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PRELIMINARY SAFETY ASSESSMENT OF THE WIPP FACILITY

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INTRODUCTION

This paper summarizes the efforts to perform a safety assessment of the WIPP facility being proposed for southeastern New Mexico. The work has been performed by a team of individuals integrated for this effort by Sardin Laboratories. Extensive consideration of the results presented here are included in the WIPP Draft EIS to be released this spring. Consequences of the events which result in loss of containment are of fundamental importance when making site selection, design decisions, and waste form acceptance criteria. This preliminary safety assessment of the WIPP facility is limited to a consequence assessment in terms of the dose to a maximally exposed individual as a result of introducing the radionuclides into the biosphere. No

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attempt has been made to extend the consequences to population dose or to weight the dose with probability of the events.

Inherent in the methodology developed for this analysis are several assumptions that were required to reduce the problem to one that could be approached with the available resources and data. These include the following:

- Static ecology and biosphere pathways
- Breach event does not alter geology from that now observed
- Parameters that affect geosphere transport remain constant during transit
- Transfer coefficients for biosphere pathway components are independent of soil and chemical compounds that contain the radionuclides

The general methodology, geosphere transport, and biosphere transport are described in the following sections. Finally, the consequences of the various models developed to represent the loss of containment are summarized.

METHODOLOGY

The WIPP analysis methodology is similar to the basic methodology used in earlier studies in that it evaluates the consequences of hypothetical future events that could cause loss of containment from the repository. It differs from previous studies in several major aspects. First, the wastes are not assumed safe after any period of time. Consequences are evaluated as a function of time after each release event until a maxima is reached. Secondly, the repository is assumed to contain contact-handled TRU. Previous studies have been limited to high level waste. Third, the analysis used detailed geologic, hydrologic, and ecologic data for the WIPP site and thus is site specific. These aspects of the analysis make it directly applicable to the WIPP conceptual design and waste acceptance criteria.

The methodology involves several distinct steps leading to the final safety parameterization of the facility. The basic step was the identification of the scenarios resulting in loss of containment. The scenario description includes identification of a breaching event, a physical mechanism for transporting the waste through the breach, and the response of the storage medium to the event. Once a scenario is determined, a mathematical model is constructed describing the transport process in the

modified media. This model is utilized to determine the concentration of the various radionuclides as a function of temporal and spatial coordinates in the modeled region for a particular inventory. The radionuclides are then in a media accessible to man via natural or anthropogenic pathways. For WIPP, the natural pathway is the discharge of the Rustler aquifer into the Pecos River at Malaga Bend. The anthropogenic event analyzed is the result of exploratory drilling for natural resources and directly intercepting the repository.

When the radionuclides enter the biosphere, they are transported to a maximally exposed individual. The term "maximally" means that contaminated material or area provides all of the various exposures the individual receives. For example, all fish that are consumed come from the contaminated Pecos River. However, the individuals' exposure time and food consumption are average values determined from site specific data. The consequence parameter is the 50-year dose commitment from one year of exposure.

The safety assessment was performed for five breaching scenarios. These scenarios were chosen for their representativeness of worst case events. Scenarios 1 through 4 represent a liquid breach of the repository with the subsequent transfer of the waste material through the Rustler formation. The fifth scenario represents breach by a drilling activity which brings waste directly to the surface. All events were assumed to occur 1,000 years after decommission of the facility.

The Rustler formation consists of two aquifers, the Culebra and Magenta, which flow to the southwest and empty into the Pecos River at Malaga Bend. These two aquifers were modeled as a single aquifer. Two values for the permeability of the formation furnished upper and lower bounds on the transport rate of the materials through the geosphere. The waste material was assumed to be leached out of the repository at the same rate as the salt. The additional density due to the material in solution was ignored. These conditions produce upper bounds on the amounts and rates of release of the waste. A geologic cross section of the WIPP site is presented in figure 1.

Scenario 1 represents a connection between the Rustler and the Bell Canyon aquifers through a failed wall shaft. The Bell Canyon aquifer is located below the Castille formation in the Delaware Mountain Group. Scenario 2 represents connection to the Rustler at both ends of the repository through a well bore and access shaft seal failure. Scenario 3 is a single connection between the repository and the Rustler aquifer resulting in a diffusion of the waste into the aquifer. Scenario 4 is of interest as a bounding condition. In this scenario, the total flow in the Rustler over the entire width of the repository passes through the repository and back to the Rustler formation.

Figure 1. Geologic Section of the Los Mandanos Area

Scenario 5 was modeled to determine the consequence of directly accessing the repository contents after decommissioning as a result of drilling activity in the region. Two types of drilling activity were considered. Mineral exploration was modeled as a 3-inch borehole with continuous coring bringing up cuttings diluted in the drilling fluid. Oil and gas exploration was modeled as a 10-inch borehole with chip coring, resulting in waste being brought to the surface diluted by drilling fluid present in the mud pit. Additional details on scenario modeling are given in reference 1.

GEOSPHERE TRANSPORT

The numerical model used for geosphere-transport calculations was developed by INTERA Environmental Consultants, Inc., for the U.S. Nuclear Regulatory Commission. It is a modified version of deep-well disposal model developed by INTERA for the U.S. Geological Survey. This three-dimensional, finite-difference model solves a set of partial differential equations describing total flow, energy, salinity, and radionuclide transport in a porous medium. The equations are coupled by the density and viscosity of the fluid. Details of the model are given in reference 2.

Geosphere-transport calculations were confined to the Rustler Formation with the discharge point at Malaga Bend on the Pecos River. The potential contours in the Rustler indicate that flow

between the repository and Malaga Bend is essentially one-dimensional toward the Pecos River and that all water from the Rustler discharges into the river. Steady-state potentials from scenario modeling were used to represent the boundary conditions for the nuclide transport. Calculations were performed up to 100,000 years after the initiation of each scenario.

BIOSPHERE TRANSPORT MODELING

The biosphere transport models define the pathways by which the radionuclides become available as dose to man. This assessment relied heavily upon existing codes for reasons of both accountability and acceptability. The codes used were developed by various government agencies and laboratories and are widely used in the performance of risk assessment calculations associated with other aspects of the nuclear fuel cycle. The primary codes and their developing agency are listed in table 1.

TABLE 1. CONSEQUENCE ASSESSMENT CODES

<u>Code</u>	<u>Agency</u>	<u>Use</u>
LADTAP	NRC	LIQUID TRANSPORT
TERMOD	ORNL	TERRISTIAL TRANSPORT
INREM	ORNL	INTERNAL DOSE
EXREM	ORNL	EXTERNAL DOSE
CDMQC	EPA	AIR TRANSPORT

These codes were interfaced using routines specific to the WIPP site. The exposure pathways for the liquid breach scenarios included ingestion of contaminated water and aquatic food and external exposure from swimming, boating and shoreline recreation. Two exposure pathways were considered in the analysis for the direct access release scenario: the direct external exposure of the drill crew members and the geologist involved in the sample collecting; and wind erosion of the mud pit with subsequent atmospheric dispersion and deposition downwind. Man is exposed through inhalation, ingestion of crops, meat and milk and to external exposure from the ground surface.

The data, programs and program interfaces required to implement the biosphere transport models are discussed in detail in reference 3. The data interfaces between the various codes required extensive resources to develop and maintain. This led to the development of the CAFIR (Consequence Assessment Program for Exposure to Radiation) computer code. This code supports a uniform data base containing information required to perform consequence assessment for a site, scenario, and inventory defined

totally by the data. The pathways are defined by a High Order language available to the user to describe the exposure system under analysis. The various transport processes are implemented as functions which the user directs to operate upon a source data set to create an output data set that becomes an element of the data base for subsequent use as input to the next function. In addition, CAFER supports data display and editing functions, data base management functions and sensitivity analysis to the parameters contained in the data base elements.

CONSEQUENCE ASSESSMENT

With the scenarios defined and the various models to represent the geospheric and biospheric pathways developed, the safety assessment for various inventories may be addressed. With the exception of early time thermal loads, the models developed are independent of the inventory contained within the facility. For this assessment, the inventory was based upon actual assay data from the Idaho National Engineering Laboratory for contact handled TEN waste. No other waste is included. The modeling included 96.6 percent of the waste mass and 98.6 percent of the activity.

Of the four liquid breach scenarios, scenarios 1 and 4 represent the worst cases. Doses to various organs are presented in table 2. Maximum doses occur approximately 100,000 years after the breaching event for the upper permeability. No results are presented for the lower permeability because no radionuclides enter the biosphere in the first 100,000 years. For comparative purposes, projected average total annual whole body dose for the United States population from various sources is presented in table 3.

TABLE 2. LIQUID BREACH CONSEQUENCES

<u>Organ</u>	<u>Dose (rems)</u>	
	<u>Scenario 1</u>	<u>Scenario 4</u>
Liver	2.0×10^{-9}	2.6×10^{-6}
Skin	2.7×10^{-9}	3.3×10^{-6}
Bone	4.5×10^{-9}	4.9×10^{-6}
Thyroid	2.0×10^{-9}	2.5×10^{-6}
Body	1.2×10^{-6}	2.0×10^{-3}
GI-III	2.4×10^{-7}	1.0×10^{-4}
Lung	2.0×10^{-6}	2.4×10^{-6}
Kidney	7.5×10^{-7}	3.0×10^{-4}

TABLE 3. DOSES FROM GENERAL SOURCES

<u>Source</u>	<u>Dose (rems)</u>
Television	1×10^{-4}
Consumer Products	1×10^{-3}
Air Transport	7×10^{-3}
Medical	90×10^{-3}
Background (WIPP site)	100×10^{-3}

As can be seen by direct comparison, if a breach of WIPP does occur for which the modeling assumptions remain valid, the consequences are several orders of magnitude less than those associated with current environment.

For scenario 5, in which the repository is penetrated by a drilling operation, the consequences are substantially higher. The primary cause for this is the immediacy of the dose since the time delay element, which is the principle motivation for deep geologic storage, is eliminated. The doses to drill crew members from chip and core samples and to the maximally exposed individual as a result of inhabiting the area downwind from the mud pit are presented in table 4. The primary exposure mode for the indirect pathways is inhalation.

TABLE 4. DOSE FROM DIRECT ACCESS TO CH WASTE REPOSITORY (REMS)

<u>Borehole</u>	<u>Drill Crew Member</u>	<u>Individual Bone Dose from Indirect Pathways</u>
10 inch diameter	1.5×10^{-5}	2.6×10^{-2}
3 inch diameter	6.0×10^{-4}	2.5×10^{-3}

CONCLUSIONS

The purpose of this analysis has been to provide data upon which the safety of the WIPP facility may be decided for contact-related TRU. No conclusions regarding the safety are made here. However, several observations regarding waste emplacement and acceptance criteria with respect to long term safety are appropriate. The extremely low doses associated with the liquid breaches of the facility should be considered in the waste acceptance criteria and consider lifetime requirements. The natural barriers provide excellent time delay to minimize the consequence to a level which would be undetectable in man with today's technology. While the doses due to drilling are high enough to be of concern, they may be reduced significantly by

choosing an emplacement scheme that prevents several containers from being penetrated by the same borehole.

In addition, several conclusions regarding the process of safety assessment of deep geologic waste storage facilities may be made as a result of this effort. At present, there is no defined methodology to provide data to support a safety assessment. However, even if this methodology were defined by a federal agency, the basic question of how to utilize the data in the decision making process remains to be addressed. This investigation has attempted to obtain a set of basic data for the entire system defined by the repository, geosphere, biosphere, and man. This has been accomplished through the integration of many technical disciplines with capabilities in each of the components of the system. Eventually, each of these components was represented by a mathematical model which was subsequently implemented using a computer code. For this effort, attempts to verify and validate the implementations were made using site specific data and analytical solutions. However, the requirements for a structured approach which defines the system, its components, and their interfaces is absent from any current or proposed criterion for evaluating the acceptability of various waste management alternatives. Thus, while there are many models constructed to represent various systems, the requirement to provide a method to identify the appropriateness of the model to determine the response of the system is missing. This is a fundamental requirement which must be met before the data generated by the model can be used as input to the decision making process.

REFERENCES

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