluated each FEP presented by DOE in Chapter 6 and Appendix SCR of the CCA, with an emphasis on those FEPs screened out of PA.

Review of Initial FEP Listing

EPA reviewed DOE's initial FEP listings at each stage of list development to determine whether the listing was comprehensive. In addition, EPA examined information sources used by DOE to compile FEP lists for completeness and accuracy of technical information. EPA also examined listings to determine whether DOE's rationale for reducing listings was appropriate and technically sufficient; see EPA Technical Support Document for Section 194.32: Scope of Performance Assessments, Tables 1-1 to 1-40 (EPA 1998a).

The comprehensiveness of the list and nature of the source were important considerations for EPA. DOE was required to identify all the 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. DOE based its CCA FEP listing upon the Draft CCA (Docket A-93-02, Item II-F-1) listing, which in turn was developed from the Swedish Nuclear Power Inspectorate (SKI) listing. The original SKI listing was not included in the CCA, although it is presented in Stenhouse et al. (1993) and Section 2.1 of EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a). The technical validity of the screening process, which EPA found to be adequate, is discussed in Section 32.E below.

Review of FEP Screening

DOE was required to justify FEP evaluations and any elimination of FEPs. DOE's evaluation and subsequent elimination of FEPs were based on the probability of a FEP occurring, the consequence of the FEP, and regulatory considerations. Criteria used to evaluate each included:

- Probability. EPA examined DOE's screening to assess whether DOE's rationale identified relevant assumptions, approximations, and measures of uncertainty. EPA examined DOE's probability arguments to determine whether they were well documented, technically appropriate (e.g., used appropriate processes or were based on relevant analogs or calculations), and in accordance with EPA's regulatory requirements.

- Consequence. EPA evaluated DOE's screening to determine whether it was supported by data, calculations, or reasoned arguments. This included reviewing the CCA to determine the technical basis and appropriateness of justifications and that, where appropriate, these justifications were reflected in calculations. Where there were modeling calculations, EPA reviewed the calculations for their affect on releases from the repository. For example, in the fluid injection analysis review, EPA reviewed whether the model setup was appropriate for the site's geology and whether the analysis incorporated the major aspects of performance-affecting processes and parameterization. EPA reviewed data specifications (e.g., bias) and assessed the nature of expert elicitations (if used). EPA also assessed FEP consequence relative to its time within the regulatory period (e.g., a FEP may not be of concern shortly after disposal, but could be of concern later). EPA evaluated consequences assigned to determine whether they were appropriate, well documented, and in accordance with EPA guidance and requirements.

- Regulatory. EPA examined DOE's screening to determine whether it was consistent with the physical and temporal constraints for activities and future states given in the Compliance Criteria. EPA also examined the screening to determine whether it contained appropriate regulatory interpretations. For example, long-term fluid injection activities were screened out since Section 194.32(c) requires that they only be considered "in the near future" (see Appendix SCR 3.3.1.3.2).

EPA's evaluation of DOE's FEPs analysis is set forth in greater detail in EPA Technical Support Document for Section 194.32: Scope of Performance Assessment, Tables 1-1 to 1-40 (EPA 1998a).

CCA included over 70 natural FEPs that were screened to determine those that should be included in the PA. Of these, approximately 26 were retained for inclusion in the PA (Appendix SCR, Table SCR-1). EPA concluded that DOE's screening methodology, which was based on examining consequences, probability, and regulatory requirements, is valid. The CCA also included information pertinent to mining, and deep and shallow drilling in Chapter 6, Appendix SCR, Appendix DEL, and associated references (NMBMMR 1995; Stoelzel and O'Brien 1996; and Stoelzel and Swift 1997.

The CCA did not include sufficient information to support certain conclusions relating to scenarios involving the connection of a Castile brine reservoir with repository waste panels. EPA required DOE to submit additional information supporting these conclusions (Docket A-93-02, Item II-I-01). In addition, the CCA did not contain adequate information supporting conclusions regarding the behavior of short-term brine flow to the surface if a brine pocket was intercepted (Docket A-93-02, Item II-I-17). Supplemental information was provided in two DOE letters (Docket A-93-02, Items II-I-24 and II-I-31). The information submitted by DOE addressed EPA's concerns as follows: the process and pressure conditions required to release substantial amount of contaminated brine to the surface are not found to be present in normal conditions. DOE also stated that the Conceptual Model Peer Review Panel concluded that entrainment of waste in Castile brine discharges during drilling would be minimal because circulation of brine will be limited and volume release will be minimal. EPA found the justifications provided by DOE to be adequately substantiated by modeling results. Based on the additional information submitted by DOE, EPA concluded that DOE appropriately considered natural processes and events, deep drilling, shallow drilling, and mining in its PA-related evaluations. See Section 194.33(a) in

CARD 33—Consideration of Drilling Events in Performance Assessments for further discussion of drilling.

<u>Review of Development of Scenarios</u>

EPA examined the scenarios presented in Chapter 6.3 of the CCA to determine how uncertainties in the FEPs were retained in the subsequent scenarios, how assumptions related to FEPS were captured, and how FEPs that were retained were accounted for in conceptual models. DOE determined whether the retained FEPs affected undisturbed or disturbed performance and developed scenarios describing disposal system performance (relative to undisturbed and disturbed performance). EPA evaluated scenario development relative to:

♦ Completeness of the FEPs retained.

♦ Appropriateness of the parameters used in representing a scenario based on the FEPs impact on the PA.

♦ Uncertainties.

♦ How effectively the range of conditions and sensitivity of the FEPs were represented through scenarios in the PA.

EPA concluded that the initial FEP list assembled by DOE was sufficiently comprehensive. This list appropriately screened out events and processes on the basis of probability, consequence, or regulatory requirements. DOE considered and incorporated into performance assessment numerous natural processes and events, mining, and deep drilling. DOE considered shallow drilling and appropriately screened it out on the basis of low consequence. DOE considered fluid injection activities and screened them out on the basis of low consequence; in addition, DOE appropriately followed regulatory requirements when it did not consider future fluid injection activities.

32.B.1 REQUIREMENT

(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. PAs 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."

32.B.2 ABSTRACT

EPA expected the CCA to discuss how mining was incorporated into the performance assessment. This discussion should include information on mining rates and probabilities, the application of institutional controls, hydraulic conductivity variations as a result of mining (including sampling thereof), and the extent of minable reserves. DOE identified potash as the only natural resource currently being mined near the WIPP. DOE used the EPA-specified frequency of mining and probability guidance provided in the CAG (pp. 43-44) in considering changes in hydraulic conductivity up to 1000 times the base hydraulic conductivity of the Culebra. In its calculation of the potash area to be mined, DOE considered minable reserves inside and outside of the controlled area.

In reviewing DOE's compliance with Section 194.32(b), 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, EPA examined the validity of DOE's potash reserve estimates, including DOE's assumptions regarding potash reserve location, quality, and minable horizons. EPA also examined the CCA to determine how hydraulic conductivity within supra-Salado units was modified relative to changes that could be caused by mining over the 10,000-year regulatory period.

32.B.3 Compliance Review Criteria

As stated in the CAG (pp. 43-44), EPA expected that the CCA would discuss:

- The method used to implement or incorporate the probability of mining in each century.
- How the mining rate effects are incorporated in PAs, including example calculations.
- How institutional control credit(s) were applied in PAs, including the time period that credit for institutional controls is assumed in PAs.
- The change in random sampling of hydraulic conductivity (using a probability distribution with a range of one to 1,000).
- How mining is incorporated into PAs.
- Evidence that the randomly sampled change in hydraulic conductivity was multiplied equally in all projected mined-out areas.
- The identity and extent of minable mineral resources currently extracted in the Delaware Basin.
- The identity of minable mineral resources in the controlled area, and the extent to which the resources are similar in quality and type to those resources currently extracted from the Delaware Basin.

EPA also expected the CCA to include graphics to illustrate the expected extent of resources used in the performance assessment.

EPA provided further guidance regarding mining probability determination for a given century, and how passive and active institutional controls should be dealt with in terms of probability. EPA also recommended that the impact of mining relative to hydraulic conductivity be limited to changes in the Culebra Dolomite. If DOE developed and selected an approach different than hydraulic conductivity, EPA required that it must be peer reviewed and documented according to Section 194.27.

32.B.4 DOE METHODOLOGY AND CONCLUSIONS

DOE stated that the only natural resource currently being mined near the WIPP is potash (potassium salts) within the McNutt member of the Salado Formation (CCA Chapter 6.4.6.2.3, p. 6-137). Consistent with Section 194.32(b), DOE therefore only considered potash mining in the performance assessment. Based upon information presented in NMBMMR 1995 and Appendix MASS.15, DOE concluded that only Zones 4 and 10 of the McNutt member are currently economically minable. The 4th ore zone is nearest to the proposed waste panel horizon; it lies about 300 feet (100 meters) above the proposed waste panel horizon. DOE outlined the extent of the horizons of both Zones 4 and 10 within and outside of the controlled zone in the CCA. DOE indicated that Zones 4 and 10 occur in a north-south trend along the eastern third of the controlled area. Outside of the controlled area, they occur in an area to the immediate southeast of the WIPP Site Boundary. However, DOE indicated that potash resources occur and are expected to be mined within the Culebra groundwater modeling domain area, which extends to the south of the controlled area. DOE also noted that no minerals are present in minable quantities or types similar to those currently being mined in the Delaware Basin, in units above the Salado Formation (CCA Chapter 6.4.6.2.3, pp. 6-136 to 6-147).

During the process of mining, effects of the mining on overlying geologic units extend beyond the mined area. DOE used the concept of "angle of draw" to identify the area in the Culebra dolomite in which the Culebra's hydraulic conductivity would be affected by mining. DOE assumed that the angle of draw (the angle "outward and upward" from the mined area that will be affected by mining) is 45 degrees. DOE considered the effects of mining within and around the controlled area under the disturbed case for the PA, while effects outside of the controlled area were considered under the undisturbed case.

The effect of mining on the Culebra dolomite's hydraulic conductivity was incorporated in the PA by multiplying location-specific values in the Culebra transmissivity field by a randomly sampled value from one to 1,000 within the areas identified by DOE to be affected by mining. Changes in hydraulic conductivity were therefore the same or higher due to mining. DOE indicated that every Latin Hypercube sample (LHS) vector and every steady state flow field used in Culebra transport simulations incorporated this change to the transmissivity field. The code ALGEBRA was used to apply the effects of potash mining to the GRASP-INV transmissivity fields (Chapter 6.4.6.2, pp. 6-123 to 6-133).

No mining within the controlled area was assumed during the active institutional control period, although reserves outside of the controlled area were assumed to be removed during this time period. During the 600 year passive institutional control period, DOE assumed PICs to be 99% effective in preventing mining. Using the mining rate specified in the CAG (p. 43), DOE assumed a mining probability of one chance in 100 in each century of the regulatory time frame after the institutional control periods, with a maximum of one occurrence during the 10,000-year time period, in accordance with Section 194.32(b). DOE interpreted this probability as a Poisson model with a probability of mining of one in 10,000 (10^{-4}) per year[1] uniform probability, although during the period of passive institutional controls, a mining probability of 10^{-6} was assumed (Chapter 6.4.12.8, pp. 6-198 to 6-199 and Appendix CCDFGF, Section 3). Calculations are presented in general terms in Chapter 6.4 and Appendix CCDFGF, Section 3.

DOE concluded that:

- The only natural resource currently being mined near the WIPP is potash within the McNutt member of the Salado Formation.

- Important effects of hydraulic conductivity change occur only within the Culebra.

- Spatially variant hydraulic conductivities were established in the Culebra, by multiplying the hydraulic conductivity by a factor of one to 1,000 where they are affected by mining, consistent with EPA's suggested probability distributions (CAG, pp. 44-45). DOE assumed that this parameter distribution is uniform and was randomly sampled in LHS (Parameter Number 34).

- DOE assumed a mining probability of one chance in a 100 in each century of the regulatory time frame, with a maximum of one occurrence during the 10,000-year time period.

The extent of resources and extent of the affected area in the Culebra Dolomite from mining that would cause hydraulic conductivity variations are shown in Figures 6-19 through 6-22 of the CCA.

32.B.5 EPA COMPLIANCE REVIEW

DOE only considered potash within the McNutt Potash horizon of the Salado formation when evaluating the effects of mining on the PA. NMBMMR (1995) identified additional minable resources, including caliche, salt, and gypsum, but DOE concluded that these resources are not economically attractive, given the low sales price of the reserves and more cheaply mined alternatives. EPA agrees with this conclusion.

[1] A probability of 1 in 10,000 per year is the same as a probability of 1 chance in 100 years for 100 centuries.

The CCA indicated that, at present, only the 4th and 10th horizons contain economically valuable (at the current market condition) potash reserves[2]. In response to the Environmental Evaluation Group's (EEG) recommendation to consider all mineable potash resources (Docket A-93-02, II-H-25), DOE responded that they considered mining inside and outside of the controlled area separately, as required under Section 194.32 (a) and (c) (Docket A-93-02, II-H-45). The Department also indicated that they based estimates of the impact of mining on EPA standards (61 FR 5229) and mining practices in the Delaware Basin. According to DOE, these estimates are conservative and represent all possible future impacts on the disposal system. In specific reference to the minable footprints, DOE concluded that this discrepancy is due to the difference between the definition of resources and reserves. That is, DOE contended that their estimates were based on actual minable reserves, which are less pervasive than resources. However, DOE also contended that this approach was consistent with the intent of Section 194.32(b), which states that DOE must consider resources "similar in quality and type" to those currently extracted. DOE concluded that since the identified zones and grade are currently being mined near the WIPP, they have met the intent of the regulation.

EPA's review of minable reserves found that DOE identified current minable thicknesses and horizons near the WIPP. DOE's estimate roughly corresponds to that identified in an EPA technical memorandum (Peake 1996). 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). EPA therefore concurred with DOE's approach.

Also, EPA noted that the CCA does not address, in detail, the extraction of brine (via dissolving of salt with fresh water) for use in oil field drilling muds. Information presented in Appendix DEL indicated that a dissolution project is present approximately 14 miles from the WIPP. DOE eliminated this activity from consideration in PA based upon limited consequences of potential subsidence. However, EPA noted in a March 19, 1997, letter to DOE (Docket A-93-02, Item II-I-17) that the impacts of this brine extraction activity should be more thoroughly addressed, including the effect that it might have upon the hydraulic characteristics of overlying units. DOE subsequently submitted information showing that brine extraction would result in little effect on the overall hydrologic system not accounted for in other PA assumptions (Docket A-93-02, Item II-I-24). This conclusion is based on the analysis that showed that the brine production between 1979 and 1991 has created a cavity of 3.4 $x10^6$ cubic feet. A cavity of this dimension will take a minimum of 50 years to be affected (Docket A-93-02, Item II-I-31). It is estimated that it will take an even longer time for the disposal system area to reach the critical ratio for subsidence to occur. Based upon DOE's supplemental information, the restricted scale of brine extraction, and the distance involved, EPA concluded that while brine extraction (solution mining) occurs, its effects were appropriately screened out from consideration in the PA (due to low consequence).

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[2] According to Guzowski and Grubel (1991), reserves are those resources that are currently economically recoverable with currently available technology, and resources are mineral deposits that are not currently economical or have not been discovered.

DOE assumed a mining probability of 10^{-4} per year after passive institutional controls have ceased, and one in 10^{-6} during the passive institutional control time period (Chapter 6.4.12.8, pp. 6-198 to 6-199; Appendix CCDFGF, Section 3). The probability of mining is implemented in CCDF calculations. EPA concluded that DOE's treatment of probability beyond the 700-year passive institutional control time frame was consistent with the regulatory requirements of Section 194.32(b), where DOE assumed a one in 100 probability of mining every 100 years. Consideration of mining during the active and passive institutional control period was consistent with potential credit requested under Sections 194.41 and 194.43; see Section 194.41(b) and Section 194.43(a) in **CARD 41—Active Institutional Controls** and **CARD 43—Passive Institutional Controls**, respectively.

DOE also assumed, in accordance with Section 194.32(b), that mined resources will be completely removed from the controlled area within the century that mining occurs, and complete removal of mineral resources was assumed to occur only once over the regulatory time frame. DOE assumed that mining will be done via room and pillar or other conventional methods, and solution mining of potash will not take place due to mineralogical and economic constraints. Although DOE's arguments appeared reasonable, a permit was recently sought to conduct a pilot study north of the WIPP to assess whether extraction of potash minerals via solution mining is a feasible technology. As such, DOE considered the impacts that this type of mining could have on the assumed mined horizons and impact on overlying units.

As a result of public comments and EPA's request for more information about the effects solution mining, DOE provided supplemental information regarding potash solution mining in a May 14, 1997 response (Docket A-93-02, Item II-I-31). In this response, DOE concluded that the impacts of solution mining for potash should be the same as those for room and pillar mining, except for potential subsidence-induced hydraulic effects in the Culebra similar to those for typical mining practices. EPA agrees that solution mining would not affect WIPP performance. Since there is a large vertical and lateral distance to the potential mined area, there is no hydraulic connection in the very low permeability Salado Formation between the potash to be mined in the permit and the waste horizon. Subsidence of overlying units due to the extraction of material would be the main problem with the solution mining, but DOE screened out subsidence effects due to mining (Docket A-93-02, Item II-I-31). EPA agrees with this conclusion because of the limited potential for interaction between the potash zone and the waste horizon.

EPA noted that DOE assumed that mining impacts the hydraulic conductivity of only the overlying Culebra member of the Rustler Formation. As presented in Section 194.32(b), and as suggested in the CAG, DOE assumed a random change in hydraulic conductivity with a probability distribution of one to 1,000 (linear distribution). The probability distribution was consistent with EPA guidance and regulations. The CCA did not discuss why hydraulic conductivity variations in other members of the Rustler Formation were not considered in the PA. However, DOE's approach in considering only Culebra transmissivity (hydraulic conductivity multiplied by the thickness, which for the Culebra thickness is modeled as constant) was consistent with EPA's intent that "DOE may use location-specific values of hydraulic conductivity. . . within the Culebra dolomite. . ." (61 FR 5229). EPA concluded that DOE's assumption of a mined angle of draw of 45 degrees was consistent with that suggested by EPA in

Chapter 9 of the Background Information Document for 40 CFR Part 194 (Docket A-92-56, Item V-B-1); see also Peake (1996).

Mining was incorporated in the PA through the application of the one to 1,000 multiplier to hydraulic conductivity in the calculated TFIELD transmissivity field for the Culebra. Appendix TFIELD and related documentation include information pertinent to this application of the transmissivity multiplier. Further, DOE stated that it applied the random multiplier equally in the projected mined out areas, which is supported by information presented in TFIELD and CCDF (Chapter 6.4.6.2.3, p. 6-138). EPA concluded that DOE addressed the suggested material presented in the CAG pertaining to the hydraulic conductivity multiplier. See Section 194.23(a) of **CARD 23—Models and Computer Codes** and in EPA Technical Support Document for Section 194.23: Parameter Report (EPA 1998e).

During the public comment period, EPA received questions that current mineable resources will not be the same as what may be mined in the future. EPA recognized that the mineral deposits that will be mined in the future may not be the same as those mined today; see EPA's Response to Comments Document, Section 8 (Docket A-93-02, Item V-C-1). However, to avoid unnecessary speculation about what the size and shape of those mineral deposits might be, EPA chose to accept the size and shape of existing mineral deposits as surrogates for the size and shape of the unknown mineral deposits that might be mined in the future. The Agency finds that the impact of solution mining on the PA does not need to be analyzed for boreholes drilled in the future as specified in Section 194.33(d).

32.C.1 REQUIREMENT

(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."

32.C.2 ABSTRACT

EPA reviewed the CCA to assess whether appropriate events were identified and considered by DOE and whether the CCA presented analysis of effects on the disposal system and the effects of existing boreholes. EPA considered how these events affected the disposal system and whether DOE addressed the potential for slant drilling. EPA also examined whether DOE addressed potentially exploitable existing leases.

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 the PA (Chapter 6.7.5). DOE divided human-initiated activities into three categories: (1) those that are currently occurring, (2) those that might be initiated in the operational phase, and (3) those that might be initiated after disposal. Human-initiated activities included three different drilling-related intrusion scenarios used in the PA, based upon the screening analysis, designated by DOE as E1, E2 and

E1E2 (Chapter 6, p. 6-77). 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 Formation. The E2 scenario included all future boreholes that penetrate a panel but do not strike an underlying brine pocket within the Castile Formation. The E1E2 scenario was defined as the occurrence of multiple boreholes that intersected a single waste panel, with at least one of the events being an E1 occurrence. Refer to Section 194.33(a) in **CARD 33—Consideration of Drilling Events in Performance Assessments** for additional discussion of the three different drilling-related intrusion scenarios. DOE's approach to mining is discussed in Section 32.B.4 above.

DOE included an assessment of the potential effects of existing boreholes as part of its FEPs screening analysis. DOE concluded that natural borehole fluid flow through abandoned boreholes would be of little consequence during current and operational phase activities. In addition, DOE screened out the occurrence of flow through undetected boreholes based on low probability. The CCA includes Appendix DEL, which describes the oil and gas exploration and exploitation activities in the Delaware Basin and immediate WIPP area. This document shows the location of oil and gas wells in the Basin and WIPP area and includes maps presenting the location of existing leases.

DOE provided additional information pertaining to brine extraction (solution mining) not included in the CCA. Although the brine extraction FEP was not explicitly addressed in the CCA, this additional information indicated that brine extraction (solution mining) will not have an impact on the PA, as any changes in disposal system hydraulics caused by brine extraction were already accounted for in Culebra transmissivity and hydraulic head uncertainties.

32.C.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 45), EPA expected the compliance application to:

- ♦ Provide an analysis of the effects of any activities on the disposal system.
- ♦ Identify the activities that occur, or are expected to occur, in the vicinity of WIPP soon after disposal, including the extraction of mineral resources similar in quality and type to those currently extracted.
- ♦ Discuss the potential effects of such activities identified to occur, or expected to occur, in the vicinity of WIPP soon after disposal.
- ♦ Discuss potential effects of existing boreholes.
- ♦ Discuss the process by which the expected lives of the oil and gas fields in existing leases were estimated.
- ♦ Identify existing leases that are being developed, or that can be reasonably expected to be developed in the near future, in the vicinity of the controlled area.

EPA provided guidance regarding what should be considered "near future" and "soon after disposal" for oil and gas drilling in the CAG. With respect to mining, EPA suggested that the terms "near future" and "soon after disposal" be applied to the estimated lives of existing mines and plans for new mines in the vicinity of WIPP. EPA recommended that DOE use current minable reserves in estimating mine lives and the extent of potential mining.

32.C.4 DOE METHODOLOGY AND CONCLUSIONS

DOE presented information pertaining to Section 194.32(c) primarily within Chapter 6.2-6.4 of the CCA, as well as Appendices DEL, SCR, CCDFGF, SA, and MASS. In addition, DOE responded to EPA requests for additional information and public comments regarding activities such as brine extraction, potash mining, and fluid injection analysis (Docket A-93-02, Items II-I-24, II-I-28, II-I-31, II-I-36, and II-I-45).

DOE indicated that Section 194.32(c) requires PAs to include an analysis of the effects on the disposal system of any activities, specifically human-initiated activities such as existing boreholes and leases, well installation, fluid injection, etc. In particular, DOE evaluated the effects of activities that might occur within the controlled area after active institutional controls expire.

Analysis of Effects: Summary of Intrusion Scenarios in the PA

In Appendix SCR, DOE divided human-initiated activities into three categories: 1) those that are currently in place, 2) those that might be initiated in the near future (e.g., during the operational phase), and 3) those that might be initiated after disposal (pp. SCR-97 to SCR-98). In accordance with Section 194.25, DOE assumed that the characteristics of the future human-initiated activities remain what they are at the time the compliance application is prepared.

In addition, DOE indicated that human-initiated activities included three different drilling-related types of intrusion scenarios used in the PA based upon their screening analysis (Chapter 6.3). The E1 scenario assumed penetration of a panel by a borehole drilled through the repository, which then struck a brine pocket present in the underlying Castile Formation. Refer to the discussion of Section 194.14(a)(2)(i) in **CARD 14—Content of Compliance Certification Application** for additional information pertaining to Castile brine pockets. The E2 scenario included all future installations of boreholes that penetrate a panel but do not strike an underlying brine pocket within the Castile Formation. The E1E2 scenario was defined as the occurrence of multiple boring installations that intersected a single waste panel, with at least one of the events being an E1 occurrence. Refer to Section 194.33(a) in **CARD 33—Consideration of Drilling Events in Performance Assessments** for additional discussion of the three different drilling-related intrusion scenarios. DOE concluded that the potential effects of these scenarios are critical to the PA and included the impacts of radionuclide releases from cuttings, cavings, spallings, brine releases, and transport of brine within the Culebra formation as they relate to the various intrusion possibilities. See Section 194.23 (a)(1) in **CARD 23—Models and Computer Codes** for a discussion of the modeling of these potential scenarios. Code CCDFGF (described in CCA Appendix CCDFGF) implemented the sampling where the puncturing of the panel by E1 and E2 intrusions is modeled (e.g., the probability of striking an underlying Castile brine pocket is taken into account). DOE conducted the sampling by using six computational scenarios (S1 through S6), with S1 representing undisturbed conditions and S6 representing an E2 intrusion at 1,000 years followed by an E1 intrusion at 2,000 years. DOE compared the CCDFs constructed to EPA standards, based upon the different intrusion scenarios and releases (brine and solids). Additional discussion of related modeling and results of the PA, including computational scenarios, is contained under Section 194.23(a) in **CARD 23—Models and Computer Codes**, Section 194.34(a) in **CARD 34—Results of Performance Assessments** and Section 194.55(a) in **CARD 55—Results of Compliance Assessments.**

Identification of Activities in the WIPP Area and Analysis of Effects

DOE identified the following human-initiated activities and their results as being present in the Delaware Basin, and potentially near the WIPP (Appendix DEL, Tables DEL-3 and DEL-7):

- ♦ Oil and gas exploration/exploitation and extraction, including enhanced oil recovery.
- ♦ Potash exploration/exploitation (extraction is addressed under Section 194.32(b)).
- ♦ Fluid injection related to oil and gas production (class 2).
- ♦ Sulfur coreholes.
- ♦ Hydrocarbon (gas) storage in geologic reservoirs.
- ♦ Gas reinjection.
- ♦ Brine wells for solution mining (salt water mining).
- ♦ Water supply wells.
- ♦ Geothermal resources.

DOE concluded that oil and gas exploration and exploitation and water and potash exploration are the principal human-initiated activities that need be considered for the PA; all other human-initiated activities were screened out (Chapter 6.2.5). DOE stated that oil and gas are the only known reserves more than 2,150 feet below the surface that have been exploited in the Delaware Basin over the last 100 years, although some deeper holes for sulfur and potash exploration have been drilled. Potash reserves near WIPP are shallower than 2150 feet, and there are no known sulfur reserves in the WIPP area. DOE stated that only potash and water-related drilling need to be considered for shallow drilling to depths less than 2,150 feet. DOE eventually screened shallow well drilling from the PA because of low consequence (Chapter 6.2.5.2). DOE also examined current activities involving water flooding, gas reinjection, and Underground Source of Drinking Water (USDW) Class 2 oil and gas production-related water injection for disposal. These latter activities occur in the Delaware basin and in the immediate area of the WIPP. Appendix DEL shows the location of injection wells in the immediate WIPP area.

DOE described oil and gas activities as consisting of exploration, exploitation (e.g., oil field development drilling once reserves are discovered), and extraction of these resources (Appendix SCR, 3.2.1.1). DOE screened out the possibility of oil and gas extraction activities from affecting the WIPP based upon low consequence during the WIPP site history and anticipated operations. For the future, DOE screened out oil and gas extraction on the basis of regulatory requirements.

FEP screening by DOE considered the possibility of both subsidence and pressure gradients in the disposal system due to oil and gas extraction, stating that surficial and associated geologic material subsidence will be minimal to nonexistent (see Appendix SCR). DOE stated that since subsidence due to mining would be less than five feet, subsidence due to oil and gas extraction would be significantly less. Also, oil and gas extraction at the WIPP occurs in well lithified strata, and would therefore not experience subsidence that could, for example, occur via oil and gas extraction from unlithified sediments, such as might occur in the Gulf of Mexico region (Brausch et al. 1982). DOE indicated that fluid extraction could affect the repository horizons outside of the controlled area due to failed borehole casings, but oil and gas extraction occurs from reservoirs so far below the disposal horizon that pressure gradients in these horizons would not affect the WIPP, unless the casing failed (Stoelzel and O'Brien 1996).

In addition, DOE noted that oil and gas extraction includes enhanced oil recovery activities, primarily waterflooding. Stoelzel and O'Brien (1996) evaluated the effects of fluid injection from two hypothetical boreholes near the WIPP using the BRAGFLO code, with some modified parameters and assumptions to fit the fluid injection conditions (e.g., a modified grid system). This report concludes that although a worst case realization did result in brine inflow from the injection location to the repository over an approximately two-mile distance within anhydrite interbeds of the Salado, the value of cumulative brine inflow was relatively small and within the bounds of brine inflow values calculated for the undisturbed scenario. Therefore, DOE eliminated the water flood FEP based upon low consequence. EPA required DOE to revisit this scenario assuming a modified injection simulation period, increased Bell Canyon (injection zone) transmissivity, and reduced disturbed rock zone (DRZ) volume. DOE still concluded that water flooding could be eliminated from the PA based on low consequence (Stoelzel and Swift 1997).

Hydrocarbon storage takes place in the Delaware Basin but involves reinjection of gas into pre-existing boreholes into depleted reservoirs. DOE indicated that this procedure does not involve installation of new boreholes. Since hydrocarbons would be injected into existing reservoirs well below the disposal system, the consequence of hydrocarbon storage would be relatively minimal (Appendix SCR, Section 3.2.1.1). Thus, DOE eliminated this activity from the PA based on low consequence.

Extraction of brine for oil field drilling muds is discussed in Appendix DEL, which indicates that there is a single brine extraction mine in the WIPP area (Appendix DEL, Tables DEL-3 and DEL-7). DOE did not include brine extraction as a FEP in the CCA, although it was considered in the DCCA (Docket A-93-02, Item II-F-1). See Section 32.B.4 of this CARD and

EPA Technical Support Document for Section 194.32: Fluid Injection Analysis (EPA 1998b). DOE did not consider geothermal energy and sulfur potentially exploitable resources, and therefore screened them out. As summarized previously, DOE considered water wells but screened them out due to low consequence (Appendix SCR, Table SCR-3).

Existing Boreholes

DOE included an assessment of the potential effects of existing boreholes as part of its FEP screening analysis. The results of DOE's assessment are presented in Appendix SCR, Section 3.3.1.4. DOE concluded that available information indicated that natural borehole fluid flow through abandoned boreholes would be of very little consequence during operational phase activities, based, for example, upon known hydrologic head conditions. DOE identified this flow to be of importance to the PA if such a borehole penetrated a Castile brine reservoir under the repository. In such a scenario the flow would only have long-term (i.e., post operational period) importance. In accordance with Section 194.25, DOE did not consider abandoned borehole flow induced by waste-related conditions in the PA. In addition, DOE screened out the occurrence of flow through undetected boreholes based on low probability, claiming that the occurrence of such undetected boreholes in the controlled area is highly unlikely given the intense scrutiny given the site over the past 25 and more years.

Oil and Gas Field Life and Lease Analysis

Appendix DEL described the oil and gas exploration and exploitation activities in the Delaware Basin and immediate WIPP area. Although DOE did not specify oil and gas field life in detail for each field near WIPP in Appendix DEL, it is possible to derive the expected active lifetimes of oil and gas fields from information presented in Appendix DEL. Also, NMBMMR (1995) presented the location of oil fields in the WIPP area. The CCA includes maps in Appendices DEL and DMP showing the location of existing leases. These maps were assembled by DOE based on current legal descriptions of mineral rights leases on file in government and commercial data bases. DOE concluded that:

- Eight general categories of human-initiated activities occur in the Delaware Basin and could potentially occur in the WIPP vicinity:

    - Oil and gas exploration/exploitation and extraction.
    - Potash exploration/exploitation (extraction is addressed under Section 194.32(b)).
    - Fluid injection related to oil and gas production, including enhanced oil recovery (class 2).
    - Sulfur coreholes.
    - Hydrocarbon (gas) storage in geologic reservoirs.
    - Gas reinjection.
    - Wells for extraction of brine
    - Water supply wells.
    - Geothermal resources

- Only oil and gas exploitation and extraction, and potash borehole installation, are of concern to the PA.

- The possibility of oil and gas extraction activities affecting the WIPP should be screened out based upon low consequence during site history and anticipated operations. For future occurrence of such activities, DOE screened out the FEP on the basis of regulatory requirements.

- FEP screening considered the possibility of both subsidence and pressure gradients in the disposal system due to oil and gas extraction. DOE stated that surficial and associated geologic material subsidence will be minimal to nonexistent.

- The fluid injection FEP should be eliminated based upon low consequence.

- Hydrocarbon storage takes place in the Delaware Basin and involves reinjection of gas into pre-existing boreholes. DOE indicated that this procedure does not involve installation of new boreholes and since hydrocarbons would be injected into existing reservoirs well below the disposal system, the consequence of this activity would be relatively minimal. It was therefore eliminated from PA based upon low consequence.

- There are brine extraction activities in the WIPP area (Appendix DEL, Tables 3-7). Brine extraction was discussed in Appendix DEL and supplementary information (DOE 1997c). DOE did not explicitly include brine extraction as a FEP in the CCA.

- Geothermal energy was not considered a potentially exploitable resource and was screened out.

- Available information indicated natural borehole fluid flow through abandoned boreholes would be of little consequence during operational phase activities, based, for example, upon known hydrologic head conditions. In addition, DOE screened out the occurrence of flow through undetected boreholes based on low probability, claiming that the occurrence of such boreholes in the controlled area is highly unlikely given the intense scrutiny given the site over the past 25+ years.

32.C.5 EPA Compliance Review

EPA examined the CCA to assess the technical validity of information pertaining to the occurrence, effect, and impact of oil and gas development and other related human-initiated activities. This assessment included lease analysis and the potential effects of existing boreholes. EPA also examined the CCA to determine whether a complete listing of FEPs related to human-initiated activities that could occur in the WIPP area was considered in the FEP development process. In addition, EPA assessed the FEP screening analysis process and results to determine specifically whether the screening performed by DOE was technically valid based upon the screening categories.

Analysis of Effects and Identification of Activities

EPA examined DOE's categorization of human-initiated activities and concluded that the activities analyzed by DOE capture the spectrum of activities that would occur during the 10,000-year regulatory time period. EPA noted that near future oil and gas activities were described by DOE as consisting of exploration (drilling) and exploitation (e.g., oil field development drilling once reserves are discovered) and extraction of these resources, including the actual impact of oil and gas extraction/pumping activities. Of these activities, DOE retained only oil and gas exploration drilling and enhanced oil and gas recovery drilling as FEPs for the PA, while the remaining FEPs were screened out from further consideration. EPA determined that this approach was reasonable. EPA's detailed review of each FEP can be found in EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a).

DOE screened out the possibility that oil and gas extraction activities would affect the WIPP based upon low consequence during site history and anticipated operations. As a result, DOE screened out long-term future oil and gas extraction (production) on the basis of regulatory requirements. EPA concluded that the FEP screening appropriately considered the possibility of both subsidence and pressure gradients in a system due to oil and gas extraction. Appendix SCR adequately supports the conclusion that surficial and associated geologic material subsidence will be minimal to nonexistent (SCR 3.3, p.108). Based on the discussion in Appendix SCR, EPA concluded that DOE considered the appropriate issues, and that the technical conclusions reached by DOE regarding screening of oil and gas extraction activities were valid.

The CCA did not contain adequate information supporting conclusions regarding the possible impacts of brine extraction (Docket A-93-02, Item II-I-17). In addition, EPA questioned several of DOE's assumptions (e.g., treatment of the waste area, disturbed rock zone, and frequency of events) regarding screening of the fluid injection FEP (Docket A-93-02, Item II-I-17, Enclosures 1-6). DOE addressed screening of drilling for waste disposal with a primary investigation for FEPs, a report by Stoelzel and O'Brien (1996)[3], and a supplementary DOE assessment (Stoelzel and Swift 1997). DOE screened out all fluid injection-related FEPs, including enhanced oil recovery (waterflooding) and salt water disposal (Class 2) production based on the results of this study. Since the fluid injection and other scenarios were the subject of many public comments and these scenarios underwent heightened EPA scrutiny, this topic is addressed in more detail below.

Fluid Injection

Brine extraction for use in drilling muds was not specifically addressed by DOE in the CCA. EPA's analysis showed that brine extraction may not be occurring in the immediate vicinity

[3] Although referenced in the CCA that was submitted on October 29, 1996, DOE did not submit Reference #611 until December 1996.

of the WIPP but is conducted near Carlsbad, approximately 26 miles from WIPP. Additional detail was requested by EPA in the March 19, 1997, letter to DOE (Docket A-93-02, II-I-17). With respect to brine extraction, DOE provided EPA with a memorandum prepared by Hicks, as well as other supporting information addressing public comments (Docket A-93-02, Items II-I-17, II-I-24, II-I-28, and II-I-45). DOE's supplemental information addressed brine cavity development and the duration of brine extraction activities. EPA reviewed this information and concurred that brine extraction activities should be screened out based on limited consequence. EPA also concurred with DOE's screening of water supply wells and geothermal energy boreholes due to low consequence. The amount of potable water available in the area is insignificant and the depth of any viable geothermal energy boreholes is unrealistic and uneconomic.

The New Mexico Attorney General (NMAG) submitted a report that contradicted DOE's fluid injection modeling (Stoelzel and O'Brien 1996) and suggested that fluid injection activities could overwhelm the WIPP with brine (Docket A-93-02, Item II-H-28). EPA reviewed the NMAG report and considered its implications in preparation for the proposed compliance determination decision. EPA used information in the NMAG report, in part, as the basis for the Agency's March 19, 1997, request for more information on the fluid injection scenario (Docket A-93-02, Item II-I-17).

EPA found that the NMAG report models highly unrealistic conditions in the WIPP area. For example, the NMAG report assumes, for all modeled scenarios, that all injected brine is directly injected into the anhydrite marker beds in the Salado Formation. This approach ignores the fact that well operators would be attempting to inject brine into certain formations thousands of feet (hundreds of meters) below the Salado where oil and gas reserves are lower. Continuous injection into one anhydrite layer several feet thick is not a viable operational possibility, especially when the intended effect is to increase oil production from units far below. Also, the NMAG report considers fractures in the anhydrite to extend for three or more kilometers and to remain open. A prerequisite for this unlikely condition, however, is high pressure, and the report states, "We can only get high pressure over the entire region if the repository pressure is also high" (Docket A-93-02, Item II-H-28, p. 21). The report further states, "If the pressure in WIPP is below lithostatic, then the area where a fracture might remain continuously open is restricted to close into the injection well. The fracture will not be continuously open all the way to WIPP; however, it might pulse open and closed. . ." However, lithostatic (high pressure) conditions occur infrequently in DOE's conditions in the CCA and the Performance Assessment Verification Test; see PAVT Tables 2.1 to 2.6 (Docket A-93-02, Items II-G-26 and II-G-28).[4]

[4] After a review of DOE's PA parameter development process, EPA directed DOE to change selected parameters and run additional calculations in the Performance Assessment Verification Test (PAVT). The PAVT results indicate that the PAVT CCDFs are similar to those in the CCA and still within the containment requirements by more than one order of magnitude. Because of the close agreement between the PA and PAVT results, EPA believes that the PAVT verifies that the original CCA parameters were adequate for use in PA and comparison against the radioactive waste containment requirements. For a detailed discussion of PAVT results, see Section 194.23 (c)(4) in **CARD 23—Models and Computer Codes** and Section 194.32(b) and (f) in **CARD 34—Results of Performance Assessments**.

According to DOE's calculations of brine flow into the waste panels and subsequent gas generation that relies on brine, high pressure will not occur for several hundred years, if at all. This period occurs after the "near future" period in which fluid injection activities could be expected to occur in the vicinity of the WIPP. Another report by NMAG on fluid injection suggests that DOE's estimate of infrequent high lithostatic conditions may be much less likely due to MgO hydration effects that use existing brine in the waste area (Docket A-93-02, Item II-H-29). See Section 194.44(a) in **CARD 44—Engineered Barriers** for further discussion of the effects of MgO backfill. Chapter 8 of the NMAG report models a high pressure scenario that "does not occur until the pressure within the repository builds up to near lithostatic" (p. 29). Since high pressure does not occur until after fluid injection activities are assumed to cease, this scenario is highly implausible.

The CCA and supplementary information on fluid injection show that there is little consequence of fluid injection activities. The supplemental information provided by DOE indicates that current well construction makes it unlikely that there could be a well failure of the nature that occurred in the Rhodes-Yates field outside the Delaware Basin (Stoelzel and Swift 1997, and Docket A-93-02, Items II-I-31 and II-I-36). DOE's analysis used reasonable estimates and concepts to screen out the fluid injection scenario as inconsequential. Although DOE did not use probability of failure to rule out fluid injection, DOE's analysis of well construction and operating practices around WIPP also shows that there is a very low probability that a well would suffer a complete failure, as assumed in the NMAG fluid injection report.

EPA notes that the nature of anhydrites, the duration of injection activities, and the presence of leaking boreholes are important considerations for injection well analyses. EPA also notes that no detailed documentation regarding Salado anhydrite fracture density or Salado Formation homogeneity were found in the discussion in Stoelzel (1996). DOE included additional information in response to EPA's comments regarding completeness of the CCA (see Docket A-93-02, Items II-I-01, II-I-02, II-I-03, II-I-04, II-I-24, II-I-27, and II-I-31), but did not demonstrate conclusively the homogeneity of anhydrite fractures (Stoelzel and Swift 1997). EPA independently assessed the homogeneity of fractures in marker beds, on both a local and regional scale; see EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a). Fracture parameters are the principal determining factor of interbed fluid flow. EPA found that the repository could theoretically experience significant increases in pressure and brine movement if fractures are oriented in a preferential direction, with a dominant pathway from the injection area toward the repository. EPA also found that if radial flow within the interbeds does not exist, but regions of higher permeability are present, the impact on the WIPP is uncertain. EPA examined fluid flow within marker beds on both micro and macro scales. EPA concluded that it is possible that fracture and fluid flow characteristics within marker beds are anisotropic and unhomogeneous on a small scale. However, when the entire Salado system in the WIPP area is considered, the overall system response is that of a more homogenous system. In addition, DOE's supplemental modeling indicated that little brine is predicted to enter the anhydrites (Docket A-93-02, Item II-I-36).

In addition, EPA's examination of the scenario modeled by DOE (Docket A-93-02, Item II-I-36) indicates that it is realistic and compatible with the current Delaware Basin oil exploitation practices. The scenario involves injection into two wells at opposite sides of the

WIPP land withdrawal boundary at a constant pressure (maximum allowable in the area). The Bell Canyon injection interval is treated as a closed finite reservoir and all others are infinite. A vertical pathway of significant permeability is assumed to extend from the Bell Canyon to Marker Bed 138. This approach allows flow from the injection interval to the Castile, interbeds, and Salado. The high permeability value (3.16×10^{-13} to 1.0×10^{-3} m^2) used to represent a leak is conservative. EPA concluded that this screening was sufficient and realistic but not adequately comprehensive (EPA 1998b).

In summary, EPA's initial assessment of DOE's screening results was that fluid injection FEPs, including enhanced oil recovery and salt water disposal (Class 2) were not appropriately modeled. The screening assessment approach used by DOE appeared to be inadequate for injection-related activities, including liquid waste disposal. EPA performed its own independent analysis of fluid injection, which showed that the injection analysis must include the nature of anhydrites, the duration of injection activities, and the presence of leaking boreholes; see EPA Technical Support Document for 194.32: Fluid Injection Analysis (EPA 1998b). Both DOE (Docket A-93-02, Item II-I-36) and EPA (EPA 1998b) performed additional modeling of the injection well scenario. EPA concluded that, although scenarios can be constructed that move fluid to the repository via injection, the probability of such an occurrence is less than one in 10,000, given the necessary combination of natural and human-induced events. DOE screened out induced system changes due to hydrocarbon storage operations in the area on the basis of low consequence during site historic and anticipated operations. DOE screened out this FEP for the long term on the basis of regulatory requirements, since EPA does not require DOE to consider in the long term those FEPs screened in the near term.

EPA received public comments on the proposed decision to certify the WIPP that pertained to fluid injection, most of which requested a more thorough analysis of the Rhodes-Yates and Vacuum Fields. In these fields, brine movement through Salado marker beds has been attributed by some to fluid injection well failure. In response to public comments, EPA revised its technical support document (EPA 1998b) to explain EPA's analysis of fluid injection in the WIPP area; see the Response to Comments Document, Section 8 (Docket A-93-02, Item V-C-1).

In addition, EPA reviewed the documentation of DOE's fluid injection screening activities for the PA, as well as supplemental information provided by DOE in response to questions raised by the Agency. EPA also developed rough estimates of the probability that a failed injection well would significantly affect the WIPP's performance. The most likely scenario for a failed injection well to affect the WIPP is for injected brine to migrate vertically upward from a deep injection zone through a faulty wellbore annulus seal to the elevation of an anhydrite interbed that intersects the WIPP repository, and then to migrate horizontally along that interbed causing a pressure transient that drives additional brine into the repository.

EPA found that fluid injection is a current practice in the vicinity of WIPP and may be expected to continue into the near future. Fluid injection is being conducted for purposes that can include brine disposal, oil field pressure maintenance, and oil field waterflooding for secondary recovery. EPA also determined that the consequence of fluid injection on WIPP repository performance is likely to be low, because the geologic conditions and the well construction and operational standards in the vicinity of WIPP mitigate against both a catastrophic injection well failure and the movement of excess brine into the WIPP repository should such a failure occur (EPA 1998b).

The principal geologic considerations are the great vertical thickness (greater than 1,900 feet) of low permeability strata between the nearest injection zone and the WIPP repository in the Salado Formation, and the presence within those intervening strata of higher permeability, subhorizontal anhydrite interbeds that can serve as thief zones to divert upward migrating brines away from the repository. In areas such as the Rhodes-Yates oil field where upward migration of significant volumes of brine may have occurred as a result of injection well failures, the thickness of geologic strata between the middle Salado and the nearest injection zone is as little as 200 feet, and there are no anhydrite thief zones in those strata (EPA 1998b).

The principal construction and operational considerations are the younger average age and (consequently) better construction practices for the wells in the vicinity of WIPP as compared with those in the Rhodes-Yates oil field where injection well failures may have occurred. In addition, oil field operations in the vicinity of WIPP are performed under comparatively stricter regulatory requirements of the New Mexico Oil Conservation Division than, for example, at the Rhodes-Yates field. The combination of improved oil field drilling and operational technology and the stricter standards regulating use of that technology has resulted in safer drilling practices that employ: dual casing strings and continuous, dual annular seals through the salt section that are less likely to corrode or degrade during the well's operational life; improved well stimulation techniques through hydrofracturing that are less likely to damage the annular cement seals; improved controls on maximum allowed injection pressures to avoid seal damage; and improved monitoring of injection tubing leaks that could pressurize the interior of the well casing.

The consequences of a catastrophic injection well failure on the performance of the WIPP repository was modeled by DOE based on WIPP site conditions. In performing that modeling, DOE found that it was necessary to assume unrealistically high permeabilities for even a failed wellbore annular cement seal to allow brine to move vertically past the anhydrite thief zones to the elevation of the interbeds that intersect the WIPP repository. EPA found that the conceptual approach used in DOE's fluid injection modeling provided an acceptable realization that is consistent with available information on WIPP site conditions. EPA determined that the modeling was performed with sufficient conservatism, and that a more realistic representation of an injection scenario would probably reduce the flow that was calculated to enter the interbeds and the repository. Even when assuming conservatively high seal permeabilities, the volume of additional brine that was calculated by DOE to move into the repository was relatively small (typically less than 1,000 m^3), as compared with the tens of thousands of cubic meters that are calculated to enter the repository from other sources.

EPA considers catastrophic injection well failures that could affect the WIPP repository to be unlikely, but even if such failures did occur, the volume of additional brine that would enter the repository would not be sufficient to affect the WIPP's performance. EPA therefore concludes that fluid injection was appropriately screened out of performance assessment by DOE.

A technical study by Stoelzel and Swift (1997) was prepared by DOE to address many of the issues related to fluid injection that EPA had questioned during its review of the FEP screening. EPA's examination of the scenarios modeled by DOE in this supplemental effort indicated that the assumptions are realistic and compatible with current oil exploitation practices in the Delaware Basin. Results presented in this study, along with the previous materials presented by DOE (Stoelzel and O'Brien 1996) show that the potential for brine influx into the repository will not be significantly altered by reasonable representations of fluid injection activities in the area and may be screened out of further consideration due to low consequence. EPA also concluded that, although scenarios can be constructed that move large volumes of fluid to the repository through injection, the probability of such an occurrence is less than one in 10,000, given the necessary combination of natural and human-induced events. These scenarios also may be appropriately screened out of the PA. Although many public comments noted the lack of a fluid injection analysis, EPA found that DOE did consider fluid injection in the scope of performance, and additional fluid injection assessments completed after submittal of the CCA adequately addressed the potential impact of fluid injection.

Natural Gas Storage

During the public comment period, EPA received many comments stating that DOE must also include gas storage in performance assessment. In response to issues raised by commenters, the Agency completed an additional analysis of the potential impact of gas storage on the WIPP. For a detailed discussion of these issues and EPA's response to the comments, see the Response to Comments Document under Section 194.32. EPA determined that DOE must consider only activities that take place in the Delaware Basin.

CO_2 Injection

EPA initially determined that DOE's decision to screen CO_2 injection from performance assessment calculations was appropriate. However, public comments submitted on the proposal to EPA suggested that CO_2 is or could be used in the vicinity of WIPP and should be evaluated. EPA reviewed available data regarding the technology and industry practice and determined that the use of CO_2 miscible flooding for enhanced oil recovery is currently practiced in the west Texas portion of the Delaware Basin. For EPA's detailed analysis of this topic, see the Response to Comments Document, Section 8 (Docket #A-93-02, Item V-C-1). Most CO_2 injection activity is located outside of the Delaware Basin. CO_2 flooding projects have not occurred within the New Mexico portion of the Delaware Basin. Site specific issues related to reservoir size, proximity to existing pipelines, and reservoir heterogeneity indicate limited potential for CO_2 injection exists in the vicinity of WIPP under current conditions. EPA therefore concluded that CO_2 injection also may be omitted from the PA on the basis of low consequence.

Air Drilling

During the public comment period on EPA's proposed certification decision, the Agency received many comments concerning the screening of air drilling from performance assessment. DOE did not identify air drilling as a current practice in the Delaware Basin and therefore did not include it in the PA. Public comments raised the issue that both air and mud drilling may occur in the Delaware Basin and that releases from air drilling could be greater than from mud drilling, potentially causing the WIPP to fail the numerical containment requirements at 40 CFR 191.13.

EPA examined the air drilling issue from several perspectives and documented its findings in EPA Technical Support Document: EPA's Analysis of Air Drilling at WIPP (EPA 1998c).

Existing Boreholes

DOE assessed the potential effects of existing boreholes as part of the FEP screening analysis and presented the results in Appendix SCR 3.3.1.4. DOE concluded that natural fluid flow through abandoned boreholes would be of very little consequence during the operational phase, based upon known hydrologic head conditions. EPA concluded that DOE's screening arguments for low consequence was reasonable; see EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a) for further discussion.

Oil and Gas Field Life and Lease Estimation and Evaluation

Stoelzel and O'Brien (1996) discussed injection activity screening and assumed a lease life of 50 years after disposal (p. 14). Although this assumption may be consistent with the typical life of leases, the CCA does not specifically address the process by which DOE estimated existing leases or probable future lease development. In addition, given the possibilities of multiple fields, EPA found that 50 years should not be considered the total life for injection well assessment purposes considering. Although the CCA does not directly include the exact expected lives of currently producing oil and gas fields in the WIPP area, supporting information is presented in NMBMMR (1995) and Appendix DEL. NMBMMR (1995) contained information regarding the specific fields in all formations in the Delaware Basin, including those that may be expected to be present below the WIPP. This information also included overall production data for fields (although ultimate life is generally not assumed). Appendix DEL includes abbreviated discussions, generally taken from NMBMMR (1995), pertaining to producing geologic units in the WIPP area; however, it generally does not specify field life, although production dates from some fields are identified.

As stated earlier, EPA expressed concerns over the lease life of 50 years due to the multiple production horizons and potash mining in the area and requested that DOE extend the period to 150 years in the fluid injection scenario. DOE used the period of 150 years in the second generation of simulation (Docket A-93-02, Item II-I-36).

Summary

EPA's review of the CCA raised questions regarding screening of human-initiated activities, including fluid injection, solution mining, air drilling. and carbon dioxide injection.

For fluid injection, DOE submitted a significant body of additional information, including additional modeling to address the effects of activities questioned by EPA and the public. EPA concluded that although scenarios can be constructed that move large volumes of fluid to the repository through injection, the probability of such an occurrence is less than one in 10,000 and therefore may be appropriately screened out of consideration in the PA. Although EPA received many public comments about the lack of a fluid injection analysis, DOE did consider fluid injection in the scope of performance, and additional fluid injection assessments completed after submittal of the CCA adequately addressed the potential impact of fluid injection.

DOE provided supplementary information pertaining to brine extraction (solution mining) that was not included in the CCA submitted on October 29, 1996. Although the brine extraction FEP was not explicitly addressed in the CCA, EPA found that the supplementary information indicated that brine extraction will not have an impact on the PA; see the Response to Comments Document.

In response to public comments, EPA conducted additional analyses of air drilling, hydrocarbon storage, and carbon dioxide injection. EPA found that these scenarios were appropriately omitted from the PA. EPA's analyses may be found in the Response to Comments Document.

32.D.1 Requirement

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

32.D.2 Abstract

EPA expected DOE to list those features, events and processes (FEPs) eliminated from the PA based on probability, and to discuss why they were not included. DOE used this requirement to screen out FEPs such as nuclear criticality, galvanic coupling, formation of new faults, glaciation, and impact of large meteorites.

32.D.3 Compliance Review Criteria

As stated in the CAG (p. 45), EPA expected the CCA to:

♦ List the processes, events, or sequences of process and events that were not included in PA results.

♦ Discuss the reasons why processes, events, or sequences of process and events were not included in PA results.

32.D.4 DOE Methodology and Conclusions

DOE used the requirement at Section 194.32(d) to screen out 23 FEPs on the basis of probability. Chapter 6.2.2.1 states that qualitative arguments were used in the absence of quantitative probability estimates. DOE excluded several FEPs from consideration on the basis of low probability, including FEPs such as nuclear criticality, galvanic coupling, formation of new faults, glaciation, and impact of large meteorites. Tables 6.2 and 6.3 of the CCA present FEPs screened by DOE based on probability. DOE screened out several natural FEPs based on low probability when there was no evidence that the natural FEP has occurred in the Delaware Basin and no quantitative calculation of probability was possible (Chapter 6, p. 6-46). For example, volcanic activity was screened out using this reasoning. Waste- and repository-induced FEPs screened out on the basis of low probability were those FEPs for which “no mechanisms have been identified that could result in their occurrence within the disposal system” (Chapter 6, p. 6-47). This includes, for example, nuclear criticality and the development of large-scale reduction/oxidation fronts. DOE screened only one human-initiated FEP, flow through undetected boreholes, based on probability (Appendix SCR, p. SCR-124). Tables 6-3, 6-4, and 6-5 in Chapter 6 list the FEPs that were screened out of the PA. The screening process is reviewed in detail in EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a). The FEPs screened by DOE on the basis of probability are listed below:

Salt deformation
Formation of fractures
Fault movement
Metamorphic activity
Solution chimneys
Collapse breccias
Freshwater intrusion (flow)
Impact of large meteorite
Permafrost
Nuclear explosions
Reduction-oxidation fronts
Galvanic coupling, transport
Diapirism
Formation of new faults
Volcanic activity
Deep dissolution
Breccia pipes
Saline intrusion (flow)
Natural gas intrusion
Glaciation
Nuclear criticality: heat
Large scale rock fracturing
Galvanic coupling, corrosion

32.D.5 EPA Compliance Review

EPA thoroughly evaluated each FEP screened from the PA based on probability. EPA examined DOE’s screening to assess DOE’s traceability assumptions, approximations, and measure of uncertainties. EPA examined DOE’s approach to determine whether it was well documented and adequately justified. EPA examined assigned probabilities to determine whether they were appropriate, documented, and in accordance with EPA regulatory requirements. EPA examined sufficiency of all data in terms of quantity and adequacy. See EPA Technical Support Document for Section 194.32: Scope of Performance Assessments, Section 4 (EPA 1998a) for a detailed discussion of the results of EPA’s review.

In some instances DOE used a qualitative rather than quantitative argument to screen out a FEP based on probability, stating, “In practice, for most FEPs screened out on the basis of low probability, it is not possible to estimate a meaningful quantitative probability. In the absence of quantitative probability estimates, a qualitative argument has been provided” (Chapter 6, p. 6-39). DOE developed probability strategies for natural and waste and repository induced FEPs based on qualitative as well as quantitative screening arguments. EPA concurs that the general strategy used to screen natural and waste- and repository-induced events based on qualitative arguments of probability was sound. EPA examined DOE’s screening arguments for each FEP and concluded that the screening process followed a systematic, supportable, and traceable process that reached reasonable conclusions.

EPA concurs with the events and processes that were screened out by DOE using the low probability criterion.

32.E.1 REQUIREMENT

(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."

32.E.2 ABSTRACT

EPA expected the compliance application to identify and assess all natural and human-initiated processes and events, as well sequences and combinations of FEPs, that may affect the disposal system. EPA also expected the compliance application to address screening criteria and potential changes to geologic conditions, as well as fluid injection activities and lease identification.

DOE stated that the first step in the FEP analysis was the identification of potential FEPs. DOE initially developed a list of FEPs using a list of over 1,200 FEPs assembled by the Swedish Nuclear Power Inspectorate (SKI). Over the past several years, DOE added and removed FEPs until it developed the Draft CCA (DCCA) FEP list of approximately 900 FEPs. The FEPs on the DCCA list were divided into nine categories: waste, canister, backfill, seal systems, repository/near-field, far field, biosphere, geology/climate, and human influences. During the CCA preparation process, DOE further consolidated the FEPs into 236 FEPs in three categories: natural FEPs, waste/repository FEPs, and human-induced FEPs. DOE initiated a side effort program to address numerous technical issues, including issues for other areas of CCA preparation, and implemented some side effort assessments for those EPs that DOE felt had inadequate screening arguments. DOE conducted approximately 300 side effort studies that can be linked to DCCA FEP analysis. EPA reviewed the DOE's FEP analysis in detail.

32.E.3 COMPLIANCE REVIEW CRITERIA

EPA reviewed DOE's initial FEP listings at each stage of list review and development to determine whether the listing was comprehensive. In addition, EPA examined information sources used by DOE to compile FEP lists for completeness and accuracy of technical information. EPA also examined listings to determine whether DOE's rationale for reducing listings was appropriate and technically sufficient.

EPA considered whether the list was comprehensive and included all potential elements that may affect the disposal system. EPA required that FEPs represent all the aspects of the repository, as specified in Section 194.32. As stated in the CAG (p. 46), EPA expected the compliance application to:

♦ Identify any human-initiated processes and events that may occur during the regulatory time frame.

- ♦ Identify potential natural processes and events that may occur during the regulatory time frame and how they may affect the disposal system.

- ♦ Discuss how the events and processes were identified (e.g., through the use of a comprehensive list with a derivation of the list).

- ♦ Identify the sequences and combinations of potential processes and events that may occur during the regulatory time frame and may affect the disposal system.

- ♦ Discuss the screening criteria and the procedures(s) used to include and eliminate processes and events.

- ♦ Discuss the application of the screening criteria to the processes and events that may occur during the regulatory time frame and may affect the disposal system.

- ♦ Discuss the effects of potential changes to geologic conditions, including, but not limited to:

  - -- Dissolution.
  - -- Near surface geomorphic processes.
  - -- Related subsidence in the geologic units of the disposal system.

- ♦ Evaluate and discuss near future fluid injection activities and other existing boreholes as part of the PA.

- ♦ Identify existing leases in the vicinity of the disposal system with boreholes that are being used for fluid injection activities.

- ♦ Identify existing leases in the vicinity of the disposal system that can be reasonably expected to be developed (e.g., for fluid injection activities) in the near future.

- ♦ Link site, waste, laboratory and other characterization information to the potential processes, events or sequences and combinations of processes and events, and the conceptual models.

32.E.4 DOE METHODOLOGY AND CONCLUSIONS

DOE addressed the FEP compilation process in Appendix SCR and Stenhouse et al. (1993). DOE identified FEPs using the list assembled by SKI. The SKI list represented a compilation of FEPs identified by nine organizations world wide, and included over 1,200 FEPs. The SKI study divided the FEPs into eight different categories based upon location of occurrence and cause: waste, canister, buffer/backfill, repository/near-field, far-field, biosphere, geological/climatic evolution, and future human actions. DOE determined that each of these categories included FEPs that could potentially impact the disposal system.

DOE developed a list in its 1995 Draft Compliance Certification Application (DCCA) (Docket A-93-02, Item II-F-1) list by taking the final SKI list to develop a list that included approximately 900 FEPs divided into nine categories: waste, canister, backfill, seal systems, repository/near-field, far field, biosphere, geology/climate, and human influences. DOE screened these 900 FEPs using the same criteria used for the CCA (UP, DP, SO-C, SO-R, SO-P; see Section 32.E.4 of this CARD for definitions). However, screening also included categories for FEPS not yet screened (RB), FEPs related to deviations from the design (RD), FEPS concerning potential design changes (RE), and FEPs considered not relevant to the WIPP performance (NR). Appendix SCR, Attachment A, Appendix A, lists all 900 DCCA FEPs. On the basis of the above criteria DOE screened out those FEPs that did not affect the disposal system and considered those that could affect the system.

During the CCA preparation process, DOE recognized that additional assessment was required for some of the 900 DCCA FEPs to determine whether the screening assignment was correct. DOE conducted a side effort program to address numerous technical issues; see Appendix SCR, Hunter (1989), and Wallace et al. (1995). DOE conducted approximately 300 side effort studies that can be linked to DCCA FEP analysis.

For the development of the CCA FEP list, the DCCA 900 FEP list was consolidated, evaluated, and otherwise modified to a listing of approximately 240 FEPs consisting of three categories: natural, waste/repository induced, and human induced. The CCA includes tables that show FEPs eliminated from the CCA listing that were included under the RD, RE, and NR DCCA categories. DOE reassigned those FEPs eliminated from the CCA listings under the RB listing to fit into one of the five CCA categories, with most of these subsequently being screened out due to low consequence. Appendix SCR, Attachment A, Appendix B, shows how each of the 900 DCCA FEPs links with the 236 FEPs presented in the CCA. Appendix SCR, Attachment 1, Appendix C, Table C-1, shows those FEPs excluded from the development of the CCA FEP list due to modeling issues, and includes such considerations as boundary conditions in near/far field, correlation issues, initial groundwater flow conditions, and time dependance. Appendix SCR, Attachment 1, Appendix C, Table C-2, shows those DCCA FEPs excluded from the CCA FEP list because the issues are not regulated by 40 CFR Part 191, such as mining of the waste. Appendix SCR, Attachment 1, Appendix C, Table C-3 lists those DCCA FEPs excluded from the development of the CCA FEP list because they relate to repository designs different from that which forms the basis of the CCA. This list included issues such as those associated with bentonite backfill, features associated with crystalline (e.g., igneous) rocks, and concerns relating to copper containers.

The 236 FEPs retained for analyses were all considered by DOE to be those FEPs that could affect the disposal system. DOE then further evaluated these 236 retained FEPs and from these selected 80 FEPS for consideration in the PA. See Section 194.23(a) in **CARD 23—Models and Computer Codes** and Section 32.F.4 of this CARD for additional discussion of retained FEPs. DOE addressed changes to geologic conditions in Appendix SCR and submitted addition information pertaining to fluid injection analysis; see Section 32.C.4 of this CARD for injection well information.

32.E.5 EPA COMPLIANCE REVIEW

EPA reviewed DOE's initial FEP listings to determine whether the listing was comprehensive. In addition, EPA examined information sources used by DOE to compile FEP lists for completeness and accuracy of technical information. EPA examined listings to determine whether DOE's rationales for reducing listings was appropriate and technically sufficient and examined sequences and combinations of events.

EPA reviewed the CCA to determine whether the list was comprehensive and included all potential elements that may affect the disposal system. EPA required that FEPs represent all the aspects of the repository, as specified in Section 194.32. DOE was required to identify all the potential processes and events or sequences and combinations of processes and events that may occur during the regulatory time frame and affect the disposal system. EPA also examined the CCA to determine whether other expectations identified in the CAG were addressed.

DOE identified over 1,200 natural and human-initiated FEPs assembled from the SKI FEP analysis and analyzed how these could affect the WIPP disposal system. EPA examined this list of FEPs and determined that the initial FEP identification and screening performed by DOE was thorough, although poorly documented in the CCA; see EPA Technical Support Document for 194.32: Scope of Performance Assessments (EPA 1998a). Because of the poor documentation of FEP identification and screening in the CCA, EPA reviewed numerous documents in the Sandia National Laboratories Records Center, which were analyzed with respect to identification of scenarios (EPA 1998a). After review of the CCA, associated references, and information in the SNL Records Center, EPA concluded that DOE considered all human-initiated and natural processes and events that may reasonably be predicted to occur within the regulatory time frame in the WIPP area.

DOE identified those events and processes and sequences/combinations of events and processes that may occur during the regulatory time period that may affect the repository. EPA concluded that these FEPs represented those most critical in terms of affecting the disposal system. EPA initially expressed concern that DOE screened out brine extraction (solution mining) without providing the appropriate justification, but supplementary information sent by DOE resolved this concern; see Section 32.C.5 of this CARD for a detailed discussion.

The general screening criteria used by DOE to simplify the DCCA analysis were sound, although the process used to document the FEP screening was inadequate. EPA determined, however, that DOE's application of screening criteria for the DCCA/CCA process was satisfactory because it examined scenarios based on probability, consequence, or regulatory requirements. EPA raised several questions concerning the single table that shows the results of the DCCA/CCA reduction process (Docket A-93-02, Item II-I-01), which DOE addressed in supplemental information (Docket A-93-02, Items II-I-02 and II-I-03). EPA concluded that no additional FEPs should be added to the CCA listing. EPA also concluded that DOE presented the information requested in the CAG in regard to documentation and cross-linking of FEPs.

The CCA includes FEPs for dissolution (e.g., shallow, lateral, deep, and breccia pipes) and near surface geomorphic processes (e.g., erosion, sedimentation, and weathering). DOE screened out these FEPs on the basis of low consequences and retained only shallow dissolution for consideration (Chapter 6, p. 6-43). Based on the information provided, the Agency found the justifications reasonable and adequate. The effects of subsidence and fracture fillings related to dissolution also were considered adequately by DOE (Appendix SCR.1.4 and 1.12). EPA concurs that these FEPs do not have any affect on the system; see also **CARD 25—Future State Assumptions**.

The CCA includes analysis of the future impacts of fluid injection on the disposal system. As discussed above, DOE concluded that future fluid injection activities, such as water flooding or salt water disposal, would not result in brine inflow to the repository beyond what is projected by BRAGFLO calculations. Therefore, the Department concluded that this FEP will be of minimum consequence to the overall performance of the disposal system. EPA conducted its own verification analysis and found that not only is the consequence of this process minimal, but the probability of all factors combining to create a condition that would affect the disposal system is very low (EPA 1998b).

Appendices DEL and DMP include maps that present the location of injection wells and associated mineral leases (Figure DMP-2). The CCA specifies whether these leases can be used as injection wells; these are treated in a general sense in that an injection well may be anywhere outside the WIPP area and its effects will be minimal. EPA considered this approach adequate.

32.F.1 REQUIREMENT

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

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

32.F.2 ABSTRACT

EPA expected the CCA to identify the processes and events or sequences and combinations of processes and events included in the performance assessment, including natural and human-initiated processes and events. Evaluations of mining, deep drilling and shallow drilling must be included. Linkages to PA codes and conceptual models and scenario development should be included. Scenarios are combinations of FEPs that may be pertinent to the WIPP disposal system. They include combinations pertinent to both disturbed and undisturbed repository performance.

Once DOE developed the list of potentially applicable 236 FEPs from the 900 DCCA FEPs, DOE proceeded with the screening process. DOE presented a brief discussion of the screening process in Chapter 6.2 of the CCA. DOE divided the FEPs into three major categories: natural, waste- and repository-induced, and human-initiated. DOE screened out FEPs based on the following criteria: regulation, probability, and consequence.

DOE concluded that 16 of the 70 natural FEPs should be retained for the PA, including stratigraphy, shallow dissolution, saturated groundwater, infiltration, precipitation, and climate change. Of the 108 waste and repository induced FEPs, DOE concluded that 50 of these should be retained for the PA, including disposal geometry, waste inventory, salt creep, backfill chemical composition, actinide solubility, spallings, and cavings. DOE concluded that 15 of the 57 human-initiated EPs should be retained for the PA, including oil and gas exploration.

DOE assessed scenarios ranging from the effects of deep and shallow drilling and mining to undisturbed disposal system performance. DOE retained the scenarios describing both undisturbed and disturbed system performance. Disturbed performance includes both mining and deep drilling (E1, E2, and E1E2 scenarios). In Chapter 6, Table 6-6, DOE identified the specific locations in the CCA that related to modeling of the individual FEPs. These discussions focus on conceptual model development, but often link these conceptualizations with associated computational (computer) models.

EPA reviewed the CCA to determine whether FEPs and subsequent scenarios were appropriately screened, adequately justified, and completely supported. In addition, EPA examined combinations of FEPs and scenarios included in the PA.

32.F.3 Compliance Review Criteria

DOE must identify and discuss the FEPs included in PA. In addition, DOE must document that conceptual models have been peer reviewed and discuss the components and construction of conceptual scenarios used in the PA. As stated in the CAG (p. 46), EPA expected the CCA to include evaluations of:

- Mining.
- Deep drilling.
- Shallow drilling.

In addition, EPA expected the CCA to:

- List and discuss the events and processes and the combinations of potential processes, events or sequences and combinations of processes and events, that could have an effect on radionuclide transport to the accessible environment and that are included in the PA.
- Discuss the effect of the sequence of processes and events on the disposal system on the PA calculations. for example, the relative timing of mining and a deep drilling event that intersects the waste may affect the amount of radionuclides that may reach the accessible environment during the regulatory time frame.

- ♦ Specify the models and codes in which the individual potential processes, events, or sequences and combinations of processes and events are included. For example, gas generation is a process associated with the waste that could affect room closure and releases from a drilling event; gas generation is discussed in the conceptual models found in Chapter 6.4.3.3 and the computer models discussed in Chapter 6.4.10.

- ♦ Indicate the events and processes incorporated into the PA are reflected in the appropriate portions of the application; for example, incorporation of the process of gas generation in the waste (if it occurs) into performance assessment modeling should be identified and discussed in any compliance assessment and cross referenced appropriately.

- ♦ Provide documentation that the conceptual models used in the PA were peer reviewed.

- ♦ Discuss the final combinations of events and processes in the context of the final conceptual scenarios used in the PA.

- ♦ Discuss how the retained potential processes, events or sequences and combinations of processes and events were constructed into the scenarios used in the PA.

EPA expected that the general classes of scenarios (e.g., undisturbed processes, events, or sequences and combinations of processes and events; drilling events; mining events; and the combination of drilling and mining events) used in the PA would be discussed separately. For disturbed scenarios used in the PA, the CCA must refer to the undisturbed scenarios and focus on those elements (e.g., processes and events) that differ from the undisturbed scenarios.

32.F.4 DOE METHODOLOGY AND CONCLUSIONS

Once DOE developed the list of 236 FEPs through analysis of the 900 DCCA FEPs, DOE initiated the FEP screening process. DOE provided individual discussions for each of the 236 FEPs included in the CCA; these discussions are presented in Appendix SCR. Appendix SCR divides the FEPs into three main categories and indicates whether each FEP was screened out on the basis of regulatory requirements, consequence, or probability. If a FEP was retained, Appendix SCR indicates whether it was included as part of the undisturbed or disturbed repository PA.

DOE presented a brief discussion of the screening process for FEPs in Chapter 6.2. The 236 CCA FEPs include natural, waste- and repository-induced, and human-initiated FEPs. See Section 194.32(e)(1) of this CARD for information pertaining to the FEP identification process. To screen out FEPs, DOE applied the specific criteria shown below (Chapter 6.2.2, pp. 6-38 to 6-39):

- ♦ Screened out-Regulation (SO-R): In the process of developing 40 CFR Part 191 and Part 194, EPA allowed DOE to eliminate some of the FEPs from consideration. For example, relative to human-initiated EPs, DOE need not consider mining of the waste.

- ♦ Screened out-Probability (SO-P): Section 194.32(d) indicates that PAs need not consider processes and events that have less than a one in 10,000 chance of occurring over 10,000 years. DOE provided either qualitative or quantitative arguments pertaining to FEPs screened out based upon probability.

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

  - -- Insignificant Consequences. DOE eliminated FEPs where "there is a reasonable expectation that the remaining probability distribution of cumulative releases would not be significantly changed by such omissions."

  - -- Beneficial FEPs. FEPs that are potentially beneficial to performance of the disposal system or subsystem were eliminated to simplify the analysis. DOE also stated that 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" (Chapter 6, pp.6-39 to-6-40).

FEPs retained in the PA were accounted for under calculations of either the undisturbed performance or disturbed performance; see Chapter 6.2.2.2 and 6.2.2.3 (p. 6-40):

- ♦ Undisturbed Performance (UP). UP includes the predicted behavior of the disposal system assuming it is not disrupted by human intrusion or the occurrence of unlikely natural events. These FEPs are accounted for in PA calculations performed to support containment requirement assessments.

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

Refer to the different categories of FEPs provided in tabular form in EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a).

DOE concluded in Appendix SCR, Sections 1.1 through 1.8, that 16 of the 70 natural FEPs should be retained for the PA, including, for UP: stratigraphy, seismic activity, shallow dissolution, saturated groundwater flow, unsaturated groundwater flow, fracture flow, effects of preferential pathways, groundwater geochemistry, physiography, groundwater discharge, groundwater recharge, infiltration, precipitation, temperature, and climate change; and for DP, brine reservoirs.

Of the 108 Waste and Repository Induced FEPs considered (see Appendix SCR sections 2.1 through 2.8), DOE concluded that 50 should be retained for the PA, including, for UP: disposal geometry, waste inventory, seal physical properties, radionuclide decay and ingrowth, salt creep, backfill chemical composition, changes in the stress field (creep), pressurization (gas), brine inflow, wicking, actinide sorption and solubility, effect of metal corrosion, and colloid transport; and for DP, cavings and spallings.

DOE concluded in Appendix SCR, Sections 3.1 to 3.8, that 15 of the 57 human-initiated FEPs should be retained for the PA, including fluid injection (UP in near future; SO-R future); oil and gas exploration, oil and gas exploitation, enhanced oil and gas recovery, drilling fluid flow, blowouts, natural borehole fluid flow, potash exploration, other resources, potash mining (UP outside controlled area), drilling fluid loss, drilling-induced geochemical changes (UP in near future/ongoing), waste induced borehole flow, borehole induced geochemical changes (UP in ongoing/near future; DP in future), changes in groundwater flow due to mining (UP in ongoing/near future; DP in future), and loss of records (DP).

DOE screened out numerous issues from further consideration, including lateral dissolution (SO-C), deep dissolution (SO-P) (although DOE indicated that shallow dissolution is accounted for in TFIELD calculations), near surface geomorphic processes (SO-C), and related subsidence in the geologic units of the disposal system (SO-C). DOE included a discussion and assessment of fluid injection activities in the WIPP area and performed modified BRAGFLO analysis of the disposal system assuming injection wells at the south and north boundaries of the WIPP. DOE concluded that the injection well activities would have little or no effect on the WIPP disposal system and screened out the effects of injection wells (i.e., waste disposal and water flooding) based upon low consequence in the past, present, and near future. DOE further excluded injection activities from the PA based upon regulatory requirements in 194.32(c) that limited consideration of fluid injection activities to the near future (when oil would expected to be produced from the vicinity of WIPP). Appendix DEL, Figure DEL-6, identified the locations and associated leases for injection wells around the WIPP, indicating that the closest injection well (Class 2) is located more than 2 miles from the repository.

Tables SCR-1 through SCR-3 of Appendix SCR present each of the 236 FEPs and their screening results and link these FEPs to specific discussions in Appendix SCR. Table 6-6 also shows where the specific FEPs are addressed in Chapter 6.

Scenarios are combinations of FEPs that may be pertinent to the WIPP disposal system and include those combinations pertinent to both UP and DP. DOE included in Chapter 6.3 a discussion of scenario development based upon the FEP screening analysis. The scenarios assessed included the effects of deep drilling, shallow drilling, and mining.

Undisturbed Performance

CCA Chapter 6.3.1 (pp. 6-62 to 6-70) included all natural UP FEPs and waste/repository induced UP FEPs, except for those that are directly associated with future deep drilling within the controlled area. In addition, UP included the effects of potash mining outside of the controlled area. DOE identified approximately 70 FEPs for UP, and stated that excavation-induced fracturing, gas generation, salt creep, and MgO backfill in disposal rooms are among the most significant FEPs. DOE described several potential pathways for radionuclide migration from the repository for the undisturbed scenario, including migration of radionuclides through anhydrite interbeds, migration of contaminants up through the shaft seal system, and subsequent transport through the Culebra and other permeable units, or migration of contaminants from the shaft to the land surface. DOE concluded that "natural properties of the undisturbed system make radionuclide transport to the accessible environment via these (other) pathways unlikely" (Chapter 6, p. 6-68).

Disturbed Performance

Chapter 6.3.2 (pp. 6-71 to 6-78) describes how DOE used UP as a foundation and added scenarios associated with human intrusion for DP. DOE identified three human intrusion scenarios as part of the DP: mining, deep drilling, and mining plus deep drilling. Shallow drilling was excluded based on low consequence. The mining and deep drilling scenario are synopsized below:

- Mining. This scenario includes future mining within the controlled area. DOE modeled changes to the disposal system via mining in accordance with Section 194.32(b), wherein changes to the hydraulic conductivity of disposal system rock strata are assumed. The CCA indicates that this can further be limited to hydraulic conductivity changes in the Culebra alone. Changes in hydraulic conductivity in the Culebra can affect the rate and direction of groundwater flow in this member of the Rustler Formation. DOE used the Culebra modeling system developed to model undisturbed flow in the Culebra performance but modified the undisturbed Culebra transmissivity field to account for the effects of mining in the controlled area (described above in Section 194.32(c) of this CARD).

- Deep Drilling (E1, E2, and E1E2). The DP scenario includes deep drilling to and through the repository and may include at least one deep drilling event that penetrates through the repository to an underlying Castile brine pocket; see Chapter 6.3.2.2 (pp. 6-73 to 6-78). Radioactive waste encountered through deep drilling may be entrained in drilling mud and transported to the ground surface with drill cuttings and cavings. In addition, spallings releases (i.e., particulate material entrained via gaseous emissions when a gas-filled repository is encountered and sustained/uncontrolled "blowout" occurs) could also transport waste. Further, direct releases of brine may occur if the repository contains radionuclide-bearing brine and sufficient pressure is present within the repository to allow brine flow up the borehole.

DOE assumed that an abandoned deep borehole will be plugged in accordance with current practice in the Delaware Basin (Appendix DEL, Sections 5.5 and 6). DOE also assumed an abandoned borehole could have a degraded casing or plug that could provide a pathway for fluid flow, providing sufficient downhole pressure is present to facilitate brine flow. In addition, the borehole could serve as a conduit for upward flow of brine from the Castile brine pockets. Also, it is possible that a deep borehole could be drilled through a disposal room pillar (not encountering waste) but still penetrating the Castile brine pocket, which could depressurize the brine pocket relative to future intrusions into the same brine pocket.

DOE identified two types of deep drilling events distinguished by whether or not the borehole intersects a Castile brine pocket. A borehole that intersects a waste disposal panel and penetrates a Castile brine pocket was designated an E1 event. A borehole that intersects the repository but not a Castile brine pocket was designated an E2 event. DOE identified 18 E1 and 18 E2 events for the PA. The E1, E2, and E1E2 events presented in the CCA (pp. 6-77 to 6-78) include:

- E1. Any scenario with penetration of a waste panel that also penetrates a Castile brine reservoir. Brine, cuttings, cavings, and spallings releases may occur, with the source of brine considered to be primarily the Castile brine reservoir.

- E2. Drilling into a waste panel, wherein the panel is penetrated by a drill bit. Brine, cuttings, cavings, and spalling releases may occur. Brine source is considered to be primarily the Salado Formation. Scenarios may include more than one E2 event.

- E1E2. Defined as all futures that have multiple penetrations of a waste panel, with at least one E1 type intrusion. Includes many possible combinations of intrusion times, locations, and types of events (combinations of E1E2 events). Multiple brine sources are considered, including the possibility of Castile brine flow from an E1 borehole, through waste, to a second shallower E2 borehole, where it could flow upward.

- Mining and Deep Drilling (ME). DOE indicated that both mining and deep drilling can occur in the future, and identified the scenario ME where this occurs (Chapter 6.3.2.3, p. 6-78). DOE indicated that the difference between the M and E scenarios considered separately and the ME scenario is that the combination of drilling (E) intrusion and enhanced Culebra transmissivity resulting from mining (M) may result in more rapid contaminant transport within the Culebra. DOE considered several ME combinations in conceptual model development, including ME1, ME2, and ME1E2.

FEPs Linkage with the PA

FEPs affect not only scenario development but also model development and input parameters. In Chapter 6, Table 6-6, DOE identified the specific discussions in the CCA that related to modeling of the individual FEPs. These discussions focus on conceptual model development but often link these conceptualizations with associated computational (computer) models (Appendices PAR and MASS). DOE performed a peer review of conceptual models; see Section 194.23(a)(3)(v) in **CARD 23—Models and Computer Codes** for further discussion.

32.F.5 EPA COMPLIANCE REVIEW

EPA concluded that DOE used a process (i.e., the SKI list modified to suit conditions at the WIPP site) that identified the processes, events or sequences of combinations of processes and events. As part of this process, DOE adequately addressed and evaluated the effects of mining, deep drilling, and shallow drilling. DOE evaluated the FEPs and sequences of FEPs through calculations, estimates of probability, and comparison to regulatory requirements. EPA concluded that DOE appropriately identified, listed, and discussed the FEPs and the effects of the sequences and combinations of FEPs that result in modeled scenarios.

DOE specified the models and codes in which FEPs are included (Table 6-6). EPA concluded that DOE adequately linked FEPs to models and codes throughout the CCA (e.g., Tables SCR-1 to SCR-3). EPA found it necessary to review records at the Sandia National Laboratories Records Center because of the inadequacy of documentation in the CCA. EPA's extensive review of these records found that DOE incorporated the identified disturbed and undisturbed performance scenarios into six computational scenarios. EPA's review of DOE's computational scenarios and conceptual models is found in Section 194.23(a) in **CARD 23—Models and Computer Codes**. The CCA includes numerous tables in Appendix SCR and Chapter 6 (Tables 6.3 - 6.7 and Tables SCR-1 and SCR-3) that cross-reference specific FEPs to locations in Chapter 6 and Appendix SCR. EPA's detailed review further linked FEPs with their treatment in the PA (EPA 1998a).

EPA's review of FEPs retained in the PA indicated that DOE appropriately screened the FEPs, although the justification for this screening was sometimes lacking and the treatment of some FEPs in the PA required additional evaluation. See Sections 194.23(a)(1) and (c)(4) in **CARD 23—Models and Computer Codes** for a discussion of the implementation of FEPs in the PA through conceptual model and parameter development, respectively. DOE also identified appropriate scenarios for consideration in the PA. The following FEPs were appropriately retained in PA, but parameters related to the FEP were among those further evaluated by EPA through inclusion in the Performance Assessment Verification Test (PAVT): N2 (brine reservoirs), W18 (disturbed rock zone), W58 (dissolution of waste), W77 (solute transport), W86 (spallings), W39 (underground boreholes) and H32 (flow through boreholes). This list is not meant to include all parameters modeled in the PAVT, but to illustrate that many aspects of FEPs included in PA were further evaluated by EPA as part of the Agency's overall PA review. See Section 194.23(c)(4) in **CARD 23—Models and Computer Codes**, Section 194.14(a) and (d) in **CARD 14—Content of Compliance Certification Application**, Section 194.33(a) in **CARD 33—Consideration of Drilling Events in Performance Assessments,** and Section 194.24(b)(1) in **CARD 24 - Waste Characterization** for further discussion of specific parameters examined by the Agency.

EPA Technical Support Document for Section 194.32: Scope of Performance Assessments discusses FEPs retained for the PA process and assesses the screening results (EPA 1998a). Of these results, DOE's screening regarding treatment of other resources (H8) was most questionable because the impacts of salt water mining were not included. However, DOE submitted supplemental information that supports the decision to exclude salt water mining from the PA and EPA concurs with this conclusion. EPA's analysis of this exclusion is discussed further in Section 32.G.5 of this CARD. The final combinations of features, events and processes in conceptual scenarios used in PA were sufficiently presented. EPA also concluded that DOE adequately addressed how retained FEPs and sequences or combinations of events were used to construct PA scenarios. See Section 194.23(a) in **CARD 23—Models and Computer Codes** for EPA's review of conceptual models and the construction of PA scenarios.

32.G.1 REQUIREMENT

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

(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.G.2 ABSTRACT

EPA expected the CCA to list FEPs screened from PA and to justify their exclusion. DOE identified approximately 236 FEPs in the analysis required by Section 194.32(e)(1). These are discussed in Appendix SCR and Chapter 6.3 of the CCA. For each FEP, DOE provided a description and a generalized rationale for screening classifications.

Of the 236 FEPs analyzed, DOE screened out 154 FEPs based on either regulatory grounds, low consequence, or probability. Of the 70 natural FEPs, DOE screened out 54 FEPs, including lateral dissolution, regional tectonics, changes in fracture properties, salt deformation, solution chimneys, and deep dissolution. Of the 108 waste- and repository-induced FEPs, DOE screened out 58, including mechanical effects of backfill, heat from radioactive decay, and organic ligands, as well as nuclear criticality and reduction/oxidation fronts. Of the 57 human-initiated FEPs, DOE screened out 42, including liquid waste disposal, groundwater extraction, flow through undetected boreholes, and explosions for resource recovery.

EPA examined those FEPs screened from the PA and assessed whether DOE's screening arguments were adequately justified. EPA examined each FEP screened from consideration and developed an initial listing of 17 in which EPA questioned DOE's screening arguments, including liquid waste disposal (fluid injection), fracture infills, and the effects of dissolution. DOE submitted additional supplemental information regarding the questioned FEPs and EPA conducted its own independent analysis for others (e.g., fluid injection).

32.G.3 COMPLIANCE REVIEW CRITERIA

As stated in the CAG (p. 47), EPA expected the CCA to provide:

- A list of events and processes or sequences and combinations of processes and events that may occur during the regulatory time frame.
- The rationale for each process and event or sequences and combinations of processes and events screened out.
- Evidence that the screening process was quality assured for the individual potential processes, events, or sequences and combinations of processes and events.

32.G.4 DOE METHODOLOGY AND CONCLUSIONS

DOE identified approximately 236 FEPs in Appendix SCR and Chapter 6.3. For each FEP, DOE provided a description and a generalized rationale for screening classifications. Of the 236 FEPs analyzed, 154 were screened out on the basis of regulations (SO-R), low consequence (SO-C), or probability (SO-P). Appendix SCR included DOE's rationale for screening for each of the 236 CCA FEPs.

Of the 72 Natural FEPs identified, DOE screened out 55 FEPs (Appendix SCR, Table SCR-1):

SO-C	Changes in regional stress	Regional tectonics
	Regional uplift and subsidence	Changes in fracture properties
	Magmatic activity	Lateral dissolution
	Fracture infills	Density effect on groundwater flow
	Thermal effects on groundwater flow	Hydrogeological response to earthquakes
	Saline intrusion (chemistry)	Freshwater intrusion (chemistry)
	Changes in groundwater Eh	Changes in groundwater pH
	Effects of dissolution	Mechanical weathering
	Chemical weathering	Aeolian erosion
	Fluvial erosion	Mass wasting(erosion)
	Aeolian deposition	Fluvial deposition
	Lacustrine deposition	Mass wasting (sedimentation)
	Soil development	Stream and river flow
	Surface water bodies	Lake formation
	River flooding	Seas and oceans
	Estuaries	Coastal erosion
	Marine sediment transport and disposition	Sea level changes
	Plants	Animals
	Microbes	Natural ecological development

SO-P	Salt deformation	Diapirism
	Formation of fractures	Formation of new faults
	Fault movement	Volcanic activity
	Metamorphic activity	Deep dissolution
	Solution chimneys	Breccia pipes
	Collapse breccias	Saline intrusion (flow)
	Freshwater intrusion (flow)	Natural gas intrusion
	Impact of large meteorite	Glaciation
	Permafrost	

Of the 108 Waste- and repository-induced FEPs, 57 were screened out by DOE (Appendix SCR, Table SCR-2):

SO-C	Container form	Seal chemical composition
	Backfill physical properties	Post-closure monitoring
	Heat from radioactive decay	Radiological effects on waste
	Radiological effects on containers	Radiological effects on seals
	Subsidence	Thermal effects on material properties
	Thermally-induced stress changes	Container integrity
	Differing thermal expansion of repository	Investigation boreholes components
	Radiolysis of cellulose	Movement of containers
	Radioactive gases	Mechanical effects of backfill
	Precipitation	Convection
	Organic complexation	Kinetics of organic complexation
	Effects of radiation on microbial gas generation	Effects of pressure on microbial gas generation
	Radiolysis of brine	Helium gas production
	Concrete hydration	Rinse - Particulate transport
	Kinetics of speciation	Transport of radioactive gases
	Electrochemical effects	Kinetics of precipitation and dissolution
	Chemical gradients	Localized reducing zones
	Alpha recoil	Organic ligands
	Accumulation in soils	Exothermic reactions
	Electrophoresis	Chemical degradation of backfill
	Osmotic processes	Biofilms
	Enhanced diffusion	Soret effect
SO-P	Nuclear criticality: heat	Large scale rock fracturing
	Nuclear explosions	Galvanic coupling, corrosion
	Reduction-oxidation fronts	Galvanic coupling, transport
SO-R	Plant uptake	Animal uptake
	Ingestion (SO-C, Section 191.15)	Inhalation (SO-C, Section 191.15)
	Irradiation (SO-C, Section 191.15)	Dermal sorption (SO-C, Section 191.15)
	Injection (SO-C, Section 191.15)	

Of the 57 Human-initiated EPS, 42 were screened out by DOE (Appendix SCR, Table SCR-3):

SO-C[5]	Water resources exploration	Groundwater exploitation
	Borehole induced solution subsidence	Borehole induced mineralization
SO-R[6]	Archeological investigations	Geothermal
	Liquid waste disposal	Hydrocarbon storage
	Deliberate drilling intrusion	Other resources
	Tunneling	Construction of underground facilities
	Archeological excavations	Deliberate mining intrusion
	Explosions for resource recovery	Underground nuclear testing
	Oil and gas extraction	Groundwater extraction
	Liquid waste disposal	Enhanced oil and gas production
	Changes in groundwater flow due to explosions	Fluid-injection induced geochemical changes
	Land use changes	Changes in geochemistry due to mining
	Damming of streams and rivers	Hydrocarbon storage (fluid flow)
	Irrigation	Surface disruptions
	Demographic change/urban development	Altered soil or surface water chemistry by human activities
	Reservoirs	Lake usage
	Greenhouse effect gases	Ranching
	Damage to the ozone layer	Acid rain
	Sea water use	Coastal water use
	Arable farming	Estuarine water use
	Fish farming	
SO-P[7]	Flow through undetected boreholes	

32.G.5 EPA COMPLIANCE REVIEW

EPA reviewed Appendix SCR, CCA references, and FEP screening records packages in the Sandia National Laboratories Records Center. The specific items reviewed by EPA are identified in EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a). EPA expressed concerns about the justifications for screening out some FEPs, as discussed below.

EPA identified a number of FEPs that were excluded from the PA for which there was insufficient justification included in the CCA, including regional uplift, deformation, deep dissolution, and climate change (Docket A-93-02, Item II-I-01). In addition, DOE's justification

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[5] Screened as SO-C for both long-term future and past, current, and near future.

[6] FEPs listed as SO-R were done so for the long-term future. All SO-R FEPs were screened as SO-C or SO-P for past, current, and near future scenarios.

[7] SO-R for past, current, and near future; N/A for long-term future.

for excluding fluid injection scenarios from the PA was based on modeling that does not appropriately model this event (Docket A-93-02, Item II-I-17).

The CCA includes FEPs for dissolution (e.g., shallow, lateral, deep, and breccia pipes) and near-surface geomorphic process (e.g., erosion, sedimentation, and weathering). DOE screened out all of the dissolution processes except for shallow dissolution due to low consequence (Appendix SCR, p. 35). EPA found DOE's conclusions to be appropriate, including the argument regarding no significant dissolution of fracture fillings during the 10,000-year regulatory period. Near surface geomorphic processes and subsidence of these geologic units of the disposal system were adequately addressed in Appendix SCR, Sections SCR 1.4 and SCR 1.1.2; they have no effect on performance and they were therefore appropriately screened out:

- N22- Fracture Infills.
- N38- Effects of Dissolution.
- H28- Enhanced Oil and Gas Production.

N22- Fracture Infills, and N38-Effects of Dissolution are directly related to fractures within supra-Salado units; EPA questioned the impact that, for example, dissolution would have on supra-Salado unit transmissivity. DOE submitted information regarding fracture infill and dissolution in addition to that presented in the CCA (Docket A-93-02, Item II-I-07). This information adequately supported the conclusion that fracture infill and dissolution are not expected to occur extensively beyond that which has occurred in the past 10,000 years; see **CARD 14—Content of Compliance Certification Application** for further discussion of fracture fill and dissolution. N38 is addressed in Corbett and Knupp (1996) and further clarified by DOE in supplemental documentation (Docket A-93-02, Item II-H-44).

The CCA includes an analysis of the future impacts of fluid injection FEPs. Stoelzel and O'Brien (1996) concluded that future fluid injection activities from water flooding or salt water disposal would not result in brine inflow to the repository beyond the maximum brine inflow calculated by BRAGFLO and would, therefore, be of minimal consequence to the disposal capability of the WIPP (p. 6). EPA raised questions regarding this analysis (see Section 194.32(c) of this CARD). However, EPA examined injection well activities and concluded that regardless of the consequence argument, the probability of such an injection event that affects WIPP is very low, and so this FEP can be eliminated on the basis of low probability (EPA 1998b).

Appendices DEL and DMP include maps that present the location of injection wells and associated mineral lease holders (Figure DMP-2). This information adequately addressed EPA's request in the CAG for documentation of the location of wells and lease holders. The CCA does not specify those leases that may be reasonably expected to be used for fluid injection activities. Based upon the observed distribution, it is logical to assume that injection wells could be present within any given section that also has oil and gas production, although there would be significantly more oil and gas wells (i.e., at a 40-acre spacing) than injection wells (approximately one well/section, as presented in Figure DMP-2). However, the FEP screening presented by DOE treats the system generically, such that the injection wells could be anywhere outside the controlled area. Results of the injection modeling indicate that little injected brine could get to the anhydrite, so that the injection well could be closer than that used by DOE and still there would be little or no effect on the system.

The CCA includes a discussion of the modeled human-induced events and discusses the impacts of the different scenarios that are sampled through CCDF analysis in the Chapter 6 PA results and in Chapter 8. Documentation of these scenarios in the CCA was not adequate, but EPA located the necessary FEP screening record information at the Sandia National Laboratories Records Center. Additional discussion concerning EPA's review of conceptual models and scenarios is provided in EPA Technical Support Document for Section 194.23: Models and Computer Codes (EPA 1998d). In addition, DOE identified in Chapter 6 those codes used to implement the PA that integrate appropriate FEPs; this information also is presented in EPA Technical Support Document for Section 194.32: Scope of Performance Assessments (EPA 1998a), which shows how the FEPs are incorporated into the PA. DOE included the information suggested by the CAG pertaining to documentation and cross-linking of FEPs.

EPA conducted audits to verify the proper execution of 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, EPA concludes that QA programs were properly executed for FEP-related items and activities. See **CARD 22 - Quality Assurance** for further discussion of EPA's review of QA programs for the WIPP.

32.H References

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