# WIPP AS A TRANSURANIC WASTE REPOSITORY -- ISSUES TO BE RESOLVED

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## ABSTRACT

With the passage of the WIPP Land Withdrawal Act (P.L. 102-579) in October, 1992, the U.S. Congress has set up a process for the U.S. Department of Energy (DOE) to determine and for the U.S. Environmental Protection Agency (EPA) to certify the suitability of the Waste Isolation Pilot Plant (WIPP) as a permanent repository for defense transuranic (TRU) waste. Located int he northern part of the Delaware Basin, 25 miles east of Carlsbad in Southeastern New Mexico, the WIPP repository is intended to be the final resting place for up to 6.25 million cubic feet of TRU waste. About 2.1 million cubic feet are currently stored in an easily retrievable manner at ten national laboratories of DOE, not including those drums that are buried in shallow ground. Major issues yet to be resolved before WIPP can be declared to be a repository, include: proper characterization of the existing waste; prediction of the future inventories; repromulgation of the EPA radiation protection standards (40 CFR 191); demonstration of compliance with 40 CFR 191 and the Resource Conservation and Recovery Act (RCRA) regulations by DOE; and certification of compliance by EPA. To be able to make reasonable predictions for the 10,000 year evaluation period, a number of geohydrological and repository behavior issues have to be resolved. The DOE is planning to continue several ongoing experiments to resolve these issues and conduct some new ones. A complicating factor that may interfere with proceeding in this direction is the DOE's desire to emplace some waste at WIPP, before making the decision to use it as a repository.

## INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) located in Southeastern New Mexico, has been built by the U.S. Department of Energy (DOE) to be a repository for permanent disposal of transuranic (TRU) waste resulting from the nuclear weapons production in the USA. The total planned inventory for the repository is approximately 178,000 cubic meters (850,000 drums) of contact-handled (CH-TRU) and 7100 cubic meters (7500 canisters) of remote-handled (RH-TRU) waste, of which about 60,000 cubic meters are currently stored at ten national laboratories of DOE, and the rest will be generated in the future. The repository is located in the salt beds of the Permian age Salado Formation at a depth of 655 meters below the surface. One-eighth of the repository (seven out of fifty-six planned "rooms") was excavated before 1988, although the decision to use WIPP as a repository is not expected to be made until the year 2000. When WIPP was conceived and designed 15 years ago, the expectation was that all of the waste to be disposed would be similar to that already produced. However, with the end of the cold war and the expected decline in the nuclear weapons production in the U.S., the nature of the future inventory of WIPP-bound waste is uncertain at this time.

Uncertainty about the nature of the final inventory is only one of the several factors that will impact the long-term performance assessment calculations for the WIPP repository. WIPP has to demonstrate compliance with the Environmental Protection Agency (EPA) Standards for radioactive as well as non-radioactive hazardous waste (40 CFR 191 and 40 CFR 268) with respect to long-term integrity of the repository. The major issues remaining to be resolved relate to the information needed to assess WIPP's compliance with these *long-term* standards, and of course the performance assessment calculations to assess the compliance.

Geohydrological site characterization for the WIPP project is essentially complete, although some important input data for performance assessment are yet to be obtained. Parameters such as radionuclide retardation during contaminant transport through aquifers, mechanics of flow (double-porosity vs. single porosity, degree of diffusion in the bedrock, etc.), and the degree of recharge are yet to be narrowly defined. Solubility of the waste will be determined through tests expected to begin in April 1994 at the Los Alamos National Laboratory.

The U.S. Department of Energy (DOE) is working on the premise that some experiments with waste would be required to assess compliance with the environmental standards for long-term radiation protection and for the disposal of non-radioactive chemical mixed waste. DOE has planned to emplace up to 4500 drums of CH-TRU waste (0.5% of the total) for experiments at WIPP during a 5 to 7 year Test Phase. The proposed experiments would measure the rate of gas generation for the waste under various conditions. The "bin tests" that consist of measurement of gas from waste isolated in steel boxes do not have to be performed underground at WIPP. The "alcove tests" were designed to measure gas consumption and production from the rock vis-a-vis the waste drums, but it has been difficult to seal the alcoves and the alcove test may not be performed.

The WIPP issues remaining to be resolved before the decision to start disposing the waste at WIPP can be made are described below. Most of these issues have been discussed in previously published papers (1, 2, 3, 4). The discussion below provides the status as of February, 1993.

The Environmental Evaluation Group (EEG) performs an independent technical evaluation of the WIPP project to ensure protection of the public health and the environment of New Mexico. The group was established through a 1978 contract between the DOE and the State of New Mexico, which was continued by the 1989 Defense Authorization Act, (P.L. 100-456 assigning EEG to the New Mexico Institute of Mining and Technology). Oversight responsibilities for the EEG were

further defined in the 1992 WIPP Land Withdrawal Act, P.L. 102-579.

## ISSUES RELATED TO THE "TEST PHASE"

In order to show compliance with EPA's long-term containment standards for radiation protection and mixed waste (40 CFR 191, 40 CFR 264, 40 CFR 268), a clear understanding of the geohydrological, geomechanical and waste-behavior issues and parameters is needed. Chaturvedi and Neill (1) identified the information needed for assessing compliance with the EPA Standards, as follows:

- Geological and hydrological characteristics of the salt beds as well as the underlying and overlying layers of rock;
- Future climatic changes that may affect the hydrologic regime;
- Characteristics of the waste and the drums, canisters and other packaging materials;
- Prediction of physical, chemical, and biological conditions as will evolve in the repository after sealing of the repository and shafts. This will include development of interactions between the inflowing brine from salt, closure of the excavations due to salt creep, decomposing waste and containers, gas production from the waste and due to corrosion of metals, and backfill materials;
- Prediction of site specific scenarios including "human intrusion" through drilling by future generations after the knowledge of the repository is lost;

The DOE has been conducting several experiments, above-ground in the field and in laboratories as well as underground in the WIPP mine. Some of these experiments in the laboratories use radionuclides present in the transuranic waste. In addition, the DOE plans to conduct some experiments underground at WIPP using transuranic waste. The DOE has planned a Test Phase to begin with the first emplacement of TRU waste underground, even though most of the tests identified in the DOE's 1990 Test Phase plans (5) are continuing and some are near completion. The following discussion treats the planned experiments not requiring waste to be emplaced underground as a separate category from those experiments requiring radioactive waste shipment to WIPP.

### Proposed Experiments with Waste

The DOE and Sandia National Laboratory have planned to emplace TRU waste at WIPP before making a decision to use it as a repository from the very beginning of the project in late 1970s. The quantity of planned waste for early emplacement has been reduced from almost 200,000 drums of CH-TRU waste in 1982 to only about 100 drums in 1993. The justification for such emplacement has changed from pilot plant operation to scientific experiments essential for performance assessment. To force a decision on this matter, the WIPP Land Withdrawal Act of 1992 (PL 102-579) directs the DOE to submit a proposal for conducting these experiments to the EPA. The EPA will approve or disapprove the plans. Several unresolved issues remain with these plans.

No test plans: DOE has not yet (as of February, 1993) published the revised test plans which will provide the purpose of the test, the data to be obtained, the uncertainties to be reduced and the manner in which the data will be used.

Quantities of CH-TRU waste required: The quantities of waste required for experimentation have decreased from 125,000 drums in 1987 to 95 drum equivalents in 1992 (7). Documents issued during the past few years have proposed several different quantities. The following table provides recent references of the quantities required.

| Number of Bins Required | DOE Reference |
|---|---|
| 19 | Gas Generation and Source-Term Programs: Technical Needs Assessment the Waste Isolation Pilot Plant. DOE/WPIO/001-92, Rev. 0, 12/21/92 |
| 172 | RCRA Part B Permit Application, DOE/WIPP 91-005, Rev. 2, 11/13/92 |
| 233 | Rationale for Revised Bin-Scale Gas-Generation Tests with Contact-Handled Transuranic Wastes at the Waste Isolation Pilot Plant, SAND90-2481, 2/91 |
| 116 | WIPP Test Phase Plan: Performance Assessment, DOE/WIPP 89-011, 04/90 |

Proving relevancy of data: The WIPP land Withdrawal Act (PL 102-579) requires EPA approval that data obtained with experiments at WIPP will be "directly relevant" to performance assessment. The published performance assessment calculations by DOE to date have not identified the need for additional data on gas generation from TRU waste.

Unresolved engineering problems: Room seals for the alcove tests have yet to be constructed and tested. Pressurized bins for measuring gas production without the need to periodically purge (to maintain concentration of explosive gases below the explosibility limit) have not been designed.

Non-availability of waste for experiments: While the Idaho National Laboratory (INEL) has worked diligently to characterize waste for these WIPP experiments, after 2 years of effort, a total of 5 bins (25 drums) have been characterized for the experiments. Since each truckload can carry 6 bins in 3 TRUPACTS, this is less than one truckload.

Long term stability of underground test areas: Less than eight years after excavation, the roof of a test room had a 1500 ton roof fall in 1991. Since the DOE plans to conduct experiments with CH-TRU waste for 5 to 7 years in rooms of identical dimensions, the DOE designed an extensive structure to prevent roof falls from occurring. A design review team concluded that the structure would last for a minimum period of 7 years and the work was completed in October, 1991. Because DOE plans to do experiments for 5 to 7 years and the rate of waste characterization for the experiments has been so slow, coupled with the periods of time for emplacement and retrieval, it appears that the period of intended use exceeds the design period of roof stability.

Data are not key to demonstrating compliance: The demonstration of compliance with the EPA Standards does not require any experimentation at WIPP. DOE has no plans for such experiments for the high-level waste repository in Nevada.

Representativeness of waste: According to a Sandia National Laboratory report (6) that provided the justification for performing the bin-scale test, "Representativeness and statistical representativeness are crucial; to the bin-scale test program". The bin-scale test plan outlined in the "Rationale" report was carefully formulated to represent eleven identified

variables expected to govern the gas-generation potential of CH-TRU waste through careful selection of various TRUCON codes. Ideally, the waste selected for the bin and alcove tests should have been representative of all the CH-TRU waste to be shipped to WIPP if it becomes a permanent repository. However, the plan had to select from a universe of 9168 drums from INEL and 2582 drums from the Rocky Flats Plant (RFP) (A total of 11750 drums) that were then thought to be certifiable according to the Waste Acceptance Criteria (WAC) and were stored as non-bermed waste at those two locations.

Much effort was expended by DOE in 1990 and 1991 to develop a sampling protocol from the inventory of 11750 WAC certified Ch-TRU drums at INEL and RFP for the bin tests. However, the December, 1992 DOE report, "Gas-Generation and Source-Term Programs: Technical Needs Assessment for the Waste Isolation Pilot Plant Test Phase" (7) rejects the need for waste that is representative of a large portion on the existing inventory at INEL. The new justification states:

> "In contrast to the strategy inherent in Lappin et al. (1991), the experimental wastes need not be randomly selected from a representative population, nor are the amounts of waste to be used int he revised bin-test program sufficient to define a representative waste population of existing CH-TRU wastes" (7).
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> "Decrease in both the size and accessibility to the expected certifiable inventory of CH-TRU wastes suggest that an experimental approach based on use of statistically representative wastes would be difficult to implement. This problem, in fact, has been a major factor in reevaluation of the bin-test program, with a focus on gas-generation mechanisms" (7).
>
> "Initial implementation of the approach led to identification of the fact that the accessible and certifiable inventories of Ch-TRU wastes at RFP and INEL were smaller than originally expected. This weakened the value of statistical arguments relative to a representative inventory" (7)

However, rejection of the sampling plan requires more than a simple statement that the accessible and certifiable inventories were smaller than expected. As previously argued,

"Any modifications of the sampling plan or of the sampling frame to which it is applied must be statistically evaluated by Sandia National Laboratories for impacts on both the validity of bin-scale data interpretation and the ability to extrapolate bin-scale data interpretation and the ability to extrapolate bin-scale results to the repository-room scale and the system-wide inventory." (6).

Effects of purging on gas data: The WIPP Safety Analysis Report (FSAR Addendum) requires periodic purging on the bins to maintain the concentration of flammable gases below half the lower explosibility limit. According to the Principal Investigators who conceived and developed the Bin Scale testing plans, this requirement would impose "multiple negative impacts on the interpretations and technical validity of resultant test gas data ... and resultant predictions will not be defensible for WIPP PA purposes." (4/17/90 Memo of Record from Al Lappin and martin Molecke, SNL).

This issue has been previously discussed by Chaturvedi and Silva (1992), (2). The DOE has planned to design a new bin (Bin #2) to avoid the need for purging, but such a bin intended to contain up to 2150 psi pressure, has not yet been designed.

Relocation of solubility tests: Due to the range of solubility of the various actinides of $10^{12}$ or greater, it is essential to obtain measurements of the solubility of the waste form. Since WIPP was never designed to do research with liquid samples of plutonium and has no radiochemical laboratory analysis capability, these source term tests will be conducted at the Los Alamos National Laboratory (LANL). Problems being addressed by LANL include the design of containers to hold wastes, liquid sample containers for analyses, test plan procedures, techniques to measure dilute concentration of actinides in brine, determine the pH and the Eh in concentrated brines. The experiments at LANL are expected to begin in April, 1994 and are designed for two years of data collection with the option to continue for a longer period.

## Proposed Experiments Without Waste

Several experiments are being performed underground and above-ground at WIPP and in the laboratories to provide data needed for performance assessment calculations to assess WIPP's compliance with the EPA Standards. The status of the most important experiments is described below. These experiments are designed to provide data for the parameters identified as being particularly sensitive for the performance assessment calculations.

## Retardation Coefficients for the Rustler Formation

Radionuclide retardation during transport of contaminated fluids through the Rustler Formation aquifers, following a breach of the repository, has been identified as the most sensitive parameter for performance assessment. The calculations of the impact of a breach of the repository have to date assumed unjustifiably high degree of retardation in the absence of experimentally obtained data. Field and laboratory experiments are required to provide reliability and justifiable numbers for physical and chemical retardation. Laboratory experiments are being set up at the Sandia National Laboratories and field experiments are being planned.

## Flow Characteristics of the Culebra Dolomite

The major water-bearing zone in the Rustler Formation is the 8 meter thick fractured Culebra dolomite. Being the most prolific of the water bearing zones overlying the WIPP repository, it has been considered to be the most likely pathway for transport of radionuclide after a breach of the repository.

The calculated travel time for contaminant transport along this pathway, however, is very sensitive to assumption of fracturing in the Culebra dolomite and distribution of contributing porosity between the rock matrix and the fractures. If double-porosity flow is assumed, with diffusion of contaminants in the rock matrix, the shortest travel time from the center of the WIPP site to the southern boundary is 14,000 years. If, on the other hand, transport is assumed through fractures only (single porosity), then the travel time would be less than 100 years. Additional tracer tests designed to better define the transmissivity field at the WIPP site. Additional tracer tests designed to better define the fracture vs. matrix porosity are also needed. A seven-well flow and tracer test is planned to be conducted at the WIPP site in 1993 to better understand the mechanics of flow in the Culebra.

The Salado Formation Hydrology: The Salado Formation salt is not dry. Although the permeability of the Salado salt is very low, it does produce brine that seeps in the WIPP excavations an dries up due to ventilation in the mine. Once the repository is closed, a significant amount of brine is expected to seep into the repository and will affect the post-closure repository conditions. Experiments are underway to more accurately define the mechanics of fluid flow through salt and the expected amount of brine flow into the repository.

Disturbed Rock Behavior: Before underground excavation at WIPP began in 1982, the DOE scientists performed calculations to predict the closure history of the excavations. These calculations used the geomechanical properties of the rock strata at the selected WIPP repository horizon obtained from testing of the rock cores obtained from boreholes. The calculations predicted that a WIPP room would "close slowly in a stable manner as the salt creeps" and "relative closure values of 0.21 meters in the vertical direction and 0.28 meters in the horizontal direction as sen for the isothermal room after 10 year."(8) The WIPP excavations have behaved very differently than predicted. Vertical closure in the WIPP test rooms has varied between 75 mm and 100 mm per year (predicted 21 mm/yr) and horizontal closure has ranged between 50 mm and 75 mm per year (predicted 28 mm/yr). A "disturbed rock zone" consisting of fractured rock surrounds all the excavations. In less than 8 years after excavation, the roof of the first of the four test rooms fell in February, 1991, due to fractures propagating above the roof and creating up to 2 meter wide unstable trapezoidal beam between the roof and a thin layer of anhydrite above the roof.

The reason for the difference between the predicted and measured closure rates has been explained on the basis of having used the wrong geomechanical models and not having taken into account the details of the stratigraphy (9). While the faster closure rate will help entomb the waste sooner, it creates problems during the operations. The WIPP repository rooms should be excavated just before they are needed for waste emplacement and backfilled soon thereafter. It will also create problems in maintaining retrievability of the waste during the Test Phase.

## ADDITIONAL ISSUES

Additional issues not being directly addressed during the Test Phase but requiring resolution before disposal, are discussed below.

Certification of CH-TRU waste for disposal: In order to predict the behavior of radioactive transuranic waste, DOE has established Waste Acceptance Criteria (WAC) for the generators to meet. The system relies on the generators to document compliance with the criteria and DOE uses a committee to audit the system with approximately bi-annual visits. EEG has participated in these audits since they were established in 1980.

Oak Ridge National Laboratory (ORNL) has decided to repackage all WAC certified waste since it was noted that 40% of the waste certified prior to 1986 failed the criteria. A highly caustic waste stream at Los Alamos National Laboratory (LANL) has caused problems with CH-TRU waste containers and, under current requirements, cannot be shipped to WIPP. At Idaho National Engineering Laboratory (INEL) where waste is characterized for experiments, a total of 79 drums have been examined at the Stored Waste Examination Pilot Plant (SWEPP) and 35 drums have been rejected.

Implementing Agency Authorities: While PL 102-579 gives EPA the responsibility to implement compliance with 40 CFR 191, there are other implementing authorities remaining with DOE. Although DOE has never formally codified their authorities in the Federal Register in the past, EEG believes they should do so now.

Longevity of Type A waste container: Since 1970, CH-TRU waste has been stored in carbon steel Type A drums and metals boxes. While a design life for integrity has been required by the WAC since 1980, all references to such limits were deleted in the 1991 Revision #4 of the WAC. Degradation of containers, including the carbon steel drums has taken place. These drums are stacked on asphalt pads and covered with plywood, plastic, and/or dirt. Some are uncovered. DOE's data suggest that drums in direct contact with the soil have an estimated life of 10 years. At that point pinhole openings int he drum walls could start to appear. Then drum degradation is rapid. DOE reports estimated failure rates approaching 100% for buried drums or drums under failed plastic covers with 15 to 30 years exposure. 72% of the retrievable stored TRU waste in drums has been in storage for 10 years or more. DOE estimates that 20% to 30% of these drums contain corrosion pinholes or are badly deteriorated. The fraction is expected to rise to 30% to 40% if the drums are left in the present environment. A specific design life for the TRU waste containers should be required.

Waste form modification: The preliminary calculations by Sandia National Laboratories (10) and the Engineered Alternatives Task Force (EATF) (11) suggest that modification of some waste forms may be necessary (12). The EATF found that waste form modifications could improve repository performance by reducing radionuclide releases into the accessible environment by up to four order of magnitude, depending on the release scenario and the waste form modification. The DOE is not yet convinced that treatment would be beneficial or necessary to demonstrate compliance with EPA disposal regulations and is deferring decision on TRU waste treatment until results from the WIPP Test Phase are available to determine the acceptability of current waste forms (13). However, implementation of waste form treatment could require several years as documented by the EATF. It would only seem prudent for the DOE to consider waste form modification now and not to defer all decisions on waste treatment until the end of the Test Phase. Waste form modification would reduce the uncertainty in the performance assessment calculations, increasing the confidence in the calculations.

## CONCLUSION

Excavation for WIPP began in 1982 and all four planned shafts, major tunnels and 7 out of 56 planned "rooms" for waste disposal have been excavated. The facility was designed for a 25 year life time. While it most likely can last many years beyond that, the fact is that the DOE has constructed the facility much before it can be used for its intended purpose as a permanent repository. Furthermore, instead of concentrating on demonstrating compliance with the long-term containment standards and focusing on collecting those data needed for such compliance, the DOE has been preoccupied with attempting to place some waste in the facility. It is time for the DOE to focus on completing the requirements to use the facility for permanent disposal and make the decisions (engineered barriers, waste modification, etc.) that will assure long-term safe containment.

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