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**Sandia National Laboratories
Waste Isolation Pilot Plant**

**Analysis Plan for Calculation of CCDFs:
Compliance Recertification Application**

AP-102

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INTRODUCTION AND OBJECTIVES

In 1996 the Department of Energy (DOE) completed a performance assessment (PA) for the Waste Isolation Pilot Plant (WIPP). The PA was part of the Compliance Certification Application (CCA) submitted to the Environmental Protection Agency (EPA) to demonstrate compliance with the radiation protection regulations of 40 CFR 191 and 40 CFR 194. As required by the WIPP Land Withdrawal Act (Public Law 102-579), DOE is required to submit documentation to EPA for the recertification of the WIPP every five years following the first receipt of waste in order to continue operations at the site. This will require that a Compliance Recertification Application (CRA) be prepared and submitted to the EPA by March 26, 2004. The DOE expects to provide the CRA to the EPA during November 2003.

A new set of PA calculations will be included in the CRA submittal to EPA. The results of a PA are usually presented as a set of cumulative complementary distribution functions (CCDFs), which show the probabilities that releases from the repository will equal or exceed a given amount. Analysis plan AP-105 (Leigh, 2003) presents the full set of PA calculations required for the CRA and lists the series of analysis plans that describe the specific details for each component model that will be run for the CRA. This analysis plan (AP-102) describes the methodology to be used to calculate the CCDFs for the PA.

APPROACH

The performance assessment for the CRA involves a series of calculations to determine repository performance over the regulatory period. The PA incorporates both stochastic and subjective uncertainty; stochastic uncertainty describes the possible future states of the repository and incorporates random events such as drilling intrusions, while subjective uncertainty arises from incomplete knowledge about the physical systems affecting the repository, such as the presence or absence of brine pockets in the Castile. Consequently, the PA does not predict performance. Rather, the results of the PA are presented as CCDFs, which show a family of probability distributions of releases. The distribution of releases represented in a single CCDF arises from the stochastic uncertainty about the future states of the repository. The family of CCDFs arises from subjective uncertainty about the repository system.

Stochastic uncertainty is evaluated by a random (Monte Carlo) sampling from the probability space of future repository states. For example, elements of this probability space can define the number and location of drilling intrusions during the regulatory period. Subjective uncertainty is evaluated by a structured sampling from the probability space of parameter values for the PA models. This structured sampling uses a Latin Hypercube sampling technique to ensure that extreme values for parameters are represented and to control correlations between individual parameters. Elements of the probability space for subjective uncertainty define the uncertain properties of physical

materials, such as permeabilities, as well as the presence or absence of certain repository features, such as microbial activity in the waste. A sample from this probability space is termed a vector in this document.

Direct evaluation of stochastic uncertainty is beyond the computational capability of the WIPP PA system. To reduce the calculations to a manageable number, the WIPP PA calculates repository releases for a relatively small number of scenarios. The results of these calculations are combined through interpolation to compute the releases for any given future. For more information on the algorithms used to compute releases for a given future from the results of the scenarios, refer to the Design Document for CCDFGF 5.00 [WIPP PA, 2003a].

The WIPP PA is executed by running a series of computer models, each of which implements one or more of the conceptual models of the WIPP. Figure 1 illustrates the major component codes of the PA. The code BRAGFLO computes brine and gas flows in and around the repository and produces initial conditions for the other WIPP PA codes. Each subsequent code computes releases from the repository for a different release mechanism. The code CUTTINGS_S computes direct releases by cuttings, cavings and spillings. The code BRAGFLO is used again to compute the volumes of brine released directly to the surface during a drilling intrusion. The code PANEL computes the concentrations of radionuclides mobilized in brine within the repository, as well as releases to the Culebra in a multiple intrusion scenario. The code NUTS computes transport through the Salado to the Land Withdrawal Boundary and to the Culebra for single intrusion scenarios. The code SECOTP2D computes transport to the Land Withdrawal Boundary through the Culebra.

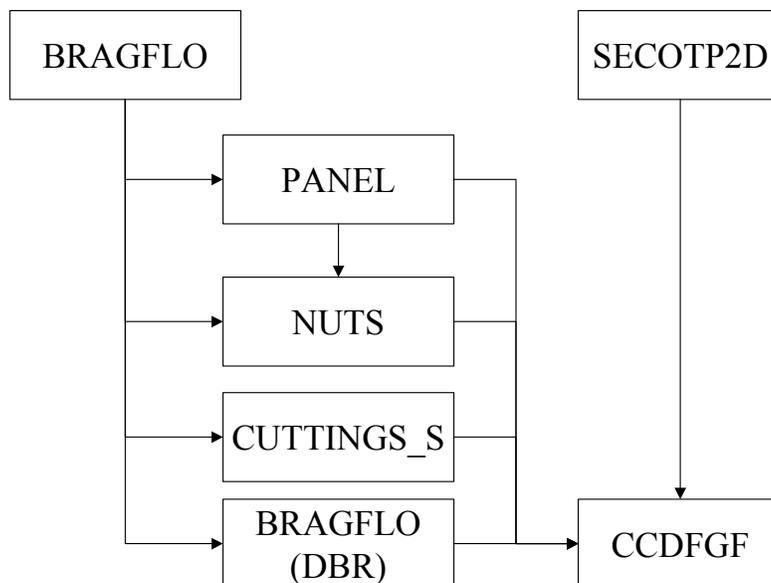


Figure 1. Sequence of Major Components of WIPP PA.

After all the component releases are calculated, the code CCDFGF computes probability distributions of total releases by generating a large number of possible futures for the repository and computing the release for each future. CCDFGF generates one distribution of releases for each vector in the structured sample for subjective uncertainty. These distributions of total releases embody the CCDFs mandated by 40 CFR 191.

CALCULATING CCDFS FOR THE CRA

The following sections describe how the CCDFs for each release mechanism will be calculated for the CRA. CCDFGF will be used to compute total CCDFs of releases for 3 replicates; each replicate will use a different sample of 100 vectors for subjective uncertainty. CCDFGF will be run for 10,000 futures for each vector.

Cuttings and Cavings

Cuttings and cavings are releases of solid material from the repository from a drilling intrusion. Cuttings are the solid materials removed by the drill bit; cavings are additional solid material that may be scoured from the walls of the borehole by the circulating drilling fluids.

The code CUTTINGS_S calculates the volume of solid material brought to the surface as cuttings and cavings for each vector of subjective uncertainty. Cuttings and cavings volumes do not depend on repository conditions at the time of intrusion; thus, they are constant for each vector. The cavings component depends on several parameters that are sampled as part of the subjective uncertainty; thus, the cuttings and cavings volumes will vary across vectors.

Cuttings and cavings releases are computed by combining the volume of cuttings and cavings with a concentration of radionuclide activity. The concentration of radionuclide activity is determined by selecting a number of waste streams, determining the activity concentration in each waste stream at the time of intrusion, then averaging the concentrations of the selected waste streams.

For the CRA we will use an average over the activity concentrations in three waste streams for intrusions into CH waste. Waste streams will be selected randomly for each drilling intrusion, with the probability of selecting a given CH waste stream determined by dividing the waste stream's volume by the total volume of CH waste.

For simplicity in the PA, all RH waste streams are combined into a single waste stream. The activity concentration for an intrusion into RH waste will be the activity of the combined RH waste stream at the time of the intrusion.

Direct Brine Releases (DBR)

The code BRAGFLO will be used to compute volumes of brine releases directly to the surface during a drilling intrusion. The methodology for these calculations is outlined in AP-104 (Stein, 2003a).

For each replicate, a total of 78 BRAGFLO runs will be made to compute volumes of brine. The combinations of scenario, location and times is the same as for spillings, and are listed in Table 1. Stein (2003a) defines the scenarios and the panel locations for the intrusion boreholes.

Table 1. DBR Calculations for the CRA

Scenario	Panels	Times
Undisturbed conditions	Upper, Middle, Lower	100, 350, 1000, 3000, 5000, 10000
E2 borehole (doesn't intersect brine pocket in the Castile)	Upper, Middle, Lower	550, 750, 2000, 4000, 10000
E1 borehole (intersects brine pocket in the Castile)	Upper, Middle, Lower	1200, 1400, 3000, 5000, 10000

Direct brine releases (DBR) are computed by multiplying the volume of brine released during an intrusion with the mobilized concentration in brine of radionuclides in the repository. The code PANEL will be used to compute the concentrations for DBR releases.

The DBR model requires a parameter called the skin factor, which represents the surface area of the cavity at the bottom of a borehole. In the CCA and the PAVT, the skin factor was derived from the spillings volume for the intrusion. In the CRA, as outlined in AP-104, a constant skin factor will be used to allow for flexibility in the implementation of the spillings model. The value for the skin factor conservatively over-estimates DBR volumes.

Spallings

The PAVT used a simple model for spillings. This model assumes that spillings occur during every intrusion into CH waste and that intrusions into RH waste do not cause spillings. The model estimates spalling volumes by sampling from a uniform

distribution from 0.5 to 4.0 m³, if repository pressure exceeds 8MPa at the time of the intrusion. If pressure is less than 8MPa, spalling volume is zero.

A new conceptual model for spallings releases is currently under development. The code DRSPALL implements the new conceptual model, and will be used to compute the volume of solid material brought to the surface as spallings from a drilling intrusion. The conceptual model embodied in the DRSPALL code is currently in peer review. After the DRSPALL model is approved by the peer review and the code has completed its quality assurance (QA) requirements, DRSPALL will be exercised to generate spalling volumes for the CRA.

Since DRSPALL run times prohibit running DRSPALL as a component of the PA system shown in Figure 1. Consequently input parameters to DRSPALL will be sampled and the code will be run to generate a set of spalling volumes. The sampled input parameters will be used as independent variables to create a regression model for spalling volumes, The regression model will be implemented in a revision to the CUTTINGS_S code, in place of the PAVT model for spallings. The construction of the regression model for spalling volumes and the sensitivity of these volumes to the sampled inputs will be documented in a separate analysis package.

The CRA will assume that spallings occur only for intrusions into CH waste. Values for the independent variables for the regression model for spallings will be obtained from the sampled parameters for subjective uncertainty and from the conditions at the time of intrusion as calculated by BRAGFLO. Spallings volumes will be computed by CUTTINGS_S for the combinations of scenarios, locations and time shown in Table 1, for a total of 78 CUTTINGS_S runs per replicate.

Spallings releases are computed by multiplying the spalling volume with a concentration of activity in solid waste. For the CRA, we will use the average activity in all CH waste streams for spallings releases.

Radionuclide Transport through the Salado

As specified in AP-099 (Stein, 2003b), the code NUTS will be used to compute radionuclide transport through the Salado to the Land Withdrawal Boundary (LWB), and to the Culebra for single intrusion scenarios. Releases to the Culebra for multiple intrusion scenarios will be computed by the code PANEL.

Radionuclide Transport through the Culebra

As specified in AP-100 (Leigh et al, 2003), transport through the Culebra will be calculated using the code SECOTP2D. SECOTP2D computes the quantity of a 1 kg source that is transported through the Culebra to the LWB, at each time up to the end of the regulatory period. Since the equations in SECOTP2D are linear, the total releases through the Culebra are computed by multiplying the amount of each radionuclide released to the Culebra at time t by the fraction of the source that can reach the LWB by

time $(10,000 - t)$, and then integrating over all t . This convolution and integration are done by the code CCDFGF.

Total Releases from the Repository

The code CCDFGF computes total releases from the repository for each of the vectors in the sample for subjective uncertainty. For each vector, CCDFGF will generate 10,000 possible futures for the repository. Each future includes a time that mining for potash will occur within the LWB, and a sequence of drilling intrusions into the repository. For each future, CCDFGF computes the total releases from the repository. For more information on the algorithms used to compute releases for a given future from the results of the scenarios, refer to the Design Document for CCDFGF 5.00 [WIPP PA, 2003a].

The parameters for subjective uncertainty will be sampled in three replicates of 100 vectors each. CCDFGF will be run once for each replicate, generating 100 CCDFs for each replicate. For each replicate, the mean and median CCDFs will be computed as the mean and median probabilities of the release exceeding a fixed value. The mean and median CCDFs will be compared between the three replicates using a t-test to determine 95% confidence intervals on these statistics, as required by 40 CFR 194.

Sensitivity Analysis

In accordance with AP-103 (Hansen, 2003), sensitivity analyses will be conducted to determine which parameters in the space for subjective uncertainty have the most influence on the uncertainty in total releases. The sensitivity analysis will consider the expected value and the median values for total releases.

SOFTWARE LIST

The WIPP PA codes listed in Table 2 will be used to compute CCDFs for the CRA. These codes will be qualified on the ES-40, ES-45, and 8400 Compaq ALPHA computers running Open VMS Version 7.3-1 (WIPP PA 2003b, 2003c and 2003d).

Table 2. WIPP PA Software for Calculating CCDFs

Code	Version	Code Function
PRECCDFGF	1.01	Formats data for CCDFGF
CCDFGF	5.00	Computes CCDFs
CCDFSUM	2.00	Plots CCDFs

SPECIAL CONSIDERATIONS

None.

APPLICABLE PROCEDURES

Analyses will be conducted in accordance with the quality assurance (QA) procedures listed below.

Training: Training will be performed in accordance with the requirements in NP 2-1, Qualification and Training.

Parameter Development and Database Management: Selection and documentation of parameter values will follow NP 9-2. The database will be managed in accordance with relevant technical procedure.

Computer Codes: All software used in this analysis will be qualified in accordance with NP 19-1.

Analysis and Documentation: Documentation will meet the applicable requirements in NP 9-1.

Reviews: Reviews will be conducted and documented in accordance with NP 6-1 and NP 9-1, as appropriate.

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WIPP PA (Performance Assessment), 2003d. "Analysis Report for the A8400 Regression Test." Sandia WIPP Central Files Records Package # 525278.

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