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SECTION 194.24: REVIEW OF THE BASELINE INVENTORY USED IN THE COMPLIANCE RECERTIFICATION APPLICATION (CRA-2009) AND THE PERFORMANCE ASSESSMENT BASELINE CALCULATION (PABC-2009)

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APPENDICES

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ACRONYMS

AK	Acceptable Knowledge
ANL-E	Argonne National Laboratory – East
ANL-W	Argonne National Laboratory – West
ATWIR	Annual Transuranic Waste Inventory Report
BL	Babcock Wilcox
CARD	Compliance Application Review Document
CBFO	Carlsbad Field Office
CCA	Compliance Certification Application
CCDF	Complementary Cumulative Distribution Function
CFR	*Code of Federal Regulations*
CH	Contact-Handled
Ci	Curie
CID	Comprehensive Inventory Database
CPR	Cellulose, Plastic, and Rubber
CRA	Compliance Recertification Application
DBR	Direct Brine Release
DOE	U.S. Department of Energy
EDTA	Ethylenediaminetetraacetic Acid
EPA	U.S. Environmental Protection Agency
GE-VNC	General Electric – Vallecitos Nuclear Center
Hanford-RL	Hanford Richland Operations Office
INL	Idaho National Laboratory
KAPL-NFS	Knolls Atomic Power Laboratory – Nuclear Fuel Services
LANL	Los Alamos National Laboratory
LANL-CO	Los Alamos National Laboratory – Carlsbad Operations
LLNL	Lawrence Livermore National Laboratory
LWA	Land Withdrawal Act (PL 102-579)
MFC	Material Fuel Complex
MgO	Magnesium Oxide
MTHM	Metric Tons of Heavy Metal
MWd	Megawatt Days
NRD	Nuclear Radiation Development
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
PA	Performance Assessment
PABC	Performance Assessment Baseline Calculation
PAIR	Performance Assessment Inventory Report
PGDP	Paducah Gaseous Diffusion Plant
QA	Quality Assurance
RFETS	Rocky Flats Environmental Technology Site

RH	Remote-Handled
RL	(Hanford) Richland
RP	(Hanford Office of) River Protection
SQS	Small Quantity Site
SRS	Savannah River Site
TDOP	Ten-Drum Overpack
TORI	Table of Radioactive Isotopes
TRU	Transuranic [Waste]
TSD	Technical Support Document
TWBID	Transuranic Waste Baseline Inventory Database
TWBIR	Transuranic Waste Baseline Inventory Report
WIPP	Waste Isolation Pilot Plant
WM	Waste Material
WMP	Waste Material Parameter
WSDT	Working Site Data Template
WUF	Waste Unit Factor
WWIS	WIPP Waste Information System

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) operates the Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico, for the disposal of defense-related transuranic (TRU) waste. DOE submitted the Compliance Certification Application (CCA) to the U.S. Environmental Protection Agency (EPA or the Agency) in 1996. After extensive review of the CCA and supplemental information provided by DOE, the Agency certified in 1998 that DOE met the relevant regulatory requirements, and WIPP began accepting waste in March 1999. DOE is required to submit a Compliance Recertification Application (CRA) every 5 years after the date that waste was first accepted at WIPP; the first CRA was submitted in March 2004 (DOE 2004).

In March 2009, DOE submitted the second CRA, referred to here as CRA-2009. On May 21, 2009, EPA informed DOE that a revised performance assessment (PA) [the 2009 Performance Assessment Baseline Calculation (referred to here as PABC-2009)] would be required before the CRA-2009 could be judged to be complete (Cotsworth 2009a).

Confirming the validity of the waste inventory information for both emplaced inventory and estimated inventories of stored wastes at the generator sites is an important input element for PA. For each of the CRAs, DOE updated the WIPP waste inventory, as required by Title 40, Part 194.15 of the *Code of Federal Regulations* (40 CFR 194.15). This Technical Support Document (TSD) describes the Agency's evaluation of DOE's inventory update process and documentation to ensure its adequacy for use in the CRA-2009 PA and the PABC-2009 PA. The results of this review document the Agency's evaluation of DOE's compliance with the requirements of relevant portions of 40 CFR Sections 194.24(a) and (b), and Section 194.15.

During its review of DOE's 2004 CRA (subsequently referred to here as CRA-2004), EPA mandated that DOE conduct a revised PA designated as the Performance Assessment Baseline Calculation (PABC-2004 or PABC04). The PABC-2004 was a key element in EPA's 2006 determination that the WIPP continued to comply with the regulatory requirements of 40 CFR 194.34, "Results of Performance Assessments." The CRA-2004 inventory was described in Chapter 4, Appendix TRU WASTE and Appendix DATA (Attachment F) of DOE 2004. The cutoff date for that inventory was September 30, 2002. A number of errors were uncovered during review of the CRA-2004 inventory, and these were corrected in the PABC-2004 inventory. The waste inventory used to develop the radionuclide source term for the PABC-2004 was based on information contained in Leigh et al. 2005. The PABC-2004 inventory was subsequently documented in greater detail in the *Transuranic Waste Baseline Inventory Report – 2004*, referred to here as TWBIR 2004 (DOE 2006). In addition, cellulosics, plastics, and rubber (CPR) used in emplacement materials were included in the inventory for the first time. Details on the changes made to develop the PABC-2004 inventory from the CRA-2004 inventory are provided in Leigh et al. 2005.

The CRA-2004 and the PABC-2004 inventories were thoroughly reviewed by EPA in support of its 2006 recertification decision that the WIPP could continue to accept TRU waste for disposal. EPA documented the results of its inventory review in the Compliance Application Review Document (CARD) for §194.24 – Waste Characterization (EPA 2006a) and in the Inventory TSD (EPA 2006b).

The DOE CRA-2009 used the PABC-2004 inventory to develop the inventory for the CRA-2009 PA. Since this inventory was carefully reviewed and validated by EPA in its previous recertification decision, it will not be reconsidered here, except for comparative purposes. The conclusion from EPA 2006b (pg. 44) is restated for the record:

> *The inventory reported in the* [2004] *CRA, as amended by the* [2004] *PABC, adequately describes the chemical, radiological, and physical composition of the existing and to-be-generated waste as required by 40 CFR 194.24(a). The descriptions provided in the inventory documents reviewed here include comprehensive lists of waste components and their approximate quantities in the waste also required by 40 CFR 194.24(a).*

Since the 2006 compliance decision, four additional inventory reports have been issued by DOE. The TWBIR 2004 documents the PABC-2004 inventory from Leigh et al. (2005) in greater detail (DOE 2006). The *Annual Transuranic Waste Inventory Report – 2007* (DOE/TRU-2008-3379, Rev. 1), revised in mid-2008, presents the status of the inventory as of December 31, 2006, with corrections after that date. The *Annual Transuranic Waste Inventory Report –2008* (DOE/TRU-2008-3425, Rev. 0), published in October 2008, presents the status of the inventory as of December 31, 2007. These documents will be referred to here as ATWIR 2007 and ATWIR 2008.

Since EPA has required a new PABC to support the 2009 CRA, DOE proposed that the stand-alone ATWIR 2008 inventory report be used for the PABC-2009, as outlined in the Executive Summary (pg. 5) of DOE/TRU-2008-3379, Revision 1. The Performance Assessment Inventory Report (PAIR) – 2008 (PAIR 2008) documents the scaling of the data in ATWIR 2008 and provides additional inventory information specific to PA that was not included in ATWIR 2008. A summary of inventory reports and their utilization in various compliance certification/ recertification activities is presented in Table 1-1.

Table 1-1. Sources of Inventory Information for Certification/Re-certifications

Certification/Recertification	Inventory Report Used
CCA	TWBIR, Revisions 2 and 3
CRA-2004	CRA 2004, Appendix DATA, Attachment F
PABC-2004	Leigh et al. 2005
CRA-2009	Leigh et al. 2005/TWBIR 2004
PABC-2009	ATWIR 2008/PAIR 2008

This TSD discusses changes in the inventory since the PABC-2004, as documented in ATWIR 2007 and ATWIR 2008/PAIR 2008. As appropriate, comparisons are made to the PABC-2004 inventory, the baseline for CRA-2009.

1.1 INVENTORY TERMINOLOGY

To assist the reader in using this report, the following definitions may be useful. An extensive glossary of inventory-related terms is included in Section 6 of ATWIR 2008.

Final waste form – Final waste form is the expected physical form of the waste. The use of the final waste form helps to group waste streams that are expected to have similar physical and chemical properties at the time of disposal. Waste is assigned to 1 of 11 final waste forms, including solidified inorganics, salt, solidified organics, soils, uncategorized metals, lead/cadmium metal, inorganic non-metals, combustibles, graphite, heterogeneous materials, and filters.

Waste – Defined term in 40 CFR 194.2. "Waste means the radioactive waste, radioactive material, and coincidental material subject to part 191 of this chapter."

Waste characteristic – Defined term in 40 CFR 194.2. "Waste characteristic means a property of the waste that has an impact on the containment of waste in the disposal system." As noted in 40 CFR 194.24(b)(1), waste characteristics include, but are not limited to, solubility, formation of colloidal suspensions containing radionuclides, production of gas from the waste, shear strength, and compactibility.

Waste component – Defined term in 40 CFR 194.2. "Waste component means an ingredient of the total inventory of the waste that influences a waste characteristic." Waste components to be analyzed per 40 CFR 194.24(b)(2) include, but are not limited to, metals, cellulosics, chelating agents, waste and other liquids, and activity in curies of each isotope of the radionuclides present.

Waste material parameter (WMP) – Waste material parameters characterize quantities of certain components of the waste that are used in PA. These parameters are usually expressed as material densities (kg/m^3) and include the following categories: Fe-based metals/alloys, Al-based metals/alloys, other metals/alloys, other inorganic materials, vitrified materials, cellulosic materials, rubber, plastics, solidified inorganic materials, cement (solidified), and soil.

1.2 PERFORMANCE ASSESSMENT INVENTORY REQUIREMENTS

As described in Section 3.1 of PAIR 2008, the specific information needs for PA include the following:

- Waste stream volumes [in cubic meters (m^3)].
- Inventory of radionuclides on a waste stream basis for both contact-handled (CH) and remote-handled (RH) TRU waste reported in activity as curies (Ci) and decayed to the years 2033, 2133, 2383, 3033, 7033, and 12033.
    - Disposal radionuclides: Am-241, Am-243, Cm-244, Cs-137, Np-237, Pu-238, Pu-39, Pu-240, Pu-241, Pu-242, Pu-244, Sr-90, Th-229, Th-230, Th-232, U-233, U-234, U-235, U-236, and U-238 on a waste stream basis.

- Disposal radionuclides: Ac-227, Am-241, Am-243, C-14, Cf-249, Cf-251, Cf-252, Cm-243, Cm-244, Cm-245, Cm-246, Cm-247, Cm-248, Cm-250, Cs-135, Cs-137, I-129, Ni-59, Ni-63, Np-237, Pa-231, Pb-210, Pd-107, Pm-147, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Pu-244, Ra-226, Se-79, Sm-147, Sm-151, Sn-121m, Sn-126, Sr-90, Tc-99, Th-229, Th-230, Th-232, U-232, U-233, U-234, U-235, U-236, U-238, and Zr-93 on a WIPP scale basis.

- Inventory of all non-radiological components (WMPs) that are tracked on a waste stream basis for both CH and RH TRU waste
  - The WMPs found in the waste include iron-based metal/alloy; aluminum-based metal/alloy; other metal/alloys; other inorganic materials; vitrified materials; CPR material; solidified inorganic material; solidified organic material; cements; and soils. The non-radiological inventory for packaging includes steel, plastic/liners, and lead from RH TRU waste. All WMPs and packaging materials are reported in average densities (kg/m^3).
- Inventory of any other non-radiological waste materials not included in existing WMPs that are discovered that account for a significant portion (greater than 5% by weight or volume) of a waste stream
- Inventory of CPR and other biodegradable materials used to facilitate emplacement of waste and magnesium oxide (MgO) in WIPP supplied as average densities (kg/m^3) for both CH and RH TRU waste
- Inventory of organic complexing agents, oxyanions (sulfate, nitrate, and phosphate), and cements reported in masses (kg)
- For emplaced waste, waste-stream-level inventories of disposal radionuclides and non-radiological average densities for WMPs

The WIPP waste inventory also includes large amounts of data not specifically required for PA, but which are used by DOE for other management purposes.

2.0 VERIFICATION OF THE INVENTORY ASSEMBLY PROCESS

2.1 INVENTORY INFORMATION ASSEMBLY AND REVIEW PROCESS

Prior to 2006, WIPP waste inventories were prepared at irregular intervals. However, beginning in 2006, DOE started publishing waste inventories annually, and ATWIR 2007 (period ending December 31, 2006) was the first in the series of annual inventory reports. Revising the inventory on an annual basis tends to reduce inventory errors. Development of the annual TRU waste inventory is currently managed by Los Alamos National Laboratory – Carlsbad Operations (LANL-CO). LANL-CO is responsible for data collection, data management, and quality assurance (QA). The umbrella document for QA of the WIPP inventory is LCO-QPD-01 (LANL-CO 2008a).

2.1.1 The Comprehensive Inventory Database (CID)

The Comprehensive Inventory Database (CID) is used to store and manage all WIPP inventory data. The CID is managed by LANL-CO as a member of the WIPP team. The CID was created from the Transuranic Waste Baseline Inventory Database, Revision 2.1, Version 3.13, Data Version D.4.16 (subsequently referred to as TWBID Revision 2.1). TWBID Revision 2.1 was the database used for the PABC-2004/CRA-2009 PAs. During preparation of the December 31, 2006, inventory report (ATWIR 2007), inventory data from TWBID Revision 2.1 for each site were transferred to a Working Site Data Template (WSDT) that was sent to each waste generator site for updating. The updated spreadsheets that were returned to LANL-CO from the waste generator sites provided the input for the CID.

To insure that the transfer of data from the TWBID Revision 2.1 to the WSDTs was complete and accurate, LANL-CO conducted the analysis described in McInroy 2006. The analysis involved manually checking the data entries for nine waste streams to insure that data information had been correctly transferred from TWBID Revision 2.1 to the WSDT for the respective waste stream. In addition, three calculations documenting data manipulation were checked via spreadsheets. These included Average Waste Parameter Density, Percent Containers Readily Shippable, and Projected Count for Current Form Container and Final Form Container. The analyses demonstrated that the required data were completely and accurately transferred from TWBID Revision 2.1 to the WSDTs.

Inventory information on emplaced wastes is collected in the WIPP Waste Information System (WWIS). This information must be transferred to the CID to insure that the CID inventory provides a complete picture of the disposal of all TRU wastes. To insure that data are accurately transferred and appropriate data transformations are correctly performed, LANL-CO developed the procedures described in INV-SAR-13 (Van Soest 2008) for the ATWIR 2008 inventory. This report describes, in detail, the database queries used to migrate the WWIS data into standardized CID Import Template files.

2.1.2 Inventory Updating Procedure

To update the annual inventory, LANL-CO sends a WSDT from the prior inventory to each site for revision. LANL-CO, sometimes accompanied by EPA, may visit the site to discuss the updating assumptions and process. LANL-CO examines the WSDTs returned from the sites and conducts a variety of screening tests on the reported data. Screening tests include comparison to regulatory and statutory requirements (e.g., is it commercial waste?). Reported suites of radionuclides in secular equilibrium are questioned if some members of the suite are reported and others are not. For example, if a site reported Pu-241 and Np-237 in a waste stream but not Am-241 (the daughter of Pu-241 formed by beta decay and the precursor to Np-237), then the site would be required to explain the reason that Am-241 was not reported. Checks are made to insure that the contents of a waste container are consistent with the container volume. If the data are found to be inaccurate or incomplete, the issue is discussed and resolved with the waste generator site, as described in LANL-CO procedure INV-SP-01 (McInroy 2007). All correspondence is documented by e-mails, which are retained in the notebook records for each site. When all issues have been resolved, the generator site signs off on the inventory, attesting to its completeness and accuracy. The validated inventory data are then entered into the CID using procedures specified in INV-SP-02 (McInroy 2009).

If subsequent changes to the CID information are required, a change form is implemented using procedures outlined in INV-SP-01 (McInroy 2007). A signed change form and any supporting documentation are filed in the site-specific notebook. The required revisions are then entered into the CID using procedures specified in INV-SP-02 (McInroy 2009).

Minimum data maintained in the site-specific notebooks to insure data traceability include the following:

- Inventory update request
- Original WSDT
- Analyses, when applicable
- Data Cover Sheet
- Updated WSDT and supporting documentation
- Signed documentation of TRU waste site validation
- Revisions received after the CID upload that were corrected in the CID and documented on Form INV-SP-01-2 “Inventory Data Form”

Other information may be included in the notebooks, such as notes on site visits and other correspondence not needed for data traceability.

2.2 SITE VISITS

In 2008, EPA held a series of meetings at the larger waste generator sites to impress upon onsite management the importance of developing high-quality data for the annual DOE inventory reports. Sites visited included Savannah River Site (SRS), February 13, 2008; Los Alamos National Laboratory (LANL), March 5, 2008; Hanford, April 16, 2008; Idaho National Laboratory (INL), May 14, 2008, and Oak Ridge National Laboratory (ORNL), October 15,

2008. The site visits also involved interaction with the DOE team responsible for complex-wide inventory development. EPA emphasized that to achieve credible PAs, the inventory data must be traceable to its source, qualified for its use, and representative of reality. The site visits are instrumental in obtaining a high-quality inventory for use in the PA.

2.3 CONCLUSION

LANL-CO has a comprehensive array of QA procedures in place to insure the accuracy of the data published in the annual inventory reports. The procedures cover not only systematic, documented revision of the WSDTs, but also data entry procedures to the CID from the WSDTs and the WWIS. Independent reality checks on submitted data are also conducted. During a site visit to LANL-CO on May 19–20, 2009, a number of records were reviewed and were found to be consistent with the relevant QA procedures. Based on the formal inventory updating process, inventory reporting is being conducted in a manner that should reduce database errors.

A detailed review of the functionality of the various codes used to process inventory information is included in the Models and Codes TSD (SC&A 2010a).

3.0 CHANGES FROM THE PABC-2004 INVENTORY TO ATWIR 2007 AND ATWIR 2008

The principal changes to the WIPP inventory since the publication of TBWIR 2004, which was used as the basis for the PABC-2004 and CRA-2009, are documented in ATWIR 2007 as follows (ATWIR 2007, Executive Summary, pg. 3):

- *Paducah's Gaseous Diffusion Plant TRU waste was re-categorized from WIPP-bound to potential, since a waste processing method has not been determined.*
- *Classified waste at all DOE TRU waste sites was categorized as potential TRU waste, since proper sanitization[1] has not been completed.*
- *Hanford Richland (RL) has categorized some of its 618-10 and 618-11 buried waste as potential TRU waste.*
- *Hanford RL K-Basin knock-out pot sludge has been re-categorized as potential TRU waste.*
- *Hanford Office of River Protection (RP) tank waste has been re-categorized as potential TRU waste.*
- *The two INL sodium-bearing waste streams have been re-categorized as potential TRU waste.*
- *Some small quantity sites were removed from the TRU waste inventory because they have been de-inventoried of TRU waste.*
- *Rocky Flats Environmental Technology Site* [RFETS] *has emplaced all of its TRU waste in the WIPP.*
- *TRU waste emplaced between the 1999 opening of the WIPP and December 31, 2006 (the inventory data cut-off date), was addressed.*

Significant changes in the ATWIR 2008 inventory, as compared to the ATWIR 2007 inventory, are summarized by DOE as follows (ATWIR 2008, Executive Summary, pg. 14):

- *Paducah's Gaseous Diffusion Plant TRU waste was re-categorized from potential to WIPP-bound, since a waste processing method has been determined.*
- *TRU waste emplaced between the 1999 opening of the WIPP and December 31, 2007 (the inventory data cut-off date), is addressed in this report.*
- *General Electric-Vallecitos Nuclear Center (GE-VNC) received a DOE contract and a defense determination for the waste in its Hot Cell; however, the waste remains in potential waste because the site did not provide radionuclides and waste material parameters (LANL-CO 2008b).*

[1] Sanitization is the process of removing any classified features in the waste.

- *Two new sites were added to this inventory collection: Babcock and Wilcox (BL) (Parks Township waste) and the Nuclear Radiation Development Site (NRD). Both sites are listed as potential waste sites. NRD is pursuing a defense determination (LANL-CO 2008c and LANL-CO 2008d). BL needs a defense determination for the Parks Township waste.*
- *Hanford RL and the Material Fuel Complex (MFC) have waste streams that exceeded the curie limit allowed in the LWA of 23,000 Ci/m^3. These two waste streams were changed from WIPP-bound to potential waste streams.*
- *Oak Ridge re-aligned all waste stream identifiers to match the identifiers of the waste stream they intend to ship to WIPP.*
- *The volume of the TRU waste stored on site at West Valley was reduced because much of the waste managed as TRU has been characterized as low-level waste.*

In 2008, DOE started producing a stand-alone, unscaled annual inventory report and a separate scaled PA-specific inventory report. Unlike ATWIR 2007, scaled inventory volumes were not reported in ATWIR 2008, nor were quantities of complexing agents, oxyanions, solidified cements, and emplacement materials (ATWIR 2008, pg. 13). These types of information are needed for PA, and the data needs were filled by compilations included in PAIR 2008.

The following sections provide detailed comparisons of waste volumes, waste material parameters, contained radioactivity, complexing materials, etc., based on the PABC-2004, ATWIR 2007, and ATWIR 2008/PAIR 2008 inventories.

3.1 WASTE VOLUMES

3.1.1 Scaling Factors

Since the volumes of stored, projected, and emplaced waste destined for the WIPP are less than the authorized volumes of 168,485 m^3 for CH TRU waste and 7,079 m^3 for RH TRU waste, it is necessary to scale waste volumes to the repository regulatory limits for PA calculations. In developing the scaling factors, only projected waste volumes are adjusted. The scaling factor for CH TRU waste, SF_{CH}, is calculated as follows:

$$SF_{CH} = (168{,}485 - (V_s + V_e))V_p \,,$$

where V_s is the volume of stored waste, V_e is the volume of emplaced waste, and V_p is the volume of projected waste. The scaling factor for RH TRU waste is similarly calculated using the appropriate RH volumes and the volume limit of 7,079 m^3. Scaling factors based on the three most-recent inventories are presented in Table 3-1.

Table 3-1. WIPP Volume Scaling Factors

Waste	PABC-2004/CRA-2009	ATWIR 2007	PAIR 2008
CH TRU	1.48	7.74	5.72
RH TRU	0.861	6.56	4.87

Source: ATWIR 2007, Table 2-1; PAIR 2008, Table 5-1.

At the time the PABC-2004/CRA-2009 inventory was developed, stored and projected RH TRU waste exceeded the authorized limit, resulting in a scaling factor of less than one. Since that time, a significant amount of waste at Hanford has been reclassified as potential waste and consequently removed from the active WIPP inventory. The scaling factor for CH TRU waste is also impacted by the decision to reclassify certain Hanford waste streams as potential waste.

3.1.2 CH TRU Waste Volumes

Table 3-2 compares the stored, projected, and emplaced waste volumes by waste generator site for CH TRU, based on the PABC04, ATWIR 2007, and ATWIR 2008 inventories. The reported values are for unscaled volumes. The emplaced waste in the PABC04 was as of the September 30, 2002, data call. Ongoing waste disposal has increased the quantity of emplaced waste to 4.6E+04 at the end of 2006, and to 5.2E+04 at the end of 2007.

Table 3-2. Comparison of Unscaled CH TRU Waste Volumes for PABC-2004/CRA-2009, ATWIR 2007 and ATWIR 2008 Inventories

Site	Stored CH TRU (m^3)	Projected CH TRU (m^3)	Emplaced CH TRU (m^3)	Stored CH TRU (m^3)	Projected CH TRU (m^3)	Emplaced CH TRU (m^3)	Stored CH TRU (m^3)	Projected CH TRU (m^3)	Emplaced CH TRU (m^3)
	PABC-2004/CRA-2009			ATWIR 2007			ATWIR 2008		
Hanford	1.7E+04	5.5E+03	9.8E+01	1.4E+04	0.0E+00	2.6E+03	2.0E+04	0.0E+00	3.3E+03
INL	6.1E+04	1.8E+04	2.9E+03	5.9E+04	0.0E+00	1.6E+04	4.0E+04	0.0E+00	2.1E+04
LANL	1.2E+04	3.3E+03	2.7E+02	1.5E+04	1.1E+03	1.5E+03	1.1E+04	8.5E+02	1.5E+03
ORNL	0.0E+00	4.5E+02	0.0E+00	6.8E+02	3.4E+02	0.0E+00	6.9E+02	1.9E+02	0.0E+00
RFETS	5.4E+03	2.8E+03	4.3E+03	0.0E+00	0.0E+00	1.5E+04	0.0E+00	0.0E+00	1.5E+04
SRS	1.3E+04	2.4E+03	2.0E+02	1.0E+04	8.4E+02	9.6E+03	5.5E+03	4.5E+03	1.1E+04
SQS	1.2E+03	2.9E+03	0.0E+00	6.5E+02	6.9E+02	6.6E+02	5.8E+02	1.1E+03	6.6E+02
Total	1.1E+05	3.5E+04	7.7E+03	1.0E+05	3.0E+03	4.6E+04	7.8E+04	6.7E+03	5.2E+04

Sources: Leigh et al. 2005, Tables 4 and 5; ATWIR 2007, Table 3-1; ATWIR 2008, Table 3-1.

3.1.3 RH TRU Waste Volumes

As shown in Table 3-3, anticipated waste volumes (sum of stored plus projected) for RH TRU decreased from 7.4×10^3 m^3 in the PABC-2004/CRA-2009 to 3.4×10^3 m^3 in the ATWIR 2007. This latter value is well below the established disposal limit of 7,079 m^3 for RH TRU waste.

Table 3-3. Comparison of Unscaled RH TRU Waste Volumes for PABC-2004/CRA-2009, ATWIR 2007 and ATWIR 2008

TRU Generator Site	Stored RH TRU (m^3)	Projected RH TRU (m^3)	Stored RH TRU (m^3)	Projected RH TRU (m^3)	Stored RH TRU (m^3)	Projected RH TRU (m^3)
	PABC-2004/CRA- 2009		ATWIR 2007		ATWIR 2008	
Hanford	4.9×10^3	1.1×10^3	1.2×10^3	1.3×10^2	8.1×10^2	3.6×10^2
INL	2.2×10^2	0.0×10^0	3.7×10^2	0.0×10^0	2.9×10^2	0.0×10^0
LANL	1.3×10^2	0.0×10^0	9.8×10^1	0.0×10^0	9.8×10^1	0.0×10^0
ORNL	0.0×10^0	6.6×10^2	9.3×10^2	3.6×10^2	4.3×10^2	1.1×10^2
SRS	0.0×10^0	2.3×10^1	4.2×10^1	3.6×10^1	4.6×10^1	3.6×10^1
SQS	9.5×10^1	3.1×10^2	7.1×10^1	1.5×10^2	4.7×10^1	5.7×10^2
Totals	5.3×10^3	2.1×10^3	2.7×10^3	6.7×10^2	1.7×10^3	1.1×10^3

Sources: Leigh et al. 2005, Table 6; ATWIR 2007, Table 3-2; ATWIR 2008, Table 3-2.

At the time ATWIR 2007 data were collected, no RH TRU had been emplaced at the WIPP. The principal reason for the decrease in RH TRU waste volumes was that tank wastes from the Hanford Office of River Protection were removed from the PABC-2004/CRA-2009 inventory and reclassified as potential wastes in ATWIR 2007. This included waste streams RP-W013 and RP-W016. As noted by DOE in Appendix D (Section D-2) of ATWIR 2007, "The largest reported volume change occurred at the RP when the DOE Carlsbad Field Office (CBFO) requested that all of the reported TRU waste from the RP tanks be re-categorized as "potential" WIPP-bound waste" (Moody 2007).

A comparison of RH TRU waste volumes in ATWIR 2007 and ATWIR 2008 is also provided in Table 3-3, which shows that anticipated RH TRU waste volumes had decreased further from 3.4×10^3 m^3 to 2.8×10^3 m^3. The main source for this change was removal of ORNL waste stream OR-W215 that was re-categorized as low-level waste (ATWIR 2008, Appendix D, Section D-2).

RH TRU waste shipments to the WIPP began in 2007, and by the end of the year, 88 m^3 of RH TRU from INL had been emplaced in the WIPP (ATWIR 2008, Table 3-2).

The sum of the anticipated and emplaced RH TRU waste volumes remains well below the established limit of 7,079 m^3.

3.2 RADIONUCLIDE INVENTORY

The containment requirements for the WIPP disposal system are defined in 40 CFR Part 191.13, "Containment Requirements," which states in part that:

> *(a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon PAs, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:*

(1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (appendix A); and

(2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (appendix A).

Table 1 of 40 CFR Part 191 Appendix A (reproduced here) specifies the release limits for specific radionuclides.

Table 1 of Appendix A. Release Limits for the Containment Requirements (U.S. Environmental Protection Agency 1985, Appendix A, Table 1)

Radionuclide	Release Limit L_i per 1,000 MTHM[a] or Other Unit of Waste[b]
Americium-241 or -243	100
Carbon-14	100
Cesium-135 or -137	1,000
Iodine-129	100
Neptunium-237	100
Pu-238, -239, -240, or -242	100
Radium-226	100
Strontium-90	1,000
Technetium-99	10,000
Thorium (Th) -230 or -232	10
Tin-126	1,000
Uranium (U) -233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000

a Metric tons of heavy metal (MTHM) exposed to a burnup between 25,000 megawatt-days (MWd) per metric ton of heavy metal (MWd/MTHM) and 40,000 MWd/MTHM.

b An amount of TRU wastes containing one million Ci of alpha-emitting TRU radionuclides with half-lives greater than 20 years.

It can be seen from footnote b of Table 1 that the release limits are per "an amount of TRU waste containing one million Ci of alpha-emitting radionuclides with half-lives greater than 20 years." The normalized release R used in PA is defined as:

$$R = \sum(Q_i/L_i)(1 \times 10^6 \text{ Ci/C}) ,$$

where Q_i is the cumulative release of the *i*th radionuclide to the accessible environment over 10,000 years, L_i is the release limit for the *i*th radionuclide from Table 1 of Appendix A, and C is the total quantity of radioactivity in alpha-emitting TRU radionuclides with half-lives greater than 20 years. Thus for PA, it is necessary to quantify all of the radionuclides covered in Table 1 of Appendix A, and also to quantify TRU radionuclides with half-lives greater than 20 years.

For the PABC-2004/CRA-2009 PAs, C was 2.32×10^6 Ci (DOE 2009, Appendix PA, Section PA-2.2.1). This is based on the WIPP-scale inventory decayed to 2033, the assumed closure date for the repository. Similarly, based on the PAIR 2008 inventory, C is 2.61×10^6 Ci (PAIR 2008, Table A1). Of the 17 reported TRU radionuclides with half-lives greater than 20 years, Am-241, Pu-238, Pu-239, and Pu-240 contribute 99.99% of the total curies. The main difference in C between the PABC04 and the PAIR 2008 inventories is an increase of 3.45E+05 Ci in the Pu-238 content in the PAIR 2008 inventory.

Expressed another way, the waste unit factor used in the PABC-2004/CRA-2009 was 2.32, compared to a value of 2.61 used in PABC-2009.[2] The total number of EPA units in the scaled inventory decayed to 2033 is obtained by the following equation:

$$E_{ws} = \Sigma E_i = \Sigma w_i/(\text{wuf} \times L_i),$$

where E_i is the number of EPA units of the *i*th radionuclide in a waste stream, w_i is the quantity of radioactivity in the *i*th waste stream (Ci), wuf is the waste unit factor, L_i is the release limit for the *i*th radionuclide, and E_{ws} is the total EPA units for the waste stream. Summing E_{ws} for all waste streams results in the total EPA units, E_T. E_T is directly proportional to the sum of all radionuclides in all the waste streams and inversely proportional to the sum of all TRU radionuclides in all the waste streams. For the PABC-2009 PA, the total number of EPA units was 10,080, which is almost identical to the 10,170 used in the CRA-2009 PA (Fox and Clayton 2010).

Radioactive inventories for 2007, scaled to the full repository volume and decayed to 2033, are included in Table 3-4, based on PAIR 2008. These values are obtained by determining the activity density (Ci/m^3), based on the individual waste stream volume and activity content of each radionuclide, and scaling these values to the full repository volumes for RH TRU and CH TRU. The scaled activity densities are multiplied by the CH TRU repository limit of 168,485 m^3 and the RH TRU limit of 7,079 m^3, as appropriate to the waste stream categorization, to obtain the scaled quantities of radioactivity. For comparison, the PABC-2004 inventory reported on the same basis was 3.53E+06 Ci (Leigh and Trone 2005, Table 2). No significant changes in the quantity of radioactivity in the scaled inventory have occurred between the PABC-2004 inventory and the PAIR 2008 inventory.

[2] Due to a minor decimal rounding difference this is reported as 2.60 by SNL (Fox, Clayton, and Kirchner 2009). The value of the WUF was independently verified in this review.

Table 3-4. Scaled Radioactivity in the WIPP Repository

Waste Type	PABC-2004/CRA-2009		ATWIR 2007		PAIR 2008	
	Radioactivity (Ci)	Reference	Radioactivity (Ci)	Reference	Radioactivity (Ci)	Reference
CH TRU	--	--	3.40E+06	ATWIR 2007, Table E-3	3.10E+06	PAIR 2008, Table A.1
RH TRU	--	--	1.41E+06	ATWIR 2007, Table E-4	3.50E+05	PAIR 2008, Table A.1
Total	3.53E+06	Leigh et al. 2005, Table 2	4.81E+06	--	3.45E+06	--

a – decayed to 2033

Perhaps a more relevant comparison is the unscaled inventory decayed to 2033, the year of assumed closure for the WIPP repository. These data are indicative of the inventory actually identified to date. Information on unscaled quantities of radioactivity from ATWIR 2008 and ATWIR 2007 inventories are included in Table 3-5.

Table 3-5. Unscaled Quantities of Radioactivity Decayed to 2033

Site	CH TRU		RH TRU	
	ATWIR 2007 Inventory (Ci)	ATWIR 2008 Inventory (Ci)	ATWIR 2007 Inventory (Ci)	ATWIR 2008 Inventory (Ci)
Hanford	2.83E+05	5.32E+05	1.21E+06	1.32E+05
Idaho National Laboratory	3.73E+05	2.80E+05	1.01E+04	6.56E+03
Los Alamos National Laboratory	4.29E+05	3.13E+05	3.41E+03	3.41E+03
Oak Ridge National Laboratory	2.01E+04	3.85E+03	2.65E+05	3.87E+03
Rocky Flats Environmental Technology Site	5.80E+05	5.80E+05	0.00E+00	0.00E+00
Savannah River Site	9.62E+05	5.03E+05	3.66E+03	4.56E+02
Total of Small Quantity Sites	2.12E+04	1.27E+04	5.12E+04	6.02E+04
Grand Total	2.67E+06	2.22E+06	1.54E+06	2.11E+05

Source: ATWIR 2008, Tables D-5 and D-6.

The large decrease in RH TRU radioactivity from 2006 to 2007, shown in Table 3-5, is mainly due to changes in Hanford-RL waste streams, where waste streams RL324-07, RL-324-08, and RL327-07 were combined into a single waste stream RL300-88. Waste stream RL300-08 exceeded the statutory limit of 23,000 Ci/m^3 and, consequently, was classified as a potential waste stream not currently qualified for disposal at the WIPP (ATWIR 2008, Table 4-2).

3.3 NON-RADIOACTIVE WASTE COMPONENTS

3.3.1 Materials Limits

According to 40 CFR §194.24(c):

> *For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system.*

In accordance with this requirement, the DOE specified the following limiting values for waste material components: ferrous metals – minimum 2×10^7 kg; CPR maximum – 2×10^7 kg; free water emplaced with the waste – maximum 1,684 m^3; and nonferrous metals (metals not containing iron) – minimum 2×10^3 kg. These limits on waste material components have remained unchanged since the CCA was published (DOE 2009, 24.3.5).[3]

3.3.2 Waste Material Parameters

The WIPP waste inventory maintains the densities of the components comprising each waste stream and types of packaging materials used to emplace the waste streams. Table 3-6 compares the average densities for waste materials and packaging materials in CH TRU waste from the PABC-2004, ATWIR 2007, and ATWIR 2008 inventories. As described below, these complex-wide waste material densities are obtained by rolling up the waste material densities and waste stream volumes for each waste stream, based on data calls to the sites. The calculational methodology (described in Section 2.2.2.1 of ATWIR 2008) is summarized here for each type of waste material (WM_m). For the *i*th waste stream:

$$WM_{mi} = \rho_i \times v_i ,$$

where ρ_i is the density (kg/m^3) of the specific waste material (e.g., Fe-based metals) in the *i*th waste stream, and v_i is the volume of the *i*th waste stream (m^3). Both of these quantities are provided from the site data calls. WM_{mi} is the mass of the specific waste material in the *i*th waste stream, calculated from the data call information. This mass is then summed over all waste streams to determine the total mass (kg) of the specific waste material in the repository:

$$WM_M = \sum_i WM_{mi}$$

The final step involves dividing the total mass of the waste material, WM_M, by the total waste volume (V) of stored, projected, and emplaced waste, to obtain the waste material density (WM_P) for all the identified WIPP-bound waste streams:

[3] The main body of CRA-2009 is organized to follow each section of 40 CFR Part 194. For example, 24.x.y refers to 40 CFR §194.24 and the extensions x and y refer to specific subsections of §194.24. This citation refers to 40 CFR §§ (c)(1), (e)(1) and (e)(2).

$WM_P = WM_M / V$

From Table 3-6, it can be observed that the amount of ferrous metals in the packaging materials has remained relatively constant, while the amount in the waste has declined about 30%. Minimum quantities of ferrous metals are specified in accordance with 40 CFR §194.24(c). This material is necessary to control the redox potential of the repository brines, insuring that actinide elements are maintained in their lower, and therefore less soluble, oxidation states (DOE 2009, Appendix SOTERM, SOTERM-2.3.4). The data in Table 3-6, multiplied by the authorized CH volume of 168,485 m^3, also show that the CH TRU packaging materials contain adequate ferrous metals to exceed the 2×10^7 kg minimum requirement for the repository, based on any of the three inventories being discussed here.

Table 3-6. Comparison of Material Densities for Components in CH TRU Wastes

Material	PABC-2004/CRA-2009[a] Average Density (kg/m^3)	ATWIR 2007[b] Average Density (kg/m^3)	ATWIR 2008/PAIR 2008[c] Average Density (kg/m^3)
Waste Material			
Fe-Base Metals/Alloys	1.1×10^2	1.8×10^2	8.1×10^1
Al-Base Metals/Alloys	1.4×10^1	1.5×10^1	1.5×10^0
Other Metals/Alloys	3.2×10^1	1.1×10^1	5.1×10^0
Other Inorganic Materials	4.0×10^1	3.4×10^1	3.6×10^1
Vitrified Materials	5.8×10^0	0.0×10^0	0.0×10^0
Cellulosic Materials	6.0×10^1	7.3×10^1	4.0×10^1
Rubber	1.3×10^1	6.6×10^0	5.6×10^0
Plastic	4.3×10^1	8.2×10^1	3.8×10^1
Solidified Inorganic Materials	7.7×10^1	1.1×10^2	1.1×10^2
Solidified Organic Materials	1.6×10^1	4.6×10^1	3.8×10^1
Cement (Solidified)	2.9×10^1	6.8×10^1	1.7×10^1
Soil	1.9×10^1	9.1×10^0	1.1×10^1
Packaging Material			
Steel	1.7×10^2	1.8×10^2	1.9×10^2
Plastic	1.7×10^1	1.9×10^1	1.6×10^1
Cellulosic Materials	0.0×10^0	4.7×10^0	5.1×10^0
Lead	1.4×10^{-2}	0.0×10^0	0.0×10^0

Sources: a – Leigh et al. 2005, Tables 9 and 11
b – ATWIR 2007, Table 3-4
c – PAIR 2008, Table 4-2

Similar data for RH TRU wastes are included in Table 3-7. It may be noted that a significant decrease in the amount of lead in packaging materials occurred between the PABC-2004 and the ATWIR 2007 and 2008 inventories. This decrease is attributable to a changed assumption as to the material used to plug the RH TRU waste canisters. It was originally assumed that a lead plug would be used, but it was subsequently determined that a cement plug would provide sufficient shielding.

Table 3-7. Comparison of Material Densities for Components in RH TRU Waste

Material	PABC-2004/CRA-2009[a] Average Density (kg/m^3)	ATWIR 2007[b] Average Density (kg/m^3)	ATWIR 2008/PAIR 2008[c] Average Density (kg/m^3)
Waste Material			
Fe-Base Metals/Alloys	5.9×10^1	1.9×10^2	1.7×10^2
Al-Base Metals/Alloys	5.0×10^0	1.1×10^1	1.1×10^1
Other Metals/Alloys	5.7×10^1	4.5×10^1	2.8×10^1
Other Inorganic Materials	1.6×10^1	2.3×10^1	4.0×10^1
Vitrified Materials	1.2×10^{-1}	7.2×10^{-2}	0.0×10^0
Cellulosic Materials	9.3×10^0	1.4×10^1	2.2×10^1
Rubber	6.7×10^0	4.7×10^0	6.6×10^0
Plastic	8.0×10^0	1.8×10^1	2.8×10^1
Solidified Inorganic Materials	6.2×10^1	5.9×10^2	1.1×10^2
Solidified Organic Materials	8.3×10^{-1}	7.1×10^{-1}	3.4×10^0
Cement (Solidified)	1.9×10^0	1.2×10^1	4.1×10^0
Soil	5.0×10^1	7.7×10^1	2.5×10^1
Packaging Material			
Steel	$5.4E+10^2$	$6.1E+10^2$	$6.3E+10^2$
Plastics	$3.1E+10^0$	$1.1E+10^1$	$1.4E+10^1$
Cellulose	$0.0E+10^0$	$0.0E+10^0$	$0.0E+10^0$
Lead	$4.2E+10^2$	$5.4E+10^0$	$3.5E+10^0$

Sources: a – Leigh et al. 2005, Tables 10 and 12
b – ATWIR 2007, Table 3-5
c – PAIR 2008, Table 4-3

3.3.3 Organic Ligands

Organic ligands can form dissolved complexes with actinide elements in the waste, resulting in increased actinide solubilities. Consequently, ligands are tracked in the WIPP waste inventory. Quantities of organic ligands (complexing agents) for the three most recent inventories are presented in Table 3-8. At the time the PABC-2004 was developed, the presence of organic ligands was not predicted in any projected waste streams, so the results of the scaled and unscaled inventories were the same. However, the PAIR 2008 inventory included three waste streams containing organic ligands that also had projected waste volumes (LA-TA-55-19 – 143.1 m^3; LL-M001 – 255 m^3; LL-W018a – 234.2 m^3). The Los Alamos waste stream (LA-TA-55-19) contains no ethylenediaminetetraacetic acid (EDTA), but does contain acetic, citric, and oxalic acids. The Lawrence Livermore National Laboratory (LLNL) waste streams (LL-M001 and LL-W-018a) account for about 9% of the EDTA mass (assumed to be NaEDTA). Most of the EDTA mass from LLNL results from applying the CH TRU scaling factor of 5.72 to the projected waste. These two LLNL waste streams combined have a scaled volume of 3,050 m^3 and contain a scaled mass of 30.7 kg EDTA (PAIR 2008, Table 4-6 and Appendix B.1). Of this total mass, 2.6 kg are associated with stored waste, 4.9 kg are associated with projected waste, and 23.2 kg are associated with the incremental volume calculated by scaling the projected waste

to the repository volume limit. Thus, about 75% of the EDTA mass in these two waste streams results from scaling.

Complexing agents were reported in PAIR 2008 for the first time for 21 waste streams.

Details of how the CID was queried to obtain data on organic ligands for inclusion in PAIR 2008 are presented in Lott 2009. This QA document includes results of hand calculations demonstrating that the CID queries produced accurate results.

Table 3-8. Disposal Mass of Complexing Agents

Compound	PABC-2004/CRA-2009[a] (kg)	ATWIR 2007[b] (kg)	ATWIR 2008/PAIR 2008[c] (kg)
Acetic Acid	1.42E+02	1.41E+04	1.32E+04
Citric Acid	1.19E+03	5.68E+03	5.68E+03
Oxalic Acid	1.38E+04	2.95E+04	2.66E+04
Sodium Acetate	8.54E+03	3.14E+04	9.70E+03
Sodium Citrate	4.00E+02	2.56E+03	2.55E+03
Sodium EDTA	2.60E+01	4.23E+02	3.54E+02
Sodium Oxalate	3.39E+04	6.58E+02	6.46E+02

Sources: a – PAIR 2008, Table 5-7
b – ATWIR 2007, Table 3-10
c – PAIR 2008, Table 4-7

3.3.4 Packaging Materials

Quantities of packaging materials were presented previously in Tables 3-6 and 3-7. In the past, each site had estimated packaging material densities, resulting in some inconsistencies in data reporting. However, in ATWIR 2007 and ATWIR 2008, WIPP-approved payload containers were assigned fixed values in the CID. During the preparation of ATWIR 2008, the CID was modified to correct the volume of the 10-drum overpack (TDOP) to 4.5 m^3 from 4.76 m^3. This resulted in a small decrease in the final waste form volume at sites using the TDOP (ATWIR 2008, Section 3.2.2).

3.3.5 Oxyanions in the Waste Inventory

The WIPP inventory also tracks certain oxyanions, including SO_4^{-2}, PO_4^{-3}, and NO_3^{-1}. These species play differing roles in microbial degradation of CPR materials in the repository and, consequently, knowledge of their relative availability contributes to understanding which microbial reactions occur and how much gas is generated. Oxyanion masses are summarized in Table 3-9.

Table 3-9. Scaled Masses of Oxyanions in WIPP

Inventory	PABC-2004/CRA-2009 (kg)	ATWIR 2007 (kg)	PAIR 2008 (kg)
Nitrates	2.67E+06	2..70E+06	1.73E+06
Sulfates	4.43E+05	5.96E+05	5.91E+05
Phosphates	1.05E+05	5.35E+05	1.99E+05

Sources: PABC-2004/CRA 2009; Leigh et al. 2005, Table 17; ATWIR 2007, Table 3-12; PAIR 2008, Table 4-9.

Only small changes in the masses of nitrates and sulfates have occurred between the various inventories. The significant change in phosphates from ATWIR 2007 to PAIR 2008 is associated with re-evaluation of waste stream RLPFP-01 at Hanford (PAIR 2008, Table 4.8; ATWIR 2007, Table 3-11). This single waste stream contributed about 96% of the entire phosphate inventory identified in ATWIR 2007, and about 61% of the phosphate inventory in PAIR 2008.

Details of how the CID was queried to obtain data on oxyanions for inclusion in PAIR 2008 are presented in Lott 2009. This QA document includes results of hand calculations demonstrating that the CID queries produced accurate results.

3.3.6 Other Materials

As noted in Section 1.2 above, information on cements was also requested by the WIPP PA team; however, there is no indication that this information was used quantitatively to support PA. Cement could be a source of mineral-fragment-type colloids (DOE 2004, Appendix PA, Attachment SOTERM, pg. 31). Cement could also affect the pH of repository brines. As noted in CRA 2004 (Chapter 6, pg. 6-87), the amount of portlandite [$Ca(OH)_2$] associated with Portland cement used to dewater sludges is insufficient to overcome the buffer capacity of the MgO engineered barrier. In its completeness comments on CRA-2009, EPA requested that DOE provide additional information on the role of cement on pH (Comment 2-C-24). (See Section 3.5.1.4 below.)

The scaled cement masses based on ATWIR 2007 and PAIR 2008 inventories are summarized in Table 3-10. For comparison, the scaled mass of cement cited in the PABC04 inventory was 8.8E+06 kg (DOE 2006, Section 3.2.3.1).

Table 3-10. Scaled Cement Masses for Disposal at WIPP

Site	Mass of Cement (kg)	
	ATWIR 2007 (Table 3-8)	PAIR 2008 (Table 4-11)
ANL-E	8.67E+03	8.67E+03
ANL-W (MFC)	2.05E+04	5.55E+02
INL	7.03E+06	6.28E+06
KAPL-NFS	2.20E+06	1.90E+06
LANL	4.29E+06	3.18E+06
LLNL	2.28E+05	2.29E+05
NTS	8.89E+03	9.44E+03
ORNL	6.60E+04	1.25E+03
PGDP	—	5.68E+03
Hanford	2.66E+05	2.66E+05
RFETS	3.58E+05	3.58E+05
SRS	1.58E+04	2.24E+04
TOTAL	**1.45E+07**	**1.23E+07**

The total mass of cement has increased about 40% from the PABC-2004 inventory to the PAIR 2008 inventory.

Details of how the CID was queried to obtain data on cements for inclusion in PAIR 2008 is presented in Lott 2009. This QA document includes results of hand calculations demonstrating that the CID queries produced accurate results.

It should be noted that if one uses the cement waste material densities from Tables 3.6 and 3.7 above and the full repository volumes of 168,485 m^3 for CH waste and 7,079 m^3 for RH waste, the calculated mass of cement is substantially lower than the mass reported in Table 3-10. This apparent discrepancy was discussed with the LANL-CO inventory team. LANL explained that the value in Table 3-10 is the correct value and was verified in Lott 2009. The cement mass based on the average waste material densities in Tables 3.6 and 3.7 is low, because cement data on emplaced waste are not tracked by the WWIS. This issue, which is unique to cement, should be explained in future inventory reports.

3.3.7 Emplacement Materials

Materials used to assist in the emplacement of waste in the WIPP repository include cardboard and plastic slip sheets between stacked drums, plastic wrapping of 7-drum packs, and plastic sacks used to contain MgO. No emplacement materials are used for RH TRU waste. These materials add to the mass of CPR materials and increase the potential for gas generation within the repository if they are microbially degraded. These materials were not included in the CRA-2004 PA. EPA required DOE to include these materials in the inventory used for the PABC-2004; however, this change was inadvertently not implemented in the PABC04 (DOE 2009, Section 24.6.2). This oversight was corrected in CRA-2009 by introducing six new parameters into PA (density of CPR for both RH TRU and CH TRU waste). Quantities of CPR in emplacement materials are summarized in Table 3-11. No rubber has been identified in emplacement materials.

Table 3-11. Scaled CPR Masses in Emplacement Materials

Component	PABC-2004/CRA-2009[a] (kg)	ATWIR 2007 (Table 3-6) (kg)	PAIR 2008 (Table 4-4) (kg)
Cellulose	2.07 E+05	2.36E+05	2.26E+05
Plastics	1.48 E+06	1.42 E+06	1.11E+06

a - Leigh et al. 2005, Table 13.

Small changes in the quantities of emplacement materials have occurred between the PABC-2004/CRA-2009, the ATWIR 2007, and the ATWIR 2008/PAIR 2008 inventories. The total moles of carbon[4] in emplacement materials decreased by about 20% from the PABC-2004/CRA-2009 to the PAIR 2008 inventory, which would, in turn, decrease the amount of MgO required to sequester any carbon dioxide generated by microbial degradation of the organic materials.

3.3.8 Total Mass of CPR

The total mass of CPR, based on information derived from Tables 3-6, 3-7, and 3-11, is summarized in Table 3-12. The total CPR mass has decreased 25% from that used in the PABC-2004/CRA-2009 to that used in PABC-2009 (based on ATWIR 2008/PAIR 2008)

Table 3-12. Summary of CPR Masses in Recent WIPP Inventories

Material	PABC-2004/CRA-2009 (kg)	ATWIR 2007 (kg)	ATWIR 2008/PAIR 2008 (kg)
CH Waste			
Cellulosics	1.01E+07	1.23E+07	6.74E+06
Rubber	2.19E+06	1.11E+06	9.44E+05
Plastics	7.24E+06	1.38E+07	6.40E+06
CH Packaging			
Cellulosics	0.00E+00	7.92E+05	8.59E+05
Rubber	0.00E+00	0.00E+00	0.00E+00
Plastics	2.86E+06	3.20E+06	2.70E+06
RH Waste			
Cellulosics	6.58E+05	9.91E+04	1.56E+05
Rubber	4.74E+05	3.33E+04	4.67E+04
Plastics	5.66E+05	1.27E+05	1.98E+05
RH Packaging			
Cellulosics	0.00E+00	0.00E+00	0.00E+00
Rubber	0.00E+00	0.00E+00	0.00E+00
Plastics	2.19E+04	7.79E+04	9.91E+04
Emplacement Materials			
Cellulosics	2.07E+05	2.36E+05	2.26E+05
Rubber	0.00E+00	0.00E+00	0.00E+00
Plastics	1.48E+06	1.42E+06	1.11E+06
TOTAL	2.43E+07	3.32E+07	1.94E+07

[4] The total moles of carbon are calculated assuming that 1.7 kg of cellulose is equivalent to 1 kg of plastics, and that each mole of cellulose contains 6 moles of C (Wang and Brush 1996).

3.4 VERIFICATION OF PARAMETERS USED IN PA

The use of all inventory-related parameters in the PA for CRA-2009 was reviewed as discussed in the 2010 CRA Parameters TSD (SC&A 2010b). The review included confirmation that the new parameters related to emplacement materials had been included (see Section 3.3.7). All inventory-related parameters were correctly implemented in the CRA-2009 PA and the PABC-2009 PA.

3.5 OTHER REVIEW ACTIVITIES

EPA verified the radioactive decay calculations in ATWIR 2008 by conducting independent spot checks of the ORIGEN 2.2 calculations. These calculations, which are summarized in Appendix A, demonstrated that the LANL/DOE results are appropriate for use in PA. EPA also spot- checked various randomly selected values in the tables appended to PAIR 2008 and determined that the selected values were correct. Selected values of EPA units in Table 1 of Fox et al. 2009 were also checked to insure that the EPA units were correctly calculated using the data from Table A1 of PAIR 2008.

During the course of its review of the CRA-2009 and PABC-2009 documents, EPA raised completeness issues in several letters to DOE (Cotsworth 2009a and 2009b; Kelly 2009 and 2010), and DOE provided responses in a companion series of letters (Moody 2009a, 2009b, and 2009c; Moody 2010a and 2010b). The issues and responses are summarized in some detail in Appendix B. EPA is satisfied that DOE has adequately responded to the inventory-related completeness comments and there are no unresolved questions.

4.0 CONCLUSIONS

The waste inventory used in the CRA-2009 PA was basically the same as used in the PABC-2004. The PABC-2004 inventory was thoroughly reviewed by EPA as part of the 2006 recertification decision, and findings were documented in the 194.24 CARD (EPA 2006a) and in the Inventory TSD (EPA 2006b). One minor change was to introduce six new parameters related to the densities of CPR used in emplacement materials. Although it was intended that emplacement materials should be included in the PABC-2004 PA, they were inadvertently omitted. This omission, which would have only a minor impact on PA, was corrected in the CRA-2009 PA. Inclusion of the appropriate new parameters was verified in the CRA-2009 and PABC-2009 parameter reviews discussed in the Parameter TSD (SC&A 2010b).

In 2006, DOE switched from an approach where inventories were developed on an ad hoc basis to one where the inventories were developed annually. The adoption of the annual approach reduces sources of error in the inventory. The waste inventory used in PABC-2009 (the revision of CRA-2009) was based on the ATWIR 2008/PAIR 2008 inventory. This was the second annual inventory. During the course of its review, EPA examined the QA procedures used to populate the CID from the database used for CRA-2009, update the CID annually, and transfer data from the WWIS to the CID. In addition, procedures used to verify chemical components in the waste and estimate the quantities in the waste were reviewed. Spot checks were made of various calculated values in the inventory documentation, and the checked values were determined to be correct. EPA also determined that DOE had adequately responded to CRA-2009/PABC-2009 completeness comments related to inventory. On the basis of its review, EPA concluded that DOE has appropriate QA procedures in place to accurately document the WIPP waste inventory on an annual basis. EPA further concluded that the ATWIR 2008/PAIR 2008 inventory is appropriate for use in PA calculations.

5.0 REFERENCES

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APPENDIX A
AUDIT OF WIPP RADIONUCLIDE INVENTORIES

Spot checks were made of calculations performed by Los Alamos National Laboratory (LANL) of radionuclide inventories at the Waste Isolation Pilot Plant (WIPP). Our audit addressed eight radionuclides: Ac-225, Am-241, Pu-238, Pu-239, Pu-240, Pu-241, Th-229, and U-233.

The first stage of the analysis consisted of verifying the total radionuclide inventories in various waste streams at the end of 2033. The three waste streams selected for the analysis were AECHDM-S, ID-RF-S5300-A-S, and LA-MHD01.001.

The starting point was the activity concentrations in each of the three waste streams at the end of 2007, as reported in ATWIR 2008 (Appendix A).[5] We calculated the activity concentration at the end of 2033 by accounting for the radioactive decay of the reported concentration from 2007 to 2033, a period of 26 years. We also calculated in-growth of a given radionuclide from the radioactive decay of a parent or grandparent, if either or both of these nuclides were reported by DOE.[6] We performed these calculations by directly applying the Bateman Equations and using the most current radioactive decay data (half-lives and branching ratios) taken from the Web-based dataset, "WWW Table of Radioactive Isotopes" (TORI) (Firestone and Ekström 2004). We chose this approach, rather than using a canned program, since we could control the radioactive decay data used in the analysis. In only two cases—Th-229 and U-233—were nuclides earlier than the grandparent generation included in the inventories. Each of the 3-member decay chains terminating in these two nuclides includes Np-237, which has a half-life of more than 2,000,000 years. Since this progenitor nuclide would have negligible in-growth over the 26-year decay period, the contributions of preceding generations could be neglected. This conclusion was supported by the observation that the fractional contribution of the grandparents of each of these two nuclides constituted 10^{-7}–10^{-5} of the 2033 inventory. We have observed in other cases that the contribution of each generation decreases as one moves up the decay chain.

We then compared the results of our calculations to the inventories listed by LANL in PAIR 2008 (Table B1) for the three selected waste streams, multiplying our calculated activity concentrations by the volume of each waste stream listed by LANL. The results of the comparison are shown in Table A-1.

The column headed Δ in Table A-1 lists percent differences calculated by subtracting the exact value derived in our calculation from the LANL value, which is displayed with three significant figures. In most cases, the LANL and EPA values displayed in Table A-1 are exactly the same, or differ by 1 in the least significant digit. The only exception is Pu-241, where the LANL

[5] Because Ac-225 was not listed in these inventories, this stage of our analysis was limited to the remaining seven nuclides.

[6] Two of the selected nuclides—Th-229 and U-233—are the progeny of longer decay chains. However, for the time periods of interest in the present analyses, we determined that the contributions of the progenitors earlier than two generations—Pu-241 in the case of U-233, and Pu-241 and Am-241 in the case of Th-229—were many orders of magnitude smaller than the calculated results, and would thus have no impact on the outcome of the analysis.

values are greater by as much as 0.7%. This small difference is likely due to the fact that the WIPP Project used 14.4 years as the half-life for Pu-241, while we used a value 14.35 years taken from the WWW Table of Radioactive Isotopes (Firestone and Ekström 2004). The differences are not significant to performance assessment.

Table A-1. Total Inventories of Selected Nuclides in Three Waste Streams at the End of 2033 (Ci)

Waste Stream	AECHDM-S			ID-RF-S5300-A-S			LA-MHD01.001		
Nuclide	LANL	SC&A	Δ[a]	LANL	SC&A	Δ	LANL	SC&A	Δ
Am-241	5.42E+01	5.42E+01	-0.03%	8.52E+01	8.52E+01	0.06%	5.79E+03	5.80E+03	-0.10%
Pu-238	5.21E+01	5.20E+01	0.11%	5.88E+00	5.88E+00	0.06%	2.46E+04	2.46E+04	-0.11%
Pu-239	8.54E+01	8.54E+01	-0.04%	2.17E+02	2.17E+02	-0.18%	2.16E+04	2.16E+04	-0.05%
Pu-240	6.44E+01	6.45E+01	-0.08%	4.86E+01	4.86E+01	-0.02%	5.67E+03	5.68E+03	-0.19%
Pu-241	2.57E+01	2.56E+01	0.29%	9.54E+01	9.47E+01	0.70%	6.79E+03	6.76E+03	0.40%
Th-229	8.62E-03	8.62E-03	-0.02%	7.51E-04	7.56E-04	-0.68%	1.73E-03	1.74E-03	-0.33%
U-233	4.20E-02	4.20E-02	-0.11%	2.97E-01	2.97E-01	0.00%	3.42E-01	3.43E-01	-0.23%

[a] $\Delta = \frac{\text{LANL}}{\text{SC\&A}} - 1$

We next verified the LANL calculations of total inventories of the eight selected radionuclides in contact-handled (CH) and remote-handled (RH) waste at WIPP in 2133 and 3033 (PAIR 2008, Tables A2 and A4). Our starting point was the calculated inventory at the end of 2033 (PAIR 2008, Table A1). LANL Table A1 contains a much more detailed inventory, including many more nuclides that are progenitors of the eight nuclides, than was listed in ATWIR 2008 (Appendix A) for the three waste streams chosen for this analysis. We began our analyses by decaying the 2033 activities for 100 and 1,000 years, respectively, and including the in-growth from radioactive parents and grandparents. The first nuclide in our analysis, Ac-225, is the progeny of a 9-member decay chain beginning with Cf-249. (This chain has earlier members that have short half-lives and are thus not listed by LANL.) To ensure that progenitors prior to the second (grandparent) generation were not neglected in our analysis, we used the computer code RadDecay Version 3.04 (Negin 1990) to calculate the contributions of members of the decay chain prior to the second generation that were listed in LANL Table A1.

We replaced the original radioactive decay data files furnished with RadDecay Version 3.04 with more recent files supplied with MicroShield Version 4.21 (Grove 1995), which employed the same format and were thus compatible with the program. We compared the radioactive decay data in these newer files that were utilized in the Ac-225 analysis to the values listed by Firestone and Ekström (2004) and found no significant discrepancies. A similar procedure was used in the analysis of other members of the Cf-249 decay chain, namely Am-241, Pu-241, Th-229, and U-233.

The other three nuclides addressed by our study—Pu-238, Pu-239, and Pu-240—are the progeny of short (2- or 3-member) decay chains, or are the progeny of decay chains that included very short-lived ($t_{½} < 1$ day) intermediate members that have no effect on the inventories after 100 or 1,000 years, and can thus be neglected in the calculations. The inventories of these three plutonium isotopes were calculated by direct application of the Bateman Equations for 2- or

3-member decay chains. Two of these nuclides—Pu-239 and Pu-240—are each the progeny of two separate decay chains. Their inventories were calculated by summing the contributions of the two chains, as well as decaying the initial (2033) inventory of each nuclide.

Table A-2 displays the results of our analysis for the year 2133 and compares them to the corresponding values presented in PAIR 2008 (Table A2).

Table A-2. Total Inventories of Selected Nuclides in CH and RH Waste at the End of 2133 (Ci)

Nuclide	CH			RH		
	LANL	SC&A	Δ[a]	LANL	SC&A	Δ
Ac-225	1.02E+01	1.02E+01	0.07%	4.61E+00	4.63E+00	-0.41%
Am-241	4.13E+05	4.13E+05	-0.08%	3.93E+03	3.93E+03	-0.01%
Pu-238	6.66E+05	6.67E+05	-0.14%	2.32E+03	2.32E+03	0.07%
Pu-239	5.08E+05	5.09E+05	-0.11%	2.91E+03	2.91E+03	-0.06%
Pu-240	1.42E+05	1.42E+05	-0.35%	9.80E+02	9.80E+02	0.02%
Pu-241	4.11E+03	4.04E+03	1.70%	3.21E+01	3.15E+01	1.78%
Th-229	1.02E+01	1.02E+01	0.07%	4.62E+00	4.63E+00	-0.19%
U-233	1.56E+02	1.56E+02	0.03%	5.09E+01	5.09E+01	0.04%

[a] $\Delta = \frac{\text{LANL}}{\text{SC\&A}} - 1$

Almost all the LANL and SC&A values presented in Table A-2 agree within ±0.5%. The exception again is Pu-241, where the LANL values are 1.7%–1.8% greater. These differences are also attributable to use of 14.40 or 14.35 years for the half-life of Pu-241, and will not have any significant effect on PA. The corresponding results for the year 3033 are presented in Table A-3.

Table A-3. Total Inventories of Selected Nuclides in CH and RH Waste at the End of 3033 (Ci)

Nuclide	CH			RH		
	LANL	SC&A	Δ[a]	LANL	SC&A	Δ
Ac-225	2.19E+01	2.21E+01	-0.71%	8.34E+00	8.39E+00	-0.59%
Am-241	9.76E+04	9.76E+04	-0.03%	9.28E+02	9.28E+02	-0.04%
Pu-238	5.45E+02	5.43E+02	0.28%	1.90E+00	1.89E+00	0.39%
Pu-239	4.95E+05	4.96E+05	-0.11%	2.83E+03	2.84E+03	-0.26%
Pu-240	1.29E+05	1.30E+05	-0.44%	8.90E+02	8.91E+02	-0.11%
Pu-241	3.82E+00	3.81E+00	0.34%	8.03E-02	8.06E-02	-0.36%
Th-229	2.20E+01	2.21E+01	-0.26%	8.36E+00	8.39E+00	-0.35%
U-233	1.56E+02	1.56E+02	0.20%	5.07E+01	5.07E+01	0.02%

[a] $\Delta = \frac{\text{LANL}}{\text{SC\&A}} - 1$

The results displayed in Table 3 again show that most of the LANL and EPA values agree within ±0.5%. The exception in this case is Ac-225, where the discrepancy is as great as 0.7%. Except for the minor discrepancies noted in this audit, we conclude that radioactive decay and in-growth of the selected radionuclide inventories were correctly calculated for the time periods in question.

Appendix A References

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Appendix B
Completeness Comments

During the course of its review of the CRA-2009 and PABC-2009 documents, EPA raised completeness issues in several letters to DOE (Cotsworth 2009a and 2009b; Kelly 2009 and 2010), and DOE provided responses in a companion series of letters (Moody 2009a, 2009b, and 2009c; Moody 2010a and 2010b). The issues and responses are summarized here.

B.1 EPA Comment 1-23-4: Organic Ligands

AP-137 (Clayton 2008), includes the statement on pages 17 and 18 that the ligand concentrations were expected to increase from the 2004 to 2007 inventories. Clayton (2008) indicated that the effects of increased ligand concentrations would be evaluated using bounding estimates of the mean DBR and total releases at higher organic ligand concentrations. DOE (CRA-2009, Section 24.6.1) notes the existence of the 2007 inventory data, and states, "The DOE anticipates this inventory update will have only a small impact on normalized releases relative to the CRA-2009 PA, and will not be significant for compliance."

The ligand concentrations have significantly increased since the CRA-2004, PABC inventory. Higher ligand concentrations, particularly EDTA, would be likely to affect actinide solubilities based on calculations conducted during review of the CRA-2004PA. DOE should provide evidence supporting their statement that the inventory update will not have a significant impact on normalized releases.

EPA Reference

Clayton, Daniel J. 2008. *Analysis Plan for the Performance Assessment for the 2009 Copmpliance Certification Application.* AP-137. Carlsbad New Mexico. Sandia National Laboratories.

DOE Response (Moody 2009a)

Brush et al. (2008) documented the effects of increased EDTA concentration on performance PA results. The effect on the mean complementary cumulative distribution functions (CCDFs) for the direct brine releases (DBRs) and total releases were determined at EDTA concentrations of 10 times and 100 times that used for the CRA-2004 PABC (8.14×10^{-6} M). The results of this analysis show that even at increased EDTA concentrations of 100 times that used for the CRA-2004 PABC, the CCDFs for DBRs and total releases are below the release limits. Since the expected increase in the EDTA concentration was on the order of 10 times the concentration used for the CRA-2004 PABC, the DOE concluded that the increase in EDTA would have a small impact on the normalized releases, but would not endanger compliance and, therefore, was not significant for compliance. The DOE will perform a new PA that includes an updated EDTA, acetate, citrate, and oxalate concentration, based on the information provided in the *Performance Assessment Inventory Report - 2008* (Crawford et al. 2009). The DOE will document this PA and provide it to the EPA.

DOE References

Crawford, B. A., Guerin, D., Lott, S. A., McInroy, B., McTaggart, J., Van Soest, G., *2009. Performance Assessment Inventory Report -2008*. INV-PA-08, Revision 0, LAUR-09-02260. Los Alamos National Laboratory, Carlsbad Operations, Carlsbad, New Mexico.

Brush, L.J., Y. Xiong, J.W. Garner, T.B. Kirchner and J.J. Long 2008. *Sensitivity of the Long-Term Performance of the WIPP to EDTA.* ERMS 548398. Carlsbad, New Mexico: Sandia National Laboratories.

EPA Conclusion: This comment has been satisfactorily addressed by the use of the PAIR 2008 inventory in PABC-2009 PA.

B.2 EPA Comment 1-G-3: Inventory

As outlined in the Executive Summary of DOE/TRU-2008-3379, Rev. 1 (ATWIR 2007), DOE has proposed that ATWIR 2008 be used as the inventory source document if EPA requires a new Performance Assessment Baseline Calculation (i.e., PABC-2) to support the 2009 compliance re-certification application. DOE further states in ATWIR 2007 (p. 34) that, "Additional information on EDTA and chelating agents will be collected in the next TRU waste inventory update and, at that time, mass quantities of EDTA will be further refined and quantified and ultimately reported in the Annual Transuranic Waste Inventory Report - 2008."

However, DOE altered its actual reporting in ATWIR 2008 stating on p. 13 that, "Items 4, 5, 6 and 8 above [i.e., complexing agents, oxyanions, cement, and emplacement materials] are not included in this report, which provides information on waste streams only, but are collected for PA and will be reported in a separate report when requested by CBFO." EPA requests that DOE provide the date when such a report will be available.

DOE Response (Moody 2009b)

A copy of the *Performance Assessment Inventory Report – 2008* (Crawford et al. 2009) was provided.

DOE Reference

Crawford, B. A., Guerin, D., Lott, S. A., McInroy, B., McTaggart, J., Van Soest, G., 2009. *Performance Assessment Inventory Report - 2008.* INV-PA-08, Revision 0, LA-UR-09-02260. Los Alamos National Laboratory Carlsbad Operations, Carlsbad, New Mexico.

EPA Conclusion: This comment has been satisfactorily addressed with delivery of the *Performance Assessment Inventory Report – 2008*.

B.3 EPA Comment 2-G-4: Inventory-Quality Assurance Sign-offs

While reviewing some of the quality assurance documents used by the LANL-CO inventory team to develop, manipulate and maintain the WIPP waste inventory, we note that the sign-off procedure varies from document to document. In particular, some documents were signed off by the Quality Assurance Manager while others were not. Of the documents we have reviewed, INV-SAR-01, INV-SAR-13, INV-SAR-16, INV-SP-01, and INV-SP-02 do not have QA signoffs. DOE should explain this apparent discrepancy in their review procedures as to why some inventory documents have QA sign-off and other comparable documents do not.

DOE Response (Moody 2009c)

LANL-CO performs review and approval in accordance with QA procedure LCO-QP6-2, *Controlled Document Review and Approval*. LCO-QP6-2, Revision 4 (effective 2/8/2008; the most recent revision of this procedure), contains a table that summarizes the review and approval requirements for the LANL-CO QA Program. The applicable portion of this table is reproduced below. The entire table can be found on page 8 of LCO-QP6-2, Revision 4 (see references).

Table B-1 below shows that QA reviews are required for the inventory procedures and the Standard Analysis Reports, but QA approval is not required. In other words, the reviewer's signature is not required on the cover sheet of procedures and documents generated by LANL-CO.

Table B-1. Signature, Review, and Approval Authorities for LANL-CO Controlled Documents/Forms from LCO-QP6-2 Summarized for Response to 2-G-4, "Inventory-Quality Assurance Sign-offs"

Document Type	Originator	Technical	QA	Mgmt. GL	Mgmt. TL
Program/Project-Specific Procedures	S	R	R	A	A
Other Internal Plans, Reports, Papers, Etc.	S	R, A	R		R. A
External Reports	S	R	R	A	A

A: Approval S: Signature GL: Group Leader
R: Review TL: Team Leader RML: Records Management Lead

Therefore, the absence of a reviewer's signature on the cover sheet of these procedures and reports does not indicate that a review has not been performed.

The QA reviews for the procedures and reports listed in Table B-2 were performed, documented, and submitted to the LANL-CO Record Center. The LANL-CO Record Center record identification numbers for these reviews are given below.

Table B-2. List of Review Records for Documents of Interest in 2-G-4, "Inventory-Quality Assurance Sign-offs"

Document, Revision	Record ID for QA Review Record	Title of Record
INV-SAR-01, Revision 1	INV-0602-06-01-03	Document Review Form for INV-SAR-01, Revision 1, QA Review – L. Sparks
INV-SAR-13, Revision 0	INV-0809-01-01-04	Document Review Form for INV-SAR-13, Rev. 0 for QA Review by Laurie Sparks
INV-SAR-16, Revision 1	INV-0903-02-01-05	LANL-CO Document Review Form for QA and Records Review by Laurie Smith of INV-SAR-16, Revision 1, 3/25/2009

Table B-2. List of Review Records for Documents of Interest in 2-G-4, "Inventory-Quality Assurance Sign-offs"		
Document, Revision	**Record ID for QA Review Record**	**Title of Record**
INV-SP-01, Revision 5	INV-0711-01-01-04	DRF from Laurie Sparks – QA for INV-SP-01, R5, Data Collection, Data Management and Control for the Comprehensive Inventory
INV-SP-01, Revision 5AC	INV-0901-02-01-04	Email Documenting TelCon Between L. Smith and D. Guerin on 1/22/2009 Regarding RML Processing of Record Package INV-0901-02 – 1/27/2009
INV-SP-02, Revision 9	INV-0904-01-01-04	LANL-CO Document Review Form for QA and Records Review for INV-SP-02, Revision 9, by Laurie Smith – 4/6/2009

DOE References

INV-0602-06-01-03, Document Review Form for INV-SAR-01, Revision 1, QA Review – L. Sparks.

INV-0809-01-01-04, Document Review Form for INV-SAR-13, Rev. 0 for QA Review by Laurie Sparks.

INV-0903-02-01-05, LANL-CO Document Review Form for QA and Records Review by Lauri Smith of INV-SAR-16, Revision 1, 3/25/2009.

INV-0711-01-01-04, DRF from Laurie Sparks – QA for INV-SP-01, R5, Data Collection, Data Management and Control for the Comprehensive Inventory.

INV-0901-02-01-04, Email Documenting TelCon Between L. Smith and D. Guerin on 1/22/2009 Regarding Record Management Lead Processing of Record Package INV-0901-02 – 1/27/2009.

INV-0904-01-01-04, LANL-CO Document Review Form for QA and Records Review for INV-SP-02, Revision 9, by Laurie Smith – 4/6/2009.

LCO-QP6-2, Revision 4, *Controlled Document Review and Approval*.

EPA Conclusion: DOE has adequately explained the LANL QA sign-off procedures and provided documentation regarding QA review of the relevant inventory documents.

B.4 EPA Comment 2-C-24: Cement Inventory

The PA team requested data on the cement inventory as documented in PAIR 2008 (Crawford et al. 2009, Section 3.1). The scaled mass of cement was reported to be 1.23 × 10^7 kg (Table 4-11). This mass of cement is about 40% higher than the cement mass of 8.83 × 10^6 kg from the PABC [2004] inventory (DOE 2006, Section 3.2.3.1) and about 44% higher than the cement mass of 8.54 × 10^6 reported in the CCA (DOE 1996, Appendix WCA). The likely effects of cement on repository performance were not discussed in CRA 2009 Appendices SOTERM or Appendix PA (DOE 2009). In CRA2004, it was noted that cement could be a source of mineral-fragment-type colloids (DOE 2004, Appendix PA, Attachment SOTERM, page 31). It was also

noted in CRA 2004 (DOE 2004, Chapter 6, page 6-87) that the amount of portlandite [$Ca(OH)_2$] associated with Portland cement used to dewater sludges is insufficient to overcome the buffer capacity of the MgO backfill.

The possible effects of cement on actinide solubilities through its influence on the pH of intruding brines were addressed in the CCA (DOE 1996 Appendix SOTERM, Section 2.2.2, pages SOTERM-6 through SOTERM-17). However the calculations used to determine that pH would be controlled by the dissolution of brucite rather than portlandite were based on the CCA inventory amounts of MgO and cementitious materials. Since the CCA, as noted above, the amount of cement has increased significantly and the MgO excess factor has been reduced from 1.95 to 1.2. DOE should discuss the consequences of the changed amounts of MgO and cement in the repository on pH buffering of intruding brines and possible impacts on actinide solubilities.

EPA References

Crawford, B.A., D. Guerin, S.A. Lott, B. McInroy, J. McTaggart, and G. Van Soest. 2009. Performance Assessment Inventory Report – 2008. INV-PA-08, Revision 0, LA-UR-09-02260. Carlsbad, New Mexico: Los Alamos National Laboratory Carlsbad Operations.

DOE (U.S. Department of Energy) 1996. Title 40 CFR Part 191, Compliance Certification Application for the Waste Isolation Pilot. U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, New Mexico. DOE/CAO-1991-2184.

DOE (U.S. Department of Energy) 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, New Mexico. DOE/WIPP 2004-3231.

DOE (U.S. Department of Energy) 2006. Transuranic Waste Baseline Inventory Report – 2004, Revision 0, U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, New Mexico. DOE/TRU 2006-3344.

DOE (U.S. Department of Energy) 2009. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, New Mexico. DOE/WIPP 09-3424.

DOE Response (Moody 2009c)

As discussed in the CCA (U.S. DOE 1996, Appendix SOTERM, Section 2.2.2) and summarized by S. Cohen & Associates (2008, Section 2.3.1), the possible effects of the portlandite in the Portland cement on the pH of intruding brines is expected to be minimal, because of calcite precipitation. The MgO excess factor of 1.2 has been demonstrated as sufficient to prevent the acidification of the repository [Vugrin et al. 2006]. As the portlandite will react with the CO_2 first, the ability of the MgO to buffer the repository is not affected. Therefore, the reduction of the MgO excess factor will have essentially no effect on the pH buffering of brines in the repository. The calculations performed for the CCA indicated that the CO_2 produced from

degradation of only 8% of the cellulosic materials is enough to react with all the portlandite reported in the CCA inventory (U.S. DOE 1996, Appendix WCA). A 44% increase in the amount of cement, would increase the amount of degradation of cellulosic materials required to 11.5%. The impacts on actinide solubilities are not expected to effect actinide releases. As discussed in Appendix SOTERM Sections 3.2.2 (IV actinides) and 3.6.2 (III actinides), the solubilities of the actinides generally decrease between pH of the brucite buffer (~9) and that of the portlandite buffer (~12).

DOE References

S. Cohen & Associates. 2008. Verification of the Waste Isolation Pilot Plant Chemistry Conceptual Models, Final Report. U.S. Environmental Protection Agency, Washington, DC. Contract Number EP-D-05-002. Work Assignment No. 4-02.

U.S. Department of Energy (DOE) 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot. U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad Field Office, Carlsbad, New Mexico. DOE/CAO-1991-2184.

Vugrin, E.D., M.B. Nemer, and S.W. Wagner. 2007. Uncertainties Affecting MgO Effectiveness and Calculation of the MgO Effective Excess Factor (Rev. 1, June 26). ERMS 546377. Carlsbad, New Mexico: Sandia National Laboratories.

EPA Conclusion: DOE's response is reviewed in detail in Chemistry TSD (SC&A 2010). While EPA does not fully agree with DOE's response, EPA believes that the increased mass of cement can be accommodated within WIPP without altering the repository chemistry significantly.

EPA Reference

SC&A 2010. *Technical Support Document for Section 194.24: Evaluation of the Compliance Recertification Actinide Source Term, Backfill Efficacy and Culebra Dolomite Distribution Coefficient Values (Revision 1).* Draft document prepared for the Environmental Protection Agency. SC&A, Inc., Vienna, Virginia. November 2010. Docket A-98-49, Item II-B1-25.

B.5 EPA Comment 3-24-1: Inventory

Table 5-4 of PAIR 2008 provides without comment a comparison of waste material parameters used in the PABC and PABC09 (the 2009 PABC). Significant reductions are noted for materials (e.g., 26% for iron-based) and CPR (e.g., 12 to 33%). Since these materials have important implication for the PA, DOE needs to provide a discussion as to the cause for these changes.

DOE Response (Moody 2010b)

DOE noted in its response that more than 5 years had elapsed between the PABC 2004 and PABC 2009 inventories. They attributed 96% of the decrease in iron-based materials to three waste streams at Hanford—RL231-01, RLPFP-01 and RFPURX-05. These waste streams were

in the process of being emplaced at the time that data for ATWIR 2008 were being generated. The estimates were considerably more accurate than 5 years earlier.

With regard to CPR materials, DOE reported that a major decrease in cellulose was associated with INL waste stream IN-BN510. During the period between the two inventories, this waste stream was subdivided into several waste streams and re-evaluated based on improved Acceptable Knowledge (AK). About 77% of the decrease in cellulose was associated with INL waste streams. Waste stream IN-BN510 was also a major contributor to decrease in plastics and rubber. The changes in CPR materials are summarized in Table B-3.

Table B-3. Changes in CPR Materials between PABC-2004 and PABC-2009

Material	Site	TWBIR 2004 (kg)	ATWIR 2008 (kg)	Increase (kg)l	Decrease (kg)	Comments
Cellulose	INL	6,790,300	4,445,800	1,360,900	3,705,400	Decrease – IN-BN510; increase – l59% from Idaho Cleanup Project
Cellulose	All other sites	1,689,000	977,900		711,100	
Cellulose	**Total**	**8,479,300**	**5,423,700**	**1,360,900**	**4,416,500**	
Plastics	INL	4,847,900	3,079,600		1,768,300	99.8% of decrease associated with IN-BN510
Plastics	LANL	164,200	464,200	300,000		Increase due to new AK and characterization data
Plastics	SRS	226,300	606,900	380,600		Increase due to new AK and characterization data
Plastics	All other sites	1,234,700	1,078,200		156,500	
Plastics	**Total**	**6,473,100**	**5,228,900**	**680,600**	**1,924,800**	
Rubber	INL	1,589,400	266,800		1,322,500	Decrease mainly IN-BN510
Rubber	LANL	24,300	85,300	61,000		Increase due to new AK and characterization data
Rubber	SRS	45,800	122,300	76,400		Increase due to new AK and characterization data
Rubber	All other sites	360,100	294,000		66,100	
Rubber	**Total**	**2,019,600**	**768,400**	**137,400**	**1,388,600**	

EPA Conclusion: DOE has adequately explained the sources of the observed decreases in ferrous materials and CPR materials that occurred in the PABC-2004 and PABC-2009 inventory.