

**THE INTERNATIONAL COOPERATIVE PROGRAM
OF THE U.S. DOE CARLSBAD AREA OFFICE**

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ABSTRACT

The U.S. Department of Energy's (DOE) Carlsbad Area Office (CAO) administers the Waste Isolation Pilot Plant (WIPP), which hosts a deep geologic repository for safe disposal of U.S. defense-related transuranic (TRU) waste located 42 kilometers (km) east of Carlsbad, New Mexico. The WIPP site has been investigated and developed since 1974. At WIPP are surface and subsurface facilities designed to facilitate the safe handling and disposal of TRU waste. With completion of the regulatory licensing phase, the WIPP is scheduled to begin receiving waste. The U. S. Department of Energy (DOE) expects to commence disposal operations at the Waste Isolation Pilot Plant (WIPP) in 1999.

During the disposal phase, continued investigations into certain scientific issues will allow the CAO to develop more detailed knowledge which could enhance WIPP operations and performance. This is true of activities which will be conducted over the life of the operation or implemented late in the operational life. Also, improved knowledge of fluid flows in geologic media and the applicability of flow models to predict that flow could allow a reduction in the conservative approximations, now utilized in performance assessment, when the required five-year recertifications are conducted.

To facilitate gathering of scientific information in a more effective and efficient manner, the CAO has developed a vigorous international cooperative program. The primary CAO objectives of international collaboration are to:

1. Increase confidence in facility safety and reliability
2. Advance scientific expertise or collect data in areas where WIPP and international programs have common needs
3. Reduce costs
4. Expedite acquisition of necessary scientific information

In some areas of broad international interest, the CAO has developed a leading expertise through its WIPP repository and TRU waste characterization activities. In addition to participating in relevant and beneficial joint experiments, the CAO will provide the international community convenient access to this information by sponsoring and hosting symposia and workshops on relevant topics and by participation in international waste management organizations and topical meetings.

To advance its overall objectives, the CAO is engaged in the following types of international exchanges and collaborations:

1. Activities providing specific information important to the CAO's mission
2. Activities in advancing scientific disciplines that are important to assessing the future behavior of the WIPP repository
3. Activities transferring information and technology developed by the CAO to the international community projects.

This paper includes an update on the progress and achievements of CAO in developing international collaborative efforts. CAO has performed or has plans to engage in joint activities with Switzerland, Sweden, Canada, Germany, United Kingdom, Spain, Republic of Korea, Taiwan, Japan, China, France, and Russia.

INTRODUCTION

The CAO administers the WIPP site, which hosts a deep geologic repository for safe disposal of U.S. defense-related TRU waste and is located 42 kilometers (km) east of Carlsbad, New Mexico. CAO also manages the National Transuranic Waste Program (NTP), which oversees TRU waste management from generation to disposal. Upon completion of the current regulatory licensing phase, the WIPP is scheduled to begin receiving waste this year.

The CAO's main programmatic responsibility during the pending disposal phase is to operate a safe and efficient TRU waste repository at the WIPP, to operate an effective system for management of TRU waste from generation to disposal, and to comply with applicable laws, regulations, and permits. This responsibility requires maintenance and upgrades to the current technologies for TRU waste operations, monitoring, and transportation. This responsibility also requires the maintenance of scientific capabilities for evaluating the performance of the WIPP repository. This includes supporting probabilistic performance assessments with credible evidence of the nature and consequences of events and processes that may occur in the repository and the surrounding geological setting during the 10,000-year regulatory period. The CAO firmly believes that international cooperative efforts will assist in the maintenance and advancement of the technological and scientific basis for the WIPP.

The WIPP site has been investigated and developed since 1974. Located within the WIPP site's 42-km² set-aside area are surface and subsurface facilities designed to facilitate the safe handling and disposal of TRU waste. Approximately one-tenth of the underground waste disposal area has already been mined in a bedded salt formation at a depth of 650 meters (m) (Figure 1). Approximately 176,000 m³ of TRU waste containing about 12,000 kilograms of plutonium and other actinides will be emplaced in disposal rooms 4 m high, 10 m wide, and 91 m long. Magnesium oxide (MgO) backfill will be emplaced with the waste to control the actinide solubility and mobility in the disposal areas. Properties of the repository horizon have been investigated in an underground test facility excavated north of the waste disposal area, in which seals, rock mechanics, hydrology, and simulated waste emplacement tests were conducted. Geologic and hydrologic characterization of strata on the site have been conducted by surface-based boreholes and observations from the existing excavation.

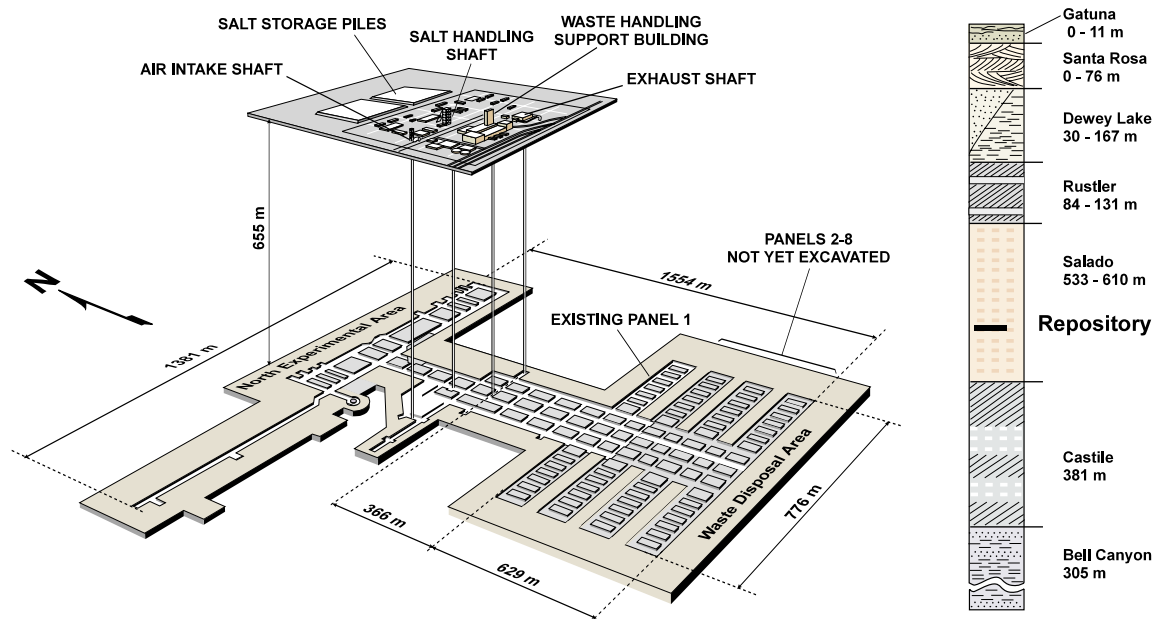


Figure 1. Schematic illustration of the WIPP repository and the geologic stratigraphy at the site.

In support of the WIPP mission, the CAO has undertaken a vigorous and proactive international cooperative program. The primary CAO objectives of international collaboration are:

1. To increase confidence in facility safety and reliability
2. To advance scientific expertise or collect data in areas where WIPP and international programs have common needs
3. To reduce costs
4. To expedite acquisition of necessary scientific information.

In some areas of broad international interest, the CAO has developed a leading expertise through its 24-year WIPP repository and TRU waste characterization activities. In addition to participating in relevant and beneficial experiments, the CAO will provide the international community convenient access to this information by sponsoring and hosting symposia and workshops on relevant topics and by participation in international waste management organizations and topical meetings.

To advance its overall objectives, the CAO will have partnerships in the following types of international exchanges and collaborations:

1. Activities providing specific information important to the CAO's mission, such as:
 - Monitoring technologies
 - Waste characterization and minimization
 - Transportation
 - Repository behavior and operations
2. Activities in advancing scientific disciplines that are important to assessing the future behavior of the WIPP repository, such as:
 - Actinide mobilization and retardation
 - Backfill and waste form interactions
 - Performance assessment modeling
 - Shaft and disposal area seal technologies
 - Two-phase flow testing and analysis
3. Activities transferring information and technology developed by the CAO to the international community, such as:
 - Repository operations
 - Backfill for use in chemical control of the disposal room (near-field)
 - Multiple-rate contaminant transport and retardation

The CAO is developing and facilitating international collaborations with its domestic contractors - Westinghouse Waste Isolation Division and Sandia National Laboratories. In addition, the CAO encourages international collaboration with the Carlsbad Environmental Monitoring and Research Center (CEMRC). The CEMRC has a world-class laboratory with technical staff expertise in radiochemistry, environmental chemistry, mechanical engineering, atmospheric science, health physics, and dose assessments. It is currently pursuing international collaborations with the International Atomic Energy Agency (IAEA).

CURRENT AND POTENTIAL INTERNATIONAL EXCHANGE ACTIVITIES

The CAO has developed and is continuing to develop collaborative efforts with other nations in the areas of seals/rock mechanics, hydrology/transport, and chemistry. The CAO is also engaging in cooperative activities with international organizations. A description of these current and potential activities is provided below in each of these major topical areas.

Seals and Rock Mechanics

As part of the Canadian Nuclear Fuel Waste Management Program and in cooperation with other foreign waste management organizations in France and Japan, a major tunnel-sealing experiment is underway now and is to be completed in the year 2000. The tunnel-sealing experiment's objectives are (1) to develop and study clay- and concrete-sealing technologies and (2) to evaluate the performance of a sealing system using these technologies. WIPP technologies used in the experiment included clay block-making expertise and machinery, cementitious grouting experience, fluid-flow modeling, and seal-design experience. In addition, the CAO is collaborating with the German program at Morsleben and a private waste disposal effort at Salzfürth to investigate sealing technologies for drifts and disturbed rock zone performance in salt. Laboratory and field tests have been performed, and mechanical and hydrological behaviors have been investigated. Also at the Asse mine in Germany, a salt healing test is planned with CAO participation. A metal sleeve was installed in this mine more than 60 years ago, and this test will assess the amount of salt healing that has taken place over that period of time. The goal of these collaborations is to enable reduction in the cost of WIPP seals through design and construction simplification as performance is demonstrated. At the Grimsel test site in Switzerland, the CAO is participating as a reviewer in the documentation of the conclusions of the 10-year long Tunnel Near-Field program.

Hydrology/Transport

The CAO is currently engaged in international collaborations to provide additional data about multi-rate transport that will be relevant to multi-rate transport models applied to the Culebra Dolomite at the WIPP site, which is fractured and has heterogeneous pore structures. The CAO has sought collaborative efforts in both fractured low porosity rock (crystalline or indurated sedimentary) and fractured high porosity rock (sedimentary/argillaceous). These two conditions cover the range of porosity heterogeneity present in the Culebra Dolomite. The crystalline rock at the Grimsel test site in Switzerland is appropriate for obtaining data and samples pertaining to fractured low-porosity rock. As part of the hyperalkaline plume in fractured rocks (HPF) experiment at Grimsel, the CAO is participating in multi-rate transport experiments. The crystalline rock present in Sweden's Äspö Hard Rock Laboratory is also relevant to this type of experiment. Thus, CAO is collaborating in the suite of tracer retention understanding experiments (TRUE) in Äspö. Although a specific partner for collaboration in multi-rate transport in fractured high-porosity rocks has not been identified yet, the CAO understands that the Mont Terri facility in Switzerland may have an appropriate rock type (the Opalinus Clay) for this type of experiment, and access may be available within a few years. The CAO is also participating in the gas migration/two-phase flow experiment being conducted at Grimsel to investigate the two-phase flow behavior of rock in the vicinity of underground excavations. In addition, the CAO is planning to host a technical workshop or symposium on multi-rate transport in the future.

Chemistry

As noted above, the CAO is participating in the Grimsel HPF experiment, which investigates chemical precipitation reactions that may occur during transport of a hyperalkaline plume through fractured crystalline rock. Depending on plume chemistry and rock mineralogy and fabrics, these reactions may affect the diffusion and sorption properties of the rock. The CAO is interested in the HPF experiment because it will assist in the evaluation of the potential for

such reactions to occur in the Culebra Dolomite, and the benefits (actinide co-precipitation) and detriments (reduced matrix diffusion) of such reactions on predictions of actinide transport in the Culebra Dolomite. In addition, the CAO is active in the Grimsel colloid and radionuclide retardation (CRR) experiment, in which simplified approaches to modeling colloid transport will be developed. Anticipated activities include microbial transport column experiments, actinide bioaccumulation approaches, microbe-contaminant association/dissociation experiments, approaches for humic actinide complexation, and in-situ speciation of redox-sensitive radionuclides. Also, in May 1998, the CAO and the Environment Agency of England and Wales co-hosted in Carlsbad an international technical workshop on the uses of backfill materials in repositories. Representatives from 13 countries attended, and there may be follow-up actions in this area in cooperation with the Nuclear Energy Agency of the Organization for Economic Cooperation and Development.

Collaborations Sponsored by International Organizations

The CAO is an ongoing partner in many collaborations sponsored by international organizations. Past collaborations, such as the 1997 joint Organization for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA) and the International Atomic Energy Agency International Peer Review of the 1996 WIPP performance assessment, and ongoing collaborations such as the Performance Assessment Advisory Group (PAAG) and the Integrated Performance Assessment Group (IPAG), have had a strong, positive impact on the credibility of the CAO's experimental programs and interpretations as well as on systems-level modeling. The CAO is also currently involved in the OECD/NEA forum on sorption modeling in performance assessment, the OECD/NEA Site Evaluation and Design of Experiments (SEDE) group, and the OECD/NEA Geological Transport of Radionuclides Predictions (GEOTRAP) Forum. In June 1999, the CAO will co-host in Carlsbad the fourth workshop of GEOTRAP in conjunction with NEA. This workshop will assess site-specific radionuclide transport models and their use in performance assessment activities. The workshop will focus on the development by various nations of models of radionuclide migration, the testing of those models, and the efforts to build confidence in the models. The CAO anticipates continued collaboration in current and new activities that may be sponsored by a variety of organizations, such as the IAEA, the OECD/NEA, and the European Commission (EC).

CAO PROGRAMS OF POTENTIAL INTEREST TO THE INTERNATIONAL COMMUNITY

There are many technical disciplines in which the CAO and other organizations/projects have similar interests and where the CAO has acquired considerable knowledge that could be of value to other programs. The similarity is based on recognition that all sites proposed for geologic disposal must be characterized for basic geologic, geochemical, hydrologic, and construction feasibility properties. All sites intend to use shaft seals and/or engineered barriers. Most sites are evaluated in the context of formal risk assessment or performance assessment. The CAO international research and development (R&D) program provides convenient access to the considerable knowledge CAO has assembled in these topical areas:

- Geology
- Hydrology
- Geochemistry
- Rock Mechanics
- Disposal Room Interactions

- Engineered Barriers
- Integration of Data and Process Models in Performance Assessment
- Facility Operations
- Institutional Controls
- Environmental Monitoring
- Waste Characterization
- Transportation

The CAO welcomes proposals for information exchange or new mutually beneficial collaborative efforts.

Through its scientific advisor, Sandia National Laboratories, the CAO has access to several specific technical capabilities in specialized facilities that may be of interest to the international community. These facilities include:

- Two-phase flow laboratory for investigating hydraulic properties of low permeability, low porosity rocks
- Actinide mobility and sorption laboratories
- Flow and transport visualization laboratories
- High-performance, massively parallel computing

The CAO welcomes proposals for collaborative investigations that may utilize these special capabilities.

SUMMARY

The CAO has established an international cooperative program to achieve its mission to open and operate the WIPP repository for safe disposal of TRU waste and to cost-effectively integrate the NTP. The objective of the international program is to stimulate mutually beneficial collaborations between the CAO and other radioactive waste management programs and organizations. The CAO desires continued and new international collaboration and partnerships in a variety of programmatic areas where such collaboration will provide either mutually beneficial enhancement of public confidence, or scientific and operational improvements which may lead to enhanced demonstration of system safety and cost savings. Types of collaboration may include, for example, experimental or technology development and/or demonstration partnerships or primarily information exchange. A continuing important part of the overall R&D program is participation on committees and in forums hosted by international organizations such as the OECD/NEA, the IAEA, and the EC. To facilitate accelerated information exchange in those areas where CAO is making significant contributions to the state of knowledge (for example, backfill use and multi-rate transport of radionuclides in fractured geologic media), the CAO will sponsor technical workshops targeted to the common needs of the U.S. and the international nuclear waste management community.

FURTHER READING ON WIPP

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