# EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is responsible for the disposition of transuranic (TRU) waste generated through atomic energy defense activities. Approximately 62,000 cubic meters have been generated and are currently stored at government defense installations across the country. The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, has been sited and constructed to meet the criteria established by the scientific and regulatory community for the safe disposal of TRU waste. The DOE has demonstrated that the WIPP facility can be operated and closed in a manner that complies with federal standards found in Title 40 of the Code of Federal Regulations, Part 191 (40 CFR Part 191), titled *Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste*. The DOE will place only TRU waste from atomic energy defense activities in the WIPP.

In 1992, the U.S. Congress passed the WIPP Land Withdrawal Act (LWA) which, among other things, mandated that the U.S. Environmental Protection Agency (EPA) certify the DOE's compliance with 40 CFR Part 191, Subparts B and C. The EPA issued the criteria that it intends to use for certification as 40 CFR Part 194, *Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations* (61 FR 5224). This application, titled *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant,* is the DOE submittal to the EPA, requesting certification. This application has been developed to be fully responsive to the requirements of 40 CFR Part 191, the criteria in 40 CFR Part 194, and the guidance in the *Compliance Application Guidance for 40 CFR Part 194*, EPA 402-R-95-014.

This application represents the culmination of over 20 years of scientific and engineering work specifically dedicated to TRU waste isolation at the WIPP. Throughout this work, the DOE and its predecessor agencies have ensured an ongoing technical oversight of the project through the services of the Environmental Evaluation Group (EEG), the National Academy of Sciences (NAS), and the New Mexico Governor's Consultation Task Force on Radioactive Waste. Frequent consultations with these organizations have served to identify important issues and their timely resolution. In addition, the DOE has involved the public in the decision-making process at key points throughout the compliance demonstration process.

The focal point of this application is the discussion of compliance with the quantitative standards in 40 CFR §§ 191.13, 191.15, 191.24, and the qualitative requirements of 40 CFR § 191.14. As a background to understanding the compliance discussions, the DOE has included extensive discussions of the geology, hydrology, and climate, the engineered facility, and the waste. In addition, this application includes two quality-related discussions. One is a description of the DOE Quality Assurance Program as it was applied to this application, and the other is the results of independent peer reviews of important portions of the WIPP compliance program.

This application references over 600 publications that support the demonstration of compliance. Expansions of these references are provided in order to assist the reviewer with additional detail within the context of the original publication. In addition, there are over 50

appendices that directly support the application. Many of these appendices were prepared to further explain the complex issues and processes associated with the demonstration of compliance, to provide background data and information, or to describe operational and postoperational compliance activities.

The DOE uses conceptual models of the WIPP disposal system to simulate the complex interactions between the natural environment, the engineered system, and the waste. All three of these aspects are important inputs to the conceptual models of the WIPP disposal system. Consequently, extensive descriptions are included in the application. Natural characteristics favorable to the isolation of TRU waste were emphasized by the DOE from the outset of the repository selection process, and the WIPP site was selected as the location that best met the siting criteria. This application summarizes these natural characteristics with emphasis on those properties that are inputs to the conceptual models.

As the DOE's knowledge of the site and its characteristics increased, so did the understanding of potential adverse characteristics. Two of these characteristics, deformation of the Castile and dissolution, have received extensive study. The results of these studies are summarized in this application. Based on the results of the studies, neither poses a significant threat to the disposal system.

The hydrology of the disposal system is another topic that has been the result of extensive field and laboratory study. This work is summarized and has resulted in the selection of a three-dimensional groundwater basin model for flow in the rocks above the Salado Formation and the development of a Darcy flow model for the Salado. A discussion of alternative conceptual models that were evaluated and rejected during the development process is also included.

Natural resources in the vicinity of the WIPP site are discussed because they have been identified by the EPA as having the potential to impact disposal system performance. These resources consist primarily of oil, natural gas, and potash. The information in the application provides the basis for incorporating these natural resources and their possible development as human-initiated events into the conceptual model of disposal system performance. These potential human-initiated events dominate total release calculated in performance assessment.

The application provides an overview of the engineered facility. The focus is on those aspects that contribute to the long-term performance of the disposal system, including the mined repository, the shaft seals, the panel closures, the borehole plugs, and the backfill. Each of these engineered features contributes to the isolation of radionuclides and is included in the final performance assessment. These engineered features have been selected to complement the natural ability of the repository to isolate radionuclides.

The manner in which the engineered features will limit releases of radionuclides is an important consideration that the DOE has included in the application. The shaft seals are designed to prevent the movement of radionuclides toward the accessible environment

through the shafts; panel closures prevent the movement of radionuclides toward the accessible environment by limiting the magnitude of releases that can occur during certain human intrusion events; backfill substantially delays the movement of radionuclides toward the accessible environment by limiting, through chemical means, the amount of actinides that can be dissolved in brines that enter the repository; and borehole plugs eliminate penetrations from the surface into the Salado so that circulating groundwaters cannot reach the salt and cause dissolution or provide release pathways.

The wastes to be managed and disposed of at the facility are described. The waste description includes the definition, sources, types, components, and characteristics of TRU waste planned for emplacement in the repository. There are two aspects to the process of identifying the waste and specifying appropriate waste characterization programs. The first is the determination of those waste properties that are important to repository performance, and the second is preparing an estimate of the inventory of those properties that can reasonably be expected to be placed into the disposal system. The first aspect came about through the iterative manner in which the DOE conducted preliminary performance assessments leading to the identification of important waste characteristics and the waste components that affect those characteristics. Eleven such components were initially identified by the DOE. The DOE assembled a baseline inventory referred to as the Transuranic Waste Baseline Inventory Report (TWBIR), which contained, among other information, projections of quantities of the 11 waste components expected to be important to performance. This baseline includes estimates of 570 stored or to-be-generated waste streams. Each of these streams is described in terms of expected volumes and the 11 components (such as radionuclide inventories, volume of corrodible metals, and organics). Waste-related input parameters were developed from the TWBIR. Because these parameters result in a complementary cumulative distribution function (CCDF) that complies with the disposal standards, they are acceptable repository limits that will be used as the basis for waste acceptance.

Waste characterization is also described in the application. This is the activity that the waste generator/shipper will have to accomplish prior to shipping waste to the WIPP.

Quality Assurance (QA) programs and plans for each of the activities completed in support of this compliance demonstration are described. The chapter on QA establishes that the DOE has had a QA program consistent with the requirements of the American Society of Mechanical Engineers-Nuclear Quality Assurance-1 (ASME-NQA-1) for many years at the WIPP facility and that the current DOE Carlsbad Area Office (CAO) Quality Assurance Program Document (QAPD) mandates, in addition to NQA-1, the ASME NQA-2a-1990 addenda to NQA-2-1989, Part 2.7, and the ASME NQA-3-1989. All WIPP project participants who perform work that affects quality are required to have QA programs that conform to the requirements of the CAO QAPD.

The performance assessment methodology and the process for identifying potential future conditions that could affect the repository are discussed. Once these possible futures are identified, they are screened on the basis of probability, consequence, or regulatory criteria to

identify those that must be retained for analysis. The resulting set of future conditions is organized into sequences of events referred to as scenarios and are incorporated into the modeling scheme. The DOE has identified six scenarios that include all the reasonable expected future natural and human-initiated processes. These are grouped as the undisturbed scenario, in which only natural processes and events act on the disposal system, and the disturbed scenarios, which include drilling, mining, and combinations of drilling and mining.

The undisturbed scenario couples natural processes such as creep closure and fluid flow with waste-induced processes such as gas generation caused by corrosion and microbial degradation of organic materials. These processes are simulated for 10,000 years into the future using numerical techniques implemented through computer codes. The modeling shows, as discussed in Chapter 6.0, that the behavior of the undisturbed disposal system will result in extremely effective isolation of the radioactive waste. Concrete, clay, and asphalt components of the shaft seal system will provide an immediate and effective barrier to fluid flow through the shafts, isolating the repository until salt creep has consolidated the compacted crushed salt components that will permanently seal the shafts. A disturbed rock zone (DRZ) will form around both the shafts and the repository excavations. The DRZ in these halite layers will heal over time, and, therefore, will not provide a ready pathway for fluid flow. Gas generation by corrosion and microbial degradation is expected to occur and will result in elevated pressures within the repository. These pressures will not significantly exceed lithostatic because fracturing within the more brittle anhydrite layers will occur and provide a pathway for gas to leave the repository. Fracturing is expected to enhance gas and brine migration from the repository, but gas transport will not contribute to the release of actinides from the disposal system. Brine flowing out of the waste disposal region through anhydrite layers may transport actinides as dissolved and colloidal species, but the quantity of actinides that may reach the accessible environment boundary during undisturbed performance through the interbeds is insignificant with regard to the compliance demonstration. The performance assessment results show that no migration of radionuclides occurs vertically through the Salado or through the shaft seal system.

Performance assessment is required by regulation to consider disturbed case scenarios that include intrusions into the repository by inadvertent and intermittent drilling for resources. The probability of these intrusions is based on a future drilling rate of 46.8 boreholes per square kilometer per 10,000 years. This rate is based on consideration of the past record of drilling events in the Delaware Basin. Results of the performance assessment indicate that human intrusion provides the only mechanism for significant releases of radionuclides from the disposal system. These releases may occur by five mechanisms: (1) cuttings, (2) cavings, (3) spallings, (4) direct brine releases, and (5) long-term brine releases. Because each of these release mechanisms would result in releases to both the surface and subsurface environments, migration pathways through the permeable layers of rock above the Salado are important in performance assessment. These are modeled based on extensive field data sets collected by the DOE. Major emphasis is placed in the Culebra Member of the Rustler Formation because this is by far the most transmissive geologic layer in the disposal system.

The DOE models multiple types of human intrusion scenarios in the performance assessment. These include both single intrusion events and combinations of multiple boreholes. Two different types of boreholes are considered: (1) those that penetrate a pressurized brine reservoir in the underlying Castile Formation and (2) those that do not. While the presence of a brine reservoir under the repository is speculative, it cannot be completely ruled out based on available information. The primary consequence of penetrating a brine reservoir is the introduction of an additional source of brine beyond that which is expected to flow into the repository from the Salado.

The DOE uses the Monte Carlo technique to perform probabilistic analysis. Key to this analysis is the specification of variables used to represent the disposal system over the regulatory time period. Fifty-seven different disposal system parameters are represented by ranges of values, with each value in the range assigned a probability. The range for any value is referred to as its uncertainty. The full range of uncertainty is included in the analysis by implementing random, stratified, and Latin hypercube sampling techniques.

Families of CCDFs and mean CCDFs for each of three replicate sets of calculations (each replicate consisting of 100 samples) are shown in Section 6.5. All 300 individual CCDFs lie below and to the left of the quantitative release limits specified in 40 CFR § 191.13(a). The overall mean CCDF determined from the three replicates also lies entirely below and to the left of the limits specified in 40 CFR § 191.13(a). Thus, the WIPP has demonstrated compliance with the containment requirements of 40 CFR Part 191.

The DOE's implementation of each of the six assurance requirements contained in 40 CFR Part 191 is discussed. Assurance requirements were mandated by the EPA to ensure that steps are taken to reduce the impacts of the uncertainties associated with making numerical predictions of events and processes 10,000 years into the future. According to the EPA, these assurance requirements are considered an essential complement to the containment requirements, which, when implemented, should ensure that the level of protection desired by the EPA is achieved. In this regard, the DOE describes its plans for active institutional controls, passive institutional controls, multiple barriers, and monitoring. In addition, the DOE addresses the resource disincentive requirements of 40 CFR § 191.14 and waste removal.

The DOE describes its compliance with the individual and groundwater protection requirements in 40 CFR Part 191. Nine of the 300 performance assessment realizations resulted in very small releases to the accessible environment laterally through marker beds. These releases are evaluated for compliance with the individual protection and groundwater protection standards and are shown to comply using an extremely conservative bounding analysis along with the additional assumption of the existence of an underground source of drinking water immediately adjacent to the controlled area. Under these conditions, the bounding doses are well below the EPA standards.

Finally, the DOE summarizes the results of peer reviews relevant to this application. The certification criteria mandated that the DOE perform peer reviews of the conceptual models, the waste characteristics analysis, and the engineered barrier study. In addition, the DOE conducted four other peer reviews, including reviews of the passive institutional controls, engineered systems data qualification, waste form and disposal room data qualification, and the natural barriers data qualification. Each of these is discussed along with the findings and recommendations of the peer panels and the DOE responses to these findings. The DOE has also documented other reviews that have been conducted for the WIPP, including major oversight activities by the EEG and the NAS. These are summarized, and supporting documentation is provided in Appendix PEER.

This application also contains supporting material included in the appendices. Four criteria were used by the DOE in deciding whether information should be included as an appendix. The criteria are (1) the information is in existing technical reports or design documents that are heavily referenced in the application, (2) the information is routinely updated by the DOE as the result of internal document review or reporting procedures and the latest version of the information is inserted just prior to submittal of the application, (3) the information is an output that is specified in the 40 CFR Part 194 certification criteria and the output is lengthy, and (4) the information is required to support several chapters and is voluminous in nature. The DOE believes that the information in the appendices is needed to make the application complete; therefore, the appendices are considered by the DOE to be an integral part of the application.

The DOE has prepared this application to be fully responsive to 40 CFR Parts 191 and 194 and the associated requirements of the LWA, and demonstrates the DOE's compliance with the final disposal standards in 40 CFR Part 191. In addition, the DOE has addressed the criteria in the EPA's compliance application guidance document. Comments or questions regarding this application should be directed to the U.S. Department of Energy, Carlsbad Area Office, PO Box 3090, Carlsbad, NM 88221, (505) 234-7300. Correspondence should be marked to the attention of the Assistant Manager, Office of Regulatory Compliance.