AN ASSESSMENT OF THE WIPP PROJECT

Lokesh Chaturvedi and Robert H. Neill
New Mexico Environmental Evaluation Group
7007 Wyoming Boulevard, NE, Suite F-2
Albuquerque, New Mexico 87109

ABSTRACT

The Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico is planned to be a repository in salt beds for permanent disposal of up to 850,000 drums of contact-handled and 7,500 canisters of remote-handled transuranic radioactive waste, generated in the defense laboratories and production plants for nuclear bombs in the United States. The project is managed by the U. S. Department of Energy (DOE). Site exploration for the project began in 1974 and by January 1992 much progress has been made towards assessing its suitability as a permanent repository, although additional data and modeling efforts are needed before that decision can be made. Unlike the proposed Yucca Mountain, Nevada repository for high level nuclear waste that will be licensed by the Nuclear Regulatory Commission (NRC), DOE has planned to emplace some waste at WIPP before deciding to use it as a repository. Justifications for these plans have varied from "full-scale demonstration" to "performance assessment experiments" and the proposed amount has been reduced from 23% in 1982 to 1% in 1992. The latest plans are to measure gas generation from the waste and solubility of the radionuclides at WIPP. There are several operational difficulties in conducting these experiments and the data on gas generation would be more readily obtained from laboratory testing. Nevertheless, these plans have diverted attention from the data collection and analyses needed for the major decision about using WIPP as a permanent repository.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is intended to be an underground geologic repository for permanent disposal of transuranic (TRU) radioactive waste generated from nuclear weapons production in the U.S.A. The facility is located in southeastern New Mexico and consists of extensive underground excavations in salt beds at a depth of 655 meters (2,150 feet), four shafts, surface facilities for receiving and handling the waste, and for administrative purposes. The repository will consist of 56 "rooms," each 91.5 meters long, 10 meters wide and 4 meters high (300 ft x 33 ft x 13 ft) grouped in eight "panels" of seven rooms each, excavated in salt. These rooms and approximately 7.5 km (4.7 miles) of access drifts will provide sufficient space to accommodate 176,000 cubic meters (6.2 million cubic feet) of contact-handled TRU (CH-TRU) waste and 7,100 cubic meters (250,000 cubic feet) of remote-handled TRU (RH-TRU) waste. Approximately one-third of the WIPP design-volume of waste currently exists, stored at ten national defense laboratories. The remaining two-thirds is expected to be generated during the 25 years of WIPP design life for disposal operations.

The CH-TRU waste is contained in 0.21 m^3 (208 liters or 55 gallons) mild carbon-steel drums that are certified to last 20 years. Approximately 850,000 drum-equivalents will be emplaced at WIPP, stacked three high in the rooms and the drifts, for permanent disposal. The RH-TRU waste will be disposed in 7,500 canisters that consist of right circular cylinders made of 6.35 mm (1/4 inch) carbon steel plate with 0.66 meters (26 inches) outside diameter, an overall length of 3.07 meters (10 feet 1 inch), and an inside volume capacity of 850 liters (30 ft^3 or 224 gallons). The canisters will be emplaced in 0.91 meters (36 inches) diameter horizontal boreholes drilled in the walls of the disposal rooms. The CH-TRU inventory of 850,000 drum-equivalents is expected to contain 9 million curies of radioactivity dispersed in trash, such as paper, rubber, sludges, metal, etc. The 7,500 RH-TRU canisters may contain 5 million curies.

While the management and disposal of other forms of radioactive waste, such as commercial spent-fuel, defense high-level, commercial low-level, and uranium mill tailings are licensed by the Nuclear Regulatory Commission (NRC), U. S. Congress exempted WIPP from NRC licensing (1).

Due to the need to assess safety for very long time frames, a nuclear waste repository is unlike any other engineering project. A vital factor in the safety assessment of a repository is to be able to predict the evolution of geohydrologic conditions for several tens of thousands of years in the future and to assess the impact of those conditions on containment of the waste. Site characterization at the WIPP site began in 1974 with geologic mapping of the area, subsurface investigations through geophysical techniques and boreholes, and hydrologic testing in specially drilled boreholes for that purpose. Studies were conducted in the early 1980s to address several issues related to the future integrity of the site. These included studies to assess the rates of dissolution of salt, origin and extent of the pressurized brine reservoirs underlying the site, the rate and extent of geologic deformation, etc. Several issues of site characterization still remain and are being investigated by DOE.

DOE started construction of the surface facilities, shafts, and underground excavation in 1981. By 1988, most of the surface facilities, three shafts and extensive underground excavation including one panel of seven rooms (1/8 of the planned repository volume) had been excavated. DOE had planned to start shipping CH-TRU waste to WIPP in October 1988 before making the decision to use WIPP as a permanent repository, but the facility was not ready to start receiving the waste. The purpose of waste emplacement (research? experiments? operational demonstration?) had not been established, radiological safety plans and procedures were not in place, a systems checkout had not been done, and a retrieval plan had not been formulated. Due to these reasons, the U. S.

Congress did not pass legislation to transfer the land from the U. S. Department of Interior (DOI) to DOE.

Since 1988, a Supplemental Environmental Impact Statement has been prepared, substantial progress has been made in obtaining experimental values of several parameters needed for performance assessment calculations, and two formal annual iterations of performance assessment reports have been published. A Safety Analysis Report for the dry bin tests has been completed. A formal integrated systems checkout has approved the operational safety of dry bin handling operations, and progress has been made in resolving the continuous air monitor (CAM) system issues. DOE wishes to begin shipping waste to WIPP for experiments before demonstrating long-term suitability of the repository. The current justification of waste emplacement is to measure the rate of gas generation from the CH-TRU waste, as well as measure the radionuclide solubility in brine.

The Environmental Evaluation Group (EEG) performs an independent technical evaluation of the WIPP project. The group was established in 1978, and is fully funded by DOE. Public Law 100-456 (the 1989 National Defense Authorization Act), provided for continued independent review and assigned EEG to New Mexico Institute of Mining and Technology. EEG has provided the only full-time independent interdisciplinary technical review and oversight of the WIPP project continuously since 1978.

The assessment of the WIPP project in this paper is concentrated on the site-specific technical issues, primarily on the broad issue of the best approach for deciding whether or not WIPP will be safe as a permanent repository for radioactive waste. Transportation, emergency preparedness, Resource Conservation and Recovery Act (RCRA) compliance, legal, and political issues are not addressed in this paper.

PROGRESS TOWARDS REPOSITORY DECISION

Performance Assessment

As of January 1992, the WIPP project is making steady progress towards accumulating and refining the parameters needed for assessing the long-term suitability of the repository for disposing the TRU waste. At the same time, conceptual and numerical models are being refined and validated to perform probabilistic analyses of the impact of potential breach scenarios for the repository. The formal procedure for this work and the upper limits of allowable releases are contained in the U. S. Environmental Protection Agency's (EPA) "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (2) codified in 40 CFR 191. The same standards apply to both the WIPP repository for TRU waste and the high-level radioactive waste repository for commercial and defense waste. The Yucca Mountain site in Nevada is currently being investigated for the high-level waste repository. The EPA standards (40 CFR 191) were promulgated in 1985, but were vacated by the First Circuit Court of Boston in 1987 on the grounds of inconsistency with the Clean Water Act of 1971 and some procedural lapses. EPA is currently working towards repromulgation of the standards. Following an agreement with the state of New Mexico, DOE has continued to assess WIPP's compliance with the vacated 1985 standards, but is also committed to demonstrate compliance with the repromulgated standards before making the decision to use WIPP as a permanent repository for TRU waste.

The information needed for assessing compliance with the EPA standards consists of the following:

- 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;
- Effectiveness of engineered barriers, including plugs and seals, backfill, and engineered modification of waste and containers;
- Prediction of the effects of potential breach scenarios through numerical modeling and comparison with the allowable limits of radionuclide releases by the EPA standards.

Proposed Experiments with Waste

From almost the very beginning of the WIPP project, DOE has planned to emplace a substantial amount of TRU waste underground at WIPP before making the decision to use it as a permanent repository. This approach is different than the one followed by the NRC regulated high-level waste repository where satisfactory assessment of compliance with the EPA standards (40 CFR 191) is required before construction can begin. In 1982, emplacement of 40,000 m^3 (1.4 million ft^3 or 193,000 CH-TRU drums) of TRU waste was proposed for "initial pilot emplacement operations . . . during the retrieval period" (3). By 1987, this amount was reduced to 15% of the total WIPP capacity or 127,500 drums (4). In 1989, DOE further reduced the proposed amount to 8% (68,000 drums) and sought to justify emplacement of 4,500 drums for gas generation experiments and the remaining for "operations demonstration" (5). By 1992, DOE has essentially dropped the idea of shipping waste to WIPP for operations demonstration, but insists that the gas generation experiments are essential and should be performed at WIPP (6).

Technical documents (7,8) published by DOE use the phrase "test phase" to consist of all the studies and experiments being performed at WIPP underground, on the surface, and in laboratories to generate data for use in performance assessment to assess WIPP's compliance with the EPA standards. These studies include Salado and Rustler Formation hydrology, plugging and sealing studies, and studies to select a suitable backfill, etc. The proposed studies to measure the rate of gas generation at WIPP that would require waste emplacement constitute a very minor part of the test phase

activities. However, in policy statements, in the Secretary's Decision Plan, and in statements at Congressional hearings, DOE has used the expressions "initiation of test phase" and "opening of WIPP' to mean first arrival of waste to WIPP for gas generation experiments. This has created a lot of confusion. Transfer of land from DOI to DOE is required prior to shipping waste to WIPP. If the initiation of test phase is used synonymously with experimental waste emplacement, then all the good scientific work under progress at WIPP (not requiring waste emplacement) is denied. An impression is created that the work at WIPP is at a standstill until the first drum or bin arrives and that all the personnel and expenditure at WIPP could be suddenly justified by the first arrival of some bins or drums of waste.

A detailed evaluation of the proposed tests with radioactive waste at WIPP has been performed (9). DOE has proposed three categories of tests to determine the rates and potential of gas generation and to understand the effect of several factors on gas generation from TRU waste. The laboratory tests are the most suitable for obtaining scientific data under controlled conditions. These are being performed and are yielding useful results. The bin tests were designed to study the bulk behavior of TRU waste in gas generation. These tests do not have to be performed at WIPP since the waste will remain tightly confined in a bin. A number of operational difficulties have been identified in the satisfactory performance of the bin tests and these need to be resolved before these tests can proceed (9). The concept of alcove tests is to emplace about 1,100 drums of CH-TRU waste in rooms (30.4 m x 7.6 m x 4 m), seal the entryways to them, and observe gas generation by collecting room air samples through a recirculation system. It has been difficult to design an effective seal for these rooms and DOE has now decided to proceed with these tests only if the laboratory and bin tests do not provide sufficient gas generation information (10). Since the alcove test constituted justification for 3,800 out of the proposed 4,500 CH-TRU drums for the five-year test phase emplacement of waste at WIPP, and since the bin tests do not have to be performed at WIPP (11), there is relatively little documented technical justification for tests with CH-TRU waste at WIPP.

Secretary's Decision Plan

Starting in October 1989, the Department of Energy focused its efforts towards getting WIPP ready to start receiving TRU waste through "The Secretary's Decision Plan." Completion of the Supplemental Environmental Impact Statement (SEIS), Final Safety Analysis Report (FSAR), Operational Readiness Review (ORR), Integrated Systems Checkout (ISC), and various other documents were tracked through this effort so that WIPP could be declared ready to start receiving CH-TRU waste. Ten revisions of the Decision Plan were published between October 1989 and September 1991, culminating in the publication of the Final Decision Plan (Rev. 10) on September 27, 1991, and a decision to start shipping the CH-TRU waste in the first week of October 1991.

The total focus of this effort was to prepare WIPP to start receiving the first shipment of CH-TRU waste. When the concept of measuring the rate of gas generation with TRU waste at WIPP was first published in April 1990 (7, p. 2-211), it was proposed to start these experiments with first receipt of CH-TRU drums for alcove experiments, immediately followed by the initiation of bin emplacement. The idea was to perform the laboratory, bin, and alcove seal experiments in parallel and have the gas generation data available for performance assessment by 1993-94. During the two year (1989-91) period of the Secretary's Decision Plan, several problems in proceeding with the waste experiments came to light. It became clear that sealing entryways to the alcoves would not be easy, and even if a suitable sealing system can be designed to work soon after excavation, it may not remain effective for several years due to the tendency of the rock surrounding the openings to fracture in time. Apparently because of these difficulties, the line item for "Alcove Mining and Outfitting" was deleted from the Secretary's Decision Plan between revision 5 (8/15/90) and revision 6 (1/16/91).

Between revisions 5 and 6, several operational problems in conducting the bin tests also came to light. EPA's approval of the No-Migration Petition for the Test Phase stipulated certain conditions for waste characterization and safety from potential explosibility. These and DOE's own safety and testing requirements indicated that the wet bin tests and solubility tests that required sampling brine contaminated with radionuclides, could not be performed at WIPP without design changes in the bins and the facilities. The Decision Plan, therefore, further narrowed its focus on only the Dry Bin Tests. The net outcome of the Decision Plan process was that when DOE announced they would begin the test phase with transuranic waste by shipping the first load of bins to WIPP in early October, only one bin was ready to be shipped to WIPP and even its radioactive content inventory had not been satisfactorily established. The only bins prepared so far consist of glassware, a waste form that is not expected to produce gas.

Waste Modification

The emphasis on the shipment of waste to WIPP for experiments has affected other activities that are required to make the decision to use WIPP as a repository. While the performance assessment calculations have not so far identified the acceptable level of gas generation in the WIPP repository, less formal calculations performed in 1989 (13) showed that the expected level of gas generation from WIPP TRU waste could pose a danger to the integrity of the repository. The main uncertainty in the projection of gas generation is the availability of brine because moisture is needed for both the microbial degradation of organics and corrosion of metals--two processes that are expected to produce the bulk of the gases. If it is determined that sufficient brine will be available for gas production, a decision may have to be made to modify the waste form and use non-metallic containers to reduce gas generation potential of the waste. A DOE sponsored study on potential waste modification was completed in July 1991 (14). More work is needed in that direction and it can be done without waiting for the results of the bin and alcove tests.

Non-Waste Experiments

The bulk of the data needed for performance assessment to make the decision to use WIPP as a permanent repository will be provided by studies and experiments that do not require waste emplacement at WIPP. There is some indication that some of the important studies have not been undertaken as vigorously as needed because of the emphasis on the proposed waste experiments. For example, radionuclide retardation is a key parameter that affects breach scenarios through

the overlying water-bearing beds in the Rustler Formation. Laboratory studies to measure the retardation coefficient on Rustler cores have only begun in late 1991 and a field sorption test may be performed sometime in the future. In the meantime, DOE has substituted "expert judgement," sometimes from its own contractor employees, for real data. In general, however, much progress has been made in understanding the geohydrologic system of the site, although work remains to be done.

CURRENT STATUS

The WIPP project is at an advanced stage of readiness with respect to the information required to make a decision to use it as a permanent repository for defense transuranic waste. Additional data on the Salado and Rustler hydrology, radionuclide retardation, radionuclide solubility, and gas generation mechanisms are needed. Models for containment transport through the aquifers; for coupled processes of room closure, brine-inflow and gas generation; and for the effect of breach scenarios are to be refined. Necessity and feasibility of waste form modification needs to be further investigated. If efforts are made to complete these items, a decision to use WIPP as a permanent repository can be made in a few years.

For the past several years, DOE has focused on getting WIPP ready to start receiving a limited quantity of waste during the interim period before a decision to use it as a repository is made. This focus appears to have diverted attention from the work that is necessary to make the major decision. This narrow focus has given rise to a perception that the entire project is on hold waiting for the first arrival of waste.

The Environmental Evaluation Group has consistently held the position of supporting any experiments, including those that require waste emplacement at WIPP, provided these experiments have a reasonable expectation of yielding useful data for use in performance assessment to make a decision whether or not to use WIPP as a permanent repository. At the same time, EEG has not supported unnecessary placement of waste at WIPP that might not be retrievable and for which a "return address" is not provided.

With respect to operational readiness from a radiological safety point of view, WIPP appears to be ready to receive radioactive material in bins with dual confinement, notwithstanding the issues of experimental objective and retrievability.

By choosing to restrict the scope of the Safety Analysis Report (FSAR Addendum for Dry Bin Test only) and proposing to use bins as waste containers, DOE avoided addressing some fundamental EEG concerns regarding operational safety. Chief among the concerns was the reliability and sensitivity of continuous air monitors (CAMs). The CAMs are required to identify accidental airborne radiological releases. Normally underground air is released unfiltered to the environment. If an underground airborne release occurs, then exhaust air can be diverted to a high particulate filtration (HEPA) system. Although the proposed test bins appear to provide a dual confinement system, and, therefore, circumvent the confinement and monitoring concerns, the CH-TRU drums provide only one level of confinement. WIPP does not claim the CAM system as a confinement barrier, therefore, an additional level of underground confinement is needed to handle CH-TRU wastes. When the FSAR is modified to consider a broader scope of work, then methods for achieving dual confinement will need to be addressed.

EEG requested in 1990 that a comprehensive operational audit be performed prior to waste receipt. DOE responded by conducting an Integrated System Checkout (ISC) audit in June and July of 1991. EEG was invited to be an official observer. The prime audit objective was to address the identification of pre-start findings. As with the FSAR Addendum, the audit review concentrated on emplacement and retrieval of doubly contained dry waste test bins. There were numerous findings related to procedural compliance and staff training. For the most part these findings were prescriptive in character, and relatively straightforward to address.

As WIPP attempts to broaden the scope of work through the FSAR process, EEG anticipates a revisit of some previously stated operational concerns. These concerns are professional staffing, contamination control, ventilation balancing, auditing, facility use, program administration, and effluent air monitoring. Most important will be effluent air monitoring, specifically the reliability and sensitivity of the CAMs. In order to operate the facility as originally planned, the CAM system should be qualified as a safety related system, or additional underground radiological confinement provided.

CONCLUSIONS

The WIPP project will be the first of its kind deep geologic repository for transuranic radioactive waste. While several issues still remain to be resolved, it appears possible that a decision on whether to use the facility for permanent disposal of TRU waste can be made through a few additional years' effort. The unresolved issues relate to the best possible prediction of conditions in the repository for the next 10,000 years or more. It is likely that some waste modification might be required to demonstrate compliance with the EPA standards (40 CFR 191, Subpart B).

From the very beginning of the WIPP project, DOE has planned to emplace some waste in the WIPP underground before making a decision to use it as a permanent repository. For the past several years, preparation of the facility to start receiving waste for the test phase period has been the focus of DOE's efforts at WIPP. This preoccupation appears to have retarded progress on resolution of those issues that will provide the documentation of compliance with standards for safe disposal and proceed with the use of WIPP as a repository.

ACKNOWLEDGEMENTS

William Bartlett, Jim Kenney, James Channell, Matthew Silva, and Anthony Gallegos reviewed this paper and provided useful suggestions. Susan Stokum and Jill Shortencarier cheerfully and promptly typed and formatted it. The authors are grateful to these colleagues.

REFERENCES

1. Public Law 96-164 (S.673), "Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980," Approved December 29, 1979.
2. U. S. Environmental Protection Agency, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic

Radioactive Wastes," 40 CFR Part 191, Federal Register, Vol. 50, No. 182, pp. 38084-38089 (September 19, 1985).

3. R. V. MATALUCCI, C. L. CHRISTENSEN, T. O. HUNTER, M. A. MOLECKE, and D. E. MUNSON, "Waste Isolation Pilot Plant (WIPP) Research and Development Program: In Situ Testing Plan," SAND 81-2628, Sandia National Laboratories Report (March 1982).
4. Hearing before the Subcommittee on Public Lands, National Parks and Forests of the Committee on Energy and Natural Resources, United States Senate, 100th Congress, First Session on S.1272, Carlsbad, NM, October 12, 1987, U.S. Government Printing Office, 84-706, p. 50 (1988). See Assistant Secretary Troy E. Wade's statement on p. 50.
5. U. S. Department of Energy, "Draft Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment and Operations Demonstration," DOE/WIPP 89-011, U. S. Department of Energy (April 1989).
6. Hearings before the Committee on Energy and Natural Resources, United States Senate, 101st Congress, 2nd Session, on the Department of Energy's Waste Isolation Pilot Plant and S.2420, U. S. Government Printing Office, 33-232 (April 1990). See Secretary Watkins Statement, pp. 32-43.
7. U. S. Department of Energy, "WIPP Test Phase Plan: Performance Assessment," DOE/WIPP 89-011, Rev. 0 (April 1990).
8. U. S. Department of Energy, "Strategy for the WIPP Test Phase," DOE/EM/48063-2 (November 1991).
9. L. CHATURVEDI AND M. SILVA, "An Evaluation of the Proposed Tests with Radioactive Waste at WIPP," Paper accepted for publication in the Proc. of the 3rd Annual International Conference on High Level Radioactive Waste Management, to be published by the American Nuclear Society (April 1992).
10. U. S. Department of Energy, "WIPP Test Phase Activities in Support of Critical Performance Assessment (40 CFR 191B) Information Needs," Attachment 1 to the February 12, 1992 letter from Mr. Mark W. Frei, Director, DOE Office of Waste Management Projects, to Dr. Charles Fairhurst, Chairman, National Academy of Sciences WIPP Panel (1992).
11. U. S. Department of Energy, "Final Supplement Environmental Impact Statement - Waste Isolation Pilot Plant," DOE/EIS-0026-FS, Vol. 1 (January 1990).
12. U. S. Environmental Protection Agency, "Conditional No-Migration Determination for the U. S. Department of Energy Waste Isolation Pilot Plant," Federal Register, Vol. 55, No. 220, pp. 47700-47721 (November 14, 1990).
13. A. R. LAPPIN and R. L. HUNTER (Editors), "Systems Analysis, Long-Term Radionuclide Transport, and Dose Assessments, Waste Isolation Pilot Plant," SAND 89-0462, Sandia National Laboratories Report (April 1989).
14. U. S. Department of Energy, "Evaluation of the Effectiveness and Feasibility of the Waste Isolation Pilot Plant Engineered Alternatives: Final Report of the Engineered Alternatives Task Force," DOE/WIPP/91-007 (July 1991).