THE DISPOSAL OF ORPHAN WASTES USING THE GREATER CONFINEMENT DISPOSAL CONCEPT*

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ABSTRACT

In the United States, radioactive wastes are conventionally classified as high-level wastes, transuranic wastes, or low-level wastes. Each of these types of wastes, by law, has a "home" for their final disposal; i.e., high-level wastes are destined for disposal at the proposed repository at Yucca Mountain, transuranic waste for the proposed Waste Isolation Pilot Plant, and low-level waste for shallow-land disposal sites. However, there are some radioactive wastes within the United States Department of Energy (DOE) complex that do not meet the criteria established for disposal of either high-level waste, transuranic waste, or low-level waste. The former are called "special-case" or "orphan" wastes. This paper describes an ongoing project sponsored by the DOE's Nevada Operations Office for the disposal of orphan wastes at the Radioactive Waste Management Site at Area 5 of the Nevada Test Site using the greater confinement disposal (GCD) concept. The objectives of the GCD project are to evaluate the safety of the site for disposal of orphan wastes by assessing compliance with pertinent regulations through performance assessment, and to examine the feasibility of this disposal concept as a cost-effective, safe alternative for management of orphan wastes within the DOE complex. Decisions on the use of GCD or other alternate disposal concepts for orphan wastes are expected to be addresed in a Programmatic Environmental Impact Statement being prepared by DOE. The ultimate decision to use GCD will require a Record of Decision through the NEPA process.

INTRODUCTION

DOE Order 5820.2A (1) addresses the disposal of three major categories of radioactive wastes: high-level wastes (HLW), transuranic wastes (TRU), and low-level wastes (LLW). Under the Nuclear Waste Policy Act of 1982 (2) and the Nuclear Waste Policy Amendments Act of 1987 (3), HLW are destined for deep geologic disposal at a repository such as the proposed repository at Yucca Mountain. TRU shall be disposed of at the Waste Isolation Pilot Plant (WIPP) as stipulated in the authorization of the WIPP geologic repository in 1980 (4). In 1983, the DOE published a reference plan (5) for the permanent disposal of TRU and outlined a long-term strategy for the disposal of newly generated wastes as well as wastes that have been in retrieval storage at several sites in the U.S. Disposal of LLW is governed by the Low-Level Radioactive Waste Policy Act of 1980 (6). However, many radioactive wastes do not fall under the aforementioned categories; thus, they require special management and disposal schemes. This latter category of wastes is usually referred to as "special-case" or "orphan" wastes simply because there is no law at present that governs its disposal. The purpose of this paper is to describe a project supported by the DOE at the Radioactive Waste Management Site (RWMS) in Area 5 of the Nevada Test Site (NTS) to examine the disposal of orphan wastes using the Greater Confinement Disposal (GCD) concept.

WASTE TYPES

As stated above, special-case or orphan wastes include those types of radioactive wastes for which there is no law at present that stipulates a specific method for their disposal. These wastes include, but are not necessarily limited to, the following:

1. non-certifiable, difficult-to-certify, and classified TRU,
2. greater-than-class C (GTCC) LLW,
3. classified LLW
4. thermal LLW,
5. high-mobility LLW.

A set of waste-acceptance criteria (WAC) for the WIPP places restrictions on waste-container type, size, weight, and handling characteristics as well as waste specific activity, surface dose rate and contamination level, gas generation potential, and thermal output. Among the most

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generic restrictions, WIPP candidate TRU cannot contain liquids, pyrophoric or explosive materials, compressed gases, or hazardous materials (unless they exist as co-contaminants with the TRU). In addition, TRU to be disposed of at the WIPP must come from unclassified sources. A small amount of waste (approximately 2% of the TRU) will not meet the WIPP WAC even with further processing of the waste, and, consequently, cannot be disposed of at the WIPP (7). There is also some TRU, the source of which cannot be divulged publicly, that is not a candidate for disposal at the WIPP. In 1987, the DOE issued a supplemental plan (7) to its 1983 Defense Waste Management Plan (5), in response to recommendations from the U.S. General Accounting Office (8). This plan established the need for an alternative disposal method for the orphan TRU.

In 1985, the Low-Level Radioactive Waste Policy Amendments Act (9) was enacted. This law identified DOE as the federal agency responsible for disposing of LLW that exceeds the class-C limits defined by the U.S. Nuclear Regulatory Commission in 10 CFR Part 61 (10). It is generally accepted that GTCC LLW is not suitable for conventional LLW shallow-land burial practices, and, therefore, an alternative disposal concept for this type of LLW is needed.

Besides the non-certifiable or classified TRU and the GTCC LLW, other potential orphan wastes have been identified (11). These include highly mobile LLW (e.g., tritium) and thermal LLW; the latter are contained in Radioisotope Thermal Generators. A disposal method is needed for these wastes as well.

PROJECT SUMMARY

In 1981, the DOE's Defense Low-Level Waste Management Program instructed the Nevada Operations Office of the DOE (DOE/NV) to demonstrate the feasibility of the GCD concept for the disposal of the GTCC LLW. Located in the RWMS in Area 5 of the NTS (Fig. 1), the disposal concept utilizes intermediate depth boreholes in desert alluvium. These shafts or boreholes, as they are commonly referred to, are approximately 3 meters (10 feet) in diameter and 36.6 meters (120 feet) deep. The waste is emplaced in the bottom 15.2 meters (50 feet) of the borehole. The remaining 21.3 meters (70 feet) from the top of the waste to the land surface is backfilled with the native soil (Fig. 2). Because of the disposal concept and its location, the GCD site at NTS is also potentially suited for the disposal of orphan TRU. For GCD technology to become a disposal method for orphan wastes in general, it is important to determine whether the disposal method has a high probability of meeting the various disposal regulations. Because there is some TRU waste currently disposed at the GCD site, this TRU provides an ideal basis for conducting a preliminary performance assessment (PPA) of the GCD site against the requirements in 40 CFR Part 191 (12).* The results of the PPA will indicate the likelihood of success in complying with the regulatory requirements in 40 CFR Part 191.

The purpose of the GCD project is twofold:

1. To assess the safety of the wastes currently disposed of at the GCD site by showing compliance with all applicable regulations through performance assessment.
2. To examine the feasibility of the GCD concept as a solution to the management and disposal of orphan wastes generated in the DOE complex and not yet disposed of.

The strategy for the project is described in detail in the Management Plan (13) prepared by DOE/NV. A summary of this strategy follows.

Project Strategy

The main objective of the GCD project is to develop and implement a safe, cost-effective disposal alternative for orphan wastes. To achieve this objective, the project is divided into seven major areas, each having specific objectives as shown in Table I.

An important aspect of the strategy for the GCD project is to build on the vast amount of information and technology already available from other DOE waste disposal efforts. This approach should minimize both the cost and time for demonstration of compliance for the GCD site at NTS with the attendant regulations. The performance assessment approach for the GCD site follows methodologies developed for the demonstration of compliance with the requirements in 40 CFR Part 191 for the proposed HLW repository at Yucca Mountain and the WIPP and advances made on these waste disposal programs.** Data collected for the Yucca Mountain site have been and shall be examined on a continuous basis for applicability to the GCD site. Any data found to be applicable will be added to the GCD database.

* 40 CFR Part 191 was vacated by the U.S. Court of Appeals of the First Circuit and remanded to the U.S. Environmental Protection Agency for repromulgation. It is expected that when this regulation is repromulgated the containment requirements (40CFR 191.13) will not have changed significantly from those in the original regulation.

** Although directed primarily to disposal in deep geologic repositories, 40 CFR Part 191 applies to land disposal of HLW, spent fuel, and TRU by any method, including the disposal of orphan TRU using the GCD concept.

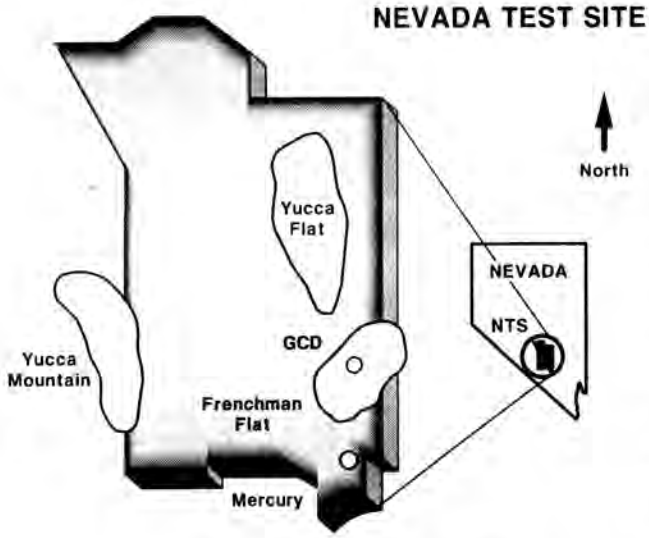

Fig. 1. Location of GCD Site.

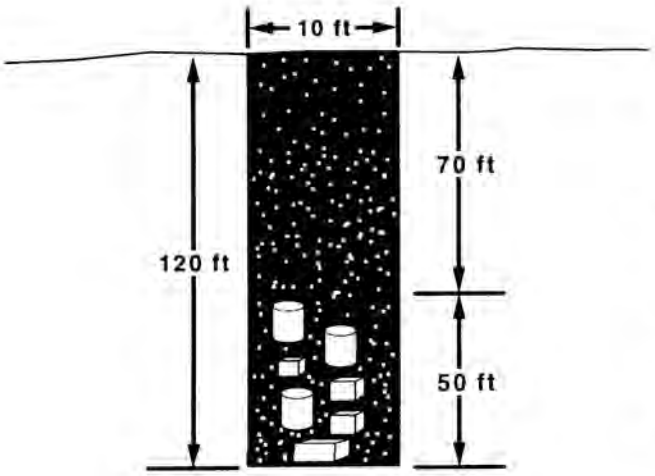

Fig. 2. Schematic of GCD borehole.

Another important aspect of this project is the coordination between performance assessment and site characterization activities. This interaction is needed as a means of increasing the likelihood that information gathered during site characterization indeed addresses the most important contributors to uncertainty in the results of a performance assessment. An iterative performance assessment-site characterization process is imperative in order to provide "reasonable assurance" that pertinent regulatory requirements are satisfied. This approach has been strongly advocated by Sandia National Laboratories in the development of performance assessment methodologies for HLW disposal (13, 14, 15, 16). The first step in the approach is to conduct a performance assessment analysis using available information about the disposal site and wastes and available models and computer codes. The results of this performance assessment analysis are used to conduct a sensitivity analysis to identify the most significant sources of uncertainty. The results of the sensitivity analysis are then used to assist in setting priorities for future data collection activities as a part of site characterization. This approach has been implemented in this project; hence, this is one of the objectives of the PPA discussed later in this paper.

Regulatory Setting

Because of the type of wastes categorized as orphan wastes, multiple regulations are likely to be applicable to the GCD site. Some of these regulations are:

1. DOE Order 5820.2A for TRU, LLW, and hazardous wastes,
2. 40 CFR Part 191 for TRU,
3. Proposed 40 CFR Part 193 for LLW,
4. Resource and Conservation Recovery Act (RCRA) for hazardous components of mixed wastes,
5. National Environmental Policy Act (NEPA), and
6. other federal and state regulations.

A preliminary analysis of regulations and attendant regulatory issues that could apply to the GCD site was conducted.* This analysis provided the rationale for initiating a regulatory analysis task that will design and implement the strategy for demonstration of compliance.

Project Participants

The GCD Project is sponsored by DOE/NV under the Environmental Restoration and Waste Management Division (ERWM), Defense Waste Branch (DWB). The DWB is responsible for all defense waste disposal operations at

* "Justification for GCD Regulatory Planning, Analysis, and Review," Letter report to P.T. Dickman, DOE/NV, Sandia National Laboratories, January 31, 1990.

TABLE I

Project Major Areas and Objectives

AREA	OBJECTIVES
Project Management	Define overall objectives, requirements, priorities, strategy, responsibilities, and control. Identify milestones and technical alternatives. Develop and track schedules. Define and implement cost-effectiveness. Oversight and monitoring. Develop and implement quality assurance. Define and coordinate special studies.
Preliminary Performance Assessment	Assess likelihood of overall site feasibility and compliance with 40 CFR Part 191 for existing transuranic waste. Prioritize future site-characterization activities. Develop preliminary geohydrological conceptual and source term models.
Site Characterization	Collect site data needed to conduct a robust and defensible demonstration of compliance. Revise preliminary geohydrological and source term conceptual models, as needed.
System Configuration	Define waste-acceptance criteria. Develop engineering design criteria, facility and system descriptions, technical specifications and operating procedures. Develop storage and disposal monitoring plans, and a 40 CFR Part 191 retrieval plan
Final Performance Assessment	Finalize regulatory analyses, source term model, release scenarios, and conceptual models. Finalize computer code development. Perform final consequence and uncertainty analyses.
Permitting and NEPA Compliance	Prepare draft and final environmental impact statements. Obtain Record of Decision to dispose.
Safety Analysis	Identify hazards and design-basis accidents. Prepare preliminary and final safety analysis reports.

the NTS, and as such, has overall responsibility for directing all activities related to the GCD project and ensuring that these activities are aimed at the demonstration of compliance with all applicable federal, state, and local regulations. Four contractor organizations provide technical assistance to DOE/NV; each of these organizations is responsible for meeting project reporting and QA guidelines stipulated in the Management Plan (17). The responsibilities of the four contractors are summarized below.

Reynolds Electrical & Engineering Company, Inc. (REECo) is the prime DOE contractor at the NTS. REECo's Environmental and Health Division is responsible for the site characterization of the RWMS in Area 5, where the GCD site is located, as well as maintenance and operation of the GCD facility. REECo also coordinates regulatory permit applications and the preparation of safety analysis reports for the GCD project.

Sandia National Laboratories' (SNL) Waste Management Systems Division is responsible for the preliminary performance assessment, system configuration, prioritization of site characterization activities, final performance assessment, quality assurance, and project management. SNL also supports special project studies and activities related to permit application and safety analyses.

Raytheon Services of Nevada (RSN) is the architect-engineer contractor for the NTS, and retains primary responsibility for facility design, planning, engineering services, surveying, research, drilling, mining engineering, inspection, procurement services, and other support services at the NTS. In the GCD project, RSN supports system configuration activities, drilling and coring activities, development of facility design criteria, and site characterization activities, particularly those related to surface and subsurface geologic studies.

Desert Research Institute (DRI) of the University of Nevada performs groundwater monitoring and modeling of radioactive and non-radioactive contaminants at the NTS. In the GCD project, DRI provides technical assistance, laboratory services, and technical review in the areas of hydrology, drilling and coring, isotope and environmental tracer studies, and aquifer testing.

It is important to emphasize the integrated nature of this project and close interactions among the participating organizations that has been effected. This approach is a significant step towards ensuring the long-term success of the project. Table II summarizes the responsibilities of the different participating organizations in a manner that indicates project integration.

PROGRESS TO DATE

During Fiscal Year 1990 (October 1989 - September 1990) work was performed in three of the major areas listed in Table I: Project Management, Preliminary Performance Assessment, and System Configuration.

TABLE II

Participating Organizations by Project Area

Project Area	Organizations
Project Management	SNL, REECo, RSN, DRI
Preliminary Performance Assessment	SNL, REECo, RSN, DRI
Site Characterization	REECo, RSN, SNL, DRI
System Configuration	SNL, REECo, RSN
Final Performance Assessment	SNL, REECo, RSN
Permitting and Regulatory Compliance	REECo, SNL
Safety Analysis	REECo, SNL

Project Management

Under Project Management, the project QA Plan (18) was developed. This QA Plan, a companion document to the project Management Plan (17), is responsive to DOE QA requirements and the QA provisions of the DOE/NV QA Manual. The QA Plan outlines general requirements that apply to all organizations participating in the project, including interfaces. The QA Plan requires each of these participating organizations to develop their own QA plans and procedures commensurate with the requirements stipulated by DOE/NV. Also, a QA plan was developed by SNL specifically for the preliminary performance assessment discussed below.

Preliminary Performance Assessment

A preliminary performance assessment (PPA) was completed in order to assess the likelihood of a successful demonstration of compliance with pertinent regulations; a detailed discussion of this analysis is given elsewhere (19,20). More specifically, the purpose of the PPA was threefold:

1. Determine the technical feasibility of the GCD concept as a solution for DOE's management of orphan wastes.
2. Examine the usefulness, in the context of performance assessment, of existing information and data for the RWMS in Area 5 at the NTS.
3. Determine the most significant uncertainties and set priorities for future site characterization efforts by performing sensitivity analyses on the results of the PPA.

The ability of the site to comply with the regulatory requirements was examined from a conservative point of view. Of the orphan wastes identified earlier, TRU waste may become the limiting waste because (1) it remains hazardous longer than the other orphan wastes, and (2) the post-closure regulatory requirements associated with disposal of TRU waste (40 CFR Part 191) are the most restrictive at present. Thus, the PPA focused on the disposal of TRU waste in GCD boreholes. Data spanning the extreme range of geologic and hydrologic parameters based on site investigations performed to date were used in the PPA. When data on specific parameters were not available, conservative values obtained from the published literature were used.

The scope of the PPA was such that only four scenarios were to be considered: base case, climate change, human intrusion, and erosion. For the base case, climate change, and erosion scenarios, the processes of radionuclide dissolution, liquid-phase and vapor-phase diffusion, hydrodynamic dispersion, convection, and retardation were considered, as shown in Fig. 3. The transport pathways were either downward through the unsaturated zone and horizontally in the saturated zone (convective pathway with steady-state flow), or upward to the ground surface (diffusive pathway). The liquid-diffusion pathway was considered here because of the relatively low recharge-flux estimates at the GCD site, and because of the relatively shallow depth of disposal (21.3 meters from the top of the waste to the land surface). For the human-intrusion scenario, the waste was assumed to be intercepted directly as a result of drilling (hence, no ground water transport processes) and the pathway was up through the well bore to the surface.

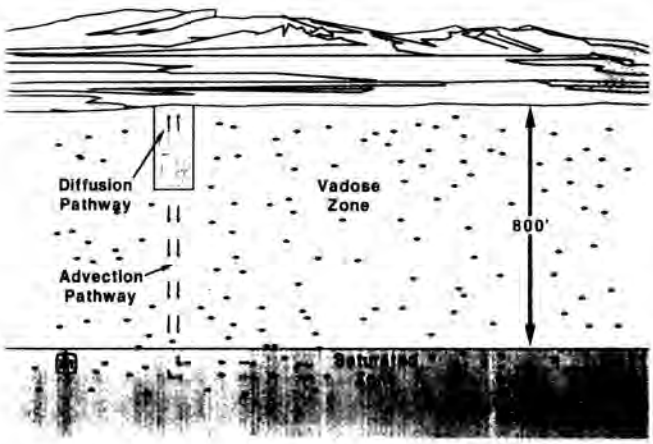

Fig. 3. Radionuclide migration pathways modeled in the PPA.

A major conclusion of the PPA is that the GCD concept is a technically feasible method for disposing of DOE's orphan wastes. This conclusion was arrived at by examining the results of the PPA against the containment requirements in 40 CFR Part 191 for undisturbed conditions (19,20). The results of the PPA also indicate that the site has a high likelihood of complying with the individual protection requirements and the groundwater protection requirements in 40 CFR Part 191. The exception could be diffusion of radon from boreholes containing thermal wastes.

The sensitivity analysis performed indicates that the most important parameters with respect to release of radionuclides to the accessible environment are those that govern groundwater flow, specifically recharge, the pressure gradient in the saturated zone, and the hydraulic conductivity in the saturated zone. Some radionuclide-specific parameters were also identified as potentially significant.

System Configuration

The work in this area focused on the identification of candidate wastes that could be disposed of using the GCD concept. These candidate waste are TRU, fission products, activation products, volatile/mobile LLW, and thermal wastes (15). Potential pre-closure and post-closure optimization criteria for use in GCD system analyses were defined. Finally, issues associated with the disposal of thermal wastes (e.g., Radioisotope Thermal Generators) at the GCD site were addressed. In addition, a study was performed to identify important issues that should be addressed in an environmental assessment and a performance assessment for disposal of thermal wastes, and issues that may be important for the development of engineering and operational guidelines and waste acceptance criteria.

Special Studies

Three working groups (WG's) were established to examine source-term information, site characterization, and regulatory issues. The source term WG identified the existing waste inventory at the GCD site. The site characterization WG identified key hydrogeologic parameters and assigned ranges and distributions values to them. Both of these WG's supported the PPA. The third WG conducted a preliminary analysis of regulatory issues that could have an impact on the GCD site (see footnote).

CURRENT ACTIVITIES

In Fiscal Year 1991 (October 1990 - September 1991) the primary emphasis of the GCD project is on collecting the necessary data and information to ascertain the validity of many of the assumptions made (i.e., the models used) in the PPA and to qualify the numerical values (i.e., ranges and distributions) of the parameters used in that analysis. The priority for data collection activities was established based on the results of the sensitivity analysis in the PPA. Site characterization in support of hydrologic modeling and climate change modeling have been initiated. Also, activities supporting the development of final source term and transport models for use in the final performance assessment have been started. Other activities that have not been completely defined at this time will be initiated during the current fiscal year. These activities pertain to system configuration and special studies.

CONCLUSIONS

In this paper we have provided an overview of the Greater Confinement Disposal Project at the Nevada Test Site. The overall goal of this project is to develop and implement a safe, cost-effective disposal alternative for orphan or special-case radioactive wastes generated in the DOE complex.

Given the information that exists to date and the results of recent studies, the GCD concept at the NTS has a high likelihood of success because of the types of wastes expected, present and expected future regulations, the disposal technology, and the location of the disposal site. To achieve the goals of the project, DOE/NV and its contractors have developed a strategy for demonstration of compliance. A major effort of this strategy is the definition of the exact set of orphan wastes that will ensure optimum and cost-effective utilization of the GCD concept.

Finally, preliminary performance assessment results have been used to identify the most significant uncertainties. These results are used to set priorities for data collection activities in a manner that maximizes the value of new information and minimizes the cost of obtaining that information.

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