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Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Plan for Evaluating Assumptions of Waste Homogeneity in WIPP Performance Assessment

AP-107

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1 INTRODUCTION AND OBJECTIVES

In 1996, the U.S. 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 (Subparts B and C) 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. This will require that a Compliance Recertification Application (CRA) be prepared and submitted to the EPA no later than March 26, 2004. The DOE expects to provide the CRA to the EPA during November 2003.

In December 2002, DOE submitted an impact assessment to EPA describing the effect on repository performance of supercompacted wastes from the Advanced Mixed Waste Treatment Project (AMWTP) (DOE, 2002). The impact assessment began with a review of features, events, and processes (FEPs) associated with the waste. The review concluded that the FEPs addressed in PA were adequate for supercompacted wastes, but that an impact assessment should be conducted to examine any effects on repository performance due to the supercompacted waste. Accordingly, DOE used reasoned arguments to prepare an impact assessment for supercompacted waste. EPA found the reasoned arguments inadequate and requested additional information and technical analyses in order to more fully assess the effects of the AMWTP waste on repository performance. (EPA, 2003)

This analysis plan (AP-107) describes the analyses that Sandia National Laboratories (SNL) will conduct in response to EPA's request. These analyses are designed to determine the effects on PA results of the emplacement of supercompacted wastes. In the course of these analyses, SNL will address a broader question, namely, what is the effect on PA results of assumptions about waste heterogeneity. The results of these analyses will be documented in analysis packages and included in the CRA, if appropriate.

2 APPROACH

This section provides background information on supercompacted wastes, summarizes the questions to be addressed by the analysis, and outlines the general approach to be used.

2.1 Background

The Idaho National Engineering and Environmental Laboratory (INEEL) has developed the Advanced Mixed Waste Treatment Project (AMWTP) to process 55-gallon drums of contact-handled transuranic (CH TRU) waste prior to shipment to the Waste Isolation Pilot Plant (WIPP). Processing at the AMWTP will involve retrieval, characterization, repackaging, and compacting 55-gallon drums of debris waste and placing the compacted drums into 100-gallon drums prior to shipment. The AMWTP will also repackage non-debris waste streams (primarily organic and inorganic sludges) without compaction.

2.2 Issues with Supercompacted Waste

WIPP PA represents the aggregate waste emplaced in the repository as homogeneous. In their response to DOE's submittal, EPA raises a number of questions about this representation, and the validity of assuming homogeneity when supercompacted wastes are present in the inventory. EPA notes that the supercompacted waste differs in several characteristics from the majority of waste planned for disposal in the WIPP, primarily due to its compaction. Specifically, EPA questions whether the supercompacted waste affects the creep closure process for rooms. EPA also questions whether the supercompacted waste's higher density of cellulosics, plastics, and rubbers (CPR) should alter assumptions about repository chemistry, and whether the spatial distribution of the supercompacted waste within the repository can affect repository performance.

2.3 Issues with Other Waste Types

During technical discussions with SNL on April 22-24, 2003, EPA indicated that similar questions might be asked about other waste types, such as the pipe overpacks. Pipe overpacks were used to package some Rocky Flats residues; the overpacks are structurally more rigid than a typical 55-gallon waste drum, and may affect repository processes in a similar manner to the supercompacted waste. The pipe overpack containers are one of several variations in the type of packaging materials that have been emplaced in the repository since the initial compliance application.

2.4 Issues Related to Waste Heterogeneity

During the review of the CCA, questions were raised regarding the PA's assumption that that the waste can be represented as mechanically and chemically homogeneous. These concerns were satisfactorily resolved as part of the certification process (Hansen et al., 1997 and Sanchez et al., 1997). However, since receipt of waste began in 1999, waste has arrived in shipping campaigns from the generator sites, resulting in the appearance that the waste is not uniformly distributed through the repository, raising additional questions about the assumption of homogeneous waste. These issues include questions about the distribution of CPR and MgO within the repository, and about the actinide solubilities used in PA. This analysis proposes to address these other issues concurrently with and in the same manner as questions about the supercompacted waste.

2.5 Summary of Analysis Approach

This analysis will evaluate the effects of the assumption that the waste can be represented as mechanically and chemically homogeneous. The waste inventory in the

WIPP inventory will be represented by three generic waste types: standard WIPP waste in 55-gallon drums and standard waste boxes; supercompacted waste from the AMWTP; and waste in pipe overpacks. These three waste types will provide sufficient variability in mechanical and chemical properties to evaluate the adequacy of representing the aggregate waste as homogeneous.

The analysis should answer the following general questions:

1. What are the mechanical properties of the waste types?
2. What chemical conditions can occur within the different waste types?
3. Are assumptions made in WIPP PA models valid for the different waste types?
4. Are variations in waste mechanical properties and chemical conditions significant to repository performance?

The AMWTP process has been developed subsequent to the CCA and therefore the supercompacted waste was not considered in the waste inventories used in the CCA and the Performance Assessment Verification Test (PAVT). The supercompacted waste will be included in the inventory for the performance assessment for the CRA. In the EPA's response to DOE's submittal requesting approval to dispose of supercompacted waste in WIPP (DOE, 2002), EPA required that any analysis of the effects of supercompacted waste to include all recent changes to the WIPP PA system for the CRA, including representation of the Option D panel closures and corrections to PA models. (EPA, 2003) For these reasons, SNL will conduct analysis of the effects of the supercompacted waste on repository performance using the PA codes, parameters, and inventory data planned for use in the CRA.

The remainder of this analysis plan describes the waste components to be considered, and explains the analyses that SNL will undertake to answer the general questions listed above.

3 DESCRIPTION OF WASTE COMPONENTS

The analysis will consider three waste types that are representative of the waste to be emplaced in WIPP: standard WIPP waste; supercompacted waste from the AMWTP; and waste in pipe overpacks. This analysis does not consider any effects of the remote-handled (RH) waste containers.

3.1 Standard WIPP Waste

Standard WIPP waste is contact-handled transuranic (CH TRU) waste that is packaged in 55-gallon drums and standard waste boxes. The standard WIPP waste is not treated by the generator sites and is emplaced as it arrives at the WIPP, without load management. Standard WIPP waste for the CRA will have similar mechanical properties to the waste properties for the CCA, and will be represented as homogeneous.

3.2 Supercompacted Waste

The AMWTP is designed to retrieve, characterize, and prepare 65,000 m^3 of CH TRU waste at INEEL for shipment to the WIPP (DOE, 2002). The CH TRU wastes at INEEL consist of non-debris waste and debris waste. The non-debris waste constitutes approximately 30% of the total volume and will not be supercompacted. The debris waste constitutes about 70% of the total volume and will be processed through a sorting, sizing, and volume reduction process termed supercompaction.

The AMWTP will compact 55-gallon drums of debris waste and place the compacted drums into 100-gallon drums before shipment to the WIPP. The compacted 55-gallon drums are referred to as “pucks.” Each puck has a final volume of 15 gallons to 35 gallons, and each 100-gallon container is anticipated to contain from three to five pucks, with an average of four pucks per container.

The 100-gallon container is made of steel. The outside height of the container (with lid) is 35 inches and its outside diameter is 32 inches. The height of a container is very similar to the height of a 55-gallon drum; however, its diameter is larger (32 inches versus 24 inches). The weight of an empty 100-gallon container is estimated to be 95 pounds (43.1 kg). The size of the 100-gallon drums is such that three 100-gallon drums roughly fill the same area as a 7-pack of standard (55 gallon) waste drums.

3.3 Waste in Pipe Overpacks

Pipe overpacks are used to ship TRU wastes contaminated with higher concentrations of plutonium and americium. The filled pipe overpack is surrounded by an impact limiter and placed inside a 55-gallon drum. The impact limiter is typically fabricated from polyethylene or a dense fiberboard. The pipe overpack and impact limiter have three key functions: (1) maintain separation of fissile material to prevent criticality, (2) provide radiation shielding, and (3) immobilize fine particulate waste materials. Pipe overpacks have been used to transport direct oxide residues (DOR) from the Rocky Flats site and have already been emplaced in Panel 1 of the repository.

3.4 Remote Handled Waste Canisters

Because remote-handled (RH) canisters are emplaced in the disposal room walls, they do not affect creep closure processes. WIPP PA represents RH waste as chemically isolated from the rest of the repository. Therefore, this analysis does not consider the effects of RH canisters on repository processes, or possible heterogeneity in RH waste.

4 MECHANICAL PROPERTIES OF WASTE

This section describes the analysis SNL will conduct to establish properties and parameters for the three waste components. In general, the supercompacted and pipe overpack waste types are viewed as more substantial, mechanically sounder, structurally stiffer, and chemically more durable, than the conventional 55-gallon drums of waste. At the same time, the supercompacted waste contains a greater quantity of CPR, thereby providing considerably more reactants than the inventory used for the CCA. The mechanical effects will be captured primarily for the cases where the more substantial waste types influence creep closure of the disposal rooms. The current PA assumes that all waste types degrade over time and become relatively homogeneous. Consequently, this analysis focuses on the other extreme case where much of the more substantial waste remains intact.

4.1 Evolution of Waste Components After Emplacement

SNL will investigate how each waste type may evolve after emplacement, including degradation of the waste containers. The performance assessment implemented for the CCA, PAVT and TBM includes repository processes, such as room closure, brine inflow and degradation that alter the mechanical properties of the waste over time. The parameters and models that represent the waste in WIPP PA are documented in WIPP records and comprise important elements of the current certification.

4.2 Waste Permeability

The PA representation of the waste as homogeneous currently uses a constant value of 2.4×10^{-13} m^2 for the waste permeability. This value represents the lower range of waste permeability, measured in laboratory tests of compressed waste surrogates (Butcher, 1996). However, the supercompacted waste may have a lower permeability than these waste surrogates, and the pipe overpack waste may be essentially impermeable, if the containers do not degrade over time. Thus, the waste emplaced in WIPP may be more accurately described as an aggregation of materials with varying permeability, in which the supercompacted waste and pipe overpacks may be surrounded by material of a higher permeability.

Brine and gas flow within the repository is modeled using two-phase Darcy flow as implemented in the BRAGFLO code. BRAGFLO uses a constant permeability tensor for each phase, combined with the saturation-dependent relative permeability to each phase. Thus, BRAGFLO requires a constant value of permeability as a material property for the waste.

SNL will estimate the combined permeability of the waste as an aggregate of the three waste types (standard, supercompacted, and pipe overpacks), accounting for each component's permeability, and accounting for uncertainty in the spatial arrangement. This effort may result in a different constant value than currently in use, or in a distribution of waste permeabilities that can be sampled as an uncertain parameter.

4.3 Effect of Waste Stiffness on Room Closure

Inclusion of rigid waste elements is expected to have the greatest influence on creep closure, as noted by the EPA (EPA, 2003). WIPP PA currently assumes that the waste comprises standard waste types in 55-gal drums and standard waste boxes, and that degradation proceeds sufficiently to comminute the waste to a spallable residue. The supercompacted waste and the waste in pipe overpacks could create stiff columns within the disposal rooms that can influence room closure. It is possible that rigid waste columns would increase overall waste porosity by shielding adjacent standard waste from compaction. This effect would be reflected in the porosity surface look-up table accessed in PA.

This analysis will evaluate how much waste porosity can be increased by the presence of pillars within the waste, and whether increased waste porosity affects repository performance significantly. Long-term effects of rigid waste on closure require that the waste remain intact, essentially undegraded and un-spallable. The most severe case of waste degradation is simulated in the current performance assessment scenarios. In contrast, of the presence of rigid, massive waste forms propping open the rooms would prevent or significantly limit spall release.

In order to evaluate the effect of these pillars on repository performance, a number of scoping calculations will be carried out to estimate closure of the rooms with different spacing of columns of stiff waste types. Once bounds of closure have been estimated, calculations will be made using SANTOS for extreme cases to determine the effect of these stiffer columns on the waste porosity.

4.4 Waste Particle Size

Waste emplaced in WIPP is packaged in a variety of waste containers, including 55-gallon drums, standard waste boxes, and other similar containers. WIPP PA makes the conservative assumption that these containers degrade rapidly, and that the waste in the containers is reduced to small particles after repository closure. Particle size was an important variable in the CCA's model for spall releases, and will be considered in the new model for spall, currently under development. The particle sizes required for spall releases are relatively small, representing waste that has undergone rampant degradation. Introduction of waste forms that are more substantial and less degraded than the conventional 55-gallon drums is unlikely to produce particle sizes smaller than those already implemented for spall releases. Hence, the substantial waste forms, if less degraded, will shift the distribution of particle sizes used in PA towards larger particle diameters, and will reduce overall releases from the repository. Therefore, the range of particle sizes currently used in PA is conservative, and this analysis will not propose a different particle size for a mix of waste types.

4.5 Waste Shear Strength

WIPP PA uses the shear strength of the waste to estimate the releases due to cavings that is due to drag on the waste caused by circulating drill mud. Currently a distribution of values is used for the shear strength of the standard waste; however, this distribution considers only conservatively low values of shear strength. Estimates of shear strength for the other two waste types will be made based upon their known mechanical form on placement and their expected degradation. These values will be used to estimate a range for this parameter. It should be noted that the shear strength for these other waste types will likely be higher than for the standard waste forms, so the effect of emplacing these in the repository may be to reduce the magnitude of cavings releases.

4.6 Waste Tensile Strength

Waste tensile strength was considered in the CCA model for spall, where a constant value of 1 psi was used. Waste tensile strength may be an important variable in the new model for spall, currently under development. The evaluation of a mechanistic model for spall (Hansen et al., 1997) evaluated tensile strength for comprehensively degraded waste. These conditions represent a bounding lower value for tensile strength. It should be noted that the tensile strength for the supercompacted waste and the pipe overpack waste will likely be higher than for the standard waste forms, so the effect of emplacing these in the repository may be to reduce the magnitude of spall releases.

5 CHEMICAL CONDITIONS WITHIN THE REPOSITORY

SNL will analyze the possible effects of supercompacted waste and waste in pipe overpacks on repository chemistry. Specifically, SNL will determine if the spatial distribution of these wastes could result in chemical conditions different from those assumed in the PAVT and in the baseline CRA PA. The analysis will focus on two issues: the MgO safety factor, and the possible effects of waste heterogeneity on actinide solubilities.

The inventory of cellulosics, plastics, rubbers, oxyanions, and organic ligands must be known in order to determine the chemical conditions in the repository. Therefore, an analysis will be performed in order to determine the waste characteristics listed above for a single panel and for the rest of repository for both homogeneous and heterogeneous waste emplacement assumptions.

5.1 Possible Effects of CPR on Repository Chemistry

SNL will use routine calculations to calculate the MgO safety factor for various spatial configurations of the waste. (The MgO safety is the ratio of the quantity of MgO emplaced to that required to consume all of the CO_2 that could be produced by microbial degradation of all of the CPR.) These calculations pertain specifically to supercompacted waste, in which the density of CPR is about ten times greater than that contained in the average CH TRU waste used for the CCA and the PAVT. However, the MgO safety factor may also be calculated for other types of waste. The assumption that methanogenesis will be the dominant microbial degradation reaction is appropriate and defensible. (This assumption resulted in a safety factor of 3.7 at the time of the CCA and the PAVT, and a safety factor of 3.2 after elimination of the MgO minisacks.) SNL will justify this assumption by describing the results of long-term microbial gas-generation experiments, which have yielded abundant evidence for methanogenesis under expected WIPP conditions, and by demonstrating that degradation of a significant fraction of the

CPR by denitrification is impossible. (The assumption that denitrification will be the dominant microbial degradation reaction is consistent with safety factors of 1.95 and 1.67 before and after, respectively, the elimination of the minisacks.)

Heterogeneity in CPR loading within the repository will be addressed in Section 7 of this analysis plan.

5.2 Possible Effects of Waste Heterogeneity on Actinide Solubilities

The waste streams packaged in pipe overpacks have higher loadings of Pu than most other waste streams. Sufficiently high loadings of Pu may create oxidizing microenvironments within the waste, in which actinide solubilities may be different than those calculated using homogeneous waste. In addition, the supercompacted and pipe overpack wastes may differ significantly from the standard waste in the concentrations of constituents, such as organic ligands, also raising questions about the solubilities used in PA.

To address the questions about Pu concentrations, SNL will compare the characteristics of pipe overpack waste to the waste that produced oxidized Pu (Pu in the +V or +VI oxidation states, or Pu(V) or Pu(VI)) in some of the experiments in the recently completed WIPP Source Term Test Program (STTP) at Los Alamos National Laboratory. The comparison will be conducted using routine calculations.

If the comparison demonstrates that the pipe overpack waste differs significantly from the waste used in the STTP experiments that yielded Pu(V) or Pu(VI), then SNL will continue to assume that Pu will not speciate as Pu(V) or Pu(VI) and that the solubilities used in PA are valid. If the wastes are not significantly different, SNL will re-examine the assumptions about the speciation of Pu used in the CCA, the PAVT, and the CRA.

To address the questions about concentrations of other waste constituents, SNL will compare the supercompacted and pipe overpack waste to the remainder of the waste inventory. These comparisons may result in calculations of actinide solubilities for subsets of the waste inventory, using the thermodynamic speciation and solubility code Fracture-Matrix Transport (FMT). For example, calculation of solubilities would be required if the concentrations of organic ligands in supercompacted or pipe overpack waste are significantly higher than those used for the FMT calculations for the CRA.

If SNL determines that waste heterogeneity could result in different solubilities than are used in the CRA, SNL will appropriately modify parameters and PA codes, and will use the PA codes to quantify the effect of variations in solubility on repository performance.

6 ASSUMPTIONS MADE IN WIPP PA MODELS

To supplement the FEPs review (DOE, 2002), SNL will review the WIPP PA conceptual models and computer codes to determine whether the assumptions made to implement waste-related FEPs in PA continue to be valid for supercompacted and overpack waste types. The following steps list the activities that will be conducted to identify assumptions about the waste, and to evaluate the validity of these assumptions to account for supercompacted and pipe overpack waste types:

Step 1 – Identify FEPs, conceptual models, and scenarios in which waste characteristics are important.
Step 2 – Determine which FEPs, conceptual models, and scenarios may be significantly affected by heterogeneity in waste materials.
Step 3 – Determine if the FEPs, conceptual models, scenarios, and assumptions used to implement waste-related FEPs, conceptual models and scenarios continue to be valid in consideration of supercompacted and overpack waste types.

During the process of performing these three steps, special attention will be applied to historic conceptual model development, alternative conceptual models not used, and scenario development as discussed in the CCA (DOE, 1996). In addition, modeling assumptions as described in the CCA related to waste properties will be evaluated for any inconsistencies or inadequacies that might be realized because of the addition of supercompacted or pipe overpack waste types.

7 EFFECTS ON REPOSITORY PERFORMANCE

To evaluate the effects on repository performance of heterogeneity in waste properties, chemical conditions and spatial distribution, SNL will incorporate any necessary adjustments to PA models, parameters and input data (such as the porosity surface), and repeat Replicate 1 of the CRA PA calculation. Adjustments to PA models, parameters and input data may result from the investigations of waste mechanical properties, chemical conditions, and the investigation of PA modeling assumptions. The sampling of uncertain parameters will be done using the same random seed as in Replicate 1, allowing vector-to-vector comparison if necessary, to identify effects of different parameter and data values.

7.1 Effects on Repository Brine and Gas Flows

The code BRAGFLO computes brine and gas flow within and around the repository. The code includes models that account for chemical reactions within the waste that may produce gas. BRAGFLO provides pressures and saturations (gas and brine) as initial conditions to the PA codes that calculate the consequences of intrusions into the repository, and consequent releases from the repository. SNL will compare the primary output of BRAGFLO (pressure, saturation, gas generation, brine flow out of the waste areas) to the corresponding output from the PA for the CRA. Significant differences in output variables will be analyzed to determine the effects of the various waste types on brine and gas flows.

7.1.1 Effect of Waste Permeability

Waste permeability is currently incorporated in BRAGFLO calculations as a constant value. If the analysis of waste permeability concludes that a different constant value (or a range of values) for waste permeability is more appropriate, the effect of changing the waste permeability will be evaluated using the PA models. If a range of values is needed for waste permeability, this parameter will be sampled by LHS.

7.1.2 Effect of Varying Waste Stiffness

The presence of columns of stiff waste forms may alter room closure, as described above. Room closure models are implemented in the BRAGFLO code as a "porosity-surface" look-up table. The porosity surface specifies the porosity of the waste as a function of gas pressure and time. BRAGFLO version 5.0 reads a set of these look-up tables from an external input file, and therefore it is relatively straightforward to implement new creep closure calculations. BRAGFLO has the capability to apply different creep closure properties to different regions in the same simulation. In regions where closure is modeled, the porosity of the material is adjusted at each time step depending on the simulation time since the start of the run and the pressure in the material.

To evaluate the effect of any "maximum porosity surface" resulting from the SANTOS calculations described above SNL will run BRAGFLO using the new porosity surface in part or all of the repository. This calculation will effectively evaluate sensitivity to a range of porosity derived from the creep closure calculations. Gas pressures and brine saturations will be compared to the results from the PA for the CRA. The effects of changes in gas pressures and brine saturations on PA results will be determined by the subsequent PA codes.

7.1.3 Distribution of Cellulosics, Plastics, and Rubbers

Biodegradation of cellulosics, plastics, and rubbers (CPR) are a possible gas generation mechanism in PA. The biodegradation is treated as an epistemic uncertainty. In 50% of PA parameter vectors, microbial activity generates gas within the waste. In half of these vectors (25% of all vectors) the microbes only consume cellulosics and leave the plastics and rubbers untouched. In the other half of these vectors (25% of all vectors) the microbes consume cellulosics, plastics, and rubbers equally. PA currently assumes that the distribution of CPR in the repository is uniform and homogeneous throughout the repository. However, BRAGFLO has the capability to represent CPR loading in a non-uniform manner.

The supercompacted waste is especially rich in CPR. This waste (waste stream IN-BN-510) is estimated to have, on average, a CPR density approximately ten times the repository average CPR density in the aggregate waste. The volume of the supercompacted waste is 11,666 m^3 (about 66% of a single panel). Because the supercompacted waste is voluminous waste type and because it contains considerably higher densities of CPR, the EPA has questioned the assumption the waste is homogeneous, since the assumption implies that the CPR is distributed uniformly throughout the repository. To test the effect of non-uniform CPR emplacement, SNL will define an extreme non-uniform case that maximizes the CPR density in a single panel.

The effects on gas pressures and brine saturations of the non-homogeneous distribution of CPR will be determined by comparing BRAGFLO results from the extreme case with BRAGFLO results from the PA for the CRA. The effects of changes in gas pressures and brine saturations on PA results will be determined by the subsequent PA codes.

7.1.4 Distribution of Iron-Based Metals and Alloys

Iron is a large component of the waste coming to WIPP. Iron corrosion is important to PA since corrosion is assumed to consume brine and generate gas in all vectors. The PA currently assumes that iron is uniformly distributed throughout the repository. There are waste streams that contain higher iron densities than the repository average, such as waste streams being packaged in pipe overpack containers. However, previous PAs have shown that in all vectors, at least 25% of the steel remains after 10,000 years, and in most vectors, a larger fraction remains. (DOE, 1996). Hence, gas generation due to iron corrosion is limited by the availability of brine rather than the inventory of iron. For this reason, there is little justification for considering scenarios where the iron is distributed non-uniformly. A non-uniform distribution of iron could not increase the total amount of gas produced; an extremely non-uniform distribution of iron within the BRAGFLO grid may even result in less total gas production than a uniform distribution. Consequently, this analysis will not include a scenario with non-uniform iron distribution.

7.2 Effects on Direct Release Volumes

Direct releases occur at the time of a drilling intrusion into the repository. Direct releases mechanisms include cuttings and cavings, spallings, and direct brine releases. Each mechanism computes a volume of material (solid or brine) that may be removed from the repository. The releases from the repository are computed by combining the release volumes with the activity in the material removed.

7.2.1 Cuttings and Cavings

Volumes released by cuttings and cavings are computed by the WIPP PA code CUTTINGS_S. These volumes may be altered by changes in waste shear strength. SNL will repeat the CUTTINGS_S calculations to quantify the effect on cuttings and cavings of any changes in waste mechanical properties.

7.2.2 Spallings

Volumes released by spallings are computed by the WIPP PA code CUTTINGS_S. Currently, CUTTINGS_S uses a very simple model for spall volume. If the pressure in the waste exceeds 8 MPa at the time of intrusion, then a volume of material is released; the volume is sampled from a uniform distribution ranging from 0.5 m^3 to 4.0 m^3. CUTTINGS_S takes its initial conditions from the BRAGFLO code; therefore any changes in the pressure computed by BRAGFLO may affect the spall volumes. SNL will repeat the CUTTINGS_S calculations to quantify the effect on cuttings and cavings of any changes in waste mechanical properties.

Concurrent with the PAVT, SNL developed a mechanistic model for spall volume. (Hansen et al, 1997) During development of the mechanistic model, SNL showed that spall volumes were generally reduced when waste heterogeneity was included. SNL will investigate if the conclusions of this previous work are still valid.

SNL is currently working on a new model for spallings (Lord, 2002), which is scheduled for peer review in June 2003. The new model for spallings accounts for waste permeability, porosity, particle size and tensile strength in its computation of spall volumes, and is similar in concept to the mechanistic model for spall volume. If the new spallings model is approved for use in WIPP PA, the new model will be used in both the CRA and in this analysis to quantify the effect on spall volumes of different waste properties.

7.2.3 Direct Brine Releases

Direct brine release (DBR) volumes are computed by the WIPP PA code BRAGFLO. These direct releases may be altered by changes in pressure, saturation, waste permeability and waste porosity. To compute DBR volumes, BRAGFLO is run a second time on a different grid, using initial conditions from the earlier BRAGFLO runs; hence any changes in the pressures and saturations computed in the earlier BRAGFLO runs may affect the DBR volumes. SNL will repeat the DBR calculations to quantify the effect on DBR volumes of different waste properties.

7.3 Effects on Radionuclide Transport

The WIPP PA code NUTS calculates radionuclide transport to the land withdrawal boundary (LWB) through the Salado. NUTS, along with the code PANEL, calculate releases from the repository to the Culebra. The WIPP PA code SECOTP2D calculates transport through the Culebra to the LWB. These codes all use BRAGFLO output as initial conditions. Since the waste material properties may result in changes to BRAGFLO results and thus affect radionuclide transport, SNL will repeat the calculations to determine any effects on radionuclide transport resulting from changes in waste properties. In addition, these transport calculations may need to be adjusted to account for variations in solubility among different waste types.

7.4 Effects on Repository Performance

After the direct releases and radionuclide transport are calculated, the code CCDFGF stochastically generates future events for the repository, and calculates total releases for each possible future, using the results of the codes listed above. The code accounts for drilling intrusions and for changes in mining conditions around the repository. CCDFGF produces the cumulative complementary distribution functions (CCDFs) of releases that are compared to the long-term disposal standards of 40 CFR 191, Subparts B and C. SNL will modify CCDFGF as required to account for any changes needed in the algorithm that calculates releases, and repeat the calculation of releases.

Each drilling intrusion that encounters CH TRU waste may produce direct releases. Currently, for cuttings and cavings releases, CCDFGF uses radionuclide concentrations from a sample of three distinct waste streams from the inventory. For this impact assessment we may find it necessary to only sample one waste stream in all or part of the repository. This would represent the impact of encountering a stack of waste from the same waste stream. For spallings and DBR releases, CCDFGF uses an average concentration for all CH TRU waste in the repository. For this analysis, spallings releases may be changed to use concentrations from single waste streams, as in cuttings and cavings. In addition, DBR releases may be adjusted to account for variations in solubility among different waste types.

8 SOFTWARE LIST

The major codes to be used for any required calculations are listed in Table 1. Except for SANTOS, calculations will be performed on qualified ES-40, ES-45, and 8400 Compaq ALPHA computers running Open VMS Version 7.3-1 (SNL, 2003). SANTOS will be run on the WIPP PC named Warthog, running Linux 2.4.18-27.7.xsmp.

Table 1. WIPP PA Codes.

Code	Version	Code Function
ALGEBRACDB	2.35	Data processor
BRAGFLO	5.00	Brine and gas flow
CCDFGF	5.00*	Future states of the repository
CUTTINGS_S	5.04A	Cuttings, cavings and spall volumes
FMT	2.4	Actinide solubilities
GENMESH	6.08	Grid generation
ICSET	2.22	Sets initial conditions
LHS	2.41	Parameter sampling
MATSET	9.10	Sets material parameters
NUTS	2.05A	Radionuclide transport
PANEL	4.02	Radionuclide concentrations and decay
POSTBRAG	4.00	BRAGFLO postprocessor
POST LHS	4.07	LHS post-processor
POSTSECOTP2D	1.04	SECOTP2D post-processor
PREBRAG	7.00	BRAGFLO preprocessor
PRECCDFGF	1.00*	CCDFGF preprocessor
PRELHS	2.30	LHS preprocessor
PRESECOTP2D	1.22	SECOTP2D preprocessor
RELATE	1.43	Grid data processor
SANTOS	2.1.5	Rock mechanics
SECOTP2D	1.41	Radionuclide transport
SUMMARIZE	2.20	Data interpolation

* - denotes codes that are in the process of being qualified.

9 TASKS

The schedule, tasks, and responsible individuals are outlined in Table 2.

Table 2. Tasks and responsibilities.

Estimated Date	Task #	Task Description	Responsible Individual	AP Section
30 Aug 2003	1	Waste mechanical properties, calculation of porosity surfaces	F. Hansen	4
30 Aug 2003	2	Waste Characteristic Determination	C. Leigh	5
30 Sept 2003	3	Chemical conditions in the repository	L. Brush	5.1, 5.2
30 Aug 2003	4	Assumptions made in WIPP PA models	R. Kirkes	6
30 Sept 2003	5	Effects on Repository Performance	C. Hansen	7

10 SPECIAL CONSIDERATIONS

None.

11 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: Codes that will be used in the analyses 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.

12 REFERENCES

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