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Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Plan for the CRA-2009
Performance Assessment Baseline Calculation

Task Number
1.2.5

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TABLE OF CONTENTS

List of Tables

1   INTRODUCTION AND OBJECTIVES

The Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico, has been developed by the U.S. Department of Energy (DOE) for the geologic (deep underground) disposal of transuranic (TRU) waste. Containment of TRU waste at the WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the regulations set forth in Title 40 of the Code of Federal Regulations (CFR), Part 191. The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194 by means of performance assessment (PA) calculations performed by Sandia National Laboratories (SNL).   WIPP PA calculations estimate the probability and consequence of potential radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure.   The models are maintained and updated with new information as part of a recertification process that occurs at five-year intervals after the first waste shipment is received at the site.

PA calculations were included in the 1996 Compliance Certification Application (CCA) (U.S. DOE 1996), and in a subsequent Performance Assessment Verification Test (PAVT) (MacKinnon and Freeze 1997a, 1997b and 1997c). Based in part on the CCA and PAVT PA calculations, the EPA certified that the WIPP met the containment criteria in the regulations and was approved for disposal of transuranic waste in May 1998 (U.S. EPA 1998). PA calculations were also an integral part of the 2004 Compliance Recertification Application (CRA-2004) (U.S. DOE 2004).   During their review of the CRA-2004, the EPA requested an additional PA calculation, referred to as the CRA-2004 Performance Assessment Baseline Calculation (PABC) (Leigh et al. 2005), be conducted with modified assumptions and parameter values (Cotsworth 2005). Based on the CRA-2004 and the CRA-2004 PABC, the EPA recertified the WIPP in March 2006 (U.S. EPA 2006).

Since the CRA-2004 PABC, additional PA calculations were completed for and documented in the 2009 Compliance Recertification Application (CRA-2009). The CRA-2009 PA resulted from continued review of the CRA-2004 PABC, including a number of technical changes and corrections, as well as updates to parameters and improvements to the PA computer codes (Clayton et al. 2008). The EPA has requested that additional information which was received between the data cutoff for the CRA-2009 PA (December 2007) and the submittal of the CRA-2009 (March 2009) be included in an additional PA calculation, referred to as the 2009 Compliance Recertification Application Performance Assessment Baseline Calculation (PABC-2009) (Cotsworth 2009). Minor error corrections or parameter updated may also be included in the PABC-2009. Any such changes will be documented in the resulting analysis reports for the PABC-2009.

2   APPROACH

The PABC-2009 analysis will be used to demonstrate compliance with the containment requirements according to the Certification Criteria in 40 CFR 194. A full set of PA calculations that include the updated information will be executed and the results of these calculations will be compared with the CRA-2009 PA results. In order to isolate the impact of including the updated information, the PABC-2009 is designed to deviate as little as possible from the CRA-2009 PA implementation. The PABC-2009 will examine all aspects of repository performance that were considered in the CRA-2009 PA analysis.

The approach used for the PABC-2009 will be very similar to that used for CRA-2009 PA (Clayton 2008a). The PA methodology begins with an analysis of the Features, Events and Processes (FEPs) that may or may not have bearing on the performance of the repository. The FEPs are screened to determine which FEPs will be accounted for in PA. These "retained" FEPs are formulated into scenarios that will be modeled. Scenarios are modeled using conceptual models that represent the physical and chemical processes of the repository. The conceptual models are implemented through a series of computer simulations and associated parameters that describe the natural and engineered components of the disposal system (e.g., site characteristics, waste forms, waste quantities, and engineered features). The computer simulations are developed from conceptual models. The results of the simulations quantify the magnitude and probability of potential releases of radioactive materials from the disposal system to the accessible environment over the 10,000-year regulatory period.

Because the CRA-2009 PA calculations were based on an approved PA baseline (U.S. EPA 2006), each step in the PA methodology listed above was not revised for the CRA-2009. Instead, only those elements of the PA methodology that were potentially affected by changes were investigated. For example, while the FEPs baseline was investigated relative to new information since the most recent compliance application, new performance scenarios and conceptual models were not considered, as no significantly different information was identified that warranted such fundamental changes in WIPP PA. Such will be the case for the PABC-2009. No new scenarios or conceptual models will be introduced, although the specific changes requested by the EPA will be evaluated against the FEPs basis to assure that these changes do not invalidate any screening rationale or justifications for WIPP FEPs as described in Appendix SCR of the CRA-2009.

The following sections detail how the PABC-2009 will be implemented and particular attention is given to how the PABC-2009 implementation will differ from the CRA-2009 PA.

2.1   Changes since the CRA-2009 PA

The PABC-2009 contains several updates from the CRA-2009 PA. The updates include the inventory, actinide solubilities, Culebra transmissivity fields, drilling parameters and input files. The following sections describe how these issues will be accounted for in the PABC-2009 and how they differ from the CRA-2009 PA.

2.1.1 Inventory

The Performance Assessment Inventory Report (PAIR) – 2008 (Crawford et al. 2009) was released on April 23, 2009, after the completion of the CRA-2009 PA. This report contains updated estimates for the radionuclide content and waste material parameters, scaled to a full repository, based on information up to December 31, 2007. In order to incorporate this update to the inventory into PA, the parameters for the initial radionuclides, chemical components and waste material inventories will be updated. The PAIR 2008 also includes information on the volume and radionuclide content for each waste stream. This information is used to generate the probability of encountering a waste stream and the normalized release as a function of time for each waste stream. Furthermore, parameters that are calculated based on the initial radionuclide inventories, such as the Waste Unit Factor (WUF) and the initial lumped radionuclide inventories will be updated as well.

Table 1 lists the inventory parameters that will be updated to include the information in the PAIR 2008 (Crawford et al. 2009). Along with the parameter updates, the analysis of the radionuclides that dominate releases will be updated. The updated inventory parameters are utilized in the Salado flow modeling code, BRAGFLO, the dissolved actinide source term modeling code, PANEL and the solid source term modeling code, EPAUNI.

Table 1. Inventory parameters to be modified for the PABC-2009.

Description	Materials	Property
WIPP-Scale Initial Radionuclide Inventory In Curies	AM241, AM243, CF252, CM243, CM244, CM245, CM248, CS137, NP237, PA231, PB210, PM147, PU238, PU239, PU240, PU241, PU242, PU244, RA226, RA228, SR90, TH229, TH230, TH232, U233, U234, U235, U236, U238	INVCHD and INVRHD
WIPP-Scale Initial Lumped Radionuclide Inventory In Curies	AM241L, TH230L, PU238L, U234L, PU239L	INVCHD and INVRHD
Waste Unit Factor	BOREHOLE	WUF
Waste Stream Information	The volume (in m^3) and radionuclide content (in Curies) of each waste stream (stored in the input files for EPAUNI)	
WIPP-Scale Masses of Nitrate and Sulfate	NITRATE, SULFATE	QINIT
Waste Material Parameters	WAS_AREA	DIRONCHW ,DIRONRHW, DIRNCCHW, DIRNCRHW, DCELLCHW, DCELLRHW, DCELCCHW, DCELCRHW, DCELECHW, DCELERHW, DPLASCHW, DPLASRHW, DPLSCCHW, DPLSCRHW, DPLSECHW, DPLSERHW, DRUBBCHW, DRUBBRHW, DRUBCCHW, DRUBCRHW, DRUBECHW, DRUBERHW

2.1.2 Solubility Calculations

The solubilities of the actinide elements are influenced by the chemical components of the waste. With the release of the PAIR 2008 (Crawford et al. 2009), updated information on the amount of various chemical components in the waste is available. To incorporate this updated information,

the parameters for the solubilities of the actinide elements will be updated. Furthermore, additional experimental results have been published in the literature, which is available to be used to enhance the uncertainty ranges and probability distributions for the actinide solubilities. The details of this activity are described in *Analysis Plan for the Calculation of Actinide Solubilities for the WIPP CRA-2009 PABC, AP-143* (Brush and Xiong 2009). Table 2 lists the solubility parameters that will be updated to include this additional information. The updated solubility parameters are used in the dissolved actinide source term modeling code, PANEL.

Table 2. Solubility parameters to be modified for the PABC-2009.

Description	Materials	Property
Actinide Solubilities in Castile and Salado Brines	SOLMOD3, SOLMOD4	SOLCOH, SOLSOH, SOLVAR
	SOLMOD5	SOLCOH, SOLSOH

2.1.3 Transmissivity Fields

Many additional Culebra transmissivity data sets are now available compared with the information utilized to generate the transmissivity fields (T-fields) used in the CRA-2009 PA. Additional locations near the WIPP site have been tested and long-term pumping tests have been performed. Updated head data has also been acquired. Furthermore, a peer review panel evaluated changes in the conceptual model to relate the Culebra transmissivity to various geologic factors; the changes to the model were subsequently approved (Burgess, Doe and Lowenstein 2008). The additional data and modified conceptual model will be used for the PABC-2009 T-field calibration. The details of this activity are described in *Analysis Plan for Evaluation and Recalibration of Culebra Transmissivity Fields, AP-114, Revision 1* (Beauheim 2008) and the results will be documented in a report. The updated T-fields are inputs to the Culebra flow modeling code, MODFLOW 2000. The Culebra flow results from MODFLOW 2000 are used to calculate parameters used to represent the Culebra and Magenta properties in the BRAGFLO calculations. Table 3 lists the Culebra and Magenta parameters that will be updated to include this information.

Table 3. Culebra and Magenta parameters to be modified for the PABC-2009.

Description	Materials	Property
Brine far-field pore pressure	CULEBRA, MAGENTA	PRESSURE
Log of intrinsic permeability	CULEBRA, MAGENTA	PRMX_LOG, PRMY_LOG, PRMZ_LOG

2.1.4 Drilling Rate and Plugging Pattern

WIPP regulations require that current drilling practices should be assumed for future inadvertent intrusions. The DOE continues to survey drilling activity in the Delaware Basin in accordance with the criteria established in 40 CFR 194.33. Local well operators are surveyed annually to provide the WIPP project with information on drilling practices, Castile brine encounters, etc. and the results are documented in the *Delaware Basin Monitoring Annual Report* (U.S. DOE 2008). The report shows that drilling practices have not changed since the summary report used for the CRA-2009 PA (U.S. DOE 2007).

The drilling parameters will be updated for the PABC-2009 to include the information in the *Delaware Basin Monitoring Annual Report* (U.S. DOE 2008). The report indicates that there is an increase in the drilling rate (GLOBAL:LAMBDAD) to 59.8 boreholes per km^2 over 10,000 years or 5.98E-3 boreholes per km^2 per year and a change in the plugging pattern type split. The percentage of boreholes that are plugged all through the salt section (GLOBAL:ONEPLG, shown as type VI in Figure 4 of U.S. DOE 2008) increased to 2.2%. The percentage of boreholes with a plug between the repository and a hypothetical brine pocket (GLOBAL:THREEPLG, shown as types II and IV in Figure 4 of U.S. DOE 2008) increased to 32.6%. This leads to a decrease in the remaining plugging pattern (GLOBAL:TWOPLG, shown as types I, III and V in Figure 4 of U.S. DOE 2008) to 65.2%. A comparison of the values of the drilling parameters for the PABC-2009 and the CRA-2009 PA are shown in Table 4. The updated drilling parameters are inputs in the complimentary cumulate distribution function (CCDF) construction code, CCDFGF.

Table 4. Drilling parameters to be modified for the PABC-2009 compared with the CRA-2009.

Name	Description	Units	Distribution	Analysis	Value
GLOBAL: LAMBDAD	Drilling rate per unit area	km^{-2} yr^{-1}	Constant	CRA-2009	5.85E-3
				PABC-2009	5.98E-3
GLOBAL: ONEPLG	Probability of having Plug Pattern 1	NONE	Constant	CRA-2009	0.015
				PABC-2009	0.022
GLOBAL: TWOPLG	Probability of having Plug Pattern 2	NONE	Constant	CRA-2009	0.696
				PABC-2009	0.652
GLOBAL: THREEPLG	Probability of having Plug Pattern 3	NONE	Constant	CRA-2009	0.289
				PABC-2009	0.326

2.1.5 Input Files

A review of the input files is conducted before the commencement of the PA calculations. Any errors discovered will be documented and corrected for the PABC-2009. Furthermore, one of the review aspects will be to ensure that the input files reference the correct parameter from the parameter database versus having a numerical value typed in the input files and if appropriate, a new parameter will be created in the parameter database to capture the numerical value in the input file. Parameters from the parameter database are conveyed into the calculations via a preprocessing step. The input files for the subsequent preprocessors and codes can then use these parameters to calculate derived parameters. Ensuring that the calculations are based on values in the parameter database will help to maintain consistency.

For example, in the solubility calculations, discussed in Section 2.1.2, the minimum brine volume in the repository required for a direct brine release (DBR) to occur is used and has been updated (17,400 m^3 from Clayton 2008b). A parameter derived from this value is used in the actinide mobilization calculations, discussed in Section 2.4.2, which was previously hand entered into the input file. In order to help maintain consistency between the analyses, this parameter will be entered into the parameter database (see Table 5), and the input file will then use the parameter from the parameter database to calculate the derived parameter. Any other parameters, that need to be entered into the parameter database, as a result of the review, will be created and used in the PABC-2009.

Table 5. Minimum brine volume for a DBR parameter to be created for the PABC-2009.

Name	Description	Units	Distribution	Analysis	Value
GLOBAL: DBRMINBV	Minimum volume of brine in the repository required for a direct brine release	m^3	Constant	PABC-2009	17,400

2.2 FEPs Re-assessment

An assessment of the current FEPs baseline must be conducted to determine if the FEPs basis remains valid in consideration of changes introduced by the PABC-2009. Discussion of how the changes in the PABC-2009 affect the FEPs and the resulting screening determination for those related FEPs will be included in the assessment.

2.3 Parameters

Table 6 lists the parameter that is to be created for the PABC-2009 and Table 7 lists parameters that will be updated from their CRA-2009 PA values for the PABC-2009. Except for the parameters listed in these tables, the PABC-2009 will use the same parameters and parameter values that were used for the CRA-2009 PA.

Table 6. Parameters to be created for the PABC-2009.

Name	Description	Application
GLOBAL: DBRMINBV	Minimum volume of brine in the repository required for a direct brine release	PANEL

Table 7. PABC-2009 parameters to be updated from the CRA-2009 PA values.

Name	Description	Application
CULEBRA: PRESSURE	Brine far-field pore pressure	BRAGFLO
CULEBRA: PRMX_LOG	Log of intrinsic permeability, X-direction	BRAGFLO
CULEBRA: PRMY_LOG	Log of intrinsic permeability, Y-direction	BRAGFLO
CULEBRA: PRMZ_LOG	Log of intrinsic permeability, Z-direction	BRAGFLO
MAGENTA: PRESSURE	Brine far-field pore pressure	BRAGFLO
MAGENTA: PRMX_LOG	Log of intrinsic permeability, X-direction	BRAGFLO
MAGENTA: PRMY_LOG	Log of intrinsic permeability, Y-direction	BRAGFLO
MAGENTA: PRMZ_LOG	Log of intrinsic permeability, Z-direction	BRAGFLO
NITRATE: QINIT	Initial quantity of material in waste	BRAGFLO
SULFATE: QINIT	Initial quantity of material in waste	BRAGFLO
WAS_AREA: DCELCCHW	Average density of cellulosics in CH waste container materials	BRAGFLO
WAS_AREA: DCELCRHW	Average density of cellulosics in RH waste container materials	BRAGFLO
WAS_AREA: DCELECHW	Average density of cellulosics in CH waste emplacement materials	BRAGFLO
WAS_AREA: DCELERHW	Average density of cellulosics in RH waste emplacement materials	BRAGFLO
WAS_AREA: DCELLCHW	Average density of cellulosics in CH waste	BRAGFLO
WAS_AREA: DCELLRHW	Average density of cellulosics in RH waste	BRAGFLO
WAS_AREA: DIRNCCHW	Bulk density of iron containers, CH waste	BRAGFLO
WAS_AREA: DIRNCRHW	Bulk density of iron containers, RH waste	BRAGFLO
WAS_AREA: DIRONCHW	Average density of iron-based material in CH waste	BRAGFLO

Name	Description	Application
WAS_AREA: DIRONRHW	Average density of iron-based material in RH waste	BRAGFLO
WAS_AREA: DPLASCHW	Average density of plastics in CH waste	BRAGFLO
WAS_AREA: DPLASRHW	Average density of plastics in RH waste	BRAGFLO
WAS_AREA: DPLSCCHW	Bulk density of plastic liners, CH waste	BRAGFLO
WAS_AREA: DPLSCRHW	Bulk density of plastic liners, RH waste	BRAGFLO
WAS_AREA: DPLSECHW	Average density of plastic in CH waste emplacement materials	BRAGFLO
WAS_AREA: DPLSERHW	Average density of plastic in RH waste emplacement materials	BRAGFLO
WAS_AREA: DRUBBCHW	Average density of rubber in CH waste	BRAGFLO
WAS_AREA: DRUBBRHW	Average density of rubber in RH waste	BRAGFLO
WAS_AREA: DRUBCCHW	Average density of rubber in CH waste container materials	BRAGFLO
WAS_AREA: DRUBCRHW	Average density of rubber in RH waste container materials	BRAGFLO
WAS_AREA: DRUBECHW	Average density of rubber in CH waste emplacement materials	BRAGFLO
WAS_AREA: DRUBERHW	Average density of rubber in RH waste emplacement materials	BRAGFLO
GLOBAL: LAMBDAD	Drilling rate per unit area	CCDFGF
GLOBAL: ONEPLG	Probability of having Plug Pattern 1	CCDFGF
GLOBAL: TWOPLG	Probability of having Plug Pattern 1	CCDFGF
GLOBAL: THREEPLG	Probability of having Plug Pattern 1	CCDFGF
BOREHOLE: WUF	Unit of Waste	CCDFGF/PANEL
AM241: INVCHD	Inventory of Contact Handled Design	PANEL
AM241: INVRHD	Inventory of Remote Handled Design	PANEL
AM241L: INVCHD	Inventory of Contact Handled Design	PANEL
AM241L: INVRHD	Inventory of Remote Handled Design	PANEL
AM243: INVCHD	Inventory of Contact Handled Design	PANEL
AM243: INVRHD	Inventory of Remote Handled Design	PANEL
CF252: INVCHD	Inventory of Contact Handled Design	PANEL
CF252: INVRHD	Inventory of Remote Handled Design	PANEL
CM243: INVCHD	Inventory of Contact Handled Design	PANEL
CM243: INVRHD	Inventory of Remote Handled Design	PANEL
CM244: INVCHD	Inventory of Contact Handled Design	PANEL
CM244: INVRHD	Inventory of Remote Handled Design	PANEL
CM245: INVCHD	Inventory of Contact Handled Design	PANEL
CM245: INVRHD	Inventory of Remote Handled Design	PANEL
CM248: INVCHD	Inventory of Contact Handled Design	PANEL
CM248: INVRHD	Inventory of Remote Handled Design	PANEL
CS137: INVCHD	Inventory of Contact Handled Design	PANEL
CS137: INVRHD	Inventory of Remote Handled Design	PANEL
NP237: INVCHD	Inventory of Contact Handled Design	PANEL
NP237: INVRHD	Inventory of Remote Handled Design	PANEL
PA231: INVCHD	Inventory of Contact Handled Design	PANEL
PA231: INVRHD	Inventory of Remote Handled Design	PANEL
PB210: INVCHD	Inventory of Contact Handled Design	PANEL
PB210: INVRHD	Inventory of Remote Handled Design	PANEL
PM147: INVCHD	Inventory of Contact Handled Design	PANEL
PM147: INVRHD	Inventory of Remote Handled Design	PANEL
PU238: INVCHD	Inventory of Contact Handled Design	PANEL
PU238: INVRHD	Inventory of Remote Handled Design	PANEL
PU238L: INVCHD	Inventory of Contact Handled Design	PANEL
PU238L: INVRHD	Inventory of Remote Handled Design	PANEL
PU239: INVCHD	Inventory of Contact Handled Design	PANEL

Name	Description	Application
PU239: INVRHD	Inventory of Remote Handled Design	PANEL
PU239L: INVCHD	Inventory of Contact Handled Design	PANEL
PU239L: INVRHD	Inventory of Remote Handled Design	PANEL
PU240: INVCHD	Inventory of Contact Handled Design	PANEL
PU240: INVRHD	Inventory of Remote Handled Design	PANEL
PU241: INVCHD	Inventory of Contact Handled Design	PANEL
PU241: INVRHD	Inventory of Remote Handled Design	PANEL
PU242: INVCHD	Inventory of Contact Handled Design	PANEL
PU242: INVRHD	Inventory of Remote Handled Design	PANEL
PU244: INVCHD	Inventory of Contact Handled Design	PANEL
PU244: INVRHD	Inventory of Remote Handled Design	PANEL
RA226: INVCHD	Inventory of Contact Handled Design	PANEL
RA226: INVRHD	Inventory of Remote Handled Design	PANEL
RA228: INVCHD	Inventory of Contact Handled Design	PANEL
RA228: INVRHD	Inventory of Remote Handled Design	PANEL
SOLMOD3: SOLCOH	Solubility in Castile Brine with Organics included Controlled by $Mg(OH)_2$/Hydromagnisite buffer (5424)	PANEL
SOLMOD3: SOLSOH	Solubility in Salado Brine with Organics included Controlled by $Mg(OH)_2$/Hydromagnisite buffer (5424)	PANEL
SOLMOD3: SOLVAR	Solubility Multiplier	PANEL
SOLMOD4: SOLCOH	Solubility in Castile Brine with Organics included Controlled by Mg(OH)2/Hydromagnisite buffer (5424)	PANEL
SOLMOD4: SOLSOH	Solubility in Salado Brine with Organics included Controlled by $Mg(OH)_2$/Hydromagnisite buffer (5424)	PANEL
SOLMOD4: SOLVAR	Solubility Multiplier	PANEL
SOLMOD5: SOLCOH	Solubility in Castile Brine with Organics included Controlled by $Mg(OH)_2$/Hydromagnisite buffer (5424)	PANEL
SOLMOD5: SOLSOH	Solubility in Salado Brine with Organics included Controlled by $Mg(OH)_2$/Hydromagnisite buffer (5424)	PANEL
SR90: INVCHD	Inventory of Contact Handled Design	PANEL
SR90: INVRHD	Inventory of Remote Handled Design	PANEL
TH229: INVCHD	Inventory of Contact Handled Design	PANEL
TH229: INVRHD	Inventory of Remote Handled Design	PANEL
TH230: INVCHD	Inventory of Contact Handled Design	PANEL
TH230: INVRHD	Inventory of Remote Handled Design	PANEL
TH230L: INVCHD	Inventory of Contact Handled Design	PANEL
TH230L: INVRHD	Inventory of Remote Handled Design	PANEL
TH232: INVCHD	Inventory of Contact Handled Design	PANEL
TH232: INVRHD	Inventory of Remote Handled Design	PANEL
U233: INVCHD	Inventory of Contact Handled Design	PANEL
U233: INVRHD	Inventory of Remote Handled Design	PANEL
U234: INVCHD	Inventory of Contact Handled Design	PANEL
U234: INVRHD	Inventory of Remote Handled Design	PANEL
U234L: INVCHD	Inventory of Contact Handled Design	PANEL
U234L: INVRHD	Inventory of Remote Handled Design	PANEL
U235: INVCHD	Inventory of Contact Handled Design	PANEL
U235: INVRHD	Inventory of Remote Handled Design	PANEL
U236: INVCHD	Inventory of Contact Handled Design	PANEL
U236: INVRHD	Inventory of Remote Handled Design	PANEL
U238: INVCHD	Inventory of Contact Handled Design	PANEL
U238: INVRHD	Inventory of Remote Handled Design	PANEL

2.4 PA Architecture and Code Use

The PABC-2009 will consist of a full set of PA compliance calculations. That is, three replicates of PA calculations, each replicate consisting of 100 vectors, will be performed. The random seeds from the CRA-2009 PA will be preserved so that results from this analysis can be compared to those from the CRA-2009 PA on a vector-by-vector basis.

The structure of the calculations for the PABC-2009 will be similar to the CRA-2009 PA. See Clayton (2008a) for a discussion of the calculation structure used for the CRA-2009 PA. The calculations that are affected by the changes discussed above will be updated, while the results from previous PAs will be used for the calculations that are unaffected by the changes. The calculations to be conducted for the PABC-2009 are listed below.

2.4.1 Parameter Sampling: LHS

Three replicates of 100 vectors will be created using the computer code LHS. The random seed and parameter ordering from the CRA-2009 PA will be used for the PABC-2009. Use of the CRA-2009 PA random seeds and ordering will result in identical sampled parameter values for parameters that are common to both the PABC-2009 and the CRA-2009 PA. In order to expedite the completion of the PA, the LHS output from the CRA-2009 PA will be used for calculations that do not include changed sampled parameters. This allows those calculation to proceed without the need to wait for the analyses to support the updated sampled parameters to be completed. Fifty-six parameters were sampled for the CRA-2009 PA (Kirchner 2008), and for the PABC-2009, the same parameters will be sampled. The code LHS version 2.42 will be used for the PABC-2009; the same code was used for the CRA-2009 PA.

2.4.2 Actinide Mobilization: PANEL

The PANEL code calculates the quantities of actinides mobilized by colloids and as dissolved species in WIPP brines. PANEL uses actinide solubilities from the parameter database that are derived from solubility calculations discussed in Section 2.1.2. The code PANEL version 4.03 will be used for the PABC-2009, which is the same code utilized to generate the actinide mobilization used for the CRA-2009 PA.

2.4.3 Salado Flow: BRAGFLO

The two-phase flow code BRAGFLO simulates the brine and gas flow in and around the WIPP repository and incorporates the effects of disposal room closure, gas generation, brine consumption, and inter-bed fracturing in response to gas pressure. The results of BRAGFLO scenarios S1-S5 are used as an input of the repository conditions for Salado radionuclide transport, DBRs and spallings releases as described in Section 2.4.4, Section 2.4.7 and Section 2.4.8. The scenario S6 is used for radionuclide transport to the Culebra as described in Section 2.4.4, but is not used for DBR or spallings releases.

A complete suite of calculations will be run for the PABC-2009: 3 replicates, 100 vectors per replicate, and 6 scenarios (Table 8) per vector. With the exception of the updated parameters discussed in Section 2, the PABC-2009 BRAGFLO calculations will use the same parameters

and procedure that were used in the CRA-2009 BRAGFLO calculations. The codes PREBRAG version 8.0, BRAGFLO version 6.0 and POSTBRAG version 4.00A will be used for the PABC-2009; the same codes were used for the CRA-2009 PA.

Table 8. WIPP PA BRAGFLO scenarios.

Scenario	# of Drilling Intrusions	Time of Intrusion (Years)	Castile Brine Pocket encountered
S1	0 (Undisturbed)	NA	NA
S2	1	350	Yes
S3	1	1,000	Yes
S4	1	350	No
S5	1	1,000	No
S6	2	1,000 and 2,000	Only at 2,000

2.4.4   Salado Transport: NUTS and PANEL

The WIPP radioisotope mobilization and decay code NUTS will be used to simulate the transport of radionuclides through the Salado Formation for scenarios S1 through S5. Since BRAGFLO results affect NUTS calculations, NUTS calculations will be run for the PABC-2009. With the exception of the updated parameters discussed in Section 2, the PABC-2009 NUTS calculations will use the same parameters and procedure that were used in the CRA-2009 NUTS calculations. The same scenarios and times (Table 9) will remain unchanged for the PABC-2009. As seen in Table 9, additional intrusion times, compared with the intrusions modeled in BRAGFLO, are modeled for the Salado transport calculations. The code NUTS version 2.05C will be used for the PABC-2009; the same code was used for the CRA-2009 PA.

Table 9. Salado transport intrusion times.

Scenario	Intrusion Times (years)
S1	N/A
S2 & S4	100, 350
S3 & S5	1000, 3000, 5000, 7000, 9000
S6	100, 350, 1000, 2000, 4000, 6000, 9000

Based on the characteristics of each drilling event, the intrusions were classified as no change (not significantly changing repository behavior), and E1 type (where the brine pocket is hit) or an E2 type (where the brine pocket is not hit). Radionuclide transport to the Culebra for the E1E2 intrusion combination (BRAGFLO scenario S6) is calculated by running the PANEL code in "intrusion mode" (PANEL_INT). PANEL_INT calculations will be run for the PABC-2009 with the same procedure that was used in the CRA-2009 PANEL_INT calculations. The code PANEL version 4.03 will be used for the PABC-2009; the same code was used for the CRA-2009 PA.

2.4.5   Culebra Flow: MODFLOW

MODFLOW 2000 will be used to calculate the Culebra flow. Since the updated T-fields discussed in Section 2.1.3 affect the MODFLOW calculations, MODFLOW calculations will be run for the PABC-2009. The MODFLOW 2000 calculations are managed under the *Analysis Plan for Culebra Transport Calculations: CRA-2009 PABC, AP-144* (Kuhlman 2009).

2.4.6   Culebra Transport: SECOTP2D

Radionuclide transport in the Culebra will be calculated using SECOTP2D. Since MODFLOW results affect SECOTP2D calculations, the radionuclide transport calculations will be run for the PABC-2009. The SECOTP2D calculations are managed under the *Analysis Plan for Culebra Transport Calculations: CRA-2009 PABC, AP-144* (Kuhlman 2009).

2.4.7   Direct Solids Releases

2.4.7.1   Spallings: DRSPALL

The implementation of the changes discussed in Section 2 does not affect the DRSPALL calculations. Thus, the DRSPALL calculations that were utilized to generate the spallings results used for the CRA-2009 PA, which are documented in Vugrin (2005) will be used in the PABC-2009.

2.4.7.2   Cuttings and Cavings: CUTTINGS_S

The code CUTTINGS_S has two major functions for WIPP PA: 1) calculation of cuttings and cavings volumes from a single borehole intrusion and 2) interpolation of DRSPALL volumes to calculate spallings volumes in the scenarios for drilling intrusions. The cuttings and cavings volumes calculated for the PABC-2009 will be unchanged from the CRA-2009 PA, since none of the changes discussed in Section 2 affect cuttings and cavings calculations. The PABC-2009 CUTTINGS_S calculations will use the same parameters and procedure that were used in the CRA-2009 CUTTINGS_S calculation

The PABC-2009 will use the same procedure to interpolate DRSPALL volumes to calculate spallings volumes in the scenarios and times (Table 10) for drilling intrusions that was used for the CRA-2009 PA. As seen in Table 10, additional intrusion times, compared with the intrusions modeled in BRAGFLO, are modeled for the direct solid release calculations. The initial repository pressure for a given scenario, time, location, and vector will be retrieved from the BRAGFLO results, and CUTTINGS_S will calculate a spallings volume for each scenario, time, location, and vector combination by interpolating the DRSPALL results using the initial pressure from the BRAGFLO results. Spallings volumes from a single borehole intrusion are calculated by DRSPALL at initial repository pressures of 10, 12, 14, and 14.8 MPa. While the spallings volumes calculated previously by DRSPALL (Vugrin 2005) will be reused for the PABC-2009, spallings releases for the PABC-2009 may differ from those in the CRA-2009 PA due to differences in repository pressures calculated by BRAGFLO. The code CUTTINGS_S version 6.02 will be used for the PABC-2009; the same code was used for the CRA-2009 PA.

Table 10. Direct solids release intrusion times.

Scenario	Intrusion Times (years)
S1	100, 350, 1000, 3000, 5000, 10000
S2 & S4	350, 550, 750, 2000, 4000, 10000
S3 & S5	1000, 1200, 1400, 3000, 5000, 10000

2.4.8 Direct Brine Releases: BRAGFLO

For WIPP PA, BRAGFLO is run in the DBR mode to calculate DBR volumes. Since the Salado flow results affect the DBR calculations, DBR calculations will be run for the PABC-2009. The PABC-2009 DBR calculations will use the same parameters and procedures that were used in the CRA-2009 DBR calculations. Conditions required for the initiation of a DBR release will remain unchanged from CRA-2009 PA, and the DBR volumes will be calculated for the same scenarios and times (Table 11). As seen in Table 11, additional intrusion times, compared with the intrusions modeled in BRAGFLO, are modeled for the direct brine release calculations. The codes PREBRAG version 8.0, BRAGFLO version 6.0 and POSTBRAG version 4.00A will be used for the PABC-2009; the same codes were used for the CRA-2009 PA.

Table 11. Direct brine release intrusion times.

DBR Scenario	Intrusion Times (years)
S1	100, 350, 1000, 3000, 5000, 10000
S2 & S4	550, 750, 2000, 4000, 10000
S3 & S5	1200, 1400, 3000, 5000, 10000

2.4.9 CCDF Construction: CCDFGF

The PABC-2009 will calculate CCDFs of individual vectors for total normalized releases, cuttings and cavings releases, spallings releases, DBRs, and releases from the Culebra. Mean CCDFs for each release pathway will be calculated by replicate and across all replicates. The 95% confidence limit on the mean across all replicates will also be calculated. The PABC-2009 CCDF calculations will use the same parameters and procedures that were used in the CRA-2009 CCDF calculations. The codes EPAUNI version 1.15A, PRECCDFGF version 1.01 and CCDFGF version 5.02 will be used for the PABC-2009; the same codes were used for the CRA-2009 PA.

2.4.10 Sensitivity Analysis: STEPWISE

The PABC-2009 will implement sensitivity analyses for results from the major codes in a manner consistent with those employed for the CRA-2009 PA. Specifically, global sensitivity analyses will be conducted on the results from CCDFGF using the linear regression code STEPWISE or other Commercial Off-The Shelf (COTS) statistical software. Since the Salado flow results from the BRAGFLO calculations are used as input to many other codes, additional sensitivity analyses will be performed with the BRAGFLO results. WIPP PA codes such as PCCSRC, as well as COTS statistical software, may be used to assess the sensitivity of BRAGFLO results to input parameters.

2.5 Reports and Documentation

Several reports will be generated as a result of this analysis plan. A report that contains the results of the inventory analysis conducted to evaluate the radionuclides that dominate releases, as well as the calculation of the derived inventory parameters will be generated. The results of the FEPs impact assessment will be documented in a report, along with a summary of the

parameters used for the PABC-2009. Each set of calculations discussed in Section 2.4 and its subsections will be documented in an analysis report. These reports will include:
1) discussion of any implementation changes (parameters, modeling assumptions, etc.) relative to the corresponding CRA-2009 PA calculations; and
2) analysis of results relevant to the long term performance of the repository. The analysis will include comparisons of PABC-2009 results with CRA-2009 PA results.

A summary report describing the major results of the PA will also be written.

An additional record of the run control will be created for the PABC-2009. This document will contain:
1. A description of the hardware platform and operating system used to perform the calculations.
2. A listing of the codes and versions used to perform the calculations.
3. A listing of the scripts used to run each calculation.
4. A listing of the input and output files for each calculation.
5. A listing of the library and class where each file is stored.
6. File naming conventions.

3   TASKS

The tasks, responsible personnel and estimated task schedule are summarized below in Table 12.

Table 12. Task list and estimated schedule for the PABC-2009.

Task	Description	Guiding Document	Approximate Completion Date	Responsible Individual(s)
1	Preparation Tasks			
1a	FEP Reassessment	SP 9-4	8/11/09	Kirkes
1b	Inventory Analysis	AP-145	7/9/09	Fox
1c	Solubility Analysis	AP-143	8/28/09	Brush
1d	T-Field Generation	AP-114	7/1/09	Beauheim
1e	Culebra and Magenta Analysis	AP-145	7/7/09	Beauheim
1f	Drilling Parameter Analysis	AP-145	Completed	Clayton
1g	Input File Analysis	AP-145	7/15/09	Clayton
2	Parameter Entry			
2a	Inventory Parameters	SP 9-5	7/9/09	Long
2b	Solubility Parameters	SP 9-5	8/31/09	Long
2c	Culebra and Magenta Parameters	SP 9-5	7/9/09	Long
2d	Drilling Parameters	SP 9-5	7/9/09	Long
2e	Other Input Parameters	SP 9-5	7/9/09	Long
3	Code Run Environment Preparation			
3a	Libraries Update	AP-145	7/1/09	Long
3b	Run Control Script Update	AP-145	7/1/09	Long
4	Calculations			
4a	Parameter Sampling: LHS	AP-145	9/7/09	Long
4b	Salado Flow: BRAGFLO	AP-145	7/24/09	Long
4c	Cuttings & Cavings: CUTTINGS_S	AP-145	7/27/09	Long
4d	Direct Brine Releases: BRAGFLO	AP-145	7/31/09	Long
4e	Actinide Mobilization: PANEL	AP-145	9/8/09	Long
4f	Salado Transport: NUTS & PANEL	AP-145	9/18/09	Long

Task	Description	Guiding Document	Approximate Completion Date	Responsible Individual(s)
4g	Culebra Transport: SECOTP2D	AP-144	8/25/09	Long
4h	Solid Normalized Releases: EPAUNI	AP-145	9/22/09	Long
4i	CCDF Construction: CCDFGF	AP-145	9/25/09	Long
4j	Sensitivity Analysis: STEPWISE	AP-145	9/29/09	Long
5	Analysis & Documentation			
5a	Inventory Analysis Report	AP-145	7/9/09	Fox
5b	FEPS Reassessment	SP 9-4	9/22/09	Kirkes
5c	Parameter Summary	AP-145	10/19/09	Fox
5d	Run Control Document	AP-145	10/20/09	Long
5e	Parameter Sampling: LHS	AP-145	10/30/09	Kirchner
5f	Salado Flow: BRAGFLO	AP-145	8/28/09	Nemer
5g	Cuttings & Cavings: CUTTINGS_S	AP-145	9/4/09	Ismail
5h	Direct Brine Releases: BRAGFLO	AP-145	9/28/09	Clayton
5i	Actinide Mobilization: PANEL	AP-145	10/6/09	Garner
5j	Salado Transport: NUTS & PANEL	AP-145	10/16/09	Ismail
5k	Solid Normalized Releases: EPAUNI	AP-145	12/1/09	Fox
5l	CCDF Construction: CCDFGF	AP-145	11/6/09	Camphouse
5m	Sensitivity Analysis: STEPWISE	AP-145	11/13/09	Kirchner
5n	Summary Report	AP-145	12/18/09	Clayton

4 SOFTWARE

The major WIPP PA codes to be under this analysis plan are listed in Table 13.   These codes will be executed on the WIPP PA Alpha Cluster, which is described in Table 14. Additionally, COTS, such as Mathematica®, Matlab®, Mathcad®, Excel®, Access®, Grapher®, or Kaleidagraph®, running on MS Windows XP®-based PC, MS Windows Vista®-based PC, or Macintosh OS X workstations may be utilized. The use of any COTS application will be verified per NP 9-1 Appendix C as appropriate.

Table 13. Codes to be used for the PABC-2009.

Code	Version	Build Date	Executable
ALGEBRACDB	2.35	31-JAN-1996	ALGEBRACDB_PA96.EXE
BRAGFLO	6.0	12-FEB-2007	BRAGFLO_QB0600.EXE
CCDFGF	5.02	13-DEC-2004	CCDFGF_QB0502.EXE
CUTTINGS_S	6.02	9-JUN-2005	CUTTINGS_S_QA0602.EXE
EPAUNI	1.15A	3-JUL-2003	EPAUNI_QA0115A.EXE
GENMESH	6.08	31-JAN-1996	GM_PA96.EXE
ICSET	2.22	1-FEB-1996	ICSET_PA96.EXE
LHS	2.42	18-JAN-2005	LHS_QA0242.EXE
MATSET	9.10	29-NOV-2001	MATSET_QA0910.EXE
NUTS	2.05C	24-MAY-2006	NUTS_QA0205C.EXE
PANEL	4.03	25-APR-2005	PANEL_QA0403.EXE
PCCSRC	2.21	23-MAY-1996	PCCSRC_PA96.EXE
POSTBRAG	4.00A	28-MAR-2007	POSTBRAG_QA0400A.EXE
POSTLHS	4.07A	25-APR-2005	POSTLHS_QA0407A.EXE
PREBRAG	8.0	8-MAR-2007	PREBRAG_QA0800.EXE
PRECCDFGF	1.01	7-JUL-2005	PRECCDFGF_QA0101.EXE
PRELHS	2.30	27-NOV-2001	PRELHS_QA0230.EXE

Code	Version	Build Date	Executable
RELATE	1.43	6-MAR-1996	RELATE_PA96.EXE
STEPWISE	2.21	2-DEC-1996	STEPWISE_PA96_2.EXE
SUMMARIZE	3.01	21-DEC-2005	SUMMARIZE_QB0301.EXE

Table 14. WIPP PA alpha cluster.

Node	Hardware Type	CPU	Operating System
CCR	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
TDN	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
BTO	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
CSN	HP AlphaServer ES45	Alpha EV68	Open VMS 8.2
GNR	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
MC5	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
TRS	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2
TBB	HP AlphaServer ES47	Alpha EV7	Open VMS 8.2

5   SPECIAL CONSIDERATIONS

Completion of the PABC-2009 is contingent on the receipt of the actinide solubility study analysis report discussed in Section 2.1.2 on August 28, 2009 and on the completed Culebra flow modeling, including the mining modifications, analysis report on August 10, 2009.

6   APPLICABLE PROCEDURES

All applicable WIPP QA procedures will be followed when conducting these analyses.
- Training of personnel will be conducted in accordance with the requirements of NP 2-1, *Qualification and Training*.
- Analyses will be conducted and documented in accordance with the requirements of NP 9-1, *Analyses*.
- All software used will meet the requirements laid out in NP 19-1, *Software Requirements* and NP 9-1, as applicable.
- The analyses will be reviewed following NP 6-1, *Document Review Process*.
- All required records will be submitted to the WIPP Records Center in accordance with NP 17-1, *Records*.
- New and revised parameters will be created as discussed in NP 9-2, *Parameters*.

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