LA-UR-03-0283
Approved for public release;
distribution is unlimited.

Title: **COMPLETION OF THE TRANSURANIC GREATER CONFINEMENT DISPOSAL BOREHOLE PERFORMANCE ASSESSMENT FOR THE NEVADA TEST SITE**

Author(s): Angela Colarusso
Bruce Crowe
John R. Cochran

Submitted to:

http://lib-www.lanl.gov/cgi-bin/getfile?00937008.pdf

COMPLETION OF THE TRANSURANIC GREATER CONFINEMENT DISPOSAL BOREHOLE PERFORMANCE ASSESSMENT FOR THE NEVADA TEST SITE

Angela Colarusso
Waste Management Division
U.S. Department of Energy
National Nuclear Security Administration/Nevada Site Office

Bruce Crowe
Los Alamos National Laboratory

John R. Cochran
Sandia National Laboratories[1]

ABSTRACT

Classified transuranic material that cannot be shipped to the Waste Isolation Pilot Plant in New Mexico is stored in Greater Confinement Disposal boreholes in the Area 5 Radioactive Waste Management Site on the Nevada Test Site. A performance assessment was completed for the transuranic inventory in the boreholes and submitted to the Transuranic Waste Disposal Federal Review Group. The performance assessment was prepared by Sandia National Laboratories on behalf of the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office using an iterative methodology that assessed radiological releases from the intermediate depth disposal configuration against the regulatory requirements of the 1985 version of 40 CFR 191 of the U.S. Environmental Protection Agency. The transuranic materials are stored at 21 to 37 m depth (70 to 120 ft) in large diameter boreholes constructed in the unsaturated alluvial deposits of Frenchman Flat. Hydrologic processes that affect long-term isolation of the radionuclides are dominated by extremely slow upward rates of liquid/vapor advection and diffusion; there is no downward pathway under current climatic conditions and there is no recharge to groundwater under future "glacial" climatic conditions. A Federal Review Team appointed by the Transuranic Waste Disposal Federal Review Group reviewed the Greater Confinement Disposal performance assessment and found that the site met the majority of the regulatory criteria of the 1985 and portions of the 1993 versions of 40 CFR 191. A number of technical and procedural issues required development of supplemental information that was incorporated into a final revision of the performance assessment. These issues include inclusion of radiological releases into the complementary cumulative distribution function for the containment requirements associated with drill cuttings from inadvertent human intrusion, verification of mathematical models used in the performance assessment, inclusion of dose calculations from collocated low-level waste in the boreholes for the individual protection requirements, further assessments of engineered barriers and conditions associated with the assurance requirements, and expansion of documentation provided for assessing the

[1] Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Corporation, for the United States Department of Energy under contract DE-AC04-94AL8500

groundwater protection requirements. The Transuranic Waste Disposal Federal Review Group approved the performance assessment for Greater Confinement Disposal boreholes in 2001 and did not approve the Application of the Assurance Requirements. Remaining issues concerned with engineered barriers and the multiple aspects of the Assurance Requirements will be resolved at the time of closure of the Area 5 Radioactive Waste Management Site. This is the first completion and acceptance of a performance assessment for transuranic materials under the U.S. Department of Energy self-regulation. The Greater Confinement Disposal boreholes are only the second waste disposal configuration to meet the safety regulatory requirements of 40 CFR 191.

INTRODUCTION

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) operates and maintains two active radioactive waste management sites (RWMS) on the Nevada Test Site (NTS) that dispose defense-generated low-level radioactive waste (LLW), minor volumes of mixed radioactive waste, and classified materials. Disposal of LLW generated from defense activities on the NTS began in 1960 and operations were expanded in 1978 to include disposal of LLW from off-site generators across the DOE complex. The Area 5 RWMS is located in north central Frenchman Flat (Fig. 1) and is used to dispose containerized LLW from predominantly actinide-bearing waste streams (1). The majority of the waste is buried in shallow trenches and pits (Fig. 2).

During the 1980's, DOE investigated the feasibility of using Greater Confinement Disposal (GCD) boreholes for disposal of high specific activity LLW and special case waste at the Area 5 RWMS. This disposal concept that corresponds to intermediate depth disposal of radioactive waste uses large boreholes that are 3 m (10 ft) in diameter, and 37 meters (120 ft) deep. Waste is emplaced in the bottom 15 m (50 ft) of the borehole (2). A total of 13 GCD boreholes were constructed and 4 of the boreholes were used to store classified transuranic (TRU) materials consisting of residue from nuclear weapons accidents and materials from nuclear weapons production or disassembly.

A performance assessment (PA) was completed by Sandia National Laboratories (Sandia) on behalf of NNSA/NSO to assess the suitability of long-term storage of classified TRU materials in the GCD boreholes of the Area 5 RWMS (2). The PA used an iterative methodology described in Section 3 of the GCD PA (2) to assess the processes of fate and transport that could lead to radiological releases of the TRU inventory from the GCD boreholes. These releases are translated into data that are assessed against the requirements of 40 CFR 191. Most TRU wastes, under DOE policies, are disposed at the now active Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico that is approved by the Environmental Protection Agency (EPA); a current restriction is that the WIPP site is not approved for disposal of classified TRU material. At the time of emplacement of the TRU materials in the GCD boreholes, DOE-generated waste was governed by DOE Order 5820.2A that recommends TRU materials meet the EPA requirements of 40 CFR 191. The EPA, in the preamble to the 1993 version of 40 CFR

191, notes that the TRU materials in the GCD boreholes are governed by the 1985 version of the EPA 40 CFR 191. The DOE Order 5820.2A is now replaced by DOE Order 435.1 that retains the requirement for assessment of the GCD TRU materials against 40 CFR 191.

The final draft of the GCD PA was submitted to NNSA/NSO in April of 2000. During fiscal year 2001 and part of fiscal year 2002, DOE/Headquarters (DOE/HQ) implemented a formal review of the GCD PA against the 1985 version and portions of the 1993 version of 40 CFR 191. The Transuranic Waste Disposal Facility Federal Review Group (TFRG), a subgroup of the Low Level Radioactive Waste Review Group (LFRG), is the responsible regulatory authority for conducting the review process.

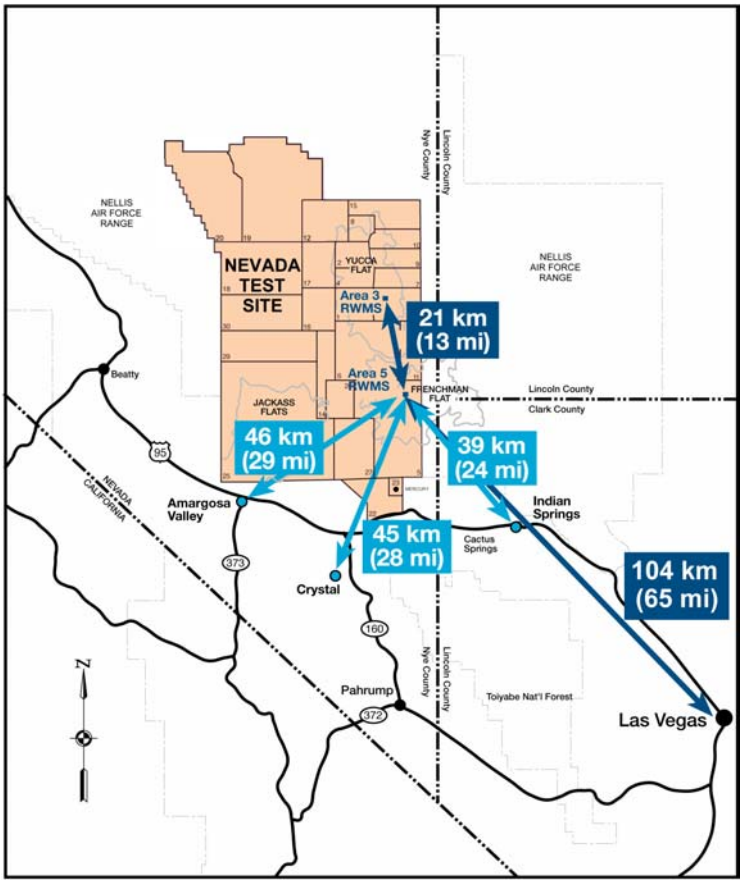

Fig. 1. Map of the Nevada Test Site showing the location of the Area 3 and Area 5 Radioactive Waste Management Sites.

Figure 2. Aerial view of the Area 5 RWMS showing the pit and trench configurations used for disposal of LLW. The yellow arrows mark the approximate locations of the four TRU GCD boreholes.

This paper provides brief background information on the disposal of classified TRU material in the GCD boreholes in the Area 5 RWMS and the PA that was prepared for assessment with respect to the regulatory requirements of 40 CFR 191. The purposes of the paper are to summarize the technical and regulatory review of the GCD PA, and to describe the technical issues that emerged and the issue resolution process that led to acceptance of the PA by the TFRG. A secondary purpose of this paper is to communicate NNSA/NSO experiences with evaluation of classified TRU materials to assist other DOE sites contemplating remediation options for TRU waste.

PERFORMANCE ASSESSMENT FOR THE GCD BOREHOLES

The Area 5 RWMS is situated on a thick sequence of alluvium composed of weakly stratified, gravelly sand (Fig. 2). Groundwater is approximately 236 m (774 ft) below the land surface. The climate is arid with an average precipitation of < 13 cm/year (5 in/year) (3). The limited precipitation and thick alluvium with generally homogeneous hydrologic

properties (1-4), coupled with generally warm temperatures, plant uptake, and low humidity, results in a hydrologic system dominated by evapotranspiration.

Extensive field studies conducted over the last decade show that the matric potential and volumetric moisture content of the upper 2 m (7 ft) are dynamic, with an average volumetric moisture content ranging from 1% to 3% (1-4). Between 2 m (7 ft) and approximately 35 m (115 ft) below the surface, the alluvium shows negative matric potential decreasing with depth (for example, negative 10 bars at 35 m (115 ft) depth and negative 75 bars at 5 m (17 ft) depth), indicating an *upward gradient in the pore water.* This upward movement of pore water from 35 m (115 ft) deep is the result of a system in transition, where the transition times are on the order of thousands of years spanning changes in climate. In the geologic past, the climate was cooler and wetter. A more xeric environment now exists, and the drying of the land surface is pulling moisture from depth, resulting in the very slow upward flux of pore water evidenced by the soil matric potentials (Fig 3). Section 5.6 of the GCD PA (2) summarizes the many studies of the hydrologic setting of the Area 5 RWMS.

The hydrologic setting of the disposal facility provides ideal conditions for disposal of radioactive waste. There is no spatially distributed groundwater recharge under current climate conditions. The processes leading to fate and transport of radionuclides in the unsaturated zone are directed upward and occur at extremely low rates. The rates are so low that they are difficult to quantify and three separate techniques were used to estimate values and to develop a probability distribution for this important transport parameter.

From 1984 through 1989, eight of the GCD boreholes were used to emplace special-case waste. Figure 3 shows an idealized cross-section of a GCD borehole loaded with waste and backfilled with alluvium. Four of the boreholes were used to emplace classified TRU material that is the topic of this paper. Boreholes 1, 2, and 3 were used to emplace containers of Nuclear Weapons Accident Residue (NWAR). Most of the NWAR is in a "stable aluminum-plutonium-uranium or aluminum-uranium slag form." The TRU materials in GCD Borehole 4 are from DOE's Rocky Flats facility. Non-TRU, LLW from Lawrence Livermore National Laboratory is also emplaced in Borehole 4.

The performance objectives for protection of human health from TRU are defined by the EPA's 40 CFR 191 Subpart B requirements promulgated in 1985. These regulations include three sets of quantitative safety requirements and a fourth set of qualitative closure or assurance requirements:

> **Containment Requirements (CRs)**. The disposal system must provide the reasonable expectation that the cumulative releases of radionuclides from all significant processes and events to the accessible environment for 10,000 years will have a likelihood of less than one chance in 10 of exceeding an EPA Sum of 1, and less than one chance in 1,000 of exceeding an EPA Sum of 10. The EPA Sum is the ratio of cumulative releases divided by the number of curies established in the release limit. The release limit is scaled to the inventory as defined in 40 CFR 191.

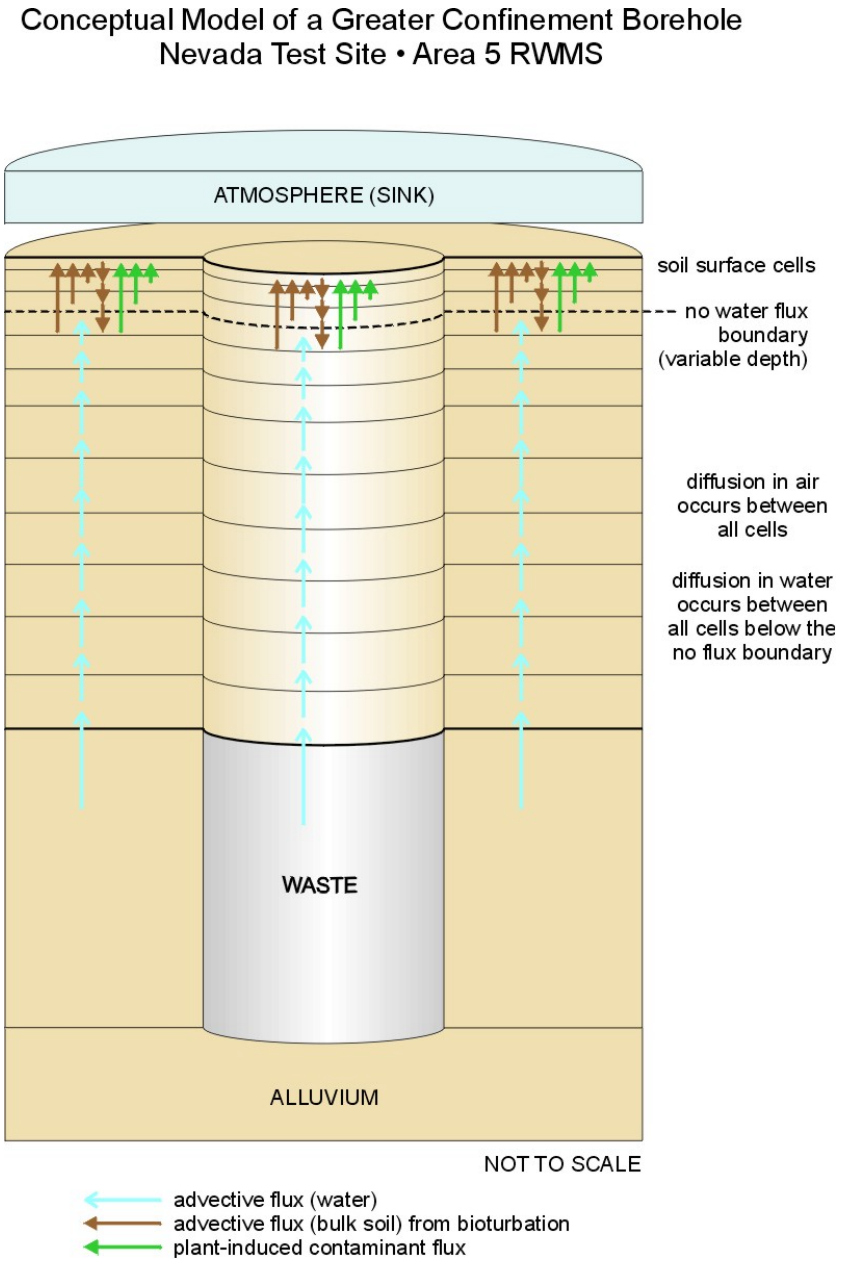

Fig 3. Generalized cross-section of a GCD borehole showing the configuration of the waste disposal zone and the hydrologic and biotic processes affecting the system.

Individual Protection Requirements (IPRs). The disposal system must provide a reasonable expectation that, for 1,000 years after disposal, the undisturbed performance of the disposal system will not result in an annual dose equivalent to any member of the public that exceeds 25 mrem to the whole body or 75 mrem to any organ.

Groundwater Protection Requirements (GWPRs). Disposal systems will be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system will not cause the radionuclide concentrations averaged over any year in water withdrawn from a special source of ground water to exceed standards defined in the regulation.
Assurance Requirements (ARs). The ARs require active institutional controls, monitoring of the disposal system, and specific actions related to closure and stewardship.

The goal of the GCD PA is *not* to predict how the system will perform but to provide simulations of a range of plausible outcomes all structured to *underestimate* the ability of the GCD boreholes to isolate waste over 10,000 years. These simulations are conducted in an iterative fashion starting with simple but defensible models.

Scenario development and screening were completed during the initial stages of development of the GCD PA (2). Four significant processes and events were identified including climate change, subsidence of the waste and overlying alluvial fill, and two scenarios involving inadvertent human intrusion (2). Four coupled analyses were undertaken to evaluate whether combined effects of subsidence and climate change might cause surface water to migrate to the water table during the next 10,000 years including:

1. Modeling the geometry of future subsidence features;
2. Using current climatic data to model precipitation, local runoff, and flooding;
3. Using data for glacial climatic conditions to model precipitation, local runoff, and flooding; and
4. Using the VS2DT code to model the two-dimensional movement of water in the subsurface.

The key result of the screening analysis was that there could be deep infiltration of surface moisture because of the capture and focusing of precipitation (current and glacial climates), but the moisture will not reach the water table in 10,000 years (2). The combined effects of subsidence, climate change, and flooding that result in downward movement of water were screened out of the GCD PA, and the conceptual model implemented for fate and transport maintains the upward pathway (upward advection). To account for the concern that subsidence and/or subsidence plus climate change will cause the return of deeper-rooted pinion-juniper woodlands, all realizations of the PA model were made with the current upward movement of pore water, coupled with a deeper-rooted pinion juniper woodland glacial plant community.

The PA models were implemented in Visual Basic as macros in an Access database. The calculations are completed in two phases. The first calculates the movement and cumulative release of summed radionuclides over 10,000 years and produces a complementary cumulative distribution function (CCDF) of the EPA Sum for assessment against the CRs of 40 CFR 191. The second calculates the cumulative radionuclide release over 1,000 years and translates those releases to doses for assessment against the requirements of the IPRs.

NNSA/NSO formed a Technical Working Group (TWG) to provide peer review and to evaluate the defensibility of the technical analyses in the GCD PA. The TWG consisted of NNSA/NSO contractors including representatives from Bechtel Nevada, Neptune and Company, Desert Research Institute, and the Harry Reid Center for Environmental Studies at the University of Nevada, Las Vegas. Seven TWG meetings were held and peer review comments were provided and resolved covering all portions of the PA. The TWG peer review enhanced and improved the PA and this review process is recommended for other DOE facilities required to submit a 40 CFR 191 PA for formal review.

PA Results (pre-review)

A total of 5,000 realizations of sampled probabilistic parameters were completed for assessing the CRs. The resulting CCDF easily met the limits specified in 40 CFR 191 (2). Probability distributions of doses were estimated for the IPRs for two exposure conditions: an offsite resident farmer and an on-site homebuilder. Doses were estimated conservatively from the cumulative releases summed over 1,000 years and included doses from radon – the only U.S. PA known to include radon in a dose assessment. The calculated doses are far below the limits of 25 mrem for whole-body dose and 75 mrem for critical organ dose specified in 40 CFR 191 (2).

REVIEW OF THE TRU GCD PA

The DOE developed the *Transuranic Waste Disposal Facility Federal Review Group Manual* in November 2000 to provide metrics for assessing the GCD PA for the classified TRU materials in the GCD boreholes. The purpose of this manual is to facilitate the review of TRU waste for which DOE has the responsibility and authority for making compliance decisions.

As required by the manual, a Federal Review Team was assembled and reviewed the GCD PA during calendar years 2000 and 2001. A technically experienced DOE manager led the team and team members were drawn from within DOE organizations, from technical specialists from other DOE facilities, from private industry, and from the US EPA. The Federal Review Team visited the NNSA/NSO site as part of the review effort including a tour of the Area 5 RWMS and for formal presentations and exchange of information with NNSA/NSO managers and support contractors, primarily Sandia staff. A subset of members of the Federal Review Team visited Sandia in Albuquerque, New Mexico to review supplemental information developed in response to preliminary review issues.

The Federal Review Team presented a draft of their report and an assessment of the adequacy of the PA with respect to the review criteria matrix to the NNSA/NSO for factual accuracy review. NNSA/NSO provided additional information in response to the draft team report and the Federal Review Team considered this supplemental information in their final report provided to the LFRG.

The Federal Review Team evaluated the TRU GCD PA against 49 criteria for the CRs, 26 criteria for the ARs, 61 criteria for the IPRs, 65 criteria for the GWPRs, and against a single composite analysis requirement established by the LFRG (not a part of 40 CFR 191). The majority of review criteria were resolved by the information in the GCD PA.

The next section of the paper provides an overview of important technical issues from the review process, and how all but a few of the review issues derived from the review criteria were resolved during the factual accuracy process. The review issues and their resolution status are summarized to provide background information that may assist other sites in developing and evaluating PAs concerned with DOE-generated TRU waste. Quality assurance issues were also a concern during the GCD review but are not summarized in this paper. Some of the review issues apply to multiple requirements of 40 CFR 191 but are included in only one section for brevity.

Exclusion of the Drilling Scenario in the Analysis of the CCDF.

Disruptive events associated with inadvertent human intrusion were evaluated in the initial screening of features, events and processes for the GCD PA (2). However, the PA did not include releases of radionuclides to the accessible environment through drill cuttings produced during drilling of a water well (drilling scenario). Exclusion of these potential releases was based on an interpretation of EPA's Appendix B guidance in 40 CFR 191.13. The Federal Review Team argued that the radiological releases associated with the drilling scenario require inclusion in the CCDF for the CRs. Their review conclusion is based on guidance provided by DOE/HQ and an estimated probability of human intrusion that exceeds PA screening criteria.

To respond to the review requirement by the Federal Review Team, Sandia calculated an additional CCDF that included the radiological releases from the drilling scenario; this CCDF was presented in the factual accuracy information submitted to the Federal Review Team. The revised CCDF used the results of an expert judgment study of the conditional probability of inadvertent intrusion into the Area 5 RWMS (5). Data from this study were adapted to the geometry of the GCD boreholes and resulted in an estimated median probability of 6×10^{-4} of randomly intersecting TRU waste in the GCD boreholes in 10,000 years. Accompanying assumptions included a drill hole diameter of 30 cm (1 ft) and an intersection time of 2170, the first year after assumed cessation of active institutional control. The estimated releases from drill cuttings were summed with the base case releases from the GCD PA to produce an additional CCDF. With and without the inclusion of releases associated with drilling cuttings, the CCDFs for the TRU GCD boreholes do not violate the probabilistic CRs established in 40 CFR 191. The review issue was resolved through inclusion of the supplemental calculations.

Verification of Mathematical Models

The Federal review team was concerned with the verification of mathematical and numerical calculations used throughout the GCD PA. This concern was directed at both the CRs and IPRs, where a custom computer code was developed for completing the

computations required for the PA. There was, in some cases, insufficient software documentation and traceability for the review team to follow all steps in the modeling calculations. Additionally, the PA presented only final results in numerical calculations that required multiple steps. Code verification information was not available for all aspects of the Visual Basic code and was not included for auxiliary codes that supplemented the GCD model. This review concern covers a common regulatory review issue over the "transparency" of complex model calculations required for conducting performance assessments.

NNSA/NSO and support contractors provided increased documentation for model verification as part of the factual accuracy process. A report by an independent contractor that conducted a code verification study of the Sandia PA code was provided to the Federal Review Team. No changes in the custom PA code were required and Sandia incorporated the comments from the code verification study into a revision of their code documentation and this revision was provided to the Federal Review Team. References were provided for all auxiliary computer codes used in the GCD PA model. These auxiliary codes were developed by government agencies and have widespread acceptance within these agencies as well as research and academic institutions. Sandia was able to efficiently rerun additional simulations of the GCD model and these simulations provided output at secondary steps in the model computations. The secondary output was included in factual accuracy information provided to the Federal Review Team. Supplementary analyses were performed using the GCD PA model to evaluate the effects of model approximations and to enhance sensitivity analysis of model parameters. The results of these analyses are summarized in Appendix P of the revised GCD PA (2).

A series of benchmarking exercises were completed that compare the results of the GCD model with documented and reviewed computer codes that could replicate the GCD model calculations. The selected codes include GoldSim (6, 7) and a suite of analytical and numerical codes used in the calculations for the Area 5 PA (1). The GoldSim modeling platform is used for PA calculations by the Yucca Mountain Project and has extensive verification and quality assurance documentation (7); the Area 5 PA calculations were approved by the LFRG. The results of the benchmark exercises were provided to the Federal Review Team. The Team investigated the requirements for model verification and noted that there are no specific references to model verification in either the 1985 or 1993 versions of 40 CFR 191. They defined, as part of the review process, model verification as demonstration that there is a reasonable expectation that compliance will be achieved. Based on this definition and the supplemental information provided by NNSA/NSO in the factual accuracy process, the review criterion on verification of mathematical models was resolved.

An important lesson from this review issue is the impact of custom code development on a small environmental management project. The custom code developed by Sandia in an Access database served the project needs and was tailored specifically to the requirements of the GCD PA and the regulatory requirements of 40 CFR 191. However, the requirements of code verification, benchmarking and code documentation for development of a custom computer code are substantial and difficult to fulfill.

Review Findings with the Individual Protection Requirements

Two review issues emerged with the IPRs of 40 CFR 191: inclusion of collocated waste in the GCD boreholes, and the time period of the dose calculations used for the IPRs. Both issues are associated in part with changes between the 1985 and 1993 versions of 40 CFR 191.

The GCD PA carefully identified and documented the approach used to establish the TRU inventory in Section 5.9.2 of the GCD PA. The inventory was established on an individual waste package basis. If a package met the definition of TRU waste, the full inventory of that package, including both TRU and any LLW, were included in the IPR calculations. Collocated LLW in a TRU GCD borehole but not in a TRU waste package was *not* included in the inventory used to evaluate radiological doses for the IPRs in the draft GCD PA. The Federal Review Team argued based partly on interpretation by DOE/HQ of guidance in 40 CFR 191 that all collocated waste in a TRU GCD borehole should be considered in the IPRs. Accordingly, the review criterion could not be resolved with the data in the draft version of the GCD PA.

The NNSA/NSO and Sandia completed revised dose calculations through the factual accuracy process and these revised calculations include co-located LLW waste in the four TRU GCD boreholes. The inventory of LLW in the four GCD boreholes was summed from inventory records and decay corrected to 2170, the projected time of loss of institutional control. Minor amounts of tritium and ^{137}Cs were added but can be neglected after decay corrections. Radionuclides added to the TRU inventory in the GCD boreholes include ^{235}U, ^{238}U, and ^{232}Th. This augmented inventory was used to revise dose calculations for the offsite farmer and onsite homebuilder exposure conditions. The change in inventory resulted in almost imperceptible changes in doses for both exposure conditions and is the basis for resolution of the first IPR review issue.

The Federal Review Team additionally requested extension of the IPR dose calculations beyond 1,000 years to resolve review criteria specific to the criteria in the DOE TRU Manual. Resolution of this review issue was somewhat problematic. NNSA/NSO argued that the extremely conservative approach used in the GCD PA to estimate the IPR dose calculations should be sufficient to resolve the time extension issue. The IPRs require calculation of a peak dose per year; the GCD PA summed radioactive releases to the accessible environment over 1,000 years and calculated a cumulative *annual* dose at year 1,000. The Federal Review Team agreed that doses calculated over a longer time period would show compliance but still requested dose calculations over an extended time period. The LFRG concluded in their closeout meeting of the GCD PA review that there was sufficient information to resolve this issue.

Engineered Barriers and Assurance Requirements

Multiple issues under the general category of ARs were identified from the formal review of Volume 4: Application of Assurance Requirements (9). These issues include the lack

of an engineered barrier system and multiple concerns with specific requirements under the ARs. The lack of an engineered barrier system also overlaps with and impacts the CRs and the IPRs.

The engineered barrier concern expressed by the Federal Review Team is with the specific regulatory requirement for the presence of and an assessment of the performance assessment benefits of engineered barriers, benefits that should augment the natural geologic isolation. The case presented in the GCD PA is that engineered barriers are an integral part of the overall GCD disposal system and include the combination of intermediate depth burial, the emplacement of probertite in the GCD boreholes to prevent nuclear criticality, and the presence of more than 20 meters (70 ft) of alluvial fill covering the TRU material. The performance of these "engineered barriers" was not calculated separately but instead is included in the overall results of the PA. The Federal Review Team argued that the GCD borehole design does not include any components that can be defined as engineered barriers under 40 CFR 191 and the regulations call for a separate analysis of the enhanced performance associated with the *addition* of engineered barriers. The review issue was resolved through agreement by NNSA/NSO that an acceptable engineered barrier and an analysis of that barrier will be provided for the GCD boreholes at the time of facility closure.

An assessment of the ARs of 40 CFR 191 also proved to be a somewhat problematic issue during the review of the GCD PA. The problem fundamentally revolved around the definition of a TRU facility. The ARs of 10 CFR 191 are written for application to a dedicated and operational TRU facility. The TRU GCD boreholes are inactive disposal cells within the operationally active Area 5 RWMS, a facility dedicated to disposal of DOE-generated LLW. NNSA/NSO cannot fully commit to a detailed resolution of the ARs without consideration of the operational and closure requirements of the encompassing Area 5 facility. The Federal Review Team argued that there was insufficient detailed information in the Assurance Requirements volume (8) to resolve multiple issues for the ARs including passive and active institutional controls, monitoring of the GCD boreholes, the absence of economically useful minerals in the area, and removal of waste. Resolution was achieved through NNSA/NSO agreement to address the remaining issues for the GCD boreholes at the time of closure of the Area 5 RWMS. This commitment was written into the requirements of the closure and monitoring plan for the facility (9).

Groundwater Protection Requirements

The GCD PA concluded that the GWPRs of 40 CFR 191 are not applicable because the groundwater potentially impacted by the disposal of TRU waste is not a special source of groundwater as defined by the EPA. The initial finding of the Federal Review Team was that there was insufficient documentation in the PA to support non-applicability of the GWPRs. NNSA/NSO provided expanded information to document the conclusions with respect to the GWPRs in their factual accuracy response. They reviewed the regulatory requirements for the GWPRs for the 1985 version of 40 CFR 191 and noted that four, and all four, specific requirements must be met to qualify as a special source of groundwater.

The first requirement is the groundwater must be a Class I groundwater. Guidance for determining if a contaminated ground water is Class I, II, or III is set forth in the EPA Guidelines for Groundwater Classification (10). An analysis of the classification of groundwater at the NTS, including Frenchman Flat, was completed in 1994 (11) and the result of that analysis was incorporated in the final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada (12). All groundwater for all aquifers in the NTS is classified as Class II groundwater. By regulation, the GWPRs of the 1985 version of 40 CFR 191 do not apply to the groundwater beneath the GCD boreholes and the GCD PA. The Federal review team agreed with this interpretation and accepted the expanded documentation provided for the conclusion. This review issue was resolved.

FINAL COMMENTS

All of the information provided in the NNSA/NSO factual accuracy responses is included in the final revision of the GCD PA issued in September 2001 (2). The TFRG accepted the GCD review results of the Federal Review Team at a meeting in late calendar year 2001. The TFRG also conducted additional evaluations of quality assurance issues with the GCD PA. The combination of the inclusion of all factual accuracy information in the revised GCD PA (2) and the resolution of quality assurance issues led, as noted above, to acceptance of the GCD PA by the TFRG and the DOE Headquarters Office of Site Closure and Office of the Environment (13). The resolution of remaining issues for the GCD boreholes (assurance requirements, engineered barriers) will be conducted through the maintenance program for the Area 5 RWMS. Any changes in the TRU GCD boreholes will be tracked and documented in the annual summary report for the Area 5 RWMS.

The primary goal of this paper is to highlight the review process and technical issues emphasized during the review of the GCD PA as an expected aid to other DOE sites contemplating future evaluations of TRU waste. The emphasis of the paper, accordingly, is on the controversial aspects of the formal review of the GCD PA. From a positive perspective, the Federal Review Team and the TFRG accepted a lengthy GCD PA that involved development of complex, uncertain and technically challenging models of fate and transport in the unsaturated zone, and implementation of those processes in numerical models used to forecast radiological releases and doses over 10,000 years. The scope of this paper underplays the successful completion and acceptance of the GCD PA by the TFRG that required resolution of a large number of review criteria. Only a handful of issues required extended discussion and expanded information to resolve. The most significant major accomplishments signified by successful completion of the TRU GCD PA project include:

1. The first successful completion and acceptance of a PA for TRU waste under DOE self-regulation.
2. The approved PA for the GCD TRU disposal follows the WIPP site as only the second site to meet the safety regulatory requirements of 40 CFR 191 for disposal of TRU waste.

3. The GCD PA is the only approved safety assessment for intermediate depth disposal of radioactive waste.

ACKNOWLEDGMENTS

The Waste Management Division of NNSA/NSO provided funding for this project. Reference herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring the United States Government or any agency thereof or its contractors or subcontractors.

REFERENCES

1. G.J. SHOTT, L.E. BARKER, S.E. RAWLINSON, M.J. SULLY, AND B.A. MOORE, "Performance Assessment for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada," DOE/NV/11718-176 UC-721 Nevada Operations Office, Las Vegas, (1998).
2. COCHRAN, J.R., W.E. BEYELER, D.A. BROSSEAU, L.H. BRUSH, T.J. BROWN, B. CROWE, S.H. CONRAD, P.A. DAVIS, T. EHRHORN, T. FEENEY, B. FOGLEMAN, D.P. GALLEGOS, R. HAAKER, E. KALININA, L.L. PRICE, D.P. THOMAS AND S. WIRTH, "Compliance Assessment Document for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Site, Volume 2: Performance Assessment," Sandia National Laboratories Report SAND2001-2977 (2001).
3. D.G. LEVITT , M.J. SULLY, B.L. DOZIER AND C.F. LOHRSTORFER, "Determining the Performance of an Arid Zone Radioactive Waste Site Through Site Characterization, Modeling and Monitoring," Proceedings of the Waste Management'99 Conference, Tucson, Arizona (1999).
4. TYLER, S.W., J.B. CHAPMAN, S.H. CONRAD, D.P. HAMMERMEISTER, D.O. BLOUT, J.J. MILLER M.J. SULLY, AND J.M. GINANNI, "Soil-water Flux in the Southern Great Basin, United States: Temporal and Spatial Variations over the last 120,000 Years, *Water Resources Research,* v. 32, p. 1481-1499 (1996).
5. BLACK, P.K., K.J. BLACK, M.M. HOOTEN, L.P. MATHAI, T.S. STOCKTON AND M.D. NEPTUNE, "Assessing the Probability of Inadvertent Human Intrusion at the Nevada Test Site Radioactive Waste Management Sites—Volumes I and II" W-31-109-Eng-38, (2001).
6. GOLDER ASSOCIATES, INC., *GoldSim Software*, GoldSim Consulting Group, Golder Associates, Redmond, WA (2001).
7. McGRATH, T., AND C. BECKHAM, "Verification Report for GoldSim Version 7.10," GoldSim Consulting Group, Golder Associates, Inc., Redmond, WA (2001).
8. BROSSEAU, D.A., "Compliance Assessment Document for the Transuranic Waste in the Greater Confinement Disposal Boreholes at the Nevada Test Site. Volume 4: Application of Assurance Requirements," Sandia National Laboratories Report SAND2001-2977 (2001).
9. BN (BECHTEL NEVADA), "Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site, Nye

County, Nevada," DOE/NV/11718—449-REV 1. Bechtel Nevada, Las Vegas, NV, (2001).
10. U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA), "A Ground-Water Protection Strategy for the Environmental Protection Agency," August 1984**.**
11. CHAPMAN, J. B. "Classification of Groundwater at the Nevada Test Site," Desert Research Institute Pub. #45069, DOE/NV/10384-28 (1994).
12. U. S. DEPARTMENT OF ENERGY (DOE), "Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada," DOE/EIS/0243, Nevada Operations Office, Las Vegas, Nevada (1996).
13. U.S. DEPARTMENT OF ENERGY (DOE) MEMORANDUM, "Compliance Assessment for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Site," James J. Fiore and Raymond P. Berube to Carl P. Gertz, February 5, 2002.