SANDIA NATIONAL LABORATORIES
WASTE ISOLATION PILOT PLANT

FEATURES, EVENTS AND PROCESSES ANALYSIS FOR THE REPLACEMENT PANELS PLANNED CHANGE REQUEST PERFORMANCE ASSESSMENT

REVISION 0

Author:	Ross Kirkes	Ross Kirkes	8881	7/19/2023
	Print	Signature	Org.	Date
Technical Review:	Dwayne Kicker	Signature on File	8881	7/19/2023
	Print	Signature	Org	Date
QA Review:	Steve Davis	Signature on File	8880	7/19/2023
	Print	Signature	Org.	Date
Management Review:	Steve Wagner	Steve Wagner	8881	7/19/2023
	Print	Signature	Org.	Date

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TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **V**

1.0 INTRODUCTION **1**

2.0 FEPS ANALYSIS **1**

2.1 Identification of Related FEPs 4

2.2 Identification of Additional FEPs 8

2.2.1 Review of Historic FEPs Basis 8

2.3 FEPs Screening Argument and Decision Evaluation 9

2.3.1 Analysis of Screened-Out FEPs 10

2.3.2 Analysis of Screened-In FEPs 11

Subsection 16

3.0 IDENTIFICATION OF ADDITIONAL ACTIVITIES **16**

4.0 CONCLUSION **16**

5.0 REFERENCES **17**

LIST OF TABLES

Table 1: FEPs Related to Changes in AP-204 4

Table 2: "Related" FEPs "Screened-Out" in the CRA-2019 9

Information Only

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Information Only

Executive Summary

As currently permitted, the Waste Isolation Pilot Plant (WIPP) includes ten excavated panels for the placement of waste. For operational reasons, not all of the volume of the ten excavated panels will be used for waste disposal. The DOE plans to submit a Planned Change Request (PCR) to excavate two panels, termed replacement panels, to provide an equivalent disposal capability, and may consider excavating up to seven panels beyond the two replacement panels, defined here as additional panels. The Replacement Panels Planned Change Request Performance Assessment (RPPCR PA) will be performed by Sandia National Laboratories (SNL) to quantify the long-term performance of the repository with both replacement and additional panels.

This analysis report documents the Features, Events, and Processes (FEPs) analysis component of the RPPCR. This FEPs analysis was conducted according to Sandia Specific Procedure (SP) 9-4, "Performing FEPs Baseline Impact Assessments for Planned and Unplanned Changes." The results of this analysis show that the current FEPs baseline is appropriate to support the RPPCR PA.

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1.0 INTRODUCTION

The United States Department of Energy (DOE) has developed the Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico for the disposal of transuranic (TRU) wastes generated by defense programs. In May of 1998, the Environmental Protection Agency (EPA) certified that the WIPP would meet the disposal standards (EPA 1998) established in Title 40 Code of Federal Regulations (CFR) Part 191, Subparts B and C (EPA 1993), thereby allowing the WIPP to begin waste disposal operations. This certification was based on performance assessment (PA) calculations that were included in the DOE's Compliance Certification Application (CCA) (DOE 1996). These calculations demonstrated that the predicted releases of radionuclides to the accessible environment would not exceed those allowed by the EPA standard, given the assumptions and understanding of the disposal system at that time.

The WIPP Land Withdrawal Act (LWA) (U.S. Congress 1996) requires that the WIPP's compliance with the EPA's disposal standards be recertified every five years. This recertification process allows the most recent and up-to-date information to be incorporated into the PA. As such, the DOE has submitted Compliance Recertification Applications (CRAs) that demonstrate continued compliance with EPA's requirements for radioactive waste disposal in March 2004, 2009, 2014 and 2019. As part of their review of each CRA, the EPA evaluates the FEPs basis as presented by the DOE and documents their review in their Compliance Application Review Documents (CARDs) and Technical Support Documents (TSDs). The EPA completed their review of the CRA-2019 and documented their review of the FEPs baseline in the CARD for Section 194.32, "Scope of Performance Assessments," (EPA 2022a) and their TSD for Section 194.32 (EPA 2022b). While the EPA identified some FEPs that could use updates and further justification prior to the next CRA, they ultimately stated, "…the changes made by DOE to the FEPs baseline since the CRA-2014 were necessary and appropriate."

In addition to reevaluating the FEPs bases for each recertification, the Sandia National Laboratories (SNL) performance assessment (PA) department determines if the current FEPs baseline is adequate to account for any new or proposed change to the PA system. Such changes are evaluated incrementally according to SNL Specific Procedure (SP) SP 9-4, "Performing FEPs Baseline Impact Assessments for Planned and Unplanned Changes," (Kirkes 2021a). As such, the impact assessment documented in this report is called for in Analysis Plan (AP)-204, "Analysis Plan for the Performance Assessment for the Replacement Panels Planned Change Request," (Hansen et al. 2023), referred to as "AP-204" hereafter. AP-204 specifies that a FEPs impact assessment be conducted as a necessary component of the PA methodology to ensure that the proposed changes do not invalidate or conflict with the FEPs baseline and are thus appropriately included (or excluded) from PA calculations. It is not the purpose of this assessment to consider the benefit (or reduction) of WIPP performance due to the proposed changes, but only to determine if the current FEP basis is suitable to represent the proposed change in performance calculations.

2.0 FEPS ANALYSIS

As noted in the Introduction, the purpose of this document is to determine if the current FEPs baseline remains appropriate to support the analysis described in AP-204. This assessment is

Information Only

conducted according to SP 9-4 and is based on Revision 4 of the Baseline FEPs List (BFL) (Kirkes 2021b), and the CRA-2019 Appendix SCR-2019 (DOE 2019). AP-204 lays out a plan to perform a performance assessment (PA) that includes additional waste disposal panels to those represented in the previous PA conducted for the CRA-2019.

This report applies the same screening classifications used since the WIPP CCA: "UP" is the screening classification that represents those FEPs incorporated in undisturbed performance scenarios. The "DP" screening classification represents FEPs incorporated in disturbed performance scenarios. "SO-C" represents those FEPs that have been excluded or screened out of any scenario due to either low-, no-, or beneficial consequence. "SO-R" represents those FEPs that have been screened out due to regulatory provision, and "SO-P" represents those FEPs that have been screened out due to low probability. Additionally, there are two timeframes within which human-induced FEPs are applied. Historic, current, and near-future (HCN) are those FEPs that have been known to have happened in the past, are currently occurring, or may happen within the near future. Future FEPs are those which have not happened but may be possible in the long-term.

AP-204 describes the analyses necessary to evaluate the performance of a repository with nine additional waste disposal panels added to the existing repository layout. AP-204 identifies the following changes to the PA conducted for CRA-2019:

1) Waste inventory parameters will be based on the 2022 Performance Assessment Inventory Report (PAIR) (Van Soest 2022), and as analyzed by Kicker (2023).

2) Actinide baseline solubilities will be updated in conjunction with the updated inventory parameters and thermodynamic database changes.

3) Uncertainty distributions for each actinide's solubility will be updated in conjunction with the updated inventory.

4) Parameters related to microbial and intrinsic colloids are expected to be updated.

5) The grid for the Salado flow model is modified to accommodate new waste disposal panels.

6) The grid for computing direct brine release (DBR) is modified to account for the new waste disposal panels.

7) Logic for assigning panel neighbors is extended to account for the new waste disposal panels.

8) Repository area and volume parameters are updated to account for the new waste disposal panels.

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9) The procedure for calculating releases due to transport through the Culebra is modified to account for the extended repository footprint due to the new waste disposal panels.

10) An update to the iron surface area used for gas generation from iron corrosion in the Salado flow model.

11) An update to the calculation of waste area pressures at the time of closure.

12) The porosity surface used to represent creep closure of excavations in the Salado is updated to reflect changes in the modeling process and in material models.

13) Model inputs describing the Castile brine reservoir will be updated to account for a recent re-analysis of Castile reservoir data.

14) Permeability of a borehole after plug failure and degradation of borehole materials may be updated to account for a re-analysis of wellbore materials.

15) The model for the oxidation states of actinides is revised.

16) Drilling rates and borehole plugging pattern probabilities are updated to account for new data.

17) Transmissivity fields in the Culebra are updated to account for new data from wells (Bowman 2022). The new transmissivity fields are computed with different codes (MODFLOW6 and PEST++) than the codes used to compute the transmissivity fields used in the CRA-2019 (MODFLOW2000 and PEST).

18) The PRECCDFGF and CCDFGF codes are modified to accommodate new panels and the modified procedure for calculating Culebra releases.

19) The PRELHS code is revised to correct an error (SNL 2022).

20) The PBRINE parameter distribution is adjusted due to the correction of the error found in the PRELHS code.

21) MODFLOW6 will be used in place of MODFLOW2000 to calculate flow fields in the Culebra.

22) The PRESECOTP2D code is modified to work with MODFLOW6.

23) The PANEL code is changed to implement the revised model for actinide oxidation states.

24) Hardware and software are updated to migrate the PA calculation to a new computational platform (Long 2020).

The remainder of this document will follow the prescribed steps of SP 9-4.

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2.1 Identification of Related FEPs

Per SP 9-4, the first step in a FEPs analysis is to obtain the most recent version of the BFL from the Sandia Records Center. Second, this analysis will consider all FEPs listed in the BFL and identify FEPs for evaluation that are potentially related to the proposed changes identified in AP-204. Table 1 below identifies FEPs that are potentially related to the changes identified above. The identified FEPs are not necessarily affected or adversely impacted, but merely related to the proposed changes. This insures a comprehensive investigation of potential impacts to the FEPs baseline.

Table 1: FEPs Related to Changes in AP-204

Related FEPs	Screening Classification	Relationship to Proposed Change
N2 Brine Reservoirs	DP	The location of additional panels may be underlain by sources of pressurized brine.
N8 Formation of Fractures	SO-P UP (Repository)	Formation of fractures may occur around additional panels.
N9 Changes in Fracture Properties	SO-C UP (Repository)	Changes in the stress field near additional panels may change fracture properties.
N23 Saturated Groundwater Flow	UP	The extent of the footprint of the additional panels may introduce contaminants into the Culebra flow field at locations not currently considered in PA.
N24 Unsaturated Groundwater Flow	UP	The extent of the footprint of the additional panels may introduce contaminants into the Culebra flow field in an area not currently assumed in PA.
N25 Fracture Flow	UP	The extent of the footprint of the additional panels may introduce contaminants into the Culebra flow field in an area not currently assumed in PA.
N27 Effects of Preferential Pathways	UP	The extent of the footprint of the additional panels may introduce contaminants into the Culebra flow field in an area not currently assumed in PA.

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Table 1: FEPs Related to Changes in AP-204

Related FEPs	Screening Classification	Relationship to Proposed Change
N36 Changes in Groundwater Eh	SO-C	Changing the model for the oxidation states of actinides could affect radionuclide mobilization.
W1 Disposal Geometry	UP	The location of additional panels must be adequately represented in the BRAGFLO grid.
W2 Waste Inventory	UP	The updated inventory information may have an impact on calculated releases.
W109 Panel Closure Geometry	UP	The location of additional panel closures must be adequately represented in PA models.
W13 Heat from Radioactive Decay	SO-C	New inventory information may increase thermal load on the repository.
W14 Nuclear Criticality: Heat	SO-P	New inventory information may increase fissile loading.
W18 Disturbed Rock Zone (DRZ)	UP	Mining additional panels may introduce a zone of increased permeability in the host-rock (salt) adjacent to the mined openings.
W19 Excavation-Induced Changes in Stress	UP	Mining additional panels may introduce changes in stress in the host-rock.
W21 Changes in the Stress Field	UP	Mining additional panels may introduce changes in the stress field.
W22 Roof Falls	UP	Mining additional panels may increase the DRZ, which may lead to roof falls.
W23 Subsidence	SO-C	Additional panels may cause subsidence in overlying units.
W24 Large Scale Rock Fracturing	SO-P	Mining of additional panels could cause instability of the underground and lead to increased permeability and/or pathways.
W25 Disruption Due to Gas Effects	UP	Changes to the calculation of waste area pressures at the time of closure may increase gas pressures leading to fracturing of the Salado interbeds.

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Table 1: FEPs Related to Changes in AP-204

Related FEPs	Screening Classification	Relationship to Proposed Change
W26 Pressurization	UP	Changes to the calculation of waste area pressures at the time of closure may increase gas pressures, which may slow the rate of salt creep.
W39 Underground Boreholes	UP	Changing the permeability of a borehole after plug failure and degradation of borehole materials could provide pathways to the interbeds.
W42 Fluid Flow Due to Gas Production	UP	Changes to the calculation of waste area pressures at the time of closure may increase gas pressures, which could affect the rate of brine inflow.
W46 Effects of Pressure on Microbial Gas Generation	SO-C	Changes to the calculation of waste area pressures at the time of closure may increase gas pressures, which could affect microbial populations and gas generation rates.
W49 Gases from Metal Corrosion	UP	Gas generation from iron corrosion in the Salado flow model must be adequately represented in PA models.
W51 Chemical Effects of Corrosion	UP	Corrosion reactions that lower the oxidation state of brines and affect gas generation rates must be adequately represented in PA models.
W56 Speciation	UP	New inventory information may impact waste inventory-related parameters, actinide solubilities, and related uncertainty distributions.
W 64 Effects of Metal Corrosion	UP	The effects that metal corrosion has on chemical conditions in the repository by absorbing oxygen must be adequately represented in PA models.

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Table 1: FEPs Related to Changes in AP-204

Related FEPs	Screening Classification	Relationship to Proposed Change
W86 Spallings	DP	Changes to the calculation of waste area pressures at the time of closure may increase gas pressures, which may increase the amount of waste material entering a borehole and transported to the ground surface.
H1 Oil and Gas Exploration	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint.
H2 Potash Exploration	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint.
H4 Oil and Gas Exploitation	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint.
H8 Other Resources (drilling for)	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint.
H9 Enhanced Oil and Gas Recovery	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint.
H13 Conventional Underground Potash Mining	UP (HCN) DP (Future)	Potash mining above the additional panels may alter groundwater flow due to subsidence of overlying units.
H21 Drilling Fluid Flow	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint and could result in releases of radionuclides into the drilling fluid.

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Table 1: FEPs Related to Changes in AP-204

Related FEPs	Screening Classification	Relationship to Proposed Change
H22 Drilling Fluid Loss	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint and drilling fluid could be lost to thief zones encountered during drilling.
H23 Blowouts	SO-C (HCN) DP (Future)	The presence of additional panels and waste areas may increase the probability of an inadvertent human intrusion due to the increased repository footprint. Fluid could flow from pressurized zones in the borehole to the land surface.

UP: Screened in, undisturbed performance scenario
DP: Screened in, disturbed performance scenario
SO-C: Screened out, consequence
SO-P: Screened out, probability
HCN: Historic, Current, or Near-Future

2.2 Identification of Additional FEPs

2.2.1 Review of Historic FEPs Basis

This step of the FEPs impact assessment determines whether there are any unidentified FEPs that are *not* included in the BFL but are necessary to properly account for all aspects of the proposed change(s). For each of the changes identified in AP-204 the question is asked, "do the identified related FEPs account for all aspects of the changes?" In this step, the evaluator must systematically consider each proposed change and ask if the proposed changes involve FEPs not previously considered. If any new or previously excluded FEPs are identified, they must be added to those in Table 1 above and evaluated further in subsequent steps in this analysis.

Because the changes described in AP-204 do not propose any new or fundamentally different repository components than those that currently exist within the repository design, it can be concluded that no additional FEPs are needed to represent the additional panels in repository. Additionally, parameter selection, derivation, and justification in support of AP-204 are activities that are considered downstream of the FEPs identification and screening process. Therefore, these types of activities are not considered in this analysis.

Information Only

2.3 FEPs Screening Argument and Decision Evaluation

This step determines if the screening arguments and decisions associated with the FEPs listed in Table 1 remain valid and appropriate in consideration of the changes described in AP-204. This step asks the question, "Do the proposed changes invalidate, change, or render incomplete the screening arguments or decisions for FEPs identified in Step 2?" If this question is answered "no," then there is no impact to the FEPs baseline; that is, the current PA framework is suitable to account for the changes.

Of the 38 related FEPs listed in Table 1, 6 were screened out from further consideration in the CRA-2019 PA. Therefore, for these 6 FEPs, the following question is asked: "Do the changes described in AP-204 invalidate, change, or render incomplete the screening arguments or decisions used in the current PA baseline (the CRA-2019)?" Most importantly, do these changes cause these previously screened-out FEPs to be screened in? The focus is on the currently screened-out FEPs because for those screened in, changes in the implementation of the PA models will be made to appropriately account for the changes. Table 2 below lists the 6 related FEPs that were screened out in the CRA-2019 that are also related to the changes identified in AP-204. The remainder of this section will determine if these screening decisions are affected by these changes.

Table 2: "Related" FEPs "Screened-Out" in the CRA-2019

FEP	Screening Decision
N36 Changes in Groundwater Eh	SO-C
W13 Heat from Radioactive Decay	SO-C
W14 Nuclear Criticality: Heat	SO-P
W23 Subsidence	SO-C
W24 Large Scale Rock Fracturing	SO-P
W46 Effects of Pressure on Microbial Gas Generation	SO-C

SO-C: Screened out, consequence

SO-P: Screened out, probability

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2.3.1 Analysis of Screened-Out FEPs

2.3.1.1 N36 Changes In Groundwater Eh

The FEP N36 *Changes in Groundwater Eh* is identified in Section 2.1 as being related to the changes identified in AP-204. Therefore, it must be determined if and to what extent these proposed changes impact the screening decision and argument used in the CRA-2019. The screening decision for this FEP is SO-C based on the fact that no natural events and processes have been identified that could result in saline intrusion into units above the Salado, and the magnitude of any natural temporal variation from the effects of dissolution on groundwater chemistry, or because of changes in recharge, is likely to be no greater than the present spatial variation. The most likely mechanism for changes in groundwater Eh is (natural) recharge of the Culebra. An increase in the rate of recharge could reduce the ionic strength(s) of Culebra groundwaters, possibly enough to saturate the Culebra with (essentially) fresh water, at least temporarily. Such a change in ionic strength could, if enough atmospheric oxygen remained in solution, also increase the Eh of Culebra groundwaters enough to oxidize Pu from the relatively immobile III and IV oxidation states (Pu(III) and Pu(IV)) to the relatively mobile V and VI oxidation states (Pu(V) and Pu(VI)). Revising the model for the oxidation states of actinides as described in AP-204 will not affect the screening argument and conclusion for this FEP.

2.3.1.2 W13 Heat from Radioactive Decay

The FEP W13 *Heat from Radioactive Decay* is identified in Section 2.1 as being related to the changes identified in AP-204. Therefore, it must be determined if and to what extent these proposed changes impact the screening decision and argument used in the CRA-2019 for this FEP.

Appendix SCR-2019 states that the screening decision for this FEP is SO-C, and is based on the understanding that the design basis for the WIPP requires that thermal loading not exceed 10 kilowatts (kW) per acre. Numerous studies and analyses cited in Appendix SCR-2019 conclude that thermal loading within the repository will be far below the design basis limit, even using very conservative assumptions. The total activity in the inventory used for the RPPCR (Kicker 2023) is 6.51 x 10^6 curies, and is quite similar to the 6.14 x 10^6 curies for the CRA-2019 (Kicker 2019). Because this increase in activity is not significantly different from that in the CRA-2019, and because this value is far less than the repository design basis of 10 kW per acre, the screening argument and conclusion are not affected by the new inventory.

2.3.1.3 W14 Nuclear Criticality:Heat

The FEP W14 *Nuclear Criticality:Heat* is identified in Section 2.1 as being related to the changes identified in AP-204. Therefore, it must be determined if, and to what extent these proposed changes impact the screening decisions and arguments used in the CRA-2019. The screening decision for this FEP (SO-P) is based largely on recent criticality analyses conducted by Rechard (2019), Rechard and Stein (2019), Rechard et al., (2019), Rechard and Sanchez (2019), and most recently Rechard et al., (2022). These analyses conservatively assumed maximally loaded waste containers and mechanical compaction from salt creep. The waste inventory changes represented in AP-204 do not invalidate this screening due to the conservative nature represented in the aforementioned criticality analyses.

Information Only

2.3.1.4 W23 Subsidence and W24 Large Scale Rock Fracturing

The FEPs W23 *Subsidence* and W24 *Large Scale Rock Fracturing* are identified in Section 2.1 as being related to the changes identified in AP-204. They each have a screening decision of SO-C and are discussed jointly in Appendix SCR-2019. This decision of low-consequence is based on expected limited subsidence over waste disposal panels compared to area potash mines. The extraction ratios for the WIPP are limited such that significant subsidence will not occur over the WIPP panels, whereas area potash mines have a much greater extraction ratio due to the economic benefit of higher ore yields. Area studies have found no evidence that subsidence over potash mines have caused fracturing sufficient to connect the mining horizon to water-bearing units or the land surface. Therefore, by analogy, mining of WIPP waste disposal areas, using a much lower extraction ratio, will not create fluid flow paths between the repository and the overlying units. Because the design of the additional panels is based on the same extraction ratio criterion as existing panels, this screening argument remains valid and these two FEPs should remain classified as SO-C.

2.3.1.5 W46 Effects of Pressure on Microbial Gas Generation

The FEP W46 Effects of *Pressure on Microbial Gas Generation* is identified in Section 2.1 as being related to the changes identified in AP-204. Therefore, it must be determined if and to what extent these proposed changes impact the screening decision and argument used in the CRA-2019. The screening decision for this FEP (SO-C) is based in part on gas generation experiments with actual waste components at Argonne National Laboratory (Felicione et al. 2001). Few data exist from which the effects of pressure on microbial gas generation reactions that may occur in the WIPP can be assessed and quantified. Studies of microbial activity in deep-sea environments (for example, Kato et al. 1994, p. 94) suggest that microbial gas generation reactions are less likely to be limited by increasing pressures in the disposal rooms than are inorganic gas generation reactions (for example, corrosion). Therefore, updating the calculation of waste area pressures at the time of closure in AP-204 will not affect the screening argument and conclusion for this FEP.

2.3.2 Analysis of Screened-In FEPs

Of the 38 related FEPs listed in Table 1, 32 are accounted for in the RPPCR calculations. This section will determine if these 32 FEPs should remain screened in the PA calculations in consideration of the changes described in AP-204.

2.3.2.1 N2 Brine Reservoirs

The FEP N2 *Brine Reservoirs* is currently accounted for in PA calculations in the E1 scenario which assumes an inadvertent human intrusion borehole intercepts a source of pressurized brine beneath the repository. This scenario will continue to be represented in the RPPCR PA. Any changes to the implementation and representation of brine reservoirs within PA are described in AP-204.

Information Only

2.3.2.2 N23 Saturated Groundwater Flow, N24 Unsaturated Groundwater Flow, N25 Fracture Flow, and N27 Effects of Preferential Pathways are accounted for in PA calculations

The FEPs N23 *Saturated Groundwater Flow*, N24 *Unsaturated Groundwater Flow*, N25 *Fracture Flow*, and N27 *Effects of Preferential Pathways* are accounted for in PA calculations via the hydraulic properties assigned to the Culebra. These properties are spatially variable, and the location of the additional panels may introduce contaminants into the Culebra flow field at locations that are different from those considered in the current PA baseline. Modifications to the implementation of these FEPs in PA are described in AP-204.

2.3.2.3 N8 Formation of Fractures and N9 Changes in Fracture Aperture

The FEPs N8 *Formation of Fractures* (near the repository) and N9 *Changes in Fracture Aperture* are accounted for in PA calculations through the treatment of the disturbed rock zone (DRZ). Mining additional waste panels will cause similar fracturing near the excavations, and as such, should be treated in a similar fashion. The additional panels are separated from each other and from existing excavations by distances similar to those between current panels and excavations. Therefore, the screening decisions of these FEPs should not change as a result of the analysis described in AP-204. While justification of parameters and modeling implementation of these FEPs is beyond the scope of this analysis, increases in the DRZ volume as a result of additional waste panels will be as described in AP-204.

2.3.2.4 W1 Disposal Geometry

The FEP W1 *Disposal Geometry* is currently accounted for in PA calculations. This FEP has been identified as related to the changes described in AP-204 because changes to the modeling grid will be necessary to represent the additional waste disposal panels. Thoughtful and accurate representation of the repository and important components is fundamental to meaningful performance predictions and therefore FEP W1 should remain screened into PA calculations. No change is needed to the screening decision for this FEP. Changes in the implementation of Disposal Geometry are described in AP-204.

2.3.2.5 W2 Waste Inventory

Waste inventory has been identified in Section 2.1 as a change identified in AP-204. Waste inventory is accounted for in PA calculations both in radionuclide inventory and important non-radionuclide waste components. Releases from the repository are calculated based on the available radioactivity at the time of release. Non-radioactive waste components tracked in the inventory affect repository conditions such as pressure and actinide solubility. Since these characteristics are represented by parameters that are adjusted for actual inventory estimates, this FEP is not affected the AP-204 analysis.

2.3.2.6 W109 Panel Closure Geometry

The FEP W109 *Panel Closure Geometry* is currently accounted for in PA calculations. This FEP have been identified because the AP-204 analysis will contain additional panels, each with its own panel closure system. This FEP should remain classified as screened-in since panel closures

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will remain important repository features. Appropriate representation of the location of the panel closures required for the additional panels is identified in the AP-204 analysis. Therefore, the screening of this FEP remains unchanged.

2.3.2.7 W18 Disturbed Rock Zone, W19 Excavation-Induced Changes in Stress, and W21 Changes in the Stress Field

The WIPP FEPs W18 *Disturbed Rock Zone*, W19 *Excavation-Induced Changes in Stress*, and W21 *Changes in the Stress Field* are currently accounted for in PA calculations by the representation of the DRZ around the disposal room model. The additional panels will be based on similar design as the current panels and will be separated from each other and from existing excavations by distances similar to those between current panels and excavations. Because salt extraction ratios will remain the same as for the design basis of the original WIPP panels, FEPs W19 and W21 should not be affected. As mentioned above in Section 2.3.2.3, changes to the implementation of the DRZ (FEP W18) will be as described in AP-204.

2.3.2.8 W22 Roof Falls

Instability of the DRZ could lead to localized roof falls in the first few hundred years. Fracture development is most likely to be induced as the rock stress and strain distributions evolve because of creep. The flow model used in PA assumes that a higher permeability zone is associated with the DRZ. Thus, the potential effects of roof falls on flow paths are accounted for in PA calculations through appropriate ranges of the parameters describing the DRZ. The potential increase in DRZ associated with mining additional panels will not affect this screening argument or decision for this FEP.

2.3.2.9 W25 Disruption Due to Gas Effects and W26 Pressurization

The mechanical effects of gas generation, including the slowing creep closure of the repository because of gas pressurization and the fracturing of interbeds in the Salado through disruption due to gas effects are accounted for in PA calculations through the modeling of brine and gas flow in the repository and the calculation of associated pressures. Updating the calculation of waste area pressures at the time of closure will not affect the screening argument or decision for these FEPs.

2.3.2.10 W39 Underground Boreholes

The site investigation program has involved the drilling of boreholes from within the excavated part of the repository. Following their use for monitoring or other purposes, these underground boreholes will be sealed where practical, and salt creep will also serve to consolidate the seals and to close the boreholes. Any boreholes that remain unsealed will connect the repository to anhydrite interbeds within the Salado, and thus provide potential pathways for radionuclide transport. PA calculations account for fluid flow to and from the interbeds by assuming that the DRZ has a permanently enhanced permeability that allows flow of repository brines into specific anhydrite layers and interbeds. This treatment is also considered to account for the effects of any unsealed boreholes. Updating the permeability of a borehole after plug failure and degradation of borehole materials will not affect this screening argument or decision for this FEP; it remains classified as UP.

Information Only

2.3.2.11 W42 Fluid Flow Due to Gas Production

The FEP W42 *Fluid Flow Due to Gas Production* is currently accounted for in PA calculations through modeling two-phase brine and gas flow. Pressurization of the repository through gas generation could limit the amount of brine that flows into the rooms and drifts. Gas may flow from the repository through the DRZ, impure halite, anhydrite layers, or clay layers. Updating the calculation of waste area pressures at the time of closure will not affect this screening argument or decision for this FEP. It remains classified as UP.

2.3.2.12 W49 Gasses from Metal Corrosion and W51 Chemical Effects of Corrosion

Oxic corrosion of waste drums and metallic waste will occur at early times following closure of the repository and will deplete its oxygen content. Anoxic corrosion will follow the oxic phase and will produce hydrogen while consuming water. Gases from metal corrosion are accounted for in PA calculations. Updating the iron surface area used for gas generation from iron corrosion in the Salado flow model will not affect this screening argument or decision for these FEPs. They remain classified as UP.

2.3.2.13 W56 Speciation

Chemical speciation refers to the form in which elements occur under a particular set of chemical or environmental conditions. Conditions affecting chemical speciation include the temperature, pressure, radiolysis, redox conditions, presence/absence of complexants, degree of aggregation, and, and salinity (ionic strength) of the brine. The predicted chemical speciation defines the mobile actinide source term which is critical input to release scenarios that impact overall actinide mobility. Since the waste inventory has been changed for the AP-204 analysis, calculations in the estimates of mobile actinide concentrations used as the actinide source term will be redetermined. This this FEP will remain classified as UP.

2.3.2.14 W64 Effects of Metal Corrosion

Metal corrosion will influence the chemical conditions that prevail within the repository. Ferrous metals will be the most abundant metals in the WIPP, and these will corrode on contact with any brines entering the repository. Initially, corrosion will occur under oxic conditions owing to the atmospheric oxygen present in the repository at the time of closure. However, consumption of the available oxygen by corrosion reactions will rapidly lead to anoxic (reducing) conditions. These changes and controls on conditions within the repository will affect the chemical speciation of the brines and may affect the oxidation states of the actinides present. Changes to the oxidation states of the actinides will lead to changes in the concentrations that may be mobilized during brine flow. The oxidation states of the actinides are accounted for in PA calculations by the use of parameters that describe probabilities that the actinides exist in particular oxidation states. Updating the iron surface area used for gas generation from iron corrosion in the Salado flow model will not affect this screening argument or decision for this FEP. It remains classified as UP.

Information Only

2.3.2.15 W86 Spallings

The transport of radionuclides as spallings during penetration of the repository by a borehole is accounted for in PA calculations. A spallings event is a mechanism for radionuclide releases during inadvertent human intrusion into the repository by a borehole in which the repository contains gas at high pressure that causes (1) localized shear failure of the waste material surrounding the borehole and (2) entrainment of the failed waste material into and up the borehole, carried ultimately to the land surface. Updating the calculation of waste area pressures at the time of closure will not affect this screening argument or decision for this FEP. It remains classified as DP.

2.3.2.16 H1 Oil and Gas Exploration, H2 Potash Exploration, H4 Oil and Gas Exploitation, H8 Drilling for Other Resources, and H9 Enhanced Oil and Gas Recovery

The WIPP FEPs H1 *Oil and Gas Exploration*, H2 *Potash Exploration*, H4 *Oil and Gas Exploitation*, H8 *Drilling for Other Resources*, and H9 *Enhanced Oil and Gas Recovery* are currently accounted for in PA calculations in the disturbed scenario which assumes inadvertent human intrusion into the repository while drilling for resources. Because each of these FEPs may use deep drilling for exploration, exploitation, or enhanced recovery, the drilling rate as determined by current drilling rates in the region is the primary method of incorporation. The borehole model is also key to the implementation of these FEPs within PA. Related parameters such as drilling rate, borehole plugging probabilities, and borehole permeability will be that used as described in AP-204, however the screening arguments and decisions for the FEPs do not need revision; they remain classified as DP.

2.3.2.17 H13 Conventional Underground Potash Mining

The FEP H13 *Conventional Underground Potash Mining* is currently accounted for in PA calculations in the mining scenario. The mining scenario is prescribed by the EPA in 40 CFR 194.32(b). AP-204 states that flow fields will be calculated for mining scenarios in the same manner as calculated for CRA-2009 Performance Assessment Baseline Calculations. This FEP shall remain classified as DP.

2.3.2.18 H21 Drilling Fluid Flow, H22 Drilling Fluid Loss, and H23 Blowouts

The FEPs H21 *Drilling Fluid Flow,* H22 *Drilling Fluid Loss,* and H23 *Blowouts* are currently accounted for in PA calculations in the E1 and E2 scenarios. AP-204 describes changes to the long-term borehole permeability and certain characteristics of the Castile brine reservoir. These attributes implement key elements of these FEPs within PA. Therefore, their screening classifications remain DP.

Information Only

Subsection

3.0 IDENTIFICATION OF ADDITIONAL ACTIVITIES

This FEPs assessment has not identified any changes to the screening decisions for current FEPs related to the AP-204 analysis, nor has it identified any new FEPs that should be added to the FEPs baseline. No further activities that relate to the FEPs baseline are necessary.

4.0 CONCLUSION

This FEPs impact assessment has been conducted according to SP 9-4. Each change presented in AP-204 has been considered in light of the Baseline FEPs List (Kirkes 2021b) and Appendix SCR-2019 in order to determine the impact (if any) to screening arguments and decisions of related FEPs. No screening decision changes have been identified as a result of this review. It is important to restate, however, that it is beyond the scope of this assessment to determine that implementation of these changes within the PA system is appropriate. Changes to the PA are made through the associated controlling plans and procedures. Parameter revisions due to the changes represented in AP-204 must follow the steps authorized in NP 9-2, Parameters (Long 2023), and any code modifications shall be conducted according to NP 19-1, Software Requirements (Long 2020). Finally, analyses conducted pursuant to AP-204 must follow NP 9-1, Analyses (Nielsen 2020), and documentation of these results must follow NP 6-1, Document Review Process (Nielsen 2022).

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