PEER 3 - Waste Characterization Peer Review

CAO PLAN
Carlsbad Area Office

Revision 0

C-1

Title: Waste Characterization Analysis (WCA) Peer Review Plan

(Assistant Manager, Office of Regulatory Compliance, Carlsbad Area Office) 6/27/96 Date:

1. INTRODUCTION

This Waste Characterization Analysis Peer Review (WCA Peer Review) Plan describes the peer review that will be conducted to meet the peer review requirements prescribed in 40 CFR Part 194.27(a)(2).

This section stipulates that a peer review will be conducted of the analysis required in section 194.24(b), i.e., "The Department shall submit in the compliance certification application the results of an analysis which substantiates: etc." The analysis will consist of a report that describes the decisions, rationale, and determination of the list of TRU waste components and waste characteristics that are included as input to the 1996 performance assessment (PA) modeling. In addition, it will include those TRU waste components and characteristics considered and excluded from consideration in the PA. The peer review will be conducted to determine the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report."

1.1 BACKGROUND

In accordance with the regulatory requirements specified in 40 CFR Part 191 and implemented in accordance with the criteria specified in 40 CFR Part 194, section 194.27(a)(2) "Any compliance application shall include documentation of peer review that has been conducted, in a manner required by this section, for "Waste Characterization Analysis" as required in section 194.24(b)." Section 194.27(b) further specifies the manner in which the peer reviews will be conducted, i.e., "Peer review processes required in paragraph (a) of this section, and conducted subsequent to the promulgation of this part, shall be conducted in a manner that is compatible with NUREG-1297, "Peer Review for High-Level Nuclear Waste Repositories."

The regulatory requirements governing waste characterization, as specified in 40 CFR Part 191, are implemented in part through criteria in 40 CFR Part 194.24(c)(1) requiring that any compliance application shall "Demonstrate that, for the total inventory of waste proposed for disposal in the disposal system, WIPP complies with the numeric requirements of [Sec.] 194.34 and [Sec.] 194.55 for the upper or lower limits ..., as appropriate, for each waste component identified in paragraph (b)(2) of this section, and for the plausible combinations of upper and lower limits of such waste components that would result in the greatest estimated release."

Sandia National Laboratories (SNL) is responsible for the selection and development of conceptual models that reasonably represent the future states of the disposal system. These conceptual models include those processes that affect the waste disposed in the disposal system and the ability of the disposal system to contain the waste (within regulatory limits) for the regulatory period. The basis of the "Waste Characterization Analysis Report" is to identify those TRU waste components and characteristics that have been determined to be of importance to, and therefore included in, the 1996 PA modeling, as well as those that were considered and excluded.

1.2 PURPOSE

The purpose of this WIPP Peer Review Plan is to define the peer review process that will be conducted to determine the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report."

This peer review will be conducted in accordance with the requirements of NUREG-1297 which states, "A peer review is a documented, critical review performed by peers who possess qualifications at least equal to those of the individuals who conducted the original work. These individuals must be independent of the individuals who conducted the original work. These individuals must be independent of the work being reviewed; independence from the work reviewed means that the peer was not involved as a participant, supervisor, technical reviewer or advisor in the work being reviewed, and b) to the extent practical, has sufficient freedom from funding considerations to assure the work is impartially reviewed."

1.3 SCOPE

This WCA Peer Review Plan describes the peer review processes that the DOE Carlsbad Area Office (CAO) will utilize for the review of the "Waste Characterization Analysis Report." The peer review will be an in-depth critique of assumptions, alternate interpretations, methodology, and acceptance criteria employed, and of the conclusions drawn in the original work. This WCA Peer Review Plan defines the approach, methods, criteria, schedules, deliverables, and resources required for conducting the WCA Peer Review. The WCA Peer Review will confirm the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report" as required by 40 CFR Part 194.24(b). The review will consider the documentation of rationale and analyses that are described in the "Waste Characterization Analysis Report." This report summarizes the decisions, rationale, and determination of the list of TRU waste components and characteristics that are included in the PA and in the TRU waste components and characteristics considered and excluded.

2. PEER REVIEW PLANNING AND IMPLEMENTATION

2.1 APPROACH

The DOE-CAO has prepared the Office of Regulatory Compliance (ORC) Team Procedure for Peer Review (TP 10.5) to document the approach for conducting the peer review process. The WCA Peer Review Panel will conduct the peer review activities associated with the confirmation of the adequacy, reasonableness, and completeness of the waste characterization analysis in accordance with TP 10.5, the Peer Review Management Plan, and this WCA Peer Review Plan. A DOE-CAO contractor, Informatics, Inc., has developed Informatics Desk Instruction (IDI) 1.0 that will be used in conjunction with TP 10.5.

DOE-CAO has prepared the "Waste Characterization Analysis Report" which was developed to meet the requirements of 40 CFR Part 194.24(b). Background documentation used to prepare this report, plus the report itself, will form the technical basis of the peer review.

2.1.1 DATA AND INFORMATION USED TO REVIEW THE WASTE CHARACTERIZATION ANALYSIS

The Peer Review Panel will utilize the CAO TRU Waste Baseline Inventory Reports (TWBIR) that describe the chemical, radiological, and physical composition of the existing waste and, to the extent practicable, the description of the chemical, radiological, and physical composition of to-be-generated waste proposed for disposal in the disposal system. The waste characterization analysis, as prescribed in 40 CFR Part 194 section 194.24(b), is described in the "Waste Characterization Analysis Report." The Waste Characterization Analysis Peer Review Report will be based on the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report" that describes the TRU waste characteristics an components included in the PA calculations.

2.1.2 COMPOSITION OF PEER REVIEW PANEL

The WCA Peer Review Panel will be composed of a minimum of three individuals who meet requirements identified in TP 10.5. The duration of the WCA Peer Review Panel review process is anticipated to last a total of 3-5 weeks. The Peer Review Selection Committee will appoint the panel members based on their technical expertise and the requirements of TP 10.5 and this Plan.

2.1.3 LOGISTICS AND MANAGEMENT

When the WCA Peer Review Panel convenes, Panel members will receive formal orientation and training. The orientation will help to familiarize Panel members with the WIPP containment system. Each peer reviewer will be selected, oriented, and trained in accordance with approved procedures. The peer reviewers also will be familiarized with the parameter input to the PA codes and the results of prior PAs, sensitivity analyses, and critical comments from previous reviews as related to TRU waste characteristics. It is the intention of DOE-CAO to have the WCA report and other data available for review when the WCA Panel begins the review process.

2.2 METHODOLOGY

The WCA Peer Review will follow the methodology provided in NUREG-1297, as augmented by the specific requirements contained in 40 CFR Part 194.22 and is intended to meet the peer review requirements as specified in 194.27(b). The purpose for conducting a peer review of the "Waste Characterization Analysis Report" is to meet the requirement stated in 40 CFR Part 194.27(a)(2). Adequacy criteria are provided in Section 2.3.

2.3 ADEQUACY CRITERIA

Adequacy of information and analyses associated with the "Waste Characterization Analysis Report" will be based on the Peer Review Panel's determination that the information and analyses meet commonly accepted technical and scientific standards. Criteria stipulated in NUREG-1297 may include, as stipulated:

- Adequacy of requirements and criteria;
- Validity of assumptions;
- Alternate interpretations as appropriate;
- Uncertainty of results and consequences if wrong;
- Appropriateness and limitations of methodology and procedures;
- Adequacy of application;
- Accuracy of calculations; and
- Validity of conclusions.

In evaluating the existing information and analyses, the Peer Review Panel may also consider the following as appropriate:

- The source of the information and analyses, e.g., professional judgment, published source material, etc.
- The assumptions, calculations, extrapolations, interpretations, methods, and conclusions pertinent to the rationale and analyses are appropriate to identify and assess the impact of waste characteristics on the disposal system performance.

2.4 SCHEDULE

The PR Manager, working closely with CAO-ORC and SNL, has developed a preliminary schedule for conducting the WCA Peer Review. The peer review will consist of a review of the "Waste Characterization Analysis Report." Supporting data and information used to develop this document will form the basis of this review. Because of the close timing of this review and resultant report development, flexibility is required by all supporting organizations (i.e., DOE-CAO, SNL, the PR Manager, staff and panel members) to accommodate the peer review schedule and any changes made due to uncertainty in the timing of data availability. Attachment A contains a schedule of WCA Peer Review activities and milestones. This schedule will serve as the baseline schedule from which requested schedule deviations will be evaluated and approved, if appropriate. Revisions to the baseline schedule will not require revision to this plan but will be attached to the plan by reference.

2.5 DELIVERABLES

The final report for the WCA Peer Review will be submitted to DOE-CAO. A list of mandatory topics and suggested outline for the Peer Review Final Report is provided in Attachment B. This outline may be utilized to guide the review of the data and information used to confirm the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report."

3. QUALITY ASSURANCE

The WCA Peer Review process will be conducted in a controlled manner and in compliance with TP 10.5.

4. RECORDS MANAGEMENT

Records and documentation generated as a result of peer review activities defined in this WCA Peer Review Plan are identified in TP 10.5. WCA Peer Review records will be assembled and maintained in accordance with the Peer Review Mangement Plan and IDI 1.0. Upon completion of the WCA Peer Review, a complete set of WCA Peer Review records will be delivered to DOE-CAO. Ultimately, peer review records will be dispositioned in accordance with DOE-CAO records management requirements defined in CAO-MP 4.5.

5. DOCUMENT CONTROL

All plans, procedures, and other documents that require document control will be handled in accordance with the DOE-CAO document control procedure defined in CAO-MP 4.4.

ATTACHMENT A

WASTE CHARACTERIZATION ANALYSIS PEER REVIEW SCHEDULE

	DRAFT	FINAL
WCA Peer Review Plan	6/6	6/20
PR Panel Assigned	N/A	6/24
WCA Report Plan to PR Manager	NA	7/10
Draft WCA Peer Review Report	7/24	N/A
Final WCA Peer Review Report	N/A	7/30

ATTACHMENT B

PEER REVIEW REPORT OUTLINE
(SUGGESTED)

Executive Summary

1. Introduction

2. Purpose

3. Description of Work Performed

4. Evaluation of Work Performed

    A. Adequacy of Requirements and Criteria
    B. Validity of Assumptions
    C. Alternate Interpretations
    D. Uncertainty of Results and Consequences if Wrong
    E. Appropriateness and Limitations of Methodology and Procedures
    F. Adequacy of Application
    G. Accuracy of Calculations
    H. Validity of Conclusions

5. Conclusions

6. Dissenting Views

7. Summary

8. Signatures

9. Peer Review Members and Acceptability

FINAL REPORT

WASTE CHARACTERIZATION ANALYSIS PEER REVIEW REPORT

A PEER REVIEW
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FOREWORD

The Environmental Protection Agency promulgated "Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR 191 Disposal Regulations Final Rule" in Code of Federal Regulations, Title 40, 194 (40 CFR 194) on February 9, 1996. The 40 CFR 194 regulation prescribes three specific peer reviews and also provides the opportunity for the Department of Energy to use peer reviews, conducted in accordance with NUREG-1297, as a means of qualifying data and information for use in the demonstration of compliance.

This report contains the results of a peer review of the Waste Characterization Analysis used in the demonstration of WIPP compliance with 40 CFR 194. To ensure the independence of this review, the Department of Energy has directed the assignment of an independent contractor to administratively manage the peer review activities. Peer reviewers were selected based on their demonstrated independence from the work being reviewed and their technical expertise in the subject matter to be reviewed. The peer review panel members collectively possess an appropriate spectrum of knowledge and experience in the subject matter reviewed.

This peer review was conducted in compliance with the quality assurance requirements defined in 40 CFR 194.

ACRONYMS

CCA	Compliance Certification Application
CCDF	Complementary Cumulative Distribution Function
CFR	Code of Federal Regulations
CH	contract handled
DOE-CAO	U.S. Department of Energy Carlsbad Area Office
EDTA	Ethylene Diamine Triacetic Acid
EPA	U.S. Environmental Protection Agency
MDL	method detection limit
PA	performance assessment
RH	remote-handled
SNL	Sandia National Laboratory
TRU	transuranic (waste)
TWBIR	Transuranic Waste Baseline Inventory Report
WCA	Waste Characterization Analysis
WIPP	Waste Isolation Pilot Plant

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APPENDICES

EXECUTIVE SUMMARY

A peer review was conducted, in accordance with the U.S. Department of Energy-Carlsbad Area Office (DOE-CAO) plan entitled "Waste Characterization Analysis (WCA) Peer Review Plan," to assess the adequacy, reasonableness, and completeness of Appendix WCA (draft, July 26, 1996) against the requirements stipulated in 40 Code of Federal Regulations (CFR) 194.24(b). Appendix WCA is being prepared by DOE-CAO for inclusion in the Compliance Certification Application (CCA) for the Waste Isolation Pilot Plant (WIPP). A peer review panel (Panel) consisting of four members with expertise in performance assessment (PA), chemistry, process engineering, and health physics/transuranic (TRU) waste characterization was assembled and convened to conduct the review. The Panel reviewed the WCA, as described in Appendix WCA, against the criteria listed in NUREG-1297. The Panel then examined the criteria in NUREG-1297 and combined, added, and deleted some criteria based on their applicability to the evaluation of the WCA. The evaluation criteria used in the review were:

- Validity of Assumptions
  - Alternate Interpretations
  - Uncertainties and Consequences if Wrong
- Appropriateness and Limitations of Methodology and Procedures
  - Adequacy of Applications
- Validity of Conclusions
- Description of Analysis

In addition to Appendix WCA, the Panel reviewed numerous other documents, attached to Appendix WCA by reference, and an early draft of Appendix SOTERM. The Panel's opinion was that, due to the heavy dependence of Appendix WCA on the information contained in Appendix SOTERM, it was within the scope of the review to evaluate Appendix SOTERM.

In addition to the reviewed documents, the Panel made use of technical presentations by DOE-CAO, Westinghouse Waste Isolation Division, and Sandia National Laboratories staff, and a tour of WIPP, as a means to gather information for the review. The Panel members conducted the review independently and combined their independent findings into a single set. During the process, the Panel met regularly to discuss progress and any potential dissenting views. There were no dissenting views among panel members.

It is the opinion of the Panel that Appendix WCA (draft, July 26, 1996) meets its goal in some areas, is weak but defensible in others, and is inadequate in others. Section 4 discusses conclusions relative to waste characteristics and waste components. Section 6 presents a summary of overall conclusions for each area evaluated.

1.0 INTRODUCTION

Specific guidance for the peer review of waste characterization activities relative to the Waste Isolation Pilot Plant (WIPP) Performance Assessment (PA) is contained in the U.S. Department of Energy - Carlsbad Area Office (DOE-CAO) Plan entitled "Waste Characterization Analysis (WCA) Peer Review Plan," dated June 27, 1996. This plan specifies that a peer review will be conducted to assess the adequacy, reasonableness, and completeness of the "Waste Characterization Analysis Report" contained in Appendix WCA and prepared to address the specific requirements of 40 Code of Federal Regulations (CFR) 194.24(b). The peer review plan states in part: "The purpose of the WCA is to identify those TRU waste components and characteristics that have been determined to be of importance to, and therefore included in, the 1996 PA modeling, as well as those that were considered and excluded." Section 24(b) of 40 CFR 194 requires DOE to identify and describe qualitative information on those physical, chemical, and radiological characteristics of the waste which can influence disposal system performance.

There are two types of waste components that are important in transuranic (TRU) waste characterization: radioactive materials and certain non-radioactive material components which can affect mobility of the radioactive materials. Physical, chemical, and radiological characteristics of radioactive materials are needed to establish compliance with the containment requirements of 40 CFR 191.13. Non-radioactive materials whose characteristics affect mobility of radioactive materials must also be analyzed for their impact on migration of the radioactive materials in the WIPP.

40 CFR 194.24(b) identifies characteristics (solubility, radionuclide-containing colloidal suspensions, gas production, shear strength, and compressibility) and components (metals, cellulosics, chelating agents, water and other liquids, and radioactivity in terms of curies) as a minimal list of essential elements of the WCA. The WCA peer review was performed to determine the adequacy, reasonableness, and completeness of the Appendix WCA prepared for inclusion in the Compliance Certification Application (CCA) for WIPP.

2.0 PURPOSE

The purpose of the WCA Peer Review was to establish a formal process to determine the adequacy, reasonableness and completeness of the draft document dated July 26, 1996, Appendix WCA. A peer review panel, consisting of four members, was convened to undertake the work. This report is a documented summary of the Panel's activity in conducting the evaluation of the analyses performed on waste characteristics and components for compliance with the requirements in 40 CFR 194.24(b), as described in Appendix WCA.

This review was conducted in support of, and meets the regulatory requirements of 40 CFR 191, and the implementation of those requirements by 40 CFR 194. In 40 CFR 194, peer review of WCA is specifically identified by the U.S. Environmental Protection Agency (EPA) as an activity required to supplement the DOE's CCA for the WIPP.

According to 40 CFR 194.27, the peer review is to be conducted by following the guidelines in the U.S. Nuclear Regulatory Commission's NUREG-1297, Peer Review for High-Level Nuclear Waste Repositories. The evaluation criteria set forth in NUREG-1297 were used by the Panel as a baseline for reviewing the WCA. These criteria require an in-depth critique of assumptions, calculations, extrapolations, alternate interpretations, methodology, and acceptance criteria employed and of the conclusions drawn in the original work. The Panel examined the evaluation criteria in NUREG-1297 for their applicability to the review of the WCA. This examination led to some of the criteria in NUREG-1297 being retained, combined, deleted, and/or supplemented by additional criteria (see Section 3 of this report).

3.0 DESCRIPTION OF WORK/APPROACH

3.1. General

The WCA Peer Review Panel was assembled and convened to review and assess the adequacy of Appendix WCA. Three versions of the draft Appendix WCA were reviewed by the Panel because the final version had not been completed by DOE when the Panel undertook its review. This report is based upon the latest draft, dated July 26, 1996.

The Panel received background information on waste characterization and the regulatory requirements for review. The Panel was trained on the administrative and protocol aspects of the review. Following this training, the Panel received technical presentations by the authors of Appendix WCA from Sandia National Laboratories (SNL), Westinghouse Waste Isolation Division, and DOE-CAO staff. As part of the presentations, the Panel toured the WIPP site. SNL provided the Panel with numerous technical reports and memoranda in support of the information and conclusions contained in Appendix WCA. The Panel also received a presentation by members of the Environmental Evaluation Group on their assessment and opinions of the WCA and the TRU Waste Baseline Inventory Report. Finally, in addition to the technical presentations by SNL, the Panel had a number of technical discussions with SNL staff, both at panel members' requests and at SNL requests. These discussions, open to observers, were for clarification of specific technical issues.

The Panel requested and received a draft of Appendix SOTERM, which will also be included in the CCA. Panel members unanimously agreed that, because Appendix WCA heavily referenced Appendix SOTERM, a review of the latter was imperative in order to review Appendix WCA. Thus, the Panel reviewed Appendix WCA, Appendix SOTERM, and the numerous reports and memoranda supplied by SNL. These materials were the primary source of information the Panel used to make their assessment of the adequacy of Appendix WCA.

In its early meetings, the Panel defined and agreed on the scope of the review. It was agreed that the review will be limited to issues discussed in Appendix WCA as they pertain to defining a source term for use in the PA calculations for construction of the complementary cumulative distribution function (CCDF) required by 40 CFR 191.13. The Panel also reviewed the procedure and evaluation criteria contained in NUREG-1297, which 40 CFR 194 stipulates as the guidelines to be employed in the independent peer reviews for specified aspects of the CCA, including the WCA. Based on this review, the Panel unanimously agreed on the procedure and evaluation criteria that would be used to complete the review and prepare this report. The evaluation and selection of the criteria are discussed in subsection 3.2.

The Panel agreed that in conducting the review, each member would focus on his/her area of expertise. One member focused on performance assessment, another on chemistry, a third on process engineering, and the fourth one on TRU waste characterization and health physics. Each panel member reviewed the aforementioned documents independently and prepared their comments accordingly. During the process, the Panel met on a regular basis to discuss progress and any other issues, as necessary, to ensure consensus. The prepared comments were then merged into this report.

3.2. Evaluation Criteria

The Panel reviewed the criteria set forth in NUREG-1297. Based on that review, some criteria were chosen, others combined, and other deleted. The results of the review of the evaluation criteria is discussed below.

3.2.1.. Adequacy of Requirements and Criteria

The Panel agreed that this criterion would be deleted and not used in the review of Appendix WCA. The rationale for that decision was the Panel's interpretation that the criterion would require the Panel to evaluate the adequacy and appropriateness of the requirements set forth in 40 CFR 191 and 40 CFR 194. The Panel unanimously decided that an evaluation of the regulatory requirements was outside the scope of the review.

3.2.2. Validity of Assumptions

The Panel agreed that the essence of the review will involve an assessment of the assumptions made in the WCA, and therefore, this criterion was retained.

3.2.3. Alternate Interpretations

The Panel agreed that, in the assessment of the validity of the assumptions, the possibility of alternate interpretations would be explored. Therefore, it was agreed to retain this criterion, but as a subset of the "validity of assumptions."

3.2.4. Uncertainties and Consequences if Wrong

The Panel agreed that this criterion would also be used in assessing the validity of assumptions made, and therefore, it was retained as a subset of the "validity of assumptions" criterion.

3.2.5. *Appropriateness and Limitations of Methodology and Procedures*

The Panel unanimously decided that part of the review would require an assessment of the adequacy of the methods and procedures used to draw the attendant conclusions in the WCA. Therefore, this criterion was retained as a stand-alone evaluation criterion.

3.2.6. *Adequacy of Applications*

It was the Panel's opinion that, in evaluating the appropriateness and limitations of the methods and procedures, determining the adequacy of alternative applications would be necessary. Therefore, this criterion was made a subset of "Appropriateness and Limitations of Methodology and Procedures."

3.2.7. *Accuracy of Calculations*

The Panel decided to eliminate this criterion. The Panel did not have the ability to perform or repeat the calculations supporting the WCA, and consequently, it would not be possible to assess the accuracy of the calculations. Such an assessment was considered outside the scope of the review.

3.2.8. *Validity of Conclusions*

The Panel decided to retain this criterion as a stand-alone criterion. Assessing the validity of conclusions in the WCA was considered well within the scope of the review.

3.2.9. *Description of Analysis*

This particular criterion is not included in NUREG-1297; however, the Panel felt that the ability to assess the WCA would, to a large extent, depend on the adequacy, completeness, and clarity of the description of the supporting analyses in Appendix WCA and/or the referenced documents. Therefore, this criterion was added.

4.0 EVALUATION OF WORK

This section summarizes the evaluation of the WCA, as described in the draft Appendix WCA, dated July 26, 1996, by the Panel against the criteria discussed in Subsection 3.2 (Evaluation Criteria). The findings of the Panel's evaluation, as presented below, are separated into three parts consistent with 40 CFR 194.24(b): Waste Characteristics (Subsection 4.1), Waste Components (Subsection 4.2), and Exclusion of Waste (Subsection 4.3).

4.1. Waste Characteristics

This subsection summarizes the Panel's evaluation of the consideration by DOE of waste characteristics and their impact on PA. The Panel's evaluation addressed, but was not limited to, the waste characteristics listed in 40 CFR 194.24(b) (1).

4.1.1. Radionuclide Inventory and Release Limits

The analysis conducted to determine the radionuclide inventory for use in the PA, and the release limits for construction of the CCDFs is described in a series of memoranda included in Appendix WCA by reference. Characteristics of the radionuclides that are important for PA purposes are identified in various references as total curie content, TRU curie content, mass, half life, solubility, mole content, and oxidation state. This information is required in order to comply with the requirement of 40 CFR 194.24 (a), which states that a compliance application shall describe the chemical, radiological, and physical characteristics of the waste. Basic TRU waste data, and assumptions leading to preparation of additional data (such as EPA Units of Waste, EPA Units, and moles of radioactive materials), were reviewed to determine whether the information met the intent of 40 CFR 194.24(b)(1) and whether this information is considered adequate for use in PA calculations. The radioactive materials inventory was generated and calculated with the intent of addressing all radiological criteria that appear in 40 CFR 191.

Basic characteristics of the TRU wastes to be emplaced in WIPP are defined in the most recent Transuranic Waste Baseline Inventory Report (TWBIR), Revision 3. This revision was prepared specifically to support the PA, and includes descriptions of waste "currently allowed to be disposed of in WIPP." The basic inventory of TRU waste described in the TWBIR is composed of a stored waste fraction (already generated), and a projected waste fraction, based on currently authorized activities. The projected fraction does not address TRU wastes to be generated by Environmental Restoration activities or decontamination and decommissioning activities in the future, nor does it address probable changes in waste generating techniques which may serve to increase concentrations of TRU radionuclides in the waste. However, a scaling technique was applied to the stored plus projected waste inventory for contact handled (CH) waste in order to model the impacts of a full repository at closure. This technique was performed to comply with specific requirements of 40 CFR 194.24(b). Remote handled (RH) waste was not similarly scaled-up because of its limited volume.

The TWBIR is prepared on a waste stream basis by each generating/storage site. Estimates of waste volumes, based on numbers of containers in inventory, and kinds and quantities of radioactive materials (based on radio-assay measurement) are prepared. The site waste stream data are collected and consolidated into eleven more general waste forms for CH wastes and seven waste forms for RH waste. The radionuclide inventory has been prepared by calculating the quantities of 195 specific radionuclides assumed to be present in the waste, normalizing the data (correcting for decay) to December 1995, and summing the curie quantities required to produce a normalized radioactive materials inventory in terms of total curies, and an overall waste concentration in terms of curies per cubic meter. The TWBIR has been recognized by the DOE-CAO as the solely applicable TRU waste inventory in the TRU program. DOE decided that the information contained in the TWBIR was acceptable for input into PA.

The inventory, normalized to December 1995, was projected to the year 2033, the proposed date for WIPP closure. DOE decided that the minor impact on the inventory did not justify the time and expense of revising the TWBIR and associated data. The inventory was also separated into a total curie inventory.

The TWBIR data were used to determine the total number of EPA units of waste in the "full WIPP" (4.07 EPA units). Because there is a listed release limit for each radioactive material, the number of EPA units for each radionuclide (based on total EPA units and percentage composition of each radionuclide in the waste) was also calculated in order to construct the CCDF. Other calculations were performed to convert the curie load to radionuclide mass and total moles of the radionuclides, to allow performance of radioactive material mobility calculations.

To reduce costs and time to produce the source inventory, a rationale was developed to identify and use key radionuclides in the inventory for both direct release (intrusion) and indirect release (brine migration). To assess the overall importance of thermal heating on repository performance, a calculation of the maximum RH-TRU thermal heat load was performed.

For the undisturbed scenario, brine inflow into the repository, followed by transport up a shaft through the Culebra and out to the accessible environment, a homogeneous source term was calculated. For the intrusion scenarios, a heterogeneous waste source was calculated.

4.1.1.1. Validity of Assumptions

The radionuclide inventory was estimated by using data, analyses, and other information included in the TWBIR. The TWBIR captures recent information from the different DOE generating/storage sites. These data were provided to DOE-CAO, and DOE-CAO staff and contractor personnel reviewed the information for reasonableness, and consolidated the site data into the overall TRU waste baseline inventory. This process, and the decision to use the TWBIR data as the basis for the PA radionuclide inventory analysis, appear to be reasonable and adequate.

Information and methods used to establish the basic radioactive materials data and inventory were reviewed from three perspectives: 1) adequacy of the data as input for PA calculations; 2) assurance that the inventory addresses all the requirements for compliance with 40 CFR 194.24(b); and 3) assurance that the data quality is either equivalent to that which would be produced under a formal NQA-1 Quality Assurance program, or of a quality adequate for PA.

It was concluded that, in general, the basic information on CH waste in the TWBIR to be used in the establishment of the PA radiological source term is adequate and appropriate for PA purposes. However, the method by which RH inventory was constructed is not clear. Although most fission products in the RH waste streams have been excluded from the PA database, mostly due to their short half-lives, the rationale for calculating quantities of the long-lived fission products present in the inventory, and eliminating these longer-lived radionuclides from consideration in the inventory, was not addressed.

Because there had been no prior requirements to gather these types of data under a formal quality assurance (QA) program consistent with NQA-1 requirements, and a very short response time was imposed, the sites compiled their inventories using the best available information. The Panel concluded that, given these constraints, the data submitted are conservative (overstates quantities) and the best that could be obtained within reasonable time and cost.

The decision to use the inventory as decayed to 1995, rather than to renormalize all the data to 2033 (the proposed year of WIPP closure), and to use the 1995-decayed inventory as the initial inventory seems reasonable and appropriate. It was adequately demonstrated that decaying the entire inventory for an additional 38 years will have a negligible effect on WIPP performance.

Use of a homogeneous waste source term for the undisturbed scenario was clearly explained, and seems to be a reasonable approach to estimating source term transport. However, it was difficult to discern from Appendix WCA and associated documents exactly how the heterogeneous source term was developed and used in the intrusion scenarios. Further, it was not demonstrated that this approach is appropriately conservative.

The basis for estimating the current TWBIR projected source term is well defined. However, the fact that 70% of the waste destined for disposal at WIPP is yet to be generated makes the source term uncertain. The Panel concluded that not all available information was used to define the source term. A large fraction of the future waste volume is contained in formerly operated facilities, specifically in existing processing and air handling systems. The isotopic composition of the TRU materials is no different than that which is currently in the stored waste inventory. The Panel concluded that these facts are sufficient to allow further estimation of the radionuclide source term.

It is also known that the composition of the future generated wastes will change in the future. The current trend in TRU waste management is to minimize waste volumes, a technique that will tend to increase the TRU concentrations in the waste. Concentrations of fissile materials in the waste are expected to rise toward the fissile limit of 200 grams per drum, rather than stay at the current average level of about 10 grams per drum. Volumes of combustible waste, currently composing about 65% of the current waste volume, will be reduced, with a resultant reduction in the volume of cellulosic materials in the TRU waste. These events could have some impact on WIPP performance, yet they were not discussed in detail in the Appendix WCA.

4.1.1.2. Appropriateness and Limitations of Methodology and Procedures

It was concluded that a very thorough and systematic analysis was performed in estimating the parameters necessary to establish the radionuclide inventory and the release limits for constructing the CCDF. The most salient limitation of the approach was that the vast majority of the waste destined for disposal at WIPP is still to be generated. Therefore, the nature of that waste is, to a large degree, unknown. This uncertainty led to the need to project about 70% of the WIPP inventory based on 30% information, and then scale up the inventory to the "full WIPP" volume. The method used appears to be reasonable; however it is the Panel's opinion that not all available data were used in making the waste inventory projection.

It was difficult to discern from Appendix WCA and from other referenced documents exactly how the heterogeneous source term was constructed and used in the intrusion scenarios.

4.1.1.3. Validity of Conclusions

The radionuclide values determined for use in the PA seem, generally, to be acceptable and reasonable, given the information in the TWBIR and the known uncertainties in that information. Use of a homogeneous source term for the undisturbed scenario seems a valid and reasonable approach. The validity of the use of a heterogeneous source term for the intrusion scenarios could not be evaluated because the analysis used to determine this source term and its use was not clearly presented in Appendix WCA, or in the referenced material.

4.1.1.4. Description of Analysis

Various internal SNL memoranda referenced in Appendix WCA provide adequate description of the analysis conducted to estimate concentration of radionuclides in the waste and the release limits, as well as the scale-up of the inventory for use in the undisturbed performance scenario. On the other hand, the analysis used to determine the heterogeneous source term for the intrusion scenario was not clear; thus, it was not possible to assess its appropriateness.

4.1.2. Solubility

Appendix WCA describes the components and conditions that impact the estimation of actinide solubilities. The methods used to estimate these solubilities are described in more detail in Appendix SOTERM. As a result, a draft of the latter was also reviewed.

4.1.2.1. Validity of Assumptions

The controlling assumption governing radionuclide solubility is that the repository is going to be backfilled with magnesium oxide. This will keep the pH of the brines basic and the solubility of the radionuclides low. The median solubilities for the elements of interest in Salado brine range from 8.8E-06 to 6.0E-09. The estimates of actinide solubilities were performed using the FMT computer code. The chemical and other data and information needed to estimate the actinide solubilities were provided as input to FMT from a set of experiments. FMT estimated the median value of the solubilities and their associated uncertainty. The latter was estimated to be one order of magnitude or less for the chemical conditions tested (see Appendix SOTERM). While the estimated median values seem reasonable and consistent with available literature, the uncertainty range about the median seems unreasonably small. For example, a previous expert judgment study by SNL on actinide solubility concluded that ". . . the efforts resulted in the development of very wide probability distribution(s). . . due to the impact of both great uncertainty in room conditions and the nature of probability distributions ..." Thus, the estimated uncertainty in the solubility predicted by using the FMT code and a limited set of experiments seems inconsistent with earlier results of the expert judgment panel. Neither Appendix WCA nor Appendix SOTERM discuss the apparent inconsistency in the estimated and elicited uncertainty ranges for actinide solubility.

The magnesium oxide will react with any carbon dioxide generated via microbial decomposition of the organics in the waste to form magnesium carbonate. Thus, the possibility of forming actinide carbonato complexes is removed. A reducing atmosphere will be established in the repository due to the large amount of low valent metal, predominately iron, that will be present as a result of the anoxic corrosion of the steel drums. In such an atmosphere, the actinides are expected to be in lower oxidation states. Only uranium is anticipated to be present as the +VI ion.

The assumption that magnesium oxide will control pH and alleviate the effect of carbon dioxide is based on sound chemistry in aqueous solutions. However, no actual experimental data exist to support these conclusions in high ionic strength liquids such as the Salado and Castile brines. Should the magnesium oxide not react with carbon dioxide under repository conditions, the calculated solubilities of the actinides will be too low by as much as several orders of magnitude. If the assumption controlling oxidation state distribution is wrong, then the existence of Pu(VI) is possible. This oxidation state is more soluble than Pu(IV) or Pu(III).

4.1.2.2. Appropriateness and Limitations of Methodology and Procedures

The experimental methods used seem satisfactory. The major limitation is the small number of experiments conducted. It is possible that the limited set of experiments did not capture the entire range of possible chemical conditions within the repository. Consequently, the uncertainty range in the numerical value of actinide solubility seems unexpectedly narrow. There is an apparent inconsistency with the results of an earlier expert judgment elicitation study which concluded that the uncertainty in repository conditions would cause, in part, a large uncertainty in solubility values.

The controlling parameter for actinide solubility is the reaction of magnesium oxide with any carbon dioxide that is generated within the repository. If this reaction occurs in high ionic strength brines, the approach taken toward the solubility of actinides is reasonable. However, there are no experimental data that show this chemistry will occur under the anticipated repository conditions. Because one single parameter was selected to dominate the control of solubility, the Panel felt that the lack of experimental data on that parameter (i.e., MgO) leaves the entire issue unresolved.

4.1.2.3. Validity of Conclusions

The conclusions based on a limited number of experiments, insofar as the uncertainty in solubility limits is concerned, do not seem to be appropriately justified. The apparent inconsistency with the results of a previous study on the same subject is not appropriately addressed. The small uncertainty (one order of magnitude or less) has not been adequately defended.

If the magnesium oxide chemistry in WIPP brines occurs as assumed, then the treatment of actinide solubility in the WCA is judged to be reasonable. However, this assumption should not be made without supporting experimental data. Without acquiring the data, it is felt that the question of actinide solubility has not been adequately addressed in Appendix WCA.

4.1.2.4. Description of Analysis

The description of the analysis performed to estimate the actinide solubilities in Appendix SOTERM and the factors that influence the solubility in Appendix WCA is adequate. The difficulty arises from conclusions based on a very limited set of experiments and a lack of experimental data that support the assumption that magnesium oxide will control actinide solubility in WIPP brines.

4.1.3. Colloids

Appendix WCA discusses the actinide colloid source term more completely than solubility; however, the discussion relies heavily on a series of memoranda that describe how the colloid source-term parameters were determined. Therefore, the review concentrated on those memoranda, which were provided as part of the package to be reviewed (see Appendix 3).

Four types of radioactive colloids are considered in the WIPP PA calculations: 1) intrinsic colloids, 2) sorption of soluble actinides onto mineral colloids, 3) sorption of actinides onto humic colloids, and 4) sorption of actinides onto microbes. These four types of colloids were identified from a thorough review of the literature. Experimental programs were then designed and carried out to determine the amount of radioactivity that would be available for release from the repository for each of the aforementioned types of colloids.

4.1.3.1. *Validity of Assumptions*

The possibility that colloids can form and contribute to increased mobility of radionuclides has been recognized. The literature review performed to determine the types of colloids that should be considered in the PA calculations seems to have been sufficiently thorough. The selection of the aforementioned four types of colloids is consistent with the literature on radioactive colloids. Based on currently prevalent knowledge, the assumption that those four types of colloids should be the key ones is reasonable and adequate.

A number of experiments were designed and conducted to determine numerical values for six parameters to capture the amount of radioactivity that would be available for transport in the form of colloids. These parameters are:

CONCINT	concentration of actinides associated with mobile intrinsic colloids
CONCMIN	concentration of actinides associated with mobile mineral colloids
CAPHUM	maximum concentration of actinides associated with mobile humic colloids
CAPMIC	maximum concentration of actinides associated with mobile microbes
PROPHUM	proportionality constant of actinides associated with mobile humic colloids
PROPMIC	proportionality constant of actinides associated with mobile microbes

It seems reasonable to assume that these six parameters are sufficient to define the colloid actinide source term.

Even though it is not explicitly stated, implicit in the analyses conducted to determine these parameters is the assumption that the effect of one type of colloids is independent from the presence of other types of colloids. The experiments and interpretation of the data obtained were carried out by a series of principal investigators at different locations. There seems to have been no communication and/or discussion between the investigators to compare notes and explore whether each set of results could have been influenced by the other results obtained. Strong interdependencies between different types of colloids seem unlikely; however, because these were not discussed among the investigators, the possibility of interdependencies and their potential effect on the radionuclide source term will remain an open issue.

A key concern with the estimation of numerical values for the six parameters defining the colloid actinide source term is the manner in which the uncertainty in those parameters was determined. As stated in several of the memoranda referenced in Appendix WCA, the major source of uncertainty associated with these parameters was lack of knowledge. Only a very limited number of experiments were performed, and in many instances, the value of a parameter was determined from a single experiment. In those cases, a constant value was recommended for use in the PA calculations. For those parameters for which a distribution of values was estimated, this distribution centers about a likely value, and triangular distribution was assumed between the lower and upper limits of the distribution. It is believed that this approach does not adequately capture the uncertainty in the colloid actinide source. It is hard to believe, with the preponderance of different interpretations in the literature regarding colloid concentrations in repository environments, that a constant value or even a two-order of magnitude distribution of values would capture the "real" uncertainty in the colloid source term. This is one situation in which the estimation of the numerical values of the six parameters and of their respective uncertainties could have greatly benefited from an expert judgment elicitation. During such an elicitation, experts could have been provided with the experimental results and asked to augment them based on their knowledge and experience to develop a parameter value distribution that more adequately describes the uncertainty in the value of the parameters.

The value of CONCINT was measured to be 10^{-10}, which was below the minimum detection limit (MDL) of the experiment (10^{-9}). The decision was made to set the value of CONCINT to 10^{-9}. This begs the question why was not the value of CONCINT set to 0 since it is an order of magnitude below the MDL? While setting the value of CONCINT to the MDL could be argued for the sake of conservatism, it would have been more reasonable and determinable from a scientific point of view to set the value to 0.

It is assumed that the only intrinsic colloid of importance is formed by Pu(IV). This colloid is expected to be kinetically destabilized by the high ionic strength brines present in the repository. Adsorption of actinides on mineral fragment colloids was also considered. The concentration was estimated to be 2.6E-09 molar. It is assumed that the mineral fragment colloids will not contribute to the overall radionuclide mobility because they are expected to be destabilized in high ionic strength brines. Humic colloids are assumed to be present as components of the emplaced waste and as microbial decomposition products. The ratios of humic-bound actinides to dissolved actinides varies from 4.3E-04 to 6.3 in Castile brine and from 5.3E-05 to 6.3 in Salado brine. Microbial colloids are assumed to play an important role in the transport of actinides. Halophilic microbes are assumed to be present in the repository and other components of the waste (nitrates and phosphates) will serve as nutrients enhancing microbial growth. Calculations have shown the microbial colloids can transport actinides in amounts several times their dissolved concentration.

The assumptions that the Pu intrinsic colloids and the mineral fragment colloids will be kinetically destabilized in high ionic strength brines is valid based on published literature. The estimations of actinides bound to humic colloids are based on experiments that determined the solubility of humic substances in high ionic strength brines, site-binding capacity, and the stability constants for actinides with humic acids. These experiments appear relevant and well done. The values provided to PA for colloidal transport of actinides are reasonable expectations of the contribution of colloidal material to radionuclide transport.

4.1.3.2. Appropriateness and Limitations of Methodology and Procedures

The experimental methods for colloids seem adequate. Their major limitation was the fact that the number of experiments performed (for some parameters only one experiment was used) was not adequate to generate meaningful statistical samples from which the uncertainty in the values of the parameters could be defined adequately. The methodology used could have included an expert judgment elicitation process to augment the experimental results. Such a use of expert judgments would have been appropriate, and in this case, probably necessary.

4.1.3.3. Validity of Conclusions

As stated in several of the memoranda referenced in Appendix WCA, uncertainty due to lack of knowledge is the predominant uncertainty affecting the values of the parameters selected to define the colloid actinide source term. Based on this statement, it is concluded that a single value or even a two-order-of-magnitude parameter value distribution does not capture the uncertainty in the colloid actinide source term parameters adequately for purposes of PA calculations.

4.1.3.4. Description of Analysis

The various memoranda referenced in Appendix WCA adequately described the experimental process and its rationale. The experimental results are also provided, and the interested reader with proper qualifications in colloid chemistry would be able to ascertain the validity of the results and the conclusions drawn from the results. The major drawback of the analysis, as mentioned earlier, is the very few experiments that were performed for each of the parameters, and, given this situation, the fact that the analysis of the results should have been augmented with an expert judgment elicitation process.

4.1.4. Production of Gas

The production (or generation) of two gases has been considered as part of the WCA: generation of H^2 from steel corrosion and generation of CO_2 from microbial degradation of various waste components. The WCA concludes that the impact of H_2 generation will not be significant because the resulting increased gas pressures will not exceed lithostatic pressure. The WCA also concludes that the impact of CO_2 will not be significant because it will be removed primarily by reaction with the magnesium oxide backfill.

4.1.4.1. Validity of Assumptions

It is assumed that there are two major sources for gas generation, anoxic corrosion of steel and microbial degradation of organics. In the corrosion reaction, water is the oxidizing agent producing ferrous hydroxide and hydrogen. Under the conditions assumed to exist in the repository, the hydrogen will undergo no further chemistry. Microbial degradation of organics can occur by the three reactions shown below.

$$C_6H_{10}O_5 + 4.8\ H^+ + 4.8\ NO_3^- \Rightarrow 7.4\ H_2O + 6CO_2 + 24\ N_2$$

$$C_6H_{10}O_5 + 6\ H^+ + 3\ SO_4^{2-} \Rightarrow 5\ H_2O + 6CO_2 + 3\ H_2S$$

$$C_6H_{10}O_5 + H_2O \Rightarrow 3CH_4 + 3CO_2$$

The first two reactions require substantial moles of proton. It is highly unlikely that these reactions will be of any significance given the magnesium oxide backfill and the basic pH that will result. The third reaction produces 3 moles of carbon dioxide and 3 moles of methane. The carbon dioxide will react with the MgO and be of no further consequence. The disposition of the methane is not discussed in Appendix WCA.

The above assumptions concerning gas generation are judged to be valid. The only gas that would affect repository chemistry is carbon dioxide, which will be consumed by the magnesium oxide. Should it not react with MgO, then it would be available to form carbonato complexes with the radionuclides present in the waste, increasing their solubility. At closure there will exist an oxic environment in the repository for a short while. However, at this time there will not be significant concentrations of the flammable gases, hydrogen and methane, to pose a realistic explosion hazard. By the time these gases reach significant concentrations, the repository will be anoxic. It is felt that there is not a significant risk of explosion in the sealed repository.

The assumptions for concluding that gas generation will be have negligible effect on repository performance seem reasonable. For example, from a chemical standpoint, it is reasonable to expect that the presence of MgO in sufficient quantities will be enough to consume the CO_2 generated from microbial activity. It can be shown theoretically that this is a reasonable assumption; however, at this time there are no experimental data to support the assumption. Therefore, before definitive conclusions are reached on the potential insignificant impact of gas generation, experimental data ought to be collected to substantiate or negate the validity of the assumption.

4.1.4.2. Appropriateness or Limitations of Methods and Procedures

As stated above, the theoretical support for the assumptions notwithstanding, their validity will remain an open issue due to a lack of experimental data to support the assumptions.

4.1.4.3. Validity of Conclusions

Based on analytical studies, the conclusion that gas generation will not significantly impact repository performance seems reasonable. However, until experimental data supporting the conclusions are obtained, the issue will remain open.

4.1.4.4. Description of Analysis

The treatment of gas generation in Appendix WCA is generally well done. However, the Appendix does not deal with the disposition of the generated methane. This gas will be produced on a mole-per-mole basis with carbon dioxide and yet there is no mention of its fate in the repository. The experiments showing microbial production of carbon dioxide in WIPP brines are meaningful. However, they would have been more informative had they been done in the presence of the nonferrous metal concentrations anticipated in the repository.

4.1.5. Compressibility

The compressibility of the waste has been determined from tests on simulated waste materials. These tests were based on assumptions of waste content and physical characteristics. Waste compressibility was determined by combining the individual compressibilities of the different waste types into their respective proportions expected at WIPP closure. An elastic-plastic waste compaction model is used. The model and the experimental data supporting it are used as a basis for parameter determination for input into the PA.

4.1.5.1. Validity of Assumptions

Section 5.2.1 describes the basis for determination of compressibility as derived from experiments and models which assume a representative distribution of metals, plastics, combustibles, cellulosics, and sludges tested. It is apparent throughout the WCA that the exact compositions and proportions of components in a waste package are uncertain. However, the assumptions made are considered appropriate and conservative since they did not include shifts in waste form toward reduction of cellulosics and an increase in alternate waste forms.

4.1.5.2. Appropriateness and Limitations of Methods and Procedures

Use of models and experimental data are considered to be an appropriate method for developing waste compressibility parameters.

4.1.5.3. Validity of Conclusions

Even though Appendix WCA states that compressibility is expected to have a significant effect on the performance of the repository due to its impact on creep closure and waste porosity, the appendix was found to be deficient in the discussion of waste compressibility. Several previous studies are referenced that describe the analyses of waste compressibility, but Appendix WCA does not summarize the findings of the analyses. For example, Appendix WCA contains neither discussion nor references on the effect of compressibility on porosity.

4.1.5.4. Description of Analysis

Appendix WCA does not present sufficient technical information to complete an assessment of the analysis. While the Panel concurs that modeling, combined with experimental data, is an appropriate method, the Panel did not have information to assess the reasonableness or accuracy of compressibility-related parameters.

4.1.6. Strength

Waste strength properties are evaluated in the potential for release due to inadvertent human intrusion. A possible pathway for release might be created by a borehole that penetrates a waste storage room. The potential release mechanisms briefly discussed in Appendix WCA include: 1) release from the cutting actions of the drill bit itself (cuttings), 2) erosion by fluids in the borehole (caving), and 3) processes related to pressure blowout (spalling).

4.1.6.1. Validity of Assumptions

There is no discussion of the assumptions used in evaluating waste strength properties presented in Appendix WCA.

4.1.6.2. Appropriateness and Limitations of Methods and Procedures

The discussion of waste strength properties in Appendix WCA was found to be insufficient to assess reasonableness for inclusion in PA. The Panel unanimously agreed that waste strength properties should be analyzed for inclusion in PA.

4.1.6.3. Validity of Conclusions

As stated in Appendix WCA, waste strength is expected to be an important characteristic, particularly in the drilling intrusion scenario. However, the appendix does not present the rationale or technical basis for this conclusion. Similarly to compressibility, the discussion of waste strength was found to be inadequate. The Appendix makes reference to a previous study, but no indication is provided to suggest that the study discusses the analysis of waste strength.

4.1.6.4. Description of Analysis

Appendix WCA does not present adequate information to evaluate the accuracy or reasonableness of waste-strength related waste properties.

4.1.7. Porosity

There is no discussion in Appendix WCA regarding waste porosity. There is an inconsistency regarding the importance of porosity in Subsection 5.2 of Appendix WCA. In one sentence, it is stated that waste compressibility is expected to have a significant impact on repository performance because of its effect on creep closure and waste porosity, thus implying that waste porosity is important. Subsection 5.2.1 of Appendix WCA further reiterates this implication. However, in a later sentence in Subsection 5.2, it is stated also that porosity is expected to have a negligible effect on repository performance.

4.1.8. Permeability

In Subsection 5.2 of Appendix WCA, it is stated that permeability on repository performance is expected to have a negligible effect on repository performance because the waste is far more permeable than the surrounding halite. Therefore, brine flow through the halite will be the slowest step (i.e., brine flow rate is controlling). Laboratory data were cited as the supporting evidence for this conclusion. The eight orders of magnitude difference between the permeability of the halite (10^{-21} m^2) and the waste (10^{-13} m^2) supports the conclusion that waste permeability is not expected to have a significant effect on repository performance.

4.1.9. Heat Generation

Two potential sources of heat within the repository were evaluated: heat generated by RH-TRU waste and several exothermic reactions (MgO hydration and carbonization, steel corrosion, and organic biodegration). In both cases, the analyses indicate that the potential worst-case temperature rises (3° K in one case and 7° K in another) are not sufficiently high to affect repository performance. The analyses conducted to support this conclusion seem to be sufficiently adequate.

4.2. Waste Components

This subsection summarizes the Panel's evaluation of the consideration by DOE of waste components and their impact on PA. The Panel's evaluation addressed, but was not limited to, the waste components listed in 40 CFR 194.24(b) (2).

4.2.1. Metals

Ferrous metals were considered to have significant impact on repository performance in two contexts. First, they were examined as the main agents responsible for maintaining a reducing environment in the repository, in order to enhance the likelihood that the less soluble oxidation states of the actinides predominate. Second, they were considered because metal corrosion can generate H2, thus increasing gas pressure within the repository. In the first case, the presence of ferrous metals represents a favorable condition because the overall impact is to reduce actinide mobility, whereas in the second case, there is a potentially unfavorable condition due to increased gas pressures within the repository. In the latter case, the potentially unfavorable condition was determined to have negligible impact on repository performance because calculated gas pressures never exceed lithostatic levels. The consideration of ferrous metals in these contexts seems appropriate.

4.2.1.1. Validity of Assumptions

Steel drums are the major source of non-actinide metals assumed to be present in the waste. These metals include iron, nickel, manganese, and chromium. Of these, iron and nickel are the most important. Anoxic corrosion of the steels will afford Fe(II) and Ni(II). The presence of low-valent iron will create a reducing environment in the repository. However, if a reducing environment is not present in the repository, then Pu(VI) will become a significant oxidation state. Because higher oxidation states of Pu are more soluble, actinide solubility will increase.

4.2.1.2. Appropriateness and Limitations of Methodology and Procedures

The actinide oxidation states anticipated in the repository and given in Appendix WCA are reasonable based on experimental data showing that low-valent iron is a reducing agent for Pu(VI) in high ionic strength brines.

4.2.1.3. Validity of Conclusions

The conclusions are supported by experimental data obtained under simulated repository conditions. However, if substantial passivation of the steel by carbon dioxide were to occur because of the inability of MgO to react with carbon dioxide in high ionic strength brines, then the assumption of reducing conditions in the repository may not be correct.

Non-ferrous metals were considered because of their favorable effects on preventing an increase in actinide solubility by binding organic ligands. The presence of non-ferrous metals is considered to be significant to repository performance. However, this conclusion is based on simple competing calculations for dilute solutions, because experimental data for concentrated brine solutions projected at WIPP do not exist. While the calculations conducted may suggest the purported effect of non-ferrous metals on repository performance, drawing such a strong conclusion based only on a simple analysis and under conditions considerably different from those expected at WIPP is not appropriate, without the benefits of representative experimental data.

4.2.2. Cellulosics

Cellulosic materials are considered in Appendix WCA because of their effects on radioactive colloidal particle transport and in gas generation. These materials are considered a possible means for adsorbing radionuclides in solution and forming radioactive colloids that could be transported away from the repository. Cellulosics can undergo microbial degradation and generate gases, namely, methane and CO_2.

The consideration of cellulosic materials as a potential source for the generation of radioactive colloids is discussed in detail in Appendix WCA and in the referenced studies. Even though some deficiencies were found in the conclusions reached from the analysis of radioactive colloids formed from cellulosics materials, the approach itself was well thought out.

The generation of CO_2 from the microbial degradation of cellulosics is considered to have a negligible effect on repository performance because this gas would be consumed by reaction with the hydrated MgO backfill. While this conclusion has a sound basis from a chemistry standpoint, the lack of experimental data to support the conclusion weakens the validity of the assumption.

As stated earlier, no discussion could be found in Appendix WCA regarding the impact of methane generation from microbial degradation of cellulosics. Therefore, the adequacy of the consideration of methane on repository performance could not be assessed.

4.2.3. Chelating and Organic Ligand Agents

Chelators were considered as a special class of organic ligands, and therefore, the assessment of their impact as a waste component was lumped with the impact of all organic ligands. The overall effect of organic ligands is to enhance the solubility of actinides. However, these effects are deemed to be negligible in Appendix WCA because of the presence of large quantities of metals in the repository, especially ferrous metals, that effectively bind the ligands.

4.2.3.1. Validity of Assumptions

Of the 60 organic compounds present in the waste, only four are assumed to have any potential impact on actinide mobility. These are acetate, oxalate, citrate, and Ethylene Diamine Triacetic Acid (EDTA). These four were selected because of their water solubility and significant quantities in the waste. Calculations show that actinide solubilities will increase via complexation with these ligands. However, this effect will be negligible given the large amounts of nonactinide metals present in the repository that can compete successfully for the ligands. The most significant of these are the 10,000 moles of nickel. If Ni and Fe do not form stable complexes with organic ligands under the conditions expected in the repository, then the organic ligands in the waste could have a significant effect on actinide solubility.

4.2.3.2. Appropriateness and Limitations of Methodology and Procedures.

The elimination from consideration of most of the remaining organics in the waste inventory was based on their poor solubility in water and the limited quantities identified in the TWBIR. This is a reasonable approach to use; thus, citrate, oxalate, acetate, and EDTA remain as the only organics of interest.

4.2.3.3. Validity of Conclusions

The conclusion that organic ligands will not play a significant role in contributing to actinide solubility is reasonable, but would be much more defensible if there were experimental data to support it. Of specific concern is the nature of the iron and nickel species. In low-ionic strength solutions, solvent complexes of oxygen donor ligands are more stable than chloro complexes. However, in brines, the chloro complexes may be more stable simply due to the presence of large amounts of chloride. While calculations may suggest the purported effect of non-ferrous metals on repository performance, drawing such a strong conclusion based on conditions considerably different from those expected at WIPP is not appropriate. Experiments should be performed to determine whether Ni and Fe form stable complexes with acetate, citrate, oxalate, and EDTA in high-ionic strength brines.

4.2.4. Water and Other Liquids

Only the presence of water in the waste was considered. The volume of water in the waste was assumed to be 0.06% of the total free liquid; the majority of the liquid in the repository is contained in the brine. The restriction on water content comes primarily from the WIPP Waste Acceptance Criterion. It is also assumed that the presence of portland cement and other sorbents intentionally added to the waste will absorb any free-standing water. Therefore, the effect of water and other liquids in the waste itself was assumed to be negligible. There is neither an analysis nor data available to support this conclusion. The conclusion seems to be based primarily on intuitive arguments. While these arguments seem reasonable, further analyses and generation of data would increase the credibility of the conclusion.

4.3. Exclusion of Waste

This subsection summarizes the Panel's assessment of DOE's decision to exclude from PA consideration certain waste characteristics and /or components as authorized criteria set forth in 40 CFR 194.24(b)(3). Major waste components excluded from PA were: 1) many of the radionuclides in the original inventory, and 2) the hazardous constituents in the waste.

4.3.1. Exclusion of Radionuclides

A large number of radionuclides were excluded because they are present in extremely low quantities. Five radionuclides (Pu-239, Pu-240, Am-241, U-233, and U-234) dominate 99% of the EPA unit after 2000 years, and one radionuclide (PU-238) dominates the EPA unit at earlier times. The analysis performed to support this conclusion was well done; it is methodical and complete. Therefore, the exclusion of all other radionuclides from the analysis is justifiable.

4.3.2. Exclusion of Hazardous Constituents

Hazardous waste constituents other than the chelating agents identified in the WCA are excluded from the analysis because, as stated in Appendix WCA Section 1.1, these constituents are regulated by the Resource Conservation and Recovery Act (RCRA), and many have been identified in a no migration variance petition to the EPA. Therefore, the exclusion of the hazardous waste constituents from the WCA is justifiable.

5.0 DISSENTING VIEWS

None.

6.0 CONCLUSIONS

It is the opinion of the Panel that Appendix WCA (draft, July 26, 1996) meets its goal in some areas, is weak but defensible in others, and is inadequate in others. Summary findings of the peer review are below.

Radionuclide Inventory and Release Limits

1. The analysis performed in estimating the parameters needed to establish the radionuclide inventory and release limits for estimating the complementary compliance distribution function (CCDF) was very thorough and systematic. This is a solid piece of work.

2. The analysis used to determine the heterogeneous source term for the intrusion scenario was not clearly presented in Appendix WCA, resulting in an inability to judge its validity and degree of conservation.

Solubility

1. The median values for actinide solubility are reasonable, but the uncertainty ranges about the median are too low and inconsistent with earlier results from the expert judgment panel study.

2. The issue of actinide solubility is not adequately addressed in Appendix WCA because the controlling assumption concerning MgO chemistry in the repository has no experimental data to support it.

Colloids

1. The experiments dealing with colloids in the repository were well done.

2. The uncertainty given for the colloid actinide source term is not adequate for purposes of PA calculations because the number of experiments performed does not generate meaningful statistical samples from which an uncertainty could be adequately calculated.

Production of Gas

1. Appendix WCA adequately identifies the major issues of gas generation in the waste.

2. The issue of the reaction of carbon dioxide with the MgO backfill is not adequately resolved in Appendix WCA, because of a lack of experimental data which demonstrated that this chemistry occurs under conditions anticipated in the repository.

3. Appendix WCA does not adequately address the fate of microbially generated methane.

Compressibility

Appendix WCA references studies describing the analysis of waste compressibility; however, it fails to provide any discussion of the results of these studies.

Strength

Appendix WCA references a study on waste strength but fails to discuss the results of this study in the context of its impact on disposal system performance.

Porosity

There are conflicting statements in Appendix WCA concerning the importance of porosity to the performance of the repository. As a result, the Panel was unable to evaluate the treatment of this parameter.

Permeability

There are experimental data to support the conclusions about permeability discussed in Appendix WCA. The Panel concurs with the conclusions.

Heat Generation

The analyses presented in Appendix WCA concerning heat generation are well done. The conclusion that this characteristic will have a negligible effect on performance is justified.

Metals

1. The assumption that low valent metals in the repository will maintain a reducing atmosphere in the repository is substantiated by experimental data.

2. The position taken in Appendix WCA concerning the uptake of organic ligands by the transition metals is not defensible due to lack of experimental data. It is not correct to apply results from experiments performed in low ionic strength solutions to WIPP brines.

Cellulosics

Cellulosics will be microbially degraded to carbon dioxide and methane. They also may provide a source of humic colloids. Treatment of these issues by Appendix WCA has been discussed in the appropriate sections above.

Chelating Agents

The position that transition metals will react with the organic ligands in the waste to render them unavailable for reaction with actinides should be justified with experiments done in high ionic strength brines.

Water and Other Liquids

The Panel agrees with the findings in Appendix WCA. Water in the waste is not an issue in repository performance.

Exclusion of Waste

1. The analysis performed to support the exclusion of radionuclides is methodical, complete and well done.

2. The exclusion of hazardous wastes is justified.

APPENDIX 1 - SIGNATURES

I acknowledge below that I concur with the findings and conclusions documented in this Waste Characterization Analysis Peer Review Report.

Duane C. Hrncir. Ph.D.
WCA Panel Chairman

Evaristo J. Bonano. Ph.D.
WCA Panel Member

James F. Bresson
WCA Panel Member

Patricia J. Robinson
WCA Panel Member

APPENDIX 2 - MEMBERS AND ACCEPTABILITY

Duane C. Hrncir, Panel Chairman, is an Associate Professor of Chemistry and former Head of the Chemistry Programs at the University of Texas at Dallas. He holds a Ph.D. in inorganic chemistry from Texas A&M University, an M.S. in inorganic chemistry from the University of Massachusetts at Amherst, and a B.S. in Chemistry from the University of Alabama. He has 24 years of experience in research involving the interactions of metals with organic molecules. This research includes the interactions of metals and organics with mineral surfaces and the controls these interactions have on speciation and transport in aquatic environments. His current area of research involves laboratory and field experiments to study the photoreduction of metal colloids in acidic and neutral surface waters and the control this process exerts over the biogeochemistry of the stream system. He has authored 40 publications in peer-reviewed scientific journals and has made numerous presentations at national and international scientific meetings.

Evaristo J. Bonano, Panel Member, is President and Chief Executive Officer of Beta Corporation International in Albuquerque, NM. Dr. Bonano holds a Ph.D. and an M.S. in Chemical Engineering from Clarkson University, and a B.S. in Chemical Engineering from the University of Puerto Rico. His areas of expertise include transport phenomena, waste management, risk/performance assessment, regulatory compliance, elicitation and use of expert judgments, decision analysis, and environmental management. He has been involved in performance assessment for waste disposal for more than 13 years. He directed the development of performance assessment methodologies for disposal of high-level and low-level waste for the U.S. Nuclear Regulatory Commission. He is an internationally recognized expert on performance assessment, having represented the U.S. in various working groups of the Nuclear Energy Agency/Organization for Economic Cooperation and Development in Paris, France. He participated in two independent reviews (one as lead reviewer) of the risk assessment methodology application for low- and intermediate-level waste disposal in deep geologic repositories for the U.K. Department of Environment/Her Majesty's Inspectorate of Pollution.

James F. Bresson, Panel Member, is a senior scientist, currently employed by the Informatics Corporation. He holds a Master of Public Health (MPH) degree, with emphasis on radiological and environmental health, from the University of Michigan. He has more than 35 years of experience as a health physicist and radioactive waste management specialist. Prior to his retirement from federal service in 1988, Mr. Bresson worked for the Waste Management Division of the DOE Albuquerque Operations Office, where he participated in development of the WIPP Waste Acceptance Criteria (WIPP-WAC), preparation of the DOE Order "Radioactive Waste Management (DOE 5820.2A)", and was responsible for developing and implementing the first WIPP Waste Certification Program. Since leaving DOE, Mr. Bresson has worked for several contractors as a project manager, senior health physicist, and waste management specialist. Recently he has reviewed and commented on the WIPP Waste Characterization Quality Program Plan and related documents. In addition, he served as project manager for a task which required review of several key documents related to the Low-Level Waste Performance Assessment at the Idaho National Engineering Laboratory (INEL).

Patricia J. Robinson, Panel Member, is President and CEO of (n, p,) Energy, Inc., in Albuquerque, NM. She has a B.S. in Chemical Engineering from the University of Nevada, Reno and an M.S. in Nuclear Engineering from the University of California at Berkeley (pending). Her 18-year career has focused on the resolution of technical problems and issues related to the generation and management of high-level and low-level radioactive wastes for the DOE and the commercial nuclear power industry. Ms. Robinson managed national and international R&D programs for the Electric Power Research Institute and received a Technical Excellence Award in 1990 for her work in Low-Level Waste and Below Regulatory Concern (BRC), including the following disposal performance-related studies: 129I and TRU waste characterization at BWRs/PWRs; 14C plant uptake studies; LLW engineered barrier performance assessment modeling; development of waste characterization data for the validation of radioactive disposal site inventories; and development of an NRC petition for rule making for exemption of low radioactivity wastes. She was responsible for the technical interface with the NRC, EPA, State Regulatory Authorities for LLW and radiation protection regulatory development and enforcement issues. Ms. Robinson currently provides on-going strategic waste management, waste minimization, and pollution prevention for commercial nuclear power industry and the Department of Energy.

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Determination of Peer Review Member Independence Form

Currently employed by DOE or DOE Contractor? Yes/No
Employed by DOE or DOE Contractor previously? Yes/No

If yes, give dates, location, company, position type work performed.

Los Alamos National Laboratory - Subcontract #3838L0016-8N. Contract runs from 10/11/95 - 9/30/98. Support to LANL's Waste Minimization Program Office.

Do you or have you had any direct involvement or financial interest in the work under review? Yes/No

If yes, describe involvement.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is ~~impartially~~ reviewed.

Signature: [signature]

Date: 6/24/96

Peer Review Manager Approval: [signature] 6/27/96

John A. Thies

Date

Determination of Peer Review Member Independence Form

Currently employed by DOE or DOE Contractor? Yes/No
Employed by DOE or DOE Contractor previously? Yes/No

If yes, give dates, location, company, position type work performed.

DOE - AL Operations Office from 1970 - 1988
1978 - 1980 WIPP Project Office
1980 - 1988 Waste Management Division - DOE - AL
1985 - 1987 - Implemented Waste Certification Program
1/88 - Retired from Fed. Gov't

Do you or have you had any direct involvement or financial interest in the work under review? Yes/No

If yes, describe involvement.

M

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature: James F. [illegible]

Date: 6/26/96

Peer Review Manager Approval: John A. Thies 6/27/96
Date

Determination of Peer Review Member Independence Form

Yes Currently employed by DOE or DOE Contractor? Yes/No

Employed by DOE or DOE Contractor previously? Yes/No

If yes, give dates, location, company, position type work performed.

President and CEO, 1993 - Present
Beta Corporation International
6719-D Academy Road NE
Albuquerque, NM 87109

Yes Do you or have you had any direct involvement or financial interest in the work under review? Yes/No

If yes, describe involvement.

As a subcontractor to Advanced Sciences, Inc., reviewed and development of performance assessment strategies for the disposal of transuranic waste.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature:
Evaristo J. Bonano, Ph.D.

Date: 7/11/96

Peer Review Manager Approval:
John A. Thies

7/12/96
Date

Determination of Peer Review Member Independence Form

Currently employed by DOE or DOE Contractor? Yes/No

Employed by DOE or DOE Contractor previously? Yes/No

If yes, give dates, location, company, position type work performed.

Do you or have you had ~~any direct~~ involvement or financial interest in the work under review? Yes/No

If yes, describe involvement.

I hereby certify that the above information is correct to the best of my knowledge. I was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and to the extent practical, I have sufficient freedom from funding considerations to ensure the work is impartially reviewed.

Signature:

Date: 5/7/96

Peer Review Manager Approval: John A. Thies 5/28/96 Date