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4.0 WASTE DESCRIPTION

This chapter describes the type of waste that is emplaced and will be emplaced in the Waste Isolation Pilot Plant (WIPP) and provides an appraisal of the inventory of physical, chemical, and radionuclide components of the waste. This information supports the development of the performance assessment (PA) models that are used in predicting the long-term behavior of the repository. This chapter includes a waste description based on the inventories of existing and projected waste reported for the CCA (1996a) reported in the transuranic (TRU) Waste Baseline Inventory Report (TWBIR) (included in CCA Appendix BIR) and updated for CRA-2004 in Appendix DATA, Attachment F. This chapter also includes a description of the projected waste inventory, waste limits derived from both the PA and operational safety and health considerations, and methods of control to ensure compliance with the identified waste limits. Finally, this chapter provides a discussion of the applicable qualitative and quantitative waste characterization methodologies.

Inventory estimates provided in the CCA (Appendix BIR) represented the information available at that time. It was anticipated that WIPP waste inventory estimates would change as the U.S. Department of Energy (DOE) characterized the contents of waste containers prior to shipment to WIPP and as new TRU wastes were generated. Data on emplaced waste and updated estimates of the entire projected waste inventory are provided in Appendix DATA, Attachments D, E, F and H. The waste-inventory estimates reported in Appendix DATA and in this chapter are based on the available information as of September 30, 2002, unless otherwise noted.

Objectives of this chapter are to:

1. Report quantities and characteristics of the waste emplaced in the repository since certification;

2. Describe the current understanding of the WIPP waste inventory (emplaced, stored, and projected waste) in terms of waste components and characteristics;

3. Update waste inventory information for PA and compliance assessment calculations;

4. Reassess waste components and characteristics and associated waste-emplacement limits that may be important to long-term repository behavior; and

5. Identify changes or new information related to the WIPP waste characterization program that have occurred since certification.

Section 194.24(a) of 40 CFR Part 194 specifies that the DOE shall provide information pertaining to the chemical, radiological, and physical composition of the waste planned to be emplaced in the repository. Specifically, the criterion states

> Any compliance application shall describe the chemical, radiological and physical composition of all existing waste proposed for disposal in the disposal system. To the extent practicable, any compliance application shall also describe the chemical, radiological and physical composition of to-be-generated waste proposed for disposal in the disposal system. These descriptions shall include a list of waste components and their approximate quantities in the waste. The list may be

derived from process knowledge, current non-destructive examination/assay, or other information and methods.

This waste description includes the definition, sources, types, components, and characteristics of the waste planned for emplacement in the WIPP. The description provided in this chapter, along with the waste characterization analysis in Appendix TRU WASTE, Section TRU WASTE-2.0, identifies those physical, chemical, and radiological components of the waste that may singly or in combination affect the ability of the WIPP disposal system to meet the environmental performance standards contained in Part 191. This chapter is supported with several appendices. For example, waste related parameters used in PA are discussed in Appendix PA, Attachment PAR and Appendix TRU WASTE, Section TRU WASTE-2.0. Results of sensitivity analyses with respect to total releases used to generate the mean complementary cumulative distribution function (CCDF) in Section 6.5 are discussed in Appendix PA. The impact of waste components and characteristics on WIPP performance is discussed in Appendix TRU WASTE, Section TRU WASTE-2.0. Limits for waste components are discussed in CCA Appendix WCL; and in Appendix TRU WASTE, Section TRU WASTE-3.0 and summarized in this chapter. This chapter also summarizes methods of control that will be employed by the DOE to ensure that only those wastes that are consistent with those on which the PA is based are actually emplaced in the repository. One such control is the WIPP Waste Information System (WWIS) database for controlling the receipt of and tracking the emplacement of waste (see Section 4.3.2).

Before the final PA for the CCA was designed, DOE performed waste characterization analyses based on iterative preliminary PAs, related sensitivity analyses, and dedicated process studies for specific components and characteristics of the waste. A list of waste components and characteristics that were considered during these analyses, the list of and rationale for the ones retained for inclusion in the final PA, and the ones not included are documented in CCA Appendix WCL. This process has been updated for this recertification application (CRA-2004); waste components and characteristics retained for CRA-2004 PA are documented in Appendix TRU WASTE, Section TRU WASTE-2.0. Retained waste components are assigned fixed values in the final PA (see Appendix PA, Attachment PAR) based on information reported in Appendix DATA, Attachment F. Therefore, during the PA, plausible combinations of fixed values for waste components are included in all PA scenario analyses. Important imprecisely known waste characteristics are assigned ranges and distributions (see Appendix PA) from which values are drawn using a Latin hypercube sampling (LHS) technique that ensures that samples are taken from across the entire range of the distribution (see Section 6.1.5.2).

Since results demonstrate compliance with the quantitative containment requirements in Section 191.13, the individual protection requirements in Section 191.15, and the groundwater protection requirements in Section 191.24, the fixed values used for waste components define a profile of waste suitable for disposal at WIPP. Following the final PA for the CCA, sensitivity analyses determined the contribution of uncertainty in individual input variables to the uncertainty in model predictions (that is, final releases). In that sensitivity analysis, there were no waste characteristics that had a significant impact on the uncertainty about and the location of the mean CCDF reported in CCA Figure 6-39 (see CCA Appendix SA for a discussion of this uncertainty). Therefore, setting waste component limits is not based on PA results but is based on ensuring the validity of repository conditions modeled by PA (see CCA Appendix WCL). The same is true for the CRA-2004. In addition, the limits are repository-scale limits applicable to the inventory at the time of decommissioning. The process for demonstrating compliance with these limits is to track the waste-component quantity and the uncertainty associated with that quantity as waste is emplaced in the repository. For example, the curie content for plutonium (Pu) and its uncertainty (based on the fact that a large percentage of the waste has yet to be generated) can be accumulated as waste is emplaced throughout the operational phase. Then, at the time of decommissioning, when these repository limits apply, the total curie content for Pu may be provided with a specified level of confidence, such as 95 percent, to demonstrate compliance with the waste component limits.

Figure 4-1 illustrates the information flow pertaining to the waste description and its relationship to other sections of this chapter as well as Chapter 6.0 and appendices to this application.

4.1 Waste Inventory

The waste inventory is defined as the quantity of waste that is anticipated to be emplaced in the WIPP and that waste that is already emplaced. This inventory is generally characterized as the nonradionuclide inventory that consists of both physical and chemical waste constituents, generally expressed in units of density or concentration (kg/m^3); and the radionuclide inventory, which is a tabulation, by specific isotope, of anticipated radionuclides in the waste expressed in units of curies (Ci).

The term TRU waste is defined in the WIPP Land Withdrawal Act (LWA) (Public Law 102-579 as amended by Public Law 104-201) as

> waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste; (B) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations ; or (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations.

TRU waste that was disposed of in on-site, shallow landfill-type configurations prior to the early 1970s is referred to as buried waste. In 1970, the U.S. Atomic Energy Commission concluded that TRU waste should be stored in anticipation of the creation of more confining disposal facilities. TRU waste generated since that date has been segregated from other waste types and placed in retrievable storage. Waste generated after 1970, but before implementation of CBFO certified waste quality assurance (QA) program, is referred to as retrievably stored waste. Waste generated after a site's implementation of CBFO certified QA program is defined as newly generated. These and other relevant terms are defined in Appendix DATA, Attachment F.

Newly generated waste will be characterized in a similar manner to retrievably stored waste, but it will incorporate more real-time, as opposed to historical, acceptable knowledge. As of September 30, 2002, approximately 65 percent of the waste to be disposed of at the WIPP was expected to be newly generated waste, as described in the TWBIR (CCA Appendix BIR). At the time of the data call for CRA-2004 (September 30, 2002), approximately five percent of the waste DOE plans to dispose in the WIPP had been emplaced in the repository. Approximately 73 percent of the waste to be disposed of in the WIPP is classified as retrievably stored waste, approximately 22 percent of the waste identified by the TRU waste sites to be disposed of at the WIPP is expected to be newly generated waste (see Appendix DATA; Attachment F).

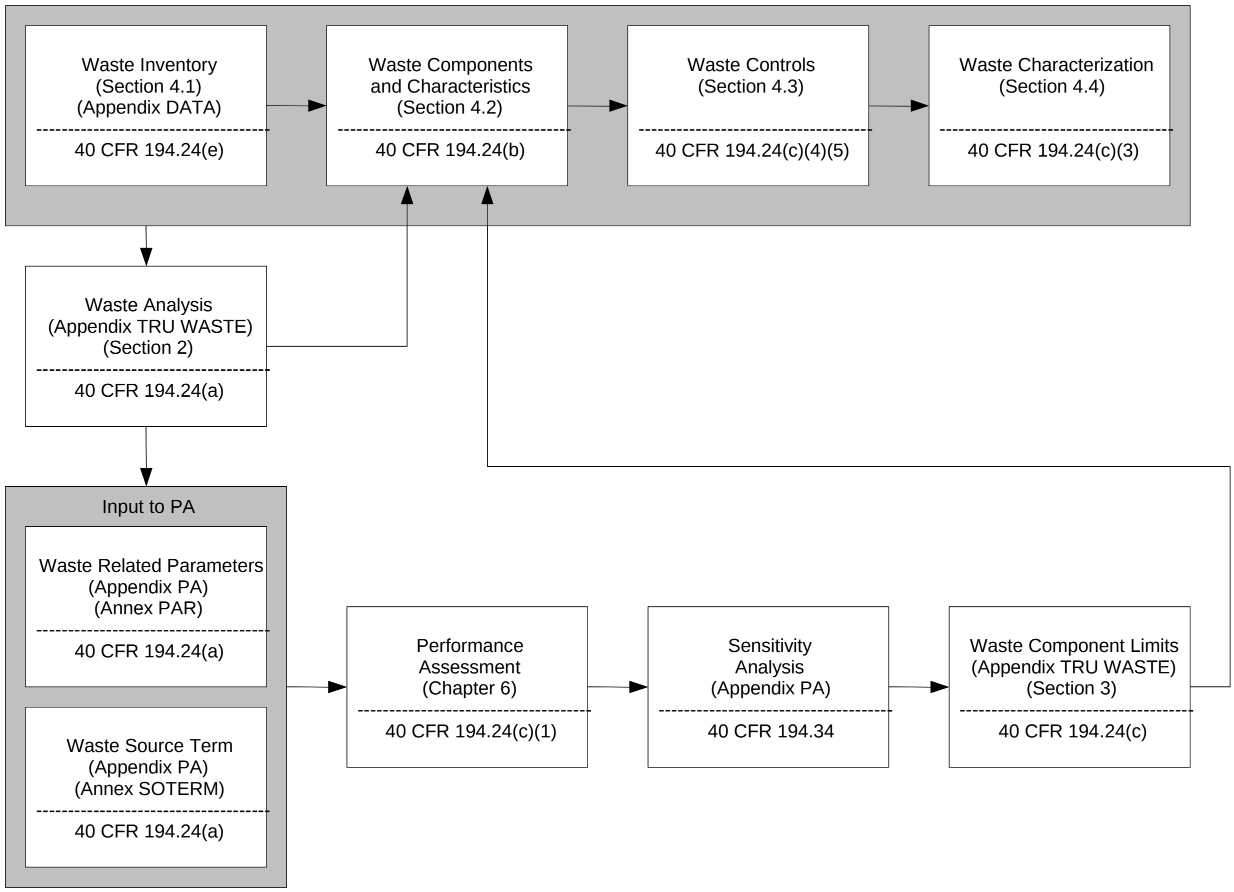

Figure 4-1. Waste Description Information Flow

TRU waste is classified as either contact-handled (CH) or remote-handled (RH) based on the contact dose rate at the surface of the waste container. If the contact dose rate is less than 200 millirem per hour (2 milliSievert per hour), the waste is defined as CH-TRU (DOE 1988). If, on the other hand, the contact dose rate is greater than or equal to 200 millirem per hour (2 milliSievert per hour), the waste and its container are defined as RH-TRU (DOE 1988). Consistent with the LWA, only RH-TRU waste less than or equal to 1000 rem per hour (10 Sievert per hour) is eligible for disposal at the WIPP. Also, to meet the requirements as set forth in the LWA, the total U capacity of WIPP by volume is 6.2 million ft3 (175,564 m3) of TRU waste. Moreover, the LWA also specifies that the emplaced RH-TRU waste is not to exceed a total activity of 5.1 million Ci ($\sim 18.9 \times 10^{16}$ Becquerel) and a total activity concentration of 23 Ci per liter maximum activity level (averaged over the volume of the canister). No more than five percent of the emplaced RH-TRU waste may exhibit a dose rate in excess of 100 rem per hour (1 Sievert per hour).

4.1.1 Sources of TRU Waste

The DOE's TRU waste, as described in this chapter, is derived primarily from Pu fabrication and processing, research and development (R&D), decontamination and decommissioning (D&D),

and environmental restoration (ER) programs at DOE sites. Most TRU waste generated at the TRU waste sites results from specific processes and activities that are well defined and well controlled, enabling the sites to characterize the waste on the basis of acceptable knowledge concerning the process, input materials, and finished products. Some examples of these operations include

- Production of nuclear products. Production of nuclear products includes reactor operation, radionuclide separation and finishing, and weapons fabrication and manufacturing. The majority of the TRU waste was generated by weapons fabrication and radionuclide separation and finishing processes. More specifically, wastes typically consist of TRU-contaminated material derived from chemical processes, air and liquid filtration, casting, machining, cleaning, product quality sampling, analytical activities, and maintenance and refurbishment of equipment and facilities.

- Pu recovery. Pu recovery wastes are TRU-contaminated items and materials from the recovery of valuable Pu, including contaminated molds, metals, glass, plastic materials, rags, salts used in electrorefining, precipitates, firebrick, soot, and filters.

- R&D. R&D projects include a variety of hot-cell or glove-box activities that often simulate full-scale operations described above, producing similar TRU wastes. Other types of R&D projects include metallurgical research, actinide separations, process demonstrations, and chemical and physical properties determinations.

- D&D. Facilities and equipment that are no longer needed or usable are decontaminated and decommissioned, resulting in TRU wastes consisting of scrap materials, cleaning agents, tools, piping, filters, Plexiglas, gloveboxes, concrete rubble, asphalt, cinder blocks, and other building materials. This is expected to be the largest category by volume of TRU waste to be generated.

- ER Programs. The implementation of environmental restoration programs at various DOE sites results in the generation of a variety of materials including contaminated soil, building materials and equipment.

Operations carried out in glove boxes and hot cells generate both combustible and noncombustible wastes. Combustible waste contains mixtures of paper, plastic materials, rags, cloth clothing, and wood resulting from Pu operations. Cloth and paper wipes are used to clean parts and glove boxes. Depending on the operations, damp combustibles are usually used and then wrung out, drained, or dried. Noncombustibles consist primarily of glass and metal. Much of this waste is laboratory equipment and glassware from R&D activities.

Filters are sometimes combinations of combustibles and non-combustibles and come from a variety of sources including high-efficiency particulate air (HEPA) filters, filter media, processed filter media, and prefilters. Prefilters and HEPA filters are used on all ventilation intake and exhaust systems associated with Pu operations. Filter frames can be either wood, aluminum, or stainless steel; and the filter media may be paper, Fiberglass, Nomex, or similar material. Filter media are generated from splitting absolute dry box and HEPA filters apart from their frames in the Pu process areas. Loose particulate materials that are dislodged from the filters are stabilized and packaged separately from the media. Filter media are packaged in plastic bottles or bags. Filter media may also be mixed with portland cement to neutralize any residual nitric acid.

Graphite waste is produced from molds that are broken, cleaned, or scraped in glove boxes to remove excess Pu. Graphite is a uniform, well-defined material.

Benelex™ and Plexiglas™ are well-defined materials that are used as neutron shielding material and in glove-box construction. Benelex™ consists mainly of cellulose with residual amounts of the phenolic resin. Plexiglas™ is a polymethyl methacrylate polymer used for glove-box windows and is generated as waste during the change-out of the glove-box windows.

Inorganic process solids include residues from evaporator and other types of storage tanks, grit, firebrick fines, ash, salts, metal oxides, and filter sludge. This waste is typically solidified in portland- or gypsum-based cements.

Soil, asphalt, and sand contaminated from spills or generated from D&D activities may also be present in the waste.

To isolate the radiological and hazardous contaminants of these wastes from humans and the environment during handling and other life-cycle operations, a primary confinement barrier is used. Both CH-TRU and RH-TRU waste at the WIPP facility will be managed using payload containers that meet the requirements of the U.S. Department of Transportation (DOT) for Type A or equivalent containers (DOE 1995c). The term payload container in this document refers to drum, drum overpack, canister, standard waste box, or ten-drum overpack unit. Internal to these payload containers may be other secondary layers of confinement, including rigid plastic inner liners and multiple layers of plastic bagging. Each container is vented using one or more filters.

4.1.2 TRU Waste Sites

The major TRU waste sites (referred to as large quantity sites [LQSs]) that are in the process of shipping or are planning to ship their TRU waste to the WIPP for disposal include

- Hanford Richland (Hanford-RL); TRU wastes at Hanford under the purview of the DOE Richland Operations Office
- Hanford River Protection (Hanford-RP); TRU wastes at Hanford under the purview of the DOE Office of River Protection
- Idaho National Engineering and Environmental Laboratory (INEEL)
- Los Alamos National Laboratory (LANL)
- Oak Ridge National Laboratory (ORNL)
- Rocky Flats Environmental Technology Site (RFETS)
- Savannah River Site (SRS)

Since certification, Lawrence Livermore National Laboratory (LLNL) and the Nevada Test Site (NTS) have been recategorized as small quantity sites (SQSs). In addition, TRU waste at the Hanford Reservation has been divided into two categories: (1) TRU waste overseen by the DOE Richland Operations Office (Hanford-RL) which corresponds to the TRU waste reported by Hanford for the CCA inventory estimate, and (2) TRU waste overseen by the DOE Office of River Protection (Hanford-RP). The DOE Office of River Protection may send both CH-TRU and RH-TRU waste to the WIPP. The Hanford-RP waste was not included in the Hanford Reservation waste reported for the CCA but is included in the 2004 CRA. The inventories for the SQSs and LQSs are reported in Appendix DATA, Attachment F, Annex J.

At the time of the CCA, INEEL, LANL, and RFETS were expected to be among the first of the major TRU waste sites to begin shipping TRU waste to the WIPP. As of September 30, 2002, the WIPP had received 1,255 shipments totaling 7,716 m^3 (2.7×10^5 ft^3) of CH-TRU waste, primarily from INEEL, LANL, and RFETS. SRS and Hanford-RL have also made shipments. Emplaced, stored, and projected waste volumes, by TRU waste site, are provided in Tables 4-1 and 4-2. No RH-TRU waste has yet been shipped to the WIPP.

Table 4-1. Emplaced, Stored, and Projected CH-TRU Waste Inventory as of September 30, 2002[1]

TRU Waste Site	Emplaced CH-TRU Volume (m^3)	Stored CH-TRU Inventory (m^3)	Projected CH-TRU Inventory (m^3)	Disposal CH-TRU Inventory[3] (m^3)
Hanford-RL	9.8×10^1	1.3×10^4	1.3×10^4	4.1×10^4
Hanford-RP	0.0×10^0	3.9×10^3	0.0×10^0	3.9×10^3
INEEL	2.9×10^3	6.1×10^4	1.2×10^2	6.4×10^4
LANL	2.7×10^2	1.2×10^4	3.3×10^3	1.9×10^4
ORNL	0.0×10^0	0.0×10^0	4.5×10^2	9.5×10^2
RFETS	4.3×10^3	5.4×10^3	2.7×10^3	1.5×10^4
SRS	2.0×10^2	1.3×10^4	2.4×10^3	1.8×10^4
SQS[2]	0.0×10^0	1.2×10^3	2.8×10^3	7.1×10^3
Totals	7.7×10^3	1.1×10^5	2.5×10^4	1.7×10^5

Source: Appendix DATA; Attachment F.

1 Volume reported by the TRU waste sites as of September 30, 2002. It is not scaled to the disposal volume.

2 Includes currently identified SQSs; at some TRU waste sites, determinations that waste is generated through defense activities have yet to be made. Inventories for those TRU waste sites are not included in this number.

3 This is the TRU waste site inventory scaled as follows: emplaced + stored + 2.11 (projected).

As TRU waste sites develop the prerequisite certification programs required for TRU waste disposal at the WIPP, they too will commence shipping waste to the WIPP. Effective implementation by the TRU waste sites of DOE Quality Assurance Program Document (QAPD) (see CCA Appendix QAPD) is a prerequisite for granting TRU waste certification authority to the TRU waste sites. A letter granting such authority will specify the date that the subject TRU waste sites effectively implemented their characterization and certification program. Any limitations imposed on the certification authority will be described in the letter.

As part of the certification for the project (63 FR 27404), the EPA promulgated a new section to the rule, Title 40 CFR 194.8. Section 194.8 establishes the approval process that must be completed before an individual TRU waste site may ship waste to the WIPP. The EPA approval considers the application of QA provisions to the waste-characterization process, including EPA audits or inspections DOE audits of TRU waste site waste-characterization

Table 4-2. Stored and Projected RH-TRU Waste Inventory as of September 30, 2002[1]

TRU Waste Site	Stored RH-TRU Inventory (m^3)	Projected RH-TRU Inventory (m^3)	Disposal RH-TRU Inventory[3] (m^3)
Hanford-RL	3.8×10^2	9.4×10^3	2.0×10^3
Hanford-RP	4.5×10^3	0.0×10^0	4.5×10^3
INEEL	2.2×10^2	0.0×10^0	2.2×10^2
LANL	1.2×10^2	0.0×10^0	1.2×10^2
ORNL	0.0×10^0	6.6×10^2	1.1×10^2
RFETS	0.0×10^0	0.0×10^0	0.0×10^0
SRS	0.0×10^0	2.3×10^1	4.0×10^0
SQS[2]	9.5×10^1	3.3×10^2	1.5×10^2
Totals	5.3×10^3	1.0×10^4	7.1×10^3

Source: Appendix DATA; Attachment F.
[1] Volume reported by the TRU waste sites as of September 30, 2002. It is not scaled to the disposal volume.
[2] Includes currently identified SQSs; at some TRU waste sites, determinations that waste is generated through defense activities have yet to be made. Inventories for those TRU waste sites are not included in this number.
[3] This is the TRU waste site inventory scaled as follows: emplaced + stored + 0.172 (projected)

programs, and provides for public review and comment. Section 194.8 also applies to the application of process knowledge by the TRU waste sites for waste characterization. The DOE must also implement a system of controls at the TRU waste sites to confirm that the total amount of each waste component emplaced in the disposal system will not exceed established limiting values.

Current information on the EPA approval of TRU waste sites to ship waste to WIPP consistent with the requirements of section 194.8 is provided in Table 4-3. In addition to these TRU waste sites, the Central Characterization Project (CCP) has been initiated by DOE and operates using mobile waste characterization equipment. As of September 30, 2003, CCP was operating and approved to ship waste from SRS, Argonne National Laboratory – East (ANL-E), and Nevada Test Site (NTS).

Table 4-3. Approved TRU Waste Site QA and Waste Characterization Programs as of September 30, 2002

TRU Waste Site
Hanford-RL
INEEL
LANL
RFETS
SRS

Source: WWIS

In addition to the major TRU waste sites, there are currently numerous SQSs planning to dispose TRU waste at the WIPP. Options to facilitate disposal of the SQS waste at the WIPP include either direct shipment to the WIPP after on-site characterization and certification or shipment to an interim facility for performing waste consolidation, treatment, and/or characterization and certification in accordance with WIPP requirements. The current list of SQSs that plan to ship directly to WIPP or to a larger site pending shipment to WIPP includes:

- Argonne National Laboratory – East (ANL-E),
- Argonne National Laboratory – West (ANL-W),
- Battelle Columbus Laboratories (BCL),
- Bettis Atomic Power Laboratory (BAPL),
- Knolls Atomic Power Laboratory (KAPL),
- Knolls Atomic Power Laboratory-Nuclear Fuel Services (KAPL-NFS),
- Lawrence Berkeley National Laboratory (LBNL),
- Lawrence Livermore National Laboratory (LLNL),
- Nevada Test Site (NTS),
- Paducah Gaseous Diffusion Plant (PGDP),
- Sandia National Laboratories/NM (SNL), and U.S. Army Material Command (USAMC).

As waste-management plans evolve at these TRU waste sites, the list is expected to change. Some TRU waste sites, for example, may ship waste to alternate facilities for processing pending shipment to WIPP. However, as of September 30, 2002, plans for shipment to alternate facilities had not been finalized. The inventories for these SQSs are reported in Appendix DATA, Attachment F, Annex J.

Six SQSs have shipped their waste to an LQS. These include:

- ARCO Medical Products Company (ARCO) – Shipped to LANL,

- Energy Technology Engineering Center (ETEC) – Shipped to Hanford-RL,
- Mound Plant – Shipped to SRS,
- Missouri University Research Reactor (MURR) – Shipped to ANL-E,[1]
- Pantex Plant - Shipped to LANL, and
- Teledyne Brown Engineering – Shipped to RFETS.

The inventories for these several SQSs are included in the LQS inventories.

Several SQSs plan to ship waste to WIPP, but their waste had not been determined to be defense waste as of September 30, 2002. These include:

- Babcock & Wilcox – Nuclear Engineering Services (B&W-NES),
- Brookhaven National Laboratory (BNL),
- Framatome,
- General Electric Vallecitos Nuclear Center (GE-VNC),
- Separations Process Research Unit (SPRU), and
- West Valley Demonstration Project (WVDP).

The inventories for these SQSs are reported in Appendix DATA, Attachment F, Annex I.

4.1.3 TRU Waste Inventory

A summary of the quantity of stored and projected TRU waste and TRU waste components is contained in Appendix DATA, Attachment F. Appendix DATA, Attachment F documents DOE’s current understanding of the total inventory of TRU waste and includes both the TRU waste that is planned to be disposed at the WIPP site and the TRU waste that is not planned to be sent to WIPP as of September 30, 2002. Only the WIPP portion of the TRU waste inventory is used in PA calculations that support the development of CRA-2004.

In preparing CRA-2004, DOE initiated a “data call” to obtain current waste inventory information from its TRU waste sites similar to the data call that was conducted prior to 1995 in preparation for the CCA. Each TRU waste site was asked to review previous data submitted regarding its TRU waste and revise those data based on current knowledge of waste at the TRU waste site.

The results of the “data call” were compiled in a database called the Transuranic Waste Baseline Inventory Database (TWBID) Revision 2.1. Data from the TWBID are reported in detail in

[1] Shipment of MURR waste to ANL-E occurred after September 30, 2002.

Appendix DATA, Attachment F and are summarized here. For the CCA, there were essentially two categories of waste: stored waste and projected waste (see CCA Section 4.1.3.1 for definitions). For CRA-2004, there are three categories of waste: emplaced waste, stored waste, and projected waste (see Section 4.1.3.1 for definitions).

For DOE to consider disposal system performance at full capacity, it is necessary to scale the waste volumes reported by the TRU waste sites. This is because the volume identified by the TRU waste sites is less than the available volume of the repository, 175,564 m^3 (6.2 million ft^3). The projected inventory reported by the TRU waste sites is scaled, to achieve a disposal inventory equal to the repository volume specified by the WIPP LWA. The repository volume remains unchanged.

As of September 30, 2002, the TRU waste sites reported a total CH-TRU waste stored inventory of 1.1×10^5 m^3 (3.9×10^6 ft^3) and a total RH-TRU waste stored inventory of 5.3×10^3 m^3 (1.9×10^5 ft^3) (see Tables 4-1 and 4-2). This is DOE's current estimate of the stored inventory destined for WIPP. In addition to identified stored volumes, the TRU waste sites project that an additional 2.5×10^4 m^3 (8.8×10^5 ft^3) of CH-TRU waste and 1.0×10^4 m^3 (3.5×10^5 ft^3) of RH-TRU waste will be generated in the future.

The stored CH-TRU waste inventory currently reported by the TRU waste sites is larger than the same inventory reported in the CCA. SRS, RFETS, Hanford, and INEEL all reported increased stored CH-TRU volumes based on new information about their waste and increased accessibility to the waste. The Hanford-RP waste was not included in the previous Hanford estimate used in the CCA, although the TWBIR indicated that it might be included in the WIPP inventory at some time in the future. Several SQSs (BCL, BAPL, KAPL, and PGDP) have identified small inventories of CH-TRU stored waste since the CCA was submitted.

While the TRU waste sites are reporting larger quantities of CH-TRU waste in storage, they are reporting smaller quantities of CH-TRU waste in the projected category. The shift from reporting waste as stored rather than projected reflects progress at the TRU waste sites towards cleanup and closure.

Overall, the anticipated CH-TRU waste inventory (stored plus projected) remaining for disposal at WIPP has decreased by an amount that is essentially equivalent to the inventory of CH-TRU waste emplaced in the repository. The total inventory (emplaced plus anticipated) of CH-TRU waste is less than the disposal limit of 168,485 m^3. Therefore, for PA calculations, the CH-TRU waste projected inventory is scaled to produce a disposal inventory equal to the repository limit.

The stored RH-TRU waste inventory currently being reported by the TRU waste sites represents an increase in the stored RH-TRU waste inventory reported in the CCA inventory estimate. Hanford-RP and Hanford-RL both reported more stored RH-TRU waste based on new information about it and increased accessibility to the waste. ANL-E, BAPL, and SNL added small amounts of stored RH-TRU waste to their inventories. ORNL moved all of their RH-TRU waste into the projected waste category because they plan to process the waste using segregation, size reduction, and evaporative drying. As its entire RH-TRU waste inventory will be processed, the ORNL RH-TRU waste is reported only as a projected inventory.

While the stored RH-TRU estimates have increased in the CRA-2004, the projected RH-TRU inventory estimates for CRA-2004 are less than what they were in the CCA inventory estimate. The greatest decrease in projected RH-TRU waste inventory was reported by Hanford-RL. The TRU waste sites report a decrease in the anticipated (stored plus projected) RH-TRU waste inventory for disposal at WIPP, a drop from over 2.6×10^4 m^3 (9.2×10^5 ft^3) reported in the CCA to about 1.0×10^4 m^3 (3.5×10^5 ft^3) as of September 30, 2002.

Nevertheless, the anticipated volume of RH-TRU reported for the CRA-2004 is greater than the repository limit for RH-TRU. Therefore, for PA calculations, the RH-TRU projected inventory is scaled down so the total disposal volume of RH TRU equals the repository limit of 7,079 m^3 (2.5×10^5 ft^3).

In support of the CCA PA, it was necessary for DOE to roll-up waste information on a repository scale. To this end, the TWBIR describes a process for grouping individual waste streams with similar physical and chemical properties into waste profiles, based on the waste matrix code (WMC) assigned by DOE TRU waste sites. The same process was followed for CRA-2004 (see Appendix DATA, Attachment F and Appendix TRU WASTE, Section TRU WASTE-2.0). Waste profiles with similar WMCs are combined across the DOE TRU waste system to provide estimated total volumes and total waste material parameters (WMPs). WMPs and waste components (as used in Section 194.24) are synonymous. Individual waste streams are evaluated to estimate the occurrence and quantities of WMPs (for example, cellulosic materials, iron-base metal and alloys, etc.) and are identified in Appendix TRU WASTE, Section TRU WASTE-2.0 as having either a significant or negligible effect on the performance of the WIPP repository.

4.1.3.1 Inventory Terminology

The following definitions are provided to help clarify the information contained in this chapter. Most of the definitions from the CCA have been included in this section without change. For CRA-2004, some definitions have been refined and others have been added.

Anticipated waste inventory – The sum of the stored and projected TRU waste inventories at DOE TRU waste sites that have not been emplaced at WIPP.

As-Generated Waste – The chemical and physical status of waste when it is generated. The as-generated term applies to both stored and projected waste.

Disposal Inventory – The volume used for CRA-2004 PA calculations. The LWA sets the total amount of TRU waste allowed in the WIPP at 175,564 m^3 (6,200,000 ft^3).

The "Agreement for Consultation and Cooperation" limits the RH-TRU inventory to 7,079 m^3 (250,000 ft^3) (DOE/NM 1981).

Emplaced waste inventory – Waste that has been placed in the repository as of September 30, 2002.

Final Waste Form – The expected physical form of a waste stream. 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 one of 11 final waste forms: solidified inorganics, salt, solidified organics, soils, uncategorized metal, lead/cadmium metal, inorganic non-metal, combustible, graphite, heterogeneous, and filter.

September 30, 2002 (the inventory date) – The date used for determining the emplaced waste inventory included in CRA-2004 and the date TRU waste sites have used as the basis for their revised inventory estimates.

Projected Inventory – The part of the TRU inventory that has not been generated but is estimated to be generated at some time in the future by the TRU waste sites. The projected inventory is the same as the to-be-generated waste referred to in Section 194.24(a).

Stored Inventory – Also referred to as "retrievably stored" inventory. The part of the anticipated waste inventory stored in such a fashion that it can be readily retrieved. Retrievably stored waste includes waste stored at the TRU waste sites since the early 1970s in buildings or berms with earthen cover and does not include waste generated prior to 1970. Retrievably stored waste also includes waste in underground storage tanks, ponds, and as decontamination and decommissioning material identified for disposal that requires retrieval at the TRU waste sites.

Scaling – The process of adjusting, if needed, the projected inventory to the repository limit (disposal inventory) is called scaling. Scaling is needed in *PA* to model the WIPP repository at full capacity (6.2 million ft^3 as set by the LWA). The scaling factor used in the CRA-2004 for CH-TRU waste is 2.11. This is only applied to the projected component of a waste stream. The scaling factor for RH-TRU waste is 0.172, which is also only applied to the projected component of a waste stream.

Scaled Inventory – Synonymous with disposal inventory. The scaled inventory is the volume that fills WIPP capacity and is used for PA calculations. This volume is calculated as the sum of the disposal volumes for all WIPP-eligible waste streams after application of RH-TRU waste and CH-TRU waste scaling computations to each WIPP-eligible projected TRU waste stream.

WIPP Waste Inventory – The sum of the emplaced waste inventory and the anticipated waste inventory.

Waste Characteristic – Section 194.2 defines waste characteristic as a property of the waste that has an impact on the containment of waste in the disposal system.

Waste Component - Section 194.2 defines waste component as an aspect of the total inventory of the waste that influences a waste characteristic.

Waste Matrix Codes (WMCs) – Codes developed by DOE, in response to the Federal Facility Compliance Act (Public Law 102-386), to aid in categorizing mixed waste streams in the DOE system into a series of five-digit alphanumeric codes (for example, S5400; Heterogeneous Debris) that represent different physical and chemical matrices. Using guidance prepared by DOE (DOE 1995e), the WMC is assigned by the TRU waste sites for all mixed waste streams and unmixed waste streams. CRA-2004 has adopted this system to remain consistent with common terminology used by the DOE TRU waste sites. WMCs are verified with radiographic examination (using either real-time radiography [RTR] or an equivalent methodology) and/or visual examination.

Waste Stream Profile – This is a description of a CH-TRU or RH-TRU waste stream. Waste stream profiles include

- waste stream description;
- waste stream source description, waste stream identification codes, final waste form;
- as-generated waste form volumes and final waste form volumes,
- estimated average values for WMP densities;;
- identification of whether the waste is CH-TRU or RH-TRU;
- final waste form radionuclide inventory (activity in Ci per cubic meter); and
- comments provided by the TRU waste sites to further explain the data provided.

WIPP Waste Profile – The WIPP waste profile represents a summary of TRU wastes at all TRU waste sites that have an identical final waste form. WIPP waste profiles include:

- the final waste form that the profile represents;
- a listing of the TRU waste sites (represented by the same final waste form) that are included in the WIPP waste profile; final waste form volumes of stored and projected waste for each TRU waste site; and
- a summary of the WMP average densities.

Waste Material Parameters (WMP) – This is one or more of the TRU waste stream constituents. The 12 WMPs have been grouped by their chemical and physical properties as shown in the following list.

<u>Inorganics</u>

- Iron-based metals and alloys — includes iron and steel alloys in the waste and does not include the waste container materials.
- Aluminum-based metals and alloys.
- Other metal and alloys — includes all other metals found in the waste materials (for example, copper, lead, zirconium, tantalum, etc.). The lead portion of lead rubber gloves and aprons is also included in this category.
- Other inorganic materials — includes inorganic nonmetal waste materials such as concrete, glass, firebrick, ceramics, sand, and inorganic sorbents.

- Vitrified materials — includes waste that has been melted or fused at high temperatures with glass-forming additives such as soil or silica to form a homogeneous glass-like matrix.

Organics

- Cellulosic Materials — includes those materials generally derived from high-polymer plant carbohydrates. Examples are paper, cardboard, kimwipes, wood, cellophane, cloth, etc.

- Rubber — includes natural or synthetic elastic latex materials. Examples are Hypalon®, neoprene, surgical gloves, leaded-rubber gloves (rubber part only), etc.

- Plastics — includes generally synthetic materials, often derived from petroleum feedstock. Examples are polyethylene, polyvinylchloride, Lucite®, Teflon®, etc.

Solidified Materials

- Inorganic matrix — includes any homogenous materials consisting of sludge or aqueous-based liquids that are solidified with cement, Envirostone™, or other solidification agents. Examples are wastewater treatment sludge, cemented aqueous liquids, inorganic particulates, etc.

- Organic matrix — includes cemented organic resins, solidified organic liquids, and sludges.

- Cement — includes the cement used in solidifying liquids, particulates, and sludges.

Soils

- Soils — generally consists of naturally occurring soils that have been contaminated with inorganic radioactive waste materials.

Although not considered to be a waste component, the associated packaging materials are also listed because they also provide input to the PA calculations.

Packaging Materials

- Steel — weight of the steel component of the standard container. Any necessary overpacking is included in the weight of steel.

- Plastics — weight of any standard plastic secondary confinement within the container.

- Lead — weight of the lead shielding.

The estimated WMP information is expressed in units of kilograms per cubic meter corresponding to the volume the waste package will occupy in the repository. This unit facilitates scaling the material parameters to address various volumes for PA calculations and sensitivity analysis.

4.1.3.2 Nonradionuclide Inventory Roll-Up

The DOE uses the eleven final waste forms as an intermediate step in determining the inventory of nonradionuclide waste components. These final waste forms are a convenient way for the DOE to categorize waste for the purpose of waste management and waste characterization prior to shipment to the WIPP. Waste streams at each TRU waste site with similar WMCs are grouped together into one of the 11 final waste forms. The grouping of individual waste stream profiles into a WIPP waste profile is based on the similar physical and chemical properties of the waste streams. Current estimates of the final waste form volumes for CH-TRU and RH-TRU waste are provided in Table 4-4. For comparison, estimates of the final waste-form volumes for CH-TRU and RH-TRU waste from the CCA are also provided in Table 4-4. The relative contribution of heterogeneous debris, solidified organics, and filters to the current reported CH-TRU waste volume has increased when compared to the CCA inventory estimate. The most notable increase is in the heterogeneous debris category. SRS, LANL, RFETS, and INEEL all reported larger expected volumes of heterogeneous debris in the CRA-2004 data call than they reported for the CCA inventory estimate. Larger volumes of heterogeneous debris are expected to come from the FB (F-Canyon at SRS) and HB (H-Canyon at SRS) process lines, facility and equipment operations at LANL, decontamination and decommissioning at RFETS, and the start-up of the Advanced Mixed Waste Treatment Facility (AMWTF) at INEEL.

The relative contribution of uncategorized metal, graphite, soil and combustibles to the current reported CH-TRU waste volume has decreased when compared to the CCA inventory estimate. The most notable decrease is in the uncategorized metal category. Hanford-RL, LANL, and INEEL all reported smaller expected volumes of uncategorized metal in the CRA-2004 data call than in the CCA inventory estimate due primarily to reassignment of the waste to other forms based on new characterization information.

The relative contribution of inorganic non-metal, filters, soils, solidified organics, and solidified inorganics to the current reported RH-TRU waste volume has increased when compared to the CCA estimate. The most notable increase is in the solidified inorganic category. Hanford-RP and Hanford-RL reported larger expected volumes of solidified inorganics in the CRA-2004 data call than in the CCA inventory estimate. Larger volumes of solidified inorganics are expected from Hanford-RP due to the waste in underground storage tanks.

The relative contribution of uncategorized metal to the currently reported RH-TRU volume has decreased when compared to the CCA estimate. Hanford-RL reassigned a significant volume of waste that was reported as uncategorized metal in the CCA to other forms based on new characterization information.

To establish the nonradioactive waste component inventory, DOE accumulated WMP information (as WMP average densities in units of kg/m^3) in the CRA-2004 data call by final waste form. This accumulation is shown as a series of tables (Tables DATA-F-10 through DATA-F-30 in Appendix DATA, Attachment F).

These average densities are further summed to determine the total WIPP waste component disposal inventory for CH-TRU and RH-TRU waste and are given in Tables DATA-F-31 and DATA-F-32 of Appendix DATA, Attachment F, and are reproduced here with a comparison to the CCA inventory values in Tables 4-5 (CH-TRU waste) and 4-6 (RH-TRU waste), respectively. It should be noted that MgO is not listed in these tables. Since MgO is not a component of the waste, it is not regarded as a WMP. A discussion of the MgO is contained in Chapter 3.0; CCA Appendix BACK and CCA Appendix SOTERM; Appendix BARRIERS; and Appendix PA, Attachment SOTERM.

Table 4-4. Nonradionuclide TRU Waste Inventory for the WIPP

Final Waste Forms	Current Inventory Volumes (m^3)				Volumes Reported in the CCA (m^3) [1]			
	Emplaced	Stored	Projected	WIPP Disposal	Emplaced	Stored	Projected	WIPP Disposal
	CH-TRU Waste				CH-TRU Waste			
Combustible	6.1×10^{2}	4.3×10^{3}	1.9×10^{3}	8.9×10^{3}	--	5.8×10^{3}	4.6×10^{3}	1.4×10^{4}
Filter	3.4×10^{2}	9.9×10^{2}	5.9×10^{2}	2.6×10^{3}	--	2.2×10^{2}	5.1×10^{2}	1.2×10^{3}
Graphite	0.0×10^{0}	1.2×10^{2}	1.3×10^{0}	1.2×10^{2}	--	5.1×10^{2}	4.8×10^{1}	6.0×10^{2}
Heterogeneous	5.7×10^{2}	4.9×10^{4}	9.7×10^{3}	7.0×10^{4}	--	2.7×10^{4}	1.3×10^{4}	5.1×10^{4}
Inorganic Nonmetal	9.7×10^{2}	1.1×10^{4}	6.8×10^{1}	1.2×10^{4}	--	3.1×10^{3}	9.4×10^{2}	4.9×10^{3}
Lead and Cadmium Metal Waste	8.1×10^{1}	1.4×10^{2}	3.2×10^{1}	2.9×10^{2}	--	3.5×10^{1}	3.3×10^{2}	6.6×10^{2}
Salt Waste	1.5×10^{3}	1.5×10^{2}	1.9×10^{2}	2.1×10^{3}	--	2.1×10^{1}	3.3×10^{2}	6.4×10^{2}
Soils	0.0×10^{0}	3.0×10^{2}	6.0×10^{3}	1.3×10^{4}	--	4.1×10^{2}	6.0×10^{3}	1.2×10^{4}
Solidified Inorganics	3.3×10^{3}	3.5×10^{4}	7.3×10^{2}	4.0×10^{4}	--	9.6×10^{3}	4.5×10^{3}	1.8×10^{4}
Solidified Organics	0.0×10^{0}	5.2×10^{3}	3.8×10^{2}	6.0×10^{3}	--	9.1×10^{2}	7.5×10^{1}	1.1×10^{3}
Uncategorized Metal	3.6×10^{2}	2.4×10^{3}	5.1×10^{3}	1.4×10^{4}	--	1.1×10^{4}	2.3×10^{4}	5.4×10^{4}
Total CH-TRU Waste Volumes	7.7×10^{3}	1.1×10^{5}	2.5×10^{4}	1.7×10^{5}	--	5.8×10^{4}	5.4×10^{4}	1.6×10^{5}

Source: Current inventory volumes - Appendix DATA, Attachment F; Volume reported in the CCA – TWBIR Revision 3

[1] Comparisons between the current inventory values and the values reported in the CCA are made in detail in Appendix DATA, Attachment F, Annex B

[2] The WIPP is limited to 7,079 m^3 of RH-TRU waste by agreement with the State of New Mexico.

Table 4-4. Nonradionuclide TRU Waste Inventory for the WIPP — Continued

Final Waste Forms	Current Inventory Volumes (m^3)				Volumes Reported in the CCA (m^3) [1]			
	Emplaced	Stored	Projected	WIPP Disposal	Emplaced	Stored	Projected	WIPP Disposal
	RH-TRU Waste				RH-TRU Waste			
Combustible	--	1.8×10^{1}	8.9×10^{-1}	1.8×10^{1}	--	3.6×10^{1}	4.9×10^{1}	--
Filter	--	8.9×10^{0}	8.9×10^{0}	1.0×10^{1}	--	--	--	--
Heterogeneous	--	6.1×10^{2}	3.8×10^{3}	1.3×10^{3}	--	2.3×10^{3}	5.5×10^{3}	--
Inorganic Non-Metal	--	4.3×10^{1}	4.4×10^{1}	5.1×10^{1}	--	4.6×10^{1}	2.1×10^{1}	--
Lead and Cadmium Metal Waste	--	1.2×10^{1}	7.1×10^{0}	1.3×10^{1}	--	7.1×10^{0}	6.7×10^{1}	--
Soils	--	0.0×10^{0}	2.0×10^{2}	3.4×10^{-1}	--	--	--	--
Solidified Inorganics	--	4.5×10^{3}	3.3×10^{2}	4.6×10^{3}	--	1.1×10^{3}	2.3×10^{2}	--
Solidified Organics	--	9.5×10^{0}	0.0×10^{0}	9.5×10^{0}	--	3.6×10^{0}	0.0×10^{0}	--
Uncategorized Metal	--	8.4×10^{1}	6.1×10^{3}	1.1×10^{3}	--	1.2×10^{2}	1.7×10^{4}	--
Total RH-TRU Waste Volumes[2]	--	5.3×10^{3}	1.0×10^{4}	7.1×10^{3}	--	3.6×10^{3}	2.3×10^{4}	– –
Total TRU Waste Volumes	7.7×10^{3}	1.1×10^{5}	3.5×10^{4}	1.8×10^{5}	-	6.2×10^{4}	7.7×10^{4}	1.7×10^{5}

Source: Current inventory volumes - Appendix DATA, Attachment F; Volume reported in the CCA – TWBIR Revision 3

[1] Comparisons between the current inventory values and the values reported in the CCA are made in detail in Appendix DATA; Attachment F, Annex B

[2] The WIPP is limited to 7,079 m^3 of RH-TRU waste by agreement with the State of New Mexico.

DOE reports the average density for WMPs because these values are used to generate the waste-related inputs for PA. Section 3.4 of the TWBIR recommends use of the average value, based on the methodology used to obtain and report data. CRA-2004 also uses average values for the WMPs to generate waste-related inputs for PA.

Analysis of the current inventory estimate and the CCA inventory estimate for CH-TRU waste shows that waste materials expected for shipment to WIPP have changed slightly since the CCA. The relative occurrence (expressed as the kg/m^3 of a given material in the waste) of iron (Fe), aluminum (Al), and other metal alloys is smaller in the current inventory estimate than it was in the CCA inventory estimate. In addition, the relative occurrence of solidified organics, cement, soils, and vitrified material is smaller in the current inventory estimate than it was in the CCA inventory estimate. In contrast, the relative occurrence of cellulosic, plastic, and rubber (CPR) materials and other inorganic materials is larger in the current inventory estimate than it was in the CCA inventory estimate. The current inventory estimate reflects a shift from an expected waste form consisting of 40 percent metals, 15 percent CPR materials and 45 percent other materials reported in the CCA to a waste form that consists of 34 percent metals, 25 percent CPR materials and 41 percent other materials. The current inventory estimate reflects a higher occurrence of CPR materials primarily because of a process change at INEEL. At the time of the CCA, INEEL expected to thermally treat a significant quantity of waste that contained higher than average quantities of CPR materials. Through the process of thermal treatment, the CPR materials in the waste would be destroyed. INEEL currently plans to supercompact the waste that they had originally planned to thermally treat. Supercompaction does not destroy CPR materials in the waste. As a consequence, the waste expected to come to WIPP from INEEL has increased CPR materials relative to those reported for the CCA.

Table 4-5. WIPP CH-TRU Waste and Container Material Disposal Inventory

Waste Materials	**Average Density Based on Current Inventory (kg/m^3)**	**Average Density Reported in the CCA (kg/m^3)**
Waste Materials		
Fe-Base Metal/Alloys	1.1×10^{2}	1.7×10^{2}
Al-Base Metal/Alloys	1.4×10^{1}	1.8×10^{1}
Other Metal/Alloys	3.0×10^{1}	6.7×10^{1}
Other Inorganic Materials	4.2×10^{1}	3.1×10^{1}
Vitrified Materials	6.2×10^{0}	5.5×10^{1}
Cellulosic Material	5.8×10^{1}	5.4×10^{1}
Rubber	1.4×10^{1}	1.0×10^{1}
Plastic	4.2×10^{1}	3.4×10^{1}
Solidified Inorganic Materials	7.7×10^{1}	5.4×10^{1}
Solidified Organic Materials	1.6×10^{1}	5.6×10^{0}
Cement (Solidified)	2.9×10^{1}	5.0×10^{1}
Soil	1.9×10^{1}	4.4×10^{1}
Container Materials		

Steel	1.7×10^{2}	1.4×10^{2}
Plastic and Liners	1.6×10^{1}	2.6×10^{1}
Lead	1.4×10^{-2}	0.0×10^{0}

Source: Appendix DATA, Attachment F.

Table 4-6. WIPP RH-TRU Waste and Container Material Disposal Inventory

Waste Materials	Average Density Based on Current Inventory (kg/m^3)	Average Density Reported in the CCA (kg/m^3)
Waste Materials		
Fe-Base Metal/Alloys	1.1×10^{2}	1.0×10^{1}
Al-Base Metal/Alloys	2.5×10^{0}	7.1×10^{0}
Other Metal/Alloys	3.2×10^{1}	2.5×10^{2}
Other Inorganic Materials	3.5×10^{1}	6.4×10^{1}
Vitrified Materials	5.7×10^{-2}	4.7×10^{0}
Cellulosic Material	4.5×10^{0}	1.7×10^{1}
Rubber	3.1×10^{0}	3.3×10^{0}
Plastic	4.9×10^{0}	1.5×10^{1}
Solidified Inorganic Materials	3.9×10^{1}	2.2×10^{1}
Solidified Organic Materials	4.0×10^{0}	9.3×10^{-1}
Cement (Solidified)	8.7×10^{-1}	1.0×10^{0}
Soil	2.6×10^{1}	
Container Materials		
Steel	4.8×10^{2}	4.5×10^{2}
Plastic and Liners	1.4×10^{0}	3.1×10^{0}
Lead	4.4×10^{2}	4.7×10^{2}

Source: Appendix DATA, Attachment F

The container materials for CH-TRU waste are primarily steel, plastic, and lead. The current inventory estimate reflects a higher occurrence of steel, a lower occurrence of plastic, and a higher occurrence of lead in the packages coming to WIPP when compared to the CCA inventory estimate. Additional steel in packages currently planned to come to WIPP results from the planned increased use of overpacks (Type A or equivalent packages, pipe overpacks, ten-drum overpacks, 100-gallon drum overpacks, etc.). The increased use of overpack containers in the current inventory estimate also leads to a reduction in the use of plastic liners in packages coming to WIPP. Thus, the density of plastic packaging material is smaller than it was in the CCA inventory estimate.

The inventory of chemical components of the waste (needed for scoping calculations to determine their importance on performance) was requested in the CRA-2004 data call. The information requested by DOE was specific to solidified waste forms destined for disposal at the WIPP and included complexing agents, nitrates, sulfates, phosphates, and cement. A summary of this information can be found in Appendix DATA, Attachment F. Additional information addressing the impact, limits, and characterization (or noncharacterization) of these chemical components is provided in Appendix TRU WASTE, Sections TRU WASTE-2.0 and TRU WASTE-3.0. The importance of these chemical components to PA is assessed in Appendix TRU WASTE, Section TRU WASTE-2.0.

4.1.3.3 Radionuclide Inventory Roll-Up

Estimates of the radionuclide inventory are included in Appendix DATA, Attachment F. TRU waste sites derive these estimates based on acceptable knowledge including any quantitative results that may be available. In the data call for CRA-2004, TRU waste sites reported estimated values for radionuclide activities on a waste stream basis including both the stored and projected components. The actual activity of disposed waste is determined quantitatively prior to shipment, as discussed in Section 4.4.2.

The disposal radionuclide inventory for PA is a calculated value based on the radionuclide activities reported for emplaced, stored, and projected waste. The radionuclide activities in the projected component of the waste are scaled using the scaling factor and added to the radionuclide activities for stored and emplaced components of the waste.

This calculation is based on all radionuclide activities decayed to the end of 2001. Radioactive decay and build-up calculations were performed using the commercially available code ORIGEN2 (Croff 1980). The levels of radioactivity reported include contributions from both parent and daughter decay products. For CH-TRU waste, the total Ci for each radionuclide is divided by the CH-TRU disposal volume to obtain a Ci per cubic meter concentration for each radionuclide on a repository level. For RH-TRU waste, the total decayed WIPP Ci for each radionuclide is divided by the RH-TRU disposal volume to obtain a radionuclide concentration in Ci per cubic meter.

The WIPP disposal radionuclide inventory used in PA for both CH-TRU and RH-TRU wastes is shown in Table 4-7. Activities at closure (2033) are used in PA. The table shows individual radionuclide activity in Ci for both CH-TRU and RH-TRU waste. Based on the total Ci shown in Table 4-7 and to the extent to which each radionuclide is regulated by Section 191.13, approximately 98.6 percent of the regulated CH-TRU activity at repository closure is contributed by ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am.

Table 4-7. Radionuclides Considered in PA

Radionuclide	Current Inventory Values			Values Reported in the CCA			Release Calculations (1)			
	Inventory at Closure (Ci)	EPA Units		Inventory at Closure (Ci)	EPA Units		Cuttings, Cavings, and Spall Release	Direct Brine Release	Salado Release	Culebra Release
		At Closure(4)	At 10,000 years		At Closure	At 10,000 years				
^{238}Pu	1.25×10^{6}	5.04×10^{3}	2.61×10^{-23}	1.94×10^{6}	5.64×10^{3}	1.32×10^{-22}	x	x	(2)	(2)
^{239}Pu	6.65×10^{5}	2.68×10^{3}	2.01×10^{3}	7.95×10^{5}	2.31×10^{3}	1.73×10^{3}	x	x	x	x
^{241}Am	4.58×10^{5}	1.84×10^{3}	2.48×10^{-4}	4.88×10^{5}	1.42×10^{3}	1.78×10^{-4}	x	x	x	x
^{240}Pu	1.08×10^{5}	4.36×10^{2}	1.51×10^{2}	2.14×10^{5}	6.22×10^{2}	2.16×10^{2}	x	x	c	c
^{137}Cs	1.79×10^{5}	7.19×10^{1}	0.00×10^{0}	9.31×10^{4}	2.71×10^{1}	0.00×10^{0}	x	--	--	--
^{90}Sr	1.42×10^{5}	5.71×10^{1}	0.00×10^{0}	8.73×10^{4}	2.54×10^{1}	0.00×10^{0}	x	--	--	--
^{233}U	1.27×10^{3}	5.12×10^{0}	4.91×10^{0}	1.95×10^{3}	5.67×10^{0}	5.44×10^{0}	x	x	c	c
^{229}Th	5.39×10^{0}	2.17×10^{-2}	3.04×10^{0}	9.97×10^{0}	2.90×10^{-2}	3.40×10^{0}	--	x	c	c
^{234}U	3.19×10^{2}	1.28×10^{0}	3.03×10^{0}	7.51×10^{2}	2.18×10^{0}	4.10×10^{0}	x	x	x	x
^{230}Th	1.76×10^{-1}	7.07×10^{-3}	2.64×10^{0}	3.06×10^{-1}	8.90×10^{-3}	3.55×10^{0}	--	x	x	x
^{238}U	1.54×10^{2}	6.21×10^{-1}	6.21×10^{-1}	5.01×10^{1}	1.46×10^{-1}	1.46×10^{-1}	--	x	--	--
^{237}Np	1.01×10^{1}	4.06×10^{-2}	4.27×10^{-1}	6.49×10^{1}	1.89×10^{-1}	4.83×10^{-1}	--	x	--	--
^{232}Th	6.83×10^{0}	2.75×10^{-1}	2.75×10^{-1}	1.01×10^{0}	2.94×10^{-2}	2.94×10^{-2}	--	x	--	--
^{226}Ra	6.28×10^{0}	2.53×10^{-2}	2.07×10^{-1}	1.14×10^{1}	3.31×10^{-2}	2.77×10^{-1}	--	--	--	--
^{210}Pb	4.94×10^{0}	1.99×10^{-2}	2.07×10^{-1}	8.75×10^{0}	2.54×10^{-2}	2.77×10^{-1}	--	x	--	--
^{242}Pu	2.71×10^{1}	1.09×10^{-1}	1.07×10^{-1}	1.17×10^{3}	3.40×10^{0}	3.34×10^{0}	--	x	c	c
^{243}Am	2.17×10^{1}	8.75×10^{-2}	5.74×10^{-2}	3.25×10^{1}	9.45×10^{-2}	3.69×10^{-2}	--	x	--	--
^{236}U	1.65×10^{0}	6.66×10^{-3}	8.62×10^{-2}	6.72×10^{-1}	1.95×10^{-3}	1.16×10^{-1}	--	x	--	--
^{235}U	2.28×10^{0}	9.18×10^{-3}	3.21×10^{-2}	1.75×10^{1}	5.09×10^{-2}	7.06×10^{-2}	--	x	--	--
^{14}C	3.25×10^{0}	1.31×10^{-2}	3.90×10^{-3}	1.28×10^{1}	3.72×10^{-2}	1.11×10^{-2}	--	--		
^{232}U	3.06×10^{0}	1.23×10^{-2}	0.00×10^{0}	1.79×10^{1}	5.20×10^{-2}	0.00×10^{0}	--	--	--	--
^{227}Ac	9.57×10^{-1}	3.85×10^{-3}	8.06×10^{-3}	5.05×10^{-1}	1.47×10^{-3}	1.28×10^{-2}	--	--	--	--
^{231}Pa	1.21×10^{0}	4.88×10^{-3}	8.06×10^{-3}	4.67×10^{-1}	1.36×10^{-3}	1.28×10^{-2}	--	--	--	--
^{243}Cm	4.07×10^{-1}	1.64×10^{-3}	0.00×10^{0}	2.07×10^{1}	6.02×10^{-2}	0.00×10^{0}	--	x	--	--
^{248}Cm	9.32×10^{-2}	3.75×10^{-4}	3.68×10^{-4}	3.72×10^{-2}	1.08×10^{-4}	1.06×10^{-4}	--	x	--	--
^{245}Cm	1.92×10^{-2}	7.72×10^{-5}	3.97×10^{-5}	1.15×10^{-2}	3.40×10^{-5}	1.85×10-^{5}	--	x	--	--

Table 4-7. Radionuclides Considered in PA — Continued

Radionuclide	Current Inventory Values			Values Reported in the CCA			Release Calculations (1)			
	Inventory at Closure (Ci)	EPA Units		Inventory at Closure (Ci)	EPA Units		Cuttings, Cavings, and Spall Release	Direct Brine Release	Salado Release	Culebra Release
		At Closure(4)	At 10,000 years		At Closure	At 10,000 years				
^{244}Pu	1.10×10^{-3}	4.44×10^{-6}	4.47×10^{-6}	1.51×10^{-6}	4.34×10^{-9}	1.26×10^{-8}	--	x	--	--
^{244}Cm	2.51×10^{3}	(3)	(3)	7.44×10^{3}	(3)	(3)	x	x	--	--
^{241}Pu	5.38×10^{5}	(3)	(3)	3.94×10^{5}	(3)	(3)	x	x	--	--
Percent of EPA Units at closure represented by nuclides in source term							99.98%	98.71%	48.95%	48.95%
Percent of EPA Units at 10,000 years represented by nuclides in source term							99.65%	99.99%	99.92%	99.92%

Source: Appendix TRU Waste, Section TRU Waste-2.0

1. See Section 6.3 for a discussion of scenarios analyzed by PA and the release pathways.
2. Pu-238 was included in the Salado transport calculations but the release to the Culebra was too low to merit calculation of its transport within the Culebra. The EPA unit percent total at closure increases to 98.71% with Pu-238 added; the percent at 10,000 years is unaffected.

3. Pu-241 and Cm-244 are not listed by Part 191 of the Code of Federal Regulations but are included because their daughters, ^{241}Am and ^{240}Pu, respectively, are significant to performance
4. At closure is decayed through 2033.

x indicates an isotope included in calculation.
c indicates isotopes that are combined for transport with isotopes having similar characteristics.

Approximately 99.5 percent of the regulated RH-TRU activity at repository closure is contributed by ^{137}Cs, ^{90}Sr, ^{239}Pu, ^{240}Pu, ^{241}Am, and ^{238}Pu (derived from data in TRU WASTE, Section TRU WASTE-2.0, Table TRU WASTE-9). The same radionuclides were identified in the CCA as the largest contributors to the regulated CH-TRU waste and RH-TRU waste activity at repository closure (see CCA Appendix WCA, Section 8.2). Overall, activity for all TRU radionuclides has decreased from 3.44×10^6 Ci (at 2033) reported in the CCA to 2.48×10^6 Ci (at 2033) in the current inventory estimate. The results for RH-TRU waste show variations in individual radionuclide activity and an overall increase in reported activity since the CCA.

The values presented in Table 4-7 are used as input to the PA calculations. A more detailed examination of the programs prepared by DOE to collect supplemental radiological data are provided in Section 4.4.

In addition to the inventory in Table 4-7, DOE has determined the average radionuclide inventory for each of the 779 (693 CH-TRU waste streams and 86 RH-TRU waste streams) CH-TRU and RH-TRU waste streams (see Appendix DATA, Attachment F*)*. In the conceptual model for PA, the distribution of 693 CH-TRU waste streams and one RH-TRU waste stream (representing all of 86 the RH-TRU waste) are randomly sampled in the PA to determine releases due to inadvertent human intrusion. This process is discussed in Section 6.4.12.4 and assumes that each container in the waste stream has the average radionuclide inventory for that stream.

4.2 Waste Components and Characteristics

This section of the application is provided to document compliance with the provisions of Section 194.24(b) and describes, in summary fashion,

- those components or characteristics of the waste that are most important in terms of their impact on the performance of the WIPP disposal system and

- the limits imposed by DOE on the significant components or characteristics of the waste to ensure that emplaced waste will behave in a manner that is consistent with the inventory assumed for the performance calculations.

4.2.1 Identification and Qualification

The waste characteristics and components expected to be most significant to performance are the predominant radionuclides and their associated characteristics and components affecting actinide mobility. These are summarized in Table 4-8; they are unchanged from the CCA.

Table 4-8. Waste Characteristics and Components Expected to be Most Significant to Performance

Component	Characteristic	Reason for Significance
^{239}Pu, ^{240}Pu, ^{241}Am, ^{233}U, and ^{234}U	Activity	99 percent of EPA unit after 2,000 years
^{238}Pu	Activity	Dominates EPA unit at early times
Pu and Am	Solubility	Large EPA unit; mobility depends on solubility
^{238}U	Activity	Very low activity; dilutes higher-activity uranium isotopes for brine-based releases
Iron	Redox Potential	Sustains reducing environment so that lower, less soluble oxidation states of actinides predominate
Cellulosic material, plastic, rubber, nitrate, sulfate	Nutrient for Microbes	Microbial nutrients that are metabolized to methane and several other gases, increasing gas pressure; formation of colloids
Humic materials, cellulose breakdown products	Colloid Formation	Formation of humic colloids that sorb and transport actinides
Nonferrous metals	Organic Complexation	Prevent increase in actinide solubility by binding with ligands
Waste	Shear Strength	Important to spalling and cavings

Source: Appendix TRU Waste, Section 2

The waste unit factor is the number of millions of Ci of alpha-emitting TRU radionuclides with half-lives longer than 20 years (Part 191 of the Code of Federal Regulations, Appendix A). In the WIPP, 2.48[2] million Ci of TRU waste will be in the repository at closure, so the waste unit factor is 2.48. The radionuclides that contribute to the waste unit factor are based on an analysis (see Appendix TRU WASTE, Section TRU WASTE-2.0) of the radionuclide inventory in Appendix DATA, Attachment F and are presented in Table 4-9 (decayed to the end of 2033). The radionuclide contributions to the waste unit factor from the CCA are also presented in Table 4-9. Waste characteristics and components with an insignificant impact on performance are summarized in Table 4-10. This table remains unchanged from CCA Table 4-9.

4.2.2 Repository Limits

The following discussion describes the criteria in Sections 194.24(c)(1) and 194.24(c)(2).

[2] The value for the waste unit factor (WUF) in the CCA was inconsistently described; Chapter 4, Section 4.2.1 correctly listed the WUF that was used in the CCA PA as 3.44. CCA Appendix WCA Sections 1.4.2 and WCA Attachment WCA.8.1 incorrectly stated the 1995 decayed value of 4.07 was used in the CCA PA, however the preface to Attachment WCA.8.2 identified and corrected the error. During the EPA's review of the CCA, EPA required DOE to recalculate a new WUF of 3.59 that was ultimately included in the EPA's PAVT (EPA 1998). After the certification, the DOE incorporated the PAVT WUF value of 3.59 in the compliance baseline through an EPA approved change request (EPA 2002).

Waste components are the controlling factors for the waste characteristics. Therefore, limits imposed on the waste components necessarily serve to limit the waste characteristics. In the case where a characteristic is benign with respect to repository performance, no control of the corresponding component is necessary and no limits need be imposed on that component. Conversely, should repository performance be sensitive to a particular waste characteristic, then control of the corresponding component is mandated and limits are established to restrict the maximum or minimum amounts of that component allowed for disposal.

Based on the PA calculations and the rationale described in Appendix TRU WASTE, Table 4-11 identifies the characteristics of the components for which determination prior to emplacement is required. Table 4-11 also lists any applicable repository-based emplacement limits for the components. Discussions of the rationale for the proposed assaying and emplacement limits for each component are presented in Appendix TRU WASTE. All of the components identified in

Table 4-9. Radionuclides That Contribute to the Waste Unit Factor

Nuclide	Half-Life (years)	Current Inventory Values		Values Reported in the CCA(1)	
		Inventory at Closure (Ci)	Percent of Waste Unit at Closure	Inventory at Closure (Ci)	Percent of Waste Unit at Closure
^{241}Am	4.33×10^{2}	4.58×10^{5}	1.82×10^{1}	4.88×10^{5}	1.42×10^{1}
^{243}Am	7.37×10^{3}	2.17×10^{1}	8.63×10^{-4}	3.25×10^{1}	9.45×10^{-4}
^{249}Cf	3.51×10^{2}	7.24×10^{-2}	2.88×10^{-6}	6.38×10^{-2}	1.85×10^{-6}
^{251}Cf	9.00×10^{2}	5.10×10^{-4}	2.03×10^{-8}	3.67×10^{-3}	1.07×10^{-7}
^{243}Cm	2.91×10^{1}	4.07×10^{-1}	1.62×10^{-5}	2.07×10^{1}	6.02×10^{-4}
^{245}Cm	8.50×10^{3}	1.92×10^{-2}	7.62×10^{-7}	1.15×10^{-2}	3.34×10^{-7}
^{246}Cm	4.76×10^{3}	2.22×10^{0}	8.80×10^{-5}	1.02×10^{-1}	2.97×10^{-6}
^{247}Cm	1.56×10^{7}	9.45×10^{0}	3.75×10^{-4}	9.51×10^{-9}	2.76×10^{-13}
^{248}Cm	3.48×10^{5}	9.32×10^{-2}	3.70×10^{-6}	3.72×10^{-2}	1.08×10^{-6}
^{237}Np	2.14×10^{6}	1.01×10^{1}	4.00×10^{-4}	6.49×10^{1}	1.89×10^{-3}
^{238}Pu	8.77×10^{1}	1.25×10^{6}	4.98×10^{1}	1.94×10^{6}	5.64×10^{1}
^{239}Pu	2.41×10^{4}	6.65×10^{5}	2.64×10^{1}	7.95×10^{5}	2.31×10^{1}
^{240}Pu	6.56×10^{3}	1.08×10^{5}	4.30×10^{0}	2.14×10^{5}	6.22×10^{0}
^{242}Pu	3.75×10^{5}	2.71×10^{1}	1.08×10^{-3}	1.17×10^{3}	3.40×10^{-2}
^{244}Pu	8.00×10^{7}	1.10×10^{-3}	4.38×10^{-8}	1.51×10^{-6}	4.39×10^{-11}
Total	---	2.48×10^{6}	9.86×10^{1}	3.44×10^{6}	9.99×10^{1}

Source: Appendix TRU WASTE, Section TRU WASTE-2.0.
(1) Radionuclide activities and the WUF were reported with conflicting values in several places in the CCA. The values used in this table were the actual values used in the performance assessment for the CCA as recorded in the PAPDB.

Table 4-10. Waste Characteristics and Components Expected to be Insignificant

Characteristics and Component	Reason for insignificant impact
Radionuclides other than those in Table 4-8	EPA unit is negligible fraction of total, even with ingrowth
Substances that may affect pH[1]	pH is buffered by MgO backfill
Substances that produce CO_2 [1]	CO_2 is removed by reaction with MgO backfill
Intrinsic and mineral fragment colloids	Fraction of actinides mobilized by these colloids is insignificant
Organic ligands	Removed by binding with Mg and nonferrous metal
Heat generated by exothermic reactions	Heats of formation are small and thermal mass of repository is large so that temperature rise is negligible
Fluid in the waste	Negligible compared to brine volume

Source: Appendix TRU WASTE [1] These components are significant for gas generation, but not for actinide solubility.

1 **Table 4-11. Repository-Based Emplacement Limits Related to PA**

Waste Components	Associated Waste Characteristics	Components Requiring Quantification	Emplacement Limits
radionuclides	radioactivity at closure radioactivity after closure solubility colloid formation reduction-oxidation state	^{241}Am ^{238}Pu ^{239}Pu ^{240}Pu ^{242}Pu ^{233}U ^{234}U ^{238}U ^{90}Sr ^{137}Cs	none[1]
ferrous metals (iron)	reduction-oxidation potential H_2 gas generation complexing with organic ligands	none	minimum = 2×10^7 kilograms (amount from containers)[2]
cellulosic, plastic, rubber materials	gas generation humic colloids (see below) gas generation	sum of emplaced components	maximum = 2.2×10^7 kilograms[3]
sulfates	gas generation	none	none[4]
nitrates	gas generation	none	none[4]
solid components	particle size effective shear resistance to erosion tensile strength	none	none
free liquid emplaced with waste	gas generation	none	maximum = 1684 cubic meters for CH-TRU (limit of 1 percent total waste volume as set by the WAC) [e]
humic substances	radionuclide-bearing humic colloids	none	none
nonferrous metals (metals other than iron)	bind with organic ligands and prevent increased solubility	none	minimum = 2×10^3 kilograms[5]
organic ligands	solubility	none	none[4]

Source: Appendix TRU WASTE, Section TRU WASTE-3.0

1 Inventory curie content will be tracked.

2 Minimum set to ensure sufficient reactants for reducing radionuclides to lower and less soluble oxidation states. .

3 Maximum set to ensure sufficient MgO backfill is available to react with CO_2 produced.

4 For the current waste generation processes that are documented in the Transuranic Waste Inventory Update Report--Supporting Information for the 2004 WIPP Compliance Recertification Application.

5 Minimum quantity for complexing with organic ligands (see Appendix PA, Attachment SOTERM).

CCA Appendix WCA and Appendix TRU WASTE, Section TRU WASTE.2-0 were found to be insignificant to disposal system performance. Therefore, it is not necessary to establish additional container-based emplacement limits for these components.

Table 4-12 is a supplement to Table 4-11; that is, it lists the repository limits imposed by the LWA . Collectively, Tables 4-11 and 4-12 define the WIPP repository-based emplacement limits on the waste.

Since the first waste shipment arrival at the WIPP, DOE has tracked the quantities of materials identified in Tables 4-11 and 4-12 that have been emplaced in the repository. The quantities of these materials emplaced in WIPP since its opening through September 30, 2002, are listed in Tables 4-13 and 4-14.

4.2.3 Waste Container Limits

Waste limits have been established by DOE as part of the WIPP's design development and by the WIPP LWA. Waste container limits relevant to the requirements of the WIPP LWA are identified in Table 4-15. The CH-TRU Waste Acceptance Criteria (WAC) restrict the physical, chemical, and radiological properties of the waste to mitigate conditions that will have adverse impacts on human health and the environment.

DOE requires the TRU waste sites to prepare a waste-certification plan that lists the methods and techniques used to determine compliance with the CH-TRU WAC and the QA program (see Appendix QAPD-2004). This includes QA and quality control criteria that are applied to the generator's waste certification program. Each participating TRU waste site is responsible for developing and implementing specific TRU waste program documents (plans) that address all activities pertaining to TRU waste characterization, certification, packaging, and transportation of TRU waste to the WIPP. These plans include the TRU Waste Certification Plan and associated QA plan, the TRUPACT-II Authorized Methods for Payload Control and associated QA plans, and the TRU waste characterization QAPjP. Methods of compliance with each criterion and requirement are documented or specifically referenced and include procedural and administrative controls.

Table 4-12. Repository-Based Emplacement Limits Imposed by the LWA

Waste Components	Emplacement Limits
Total Capacity (CH- and RH-TRU)	6.2 million ft^3 (175,564 m^3)
RH-TRU waste total Ci	5.1 million Ci ($\sim 18.9 \times 10^{16}$ Becquerels)
RH-TRU waste total dose rate	No more than five percent by volume of RH TRU waste may exceed 100 rems per hour

Table 4-13. Quantities of Radionuclides Emplaced in the Repository as of September 30, 2002[1,2]

NR=Not reported or reported at values less than 10^{-13}

Radionuclide	Quantity (Ci)	Radionuclide	Quantity (Ci)
^{227}Ac	3.64×10^{-4}	^{147}Pm	NR
^{241}Am	1.17×10^{5}	^{238}Pu	5.64×10^{3}
^{243}Am	4.81×10^{-3}	^{239}Pu	1.38×10^{5}
^{14}C	NR	^{240}Pu	3.10×10^{4}
^{249}Cf	NR	^{241}Pu	4.37×10^{5}
^{251}Cf	NR	^{242}Pu	2.96×10^{0}
^{252}Cf	NR	^{244}Pu	NR
^{243}Cm	NR	^{226}Ra	7.88×10^{-6}
^{244}Cm	NR	^{228}Ra	NR
^{245}Cm	NR	^{79}Se	NR
^{246}Cm	NR	^{151}Sm	NR
^{247}Cm	NR	^{121}Sn^{m}	NR
^{248}Cm	NR	^{126}Sn	NR
^{60}Co	3.47×10^{-7}	^{90}Sr	NR
^{135}Cs	NR	^{99}Tc	NR
^{137}Cs	3.41×10^{-9}	^{229}Th	NR
^{129}I	NR	^{230}Th	2.41×10^{-5}
^{40}K	2.87×10^{-5}	^{232}Th	2.61×10^{-6}
^{22}Na	5.34×10^{-6}	^{232}U	NR
^{59}Ni	NR	^{233}U	2.73×10^{-1}
^{63}Ni	NR	^{234}U	1.26×10^{0}
^{237}Np	4.00×10^{-1}	^{235}U	1.22×10^{-1}
^{231}Pa	5.04×10^{-4}	^{236}U	NR
^{210}Pb	NR	^{238}U	6.53×10^{0}
^{107}Pd	NR	^{93}Zr	NR

Source: WWIS

[1] These data were taken from the WWIS and differ slightly from the data reported for WIPP in Appendix DATA Attachment F. This is because all data in Appendix DATA Attachment F have been decayed to a single base year 2001 (i.e., decayed through 2001) while the data provided in the WWIS are reported values based on assay and have not been decayed to a single base year.

[2] Isotopes other than the 10 listed in Table 4-11 are not required to be tracked unless required by DOT regulations.

Table 4-14. Quantities of Non-Radionuclide Waste Components Emplaced in the Repository as of September 30, 2002, and Associated Emplacement Limits

Waste Components	Quantity	Emplacement Limit
Ferrous metal (iron)	2,487,261 kilograms	Minimum = 2×10^7 kilograms
Cellulosic, plastic, and rubber materials	700,981 kilograms	Maximum = 2.2×10^7 kilograms
Nonferrous metals (metals other than iron)	31,059 kilograms	Minimum = 2×10^3 kilograms

Source: WWIS

Table 4-15. Container-Based Limits

Waste Component or Characteristic	Limit
CH-TRU and RH-TRU waste activity	> 100 nCi/gram of waste
CH-TRU waste surface dose rate	< 200 mrem/hour (CH)
RH-TRU waste surface dose rate	≤ 1000 rem/hour (RH)
RH-TRU waste Ci per liter	23 Ci/liter averaged over the container

Based on the acceptance of the site-specific waste characterization and QA program, the CBFO Manager is responsible for granting and revoking the program certification that allows the TRU waste site to characterize and to ship waste to WIPP. The CBFO performs certification audits of the TRU waste sites to assess the implementation of and compliance with the approved plans. On the basis of acceptable results of the certification audits, the DOE grants TRU waste certification authority and transportation authority to the TRU waste site. DOE provides continuing oversight of TRU waste sites through periodic audits of TRU waste characterization, certification, and transportation activities.

Consistent with the provisions of section 194.8, the EPA also has a role in the approval process. The EPA determines compliance with requirements for site-specific QA programs.

CH-TRU WAC provides the limits for the physical, radiological, and chemical characteristics of the waste in addition to specifications for the waste packaging. Waste that is characterized according to and approved program and meets the requirements of the CH-TRU WAC can be shipped to the WIPP. Additional information regarding the TRU waste site waste characterization and QA program requirements is provided in Appendix TRU WASTE.

Appropriate changes to the CH-TRU WAC will be published to reflect new restrictions and conditions imposed by permits and certifications. These changes will be communicated to the TRU waste sites as a change to the CH-TRU WAC. Those retrievably stored or newly generated waste streams that do not meet the CH-TRU WAC, however, may require processing (including repackaging and/or treatment) until compliance can be attained. Any such processing is the responsibility of the site proposing to ship the waste to the WIPP. TRU waste that has been characterized in accordance with prior revisions of the CH-TRU WAC may be reconciled with current requirements. This reconciliation is documented and filed at the TRU waste site.

Changes related to waste characterization documents have occurred since the initial certification. Waste characterization elements of the QAPP (TRU Waste Characterization Quality Assurance Program Plan, CAO [CBFO] 94-1010) have been incorporated into recent revisions of the CH-TRU WAC, the WAP, and the QAPD. The QAPP and the TRU Waste Characterization Sampling and Analysis Methods manual (DOE 1995b) have been cancelled.

4.3 Waste Controls

This section describes those processes that ensure compliance with the limits for CH-TRU waste and RH-TRU waste to be emplaced in the WIPP disposal system.

4.3.1 Load Management

The following discusses compliance with Section 194.24(d) and (f).

Load management is the process of controlling the shipment and emplacement of TRU waste in order to achieve a predetermined (that is, nonrandom) distribution of waste within the disposal system. DOE must assess whether the spatial distribution of waste in the repository could have significance for human intrusion on long-term repository performance. As described in Section 6.4.12, drilling events are assumed to be random in time and space. The location of each intrusion borehole within the waste disposal region is sampled randomly. Each intrusion borehole that penetrates waste may encounter CH-TRU waste or RH-TRU waste. For calculating direct releases to the accessible environment, containers are assumed to be placed in the WIPP from the various waste streams which comprise CH-TRU waste in a random manner. In calculating direct releases resulting from a drill bit penetrating containers, each of the three stacked containers can come from different waste streams and have different activity loading. As described in Section 6.5, direct release from cuttings and cavings are the most important releases in assessing compliance with the quantitative containment requirements in Section 191.13(a) for both the CCA and CRA-2004.

The CCDFs presented in Section 6.5 are constructed by estimating cumulative radionuclide releases to the accessible environment for 10,000 different possible futures. The estimated release for each future includes the randomly sampled waste streams for each of the various intruding boreholes that comprise that sampled future. A sampling of 10,000 futures is large enough that the relatively low probability combination of three of the waste streams with higher activity loading occurring in a single drilling event is captured in the CCDFs presented in Section 6.5. As described in Section 6.5, the CCDF is not impacted by sampling uncertainty so the assumption of random emplacement of containers is not important to the location of the CCDF and a load management plan is not necessary to support PA assumptions.

In support of CRA-2004, DOE investigated the impact of non-homogeneous patterns of waste emplacement in the repository. The investigation verified that non-homogeneous emplacement will not have a significant impact on PA. The results of the investigation are reported in Chapter 6.0.

4.3.2 WIPP Waste Information System

The following discusses compliance with the criteria at Sections 194.24(c)(4), (c)(5), and (e).

The WWIS is an electronic data management system used by DOE to gather, store, and process information pertaining to TRU waste destined for or disposed at the WIPP. The system supports those organizations that have responsibility for managing TRU waste by collecting information into one source and providing data in a uniform format that has been verified or certified as being accurate. The WWIS is used to store information pertaining to characterization, certification, and emplacement of waste at the WIPP. Information in this system is supplied by the TRU waste sites and the WIPP facility. Figure 4-2 depicts the process and flow of data from the TRU waste sites to the WWIS.

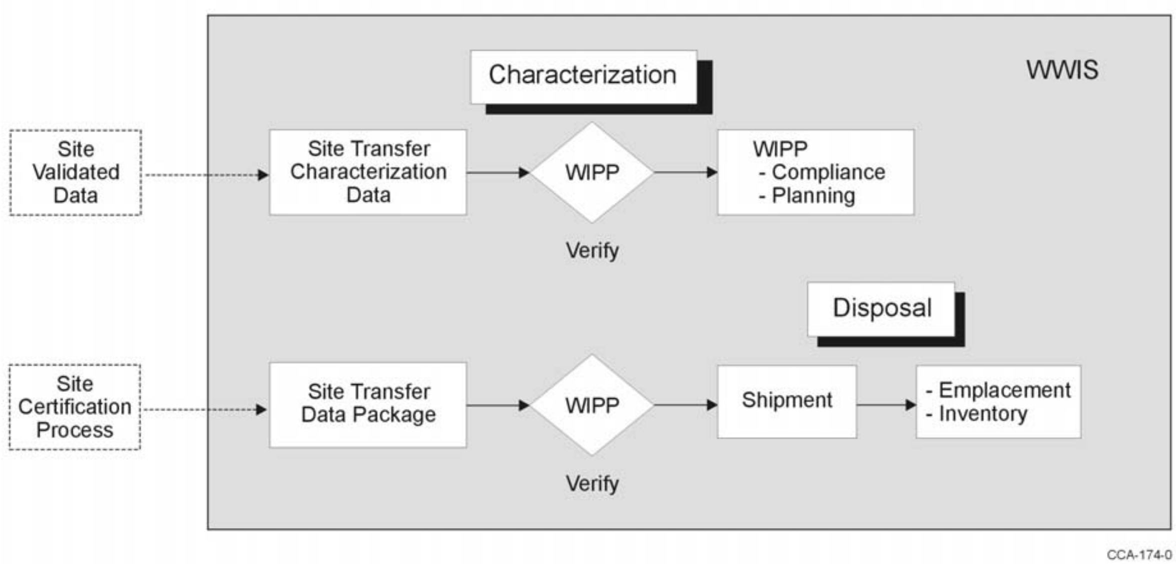

Figure 4-2. WIPP Waste Information System Process and Data Flow

At the time of the CCA, the WWIS used the Oracle (Version 7) database management system that followed American National Standards Institute (ANSI) standard query language. The database management system was resident on a Digital Equipment Corporation hardware platform, compliant with the majority of existing computer hardware throughout the DOE complex. UNIX was the operating system and supported multiuser and multitasking environments. The current computing system remains unchanged except that the software employed now is Oracle Version 9. Additional computing system upgrades may be implemented in the future.

Minor upgrades and improvements have been made to the WWIS since the EPA certification. Minor changes to several documents related to the design and operation of the system have also been made. All changes improved the system or updated information. The WWIS is available seven days a week, 24 hours a day except for periodic maintenance and supports the maximum number of simultaneous users determined by the database management system license agreement and the operating system license agreement. The network communication protocol of the WWIS is Transmission Control Protocol/Internet Protocol (TCP/IP). Other features include automatic limit, range, and QA checks; automatic report generation; and compliance with QA requirements for computer software for nuclear facility applications (American Society of Mechanical Engineers [ASME], Nuclear Quality Assurance [NQA]-1, NQA-2, Part 2.7, and NQA-3 [ASME 1989a, 1989b, and 1989c]).

The following WWIS documentation has been identified as necessary and sufficient to document the software lifecycle:

- WWIS Evaluation & Recommendation – provides an evaluation of hardware and software configurations for the WWIS and recommends an approach for implementation.

- WWIS Software Quality Assurance Plan – identifies and defines the standards and methodologies required to ensure conformance to accepted quality standards during the development, maintenance, and operation of the WWIS. This plan ensures that products conform to established technical requirements.

- WWIS Software Verification and Validation Plan – describes the criteria for verification and validation activities for the requirements, design, testing, and all necessary documentation.

- WWIS Software Requirements Specification – defines the requirements essential to the WWIS based on the WWIS Functional and Operational Requirements Document. All requirements shall be internally consistent and verifiable through demonstration, analysis, or testing.

- WWIS Software Design Description – defines the major features of the WWIS including the operating environment, databases, tables, external and internal interfaces, overall structure, sizing, modeling, and system throughput.

- WWIS Software Configuration Management Plan – describes the methods used for identifying software configuration items, controlling and implementing changes, and recording and reporting change implementation status.

- WWIS Security Plan – details the information for handling the security needs of the system (data, software, and hardware). This plan also describes password and access control procedures.

- At the time of the CCA, the DOE identified more than 130 data fields for inclusion in the WWIS. An alphabetical listing and description of these data fields is found in the WAP (NMED 2002). The majority of these data fields are considered pertinent to demonstrate compliance with TRU waste transportation and disposal requirements. These listings are now updated and maintained in the WWIS User's Manual (DOE 2001).Radionuclides present in container

- Activity of individual radionuclides

- Uncertainty associated with the activity of individual radionuclides

- Mass of the individual radionuclides
- Uncertainty associated with the mass of individual radionuclides
- Estimated weight of waste material parameters
- Date of assay

To ensure compliance with the data requirements, personnel at the WIPP review the WWIS information on each data package for completeness and adequacy before notifying the shipping site of acceptance. Thus, the WWIS becomes an integral part of the waste information screening process described in the WAP.

4.3.3 Quality Assurance

The implementation of a formal QA program demonstrates the commitment of DOE to perform all work activities and operations to the highest standards of quality. DOE has established an effective QA program that complies with applicable sections of NQA-1, NQA-2 (Part 2.7), and NQA-3. The management controls defined by the various QA plans and procedures ensure that all work is planned, documented, performed under controlled conditions, and periodically assessed to establish work item quality and process effectiveness and to promote improvement. The complexity, inherent risk, and significance of the work to the overall project and to public safety are key factors in determining applicable quality management requirements. Internal and external organizational interfaces and responsibilities are described in detail in Chapter 5.0.

The DOE TRU Waste Characterization QAPP (DOE 1995a) and the TRU Waste Characterization Sampling and Analysis Methods Manual (DOE 1995b) were replaced as of November 26, 1999. Figure 4-3 shows the revised QA document hierarchy for waste characterization.

Additional information regarding the quality assurance and quality controls used in ascertaining the waste description is given in Chapter 5.0.

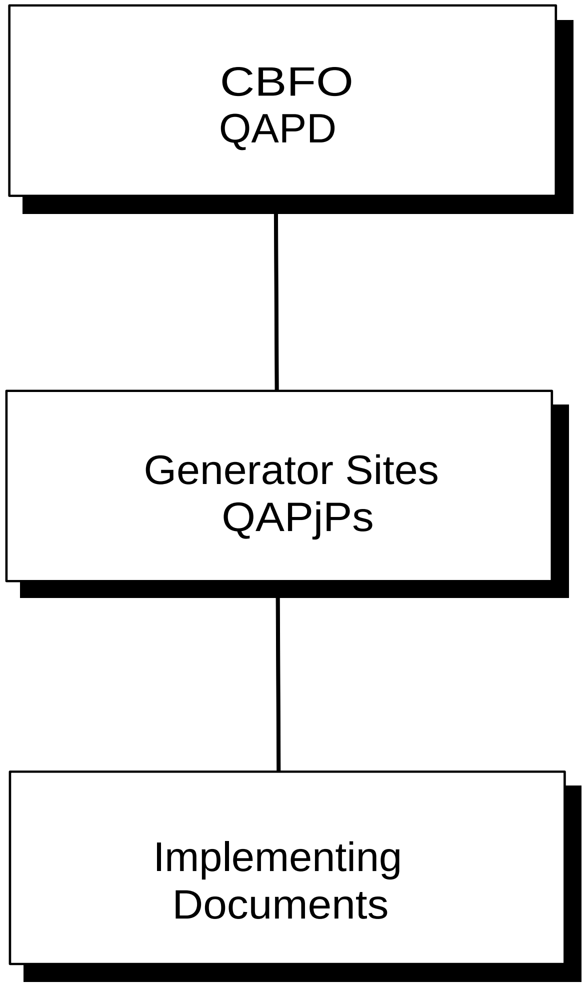

Figure 4-3. QA Documents Hierarchy

4.3.3.1 Performance Demonstration Programs

Another aspect of the waste-characterization QA process that has changed is related to the Performance Demonstration Program (PDP). The program evaluates the capability of sites to perform waste characterization within acceptable limits. Initially, participating laboratories were required to participate in the PDP twice per year. The CBFO has reduced the required frequency from twice per year to once per year. The CBFO described this change to the EPA in correspondence dated November 10, 1998, and April 22, 1999. Based on this information, the EPA determined that the changes reported did not require a modification, suspension, or revocation of the initial certification (EPA June 3, 1999).

The CBFO is the revising and approving authority for the NDA PDP and plans. The CBFO uses the PDP as part of the assessment and approval process for measurement facilities supplying characterization services for the NDA of TRU wastes intended for disposal at WIPP. The NDA PDP is similar to a blind sample program. The NDA PDP plans use 55-gallon drums or SWB's with simulated waste matrix and source standards. The NDA plans identify the elements that comprise the program, the criteria used to evaluate NDA system performance and the responsibilities of the program participants. The PDP NDA plans are revised as required. NDA analysis of drums or boxes is performed by measurement systems that have demonstrated acceptable PDP performance.

4.4 Waste Characterization

The process of waste characterization identifies the significant physical, chemical, and radiological properties of the waste using a variety of methodologies. The measured waste properties obtained by the TRU waste sites are either on a container or waste stream basis and serve to demonstrate compliance with the limits imposed by transportation requirements (DOT), the Type B package certificate of compliance, the Hazardous Waste Facility Permit (HWFP), and operational safety requirements (DOE). In contrast, the waste component limits described in Appendix WCL are on a repository basis and serve as an upper bound for the accumulative waste inventory. As described in Section 4.3.2, the linkage between the collective waste inventory and the repository limits is provided by the WWIS.

Recognizing that the CH-TRU WAP and the CH-TRU WAC provide the waste characterization requirements for waste destined for the WIPP, it is necessary to understand the complementary role played by the radiological characterization of waste. Figure 4-4 shows the requirements hierarchy governing the characterization of waste for purposes of transportation, disposal, and long-term regulatory compliance. The implementation of waste characterization occurs on a waste-stream basis at the lowest tier of the diagram through the Standard Operating Procedures (SOPs). The next higher tier of Figure 4-4 includes the CH-TRU WAC, followed by progressively higher-tier requirements. The waste characterization requirements for compliance with the EPA's regulations are implemented by the SOPs.

The WAP includes requirements necessary for compliance with the New Mexico Hazardous Waste Act — specifically the identification and quantification of their hazardous components (see Attachment B of the WAP [NMED 2002]). A combination of five waste characterization methodologies is employed by the WAP and includes acceptable knowledge, radiography, visual examination, headspace gas sampling and analysis, and solidified waste sampling and analysis. The capabilities and applicabilities of these five methodologies to TRU mixed waste are discussed in considerable detail in the WAP. Except for a brief overview of acceptable knowledge, radiography, and visual examination, a description of the five waste characterization methodologies presented in the WAP will not be repeated in this document. Radiological characterization of TRU waste is needed for compliance demonstrations to 40 CFR Parts 191 and 194. A quantitative determination of the radionuclides listed in Table 4-11 results from the need to demonstrate compliance with the release limits as specified in Appendix A to Part 191 and the RH-TRU waste curie limit established by the LWA (see Table 4-12).

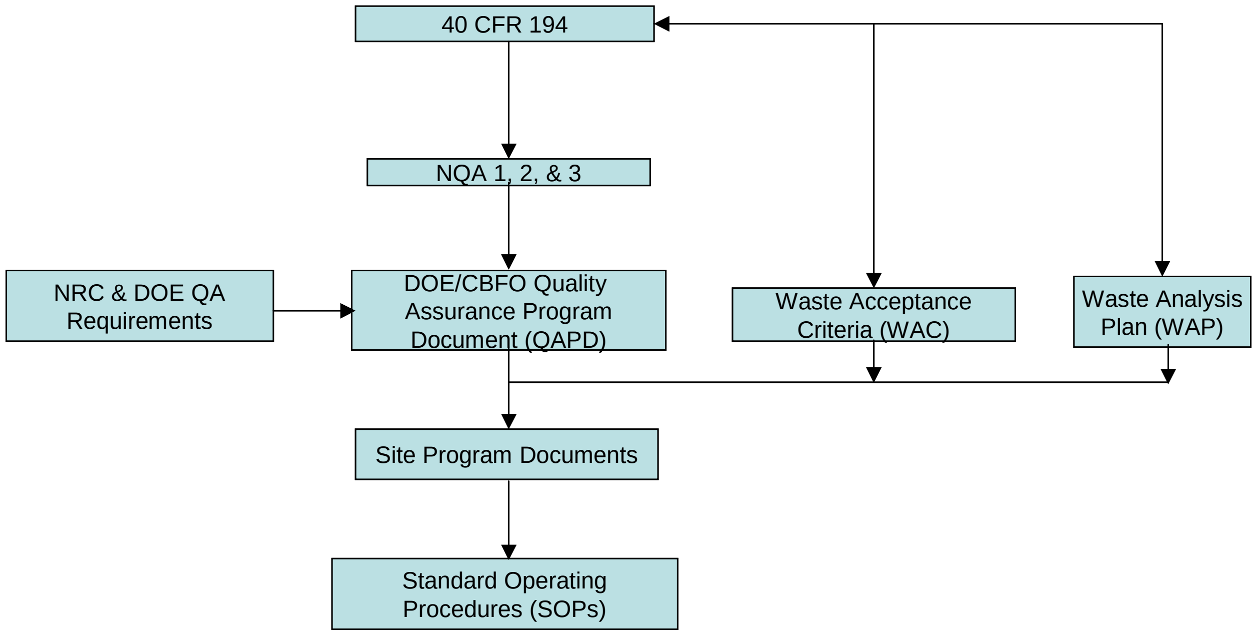

Figure 4-4. Program QA Document Hierarchy

Collectively, those elements of the waste characterization program that support long-term regulatory compliance include the determination of the radionuclide inventory (for purposes of normalizing radionuclide releases as required for comparison with Section191.13(a)), the identification of the physical and chemical waste form inventories (if applicable), and the verification that no wastes are emplaced in the WIPP that exceed the disposal system's safety and/or performance limitations.

In a manner analogous to the WAP, the WIPP waste radioassay characterization program is conducted by TRU waste site personnel and is implemented in accordance with the requirements of the CH-TRU WAC. TRU waste sites may propose alternative characterization methods, either because of the availability of newer technologies offering enhanced performance or the modification of older technologies to facilitate meeting the requirements of Appendix A of the CH-TRU WAC. In these instances, method performance must be demonstrated and approved in accordance with Section 194.8 prior to its use in characterization of TRU waste for disposal at the WIPP.

Implementation of the TRU waste characterization program at DOE TRU waste sites requires that all waste characterization activities be conducted in accordance with approved documentation that describes the management, operations, and QA aspects of the program. Conformance with applicable regulatory, programmatic, and operational requirements is monitored by CBFO audits and surveillances. Refer to Chapter 5 and CCA Appendix QAPD for a more detailed discussion of the CBFO audit and surveillance program. The documentation requirements important to the implementation of the TRU Waste Characterization Program at each TRU waste site are briefly discussed below.

- QA requirements. Implementation of individual site-specific waste certification and characterization programs must meet the QA requirements contained in the CBFO

QAPD, which are traceable to the applicable sections of ASME NQA-1 through NQA-3 (ASME 1989a, 1989b, and 1989c in the References). The WAP and the CH-TRU WAC describe the specific QA objectives (QAOs) for the TRU Waste Characterization Program. The WAP and the CH-TRU WAC, delineate approved analytical methods for meeting regulatory requirements.

- QAPjPs. TRU waste sites prepare site-specific QAPjPs that describe waste characterization activities in support of the TRU waste characterization program. These documents, developed in accordance with the applicable requirements in the CBFO QAPD and the WAP, define QA management and program elements that provide for planning, implementation, and assessment of the TRU waste characterization data-collection activities.

- SOPs. The QAPD requires that each DOE TRU waste site develop, implement, and control written SOPs that provide detailed descriptions of routine, standardized, or critical waste characterization activities. The SOPs serve as the basis for quality assessments of waste characterization activities at the site level because they provide detailed descriptions of required activities.

- PDPs. Analytical facilities characterizing waste for disposal at the WIPP must successfully participate in the applicable portions of the PDP. The PDP supports the determination of a facility's ability to meet the QA requirements identified in the CBFO QAPD. A more detailed description of the PDP can be found in Section 4.3.3.1.

As the TRU waste sites complete the necessary program documentation, they commence waste characterization activities. Information derived from these activities is on a waste-stream basis and is used in preparing the site's waste-stream profile forms required for waste acceptance at the WIPP. The waste characterization data are electronically backed-up in databases at the sites and downloaded into the WWIS database (DOE 1996b). The WWIS is described in Section 4.3.2.

TRU waste sites prepare documented and approved programs controlling their TRU waste characterization, certification (which includes characterization), and transportation processes. Site-specific TRU waste certification plans document how compliance with the CH-WAC is accomplished. Site certification is granted by the CBFO manager upon approval of the following documentation:

1. TRU waste certification plan (including QA),

2. QAPjP(s),

3. NRC Type B packaging methods for payload compliance TRU package transporter, Model 2 (TRUPACT II) Authorized Methods for Payload Compliance,

4. Packaging QA plan, and

5. Performance in applicable PDPs.

In addition to approval of this site-specific documentation, TRU waste sites must pass an initial TRU waste site certification audit where adequate and effective implementation of these programs is assessed (see Sections 5.1 and 5.3.19). Also, as described in Section 4.1.2, EPA approval of QA program documentation and implementation is also required.

Each site that is characterizing TRU waste is recertified by the CBFO annually. A recertification consists of reviewing (if applicable):

1. Site-specific program documents that are written and approved to the latest CH-TRU WAC;
2. Program implementation as determined by a TRU waste site certification audit;
3. Reports from surveillances conducted during the past year;
4. Performance in shipping TRU waste to the WIPP; and
5. Performance in the PDPs.

To ensure that DOE TRU waste sites comply with the WIPP TRU waste certification program, audits are conducted by the CBFO. An initial audit is conducted at each TRU waste site performing waste characterization activities prior to the formal acceptance of the waste-stream profile forms and/or any waste characterization data supplied by TRU waste site personnel. This formal acceptance is referred to as TRU waste site certification. Audits are performed at least annually thereafter, including the possibility of unannounced (not regularly scheduled) audits. These audits verify that the site has implemented a QA program for all certification activities. The accuracy of the physical waste description and the subsequent waste stream assignment are verified by a review of acceptable knowledge documentation, radiography data, and visual examination results (if applicable). Table 4-16 summarizes the characterization requirements and methods detailed in the CH-TRU WAC and the WAP that support this application. The EPA often observes the DOE audits in fulfilling its obligations defined in Section 194.8 (see Section 4.1.2).

Additional information regarding RH-TRU waste characterization has been developed by DOE and has been submitted to the EPA (letter from DOE to EPA December 16, 2002). No RH-TRU waste has been shipped to the WIPP at the time of CRA-2004. EPA approval of DOE's proposed RH-TRU waste characterization procedure is pending.

Table 4-16. Applicable CH- and RH-TRU Waste Component Characterization Methods

Waste Properties	Waste Components	Waste Characterization Methods
Nuclear	Radionuclides	NDA OR previous isotopic distribution from destructive radiochemistry OR previous radioassay data reconciled with CH-TRU WAC requirements
Physical	ferrous metals nonferrous metals cellulosic, plastic, rubber materials solid components free water humic substances	radiography with statistical selection for visual examination OR visual examination and documentation of container content at time of waste packaging for newly generated waste OR documentation and verification (random sampling) for newly generated waste
Chemical	sulfates nitrates organic ligands	No upper or lower limits apply to these chemicals; therefore no waste characterization methods are applied.

4.4.1 Qualitative Methodologies

The criteria at Section 194.24(a) require a description of the physical, chemical, and radiological composition of the TRU waste to be emplaced in the WIPP disposal system. With regard to the waste's nonhazardous physical and chemical components (such as cellulosic materials), there are three qualitative methodologies, used either singularly or in combination, for verifying adherence to the compliance limits. These methodologies include acceptable knowledge, nonintrusive examination using penetrating radiation such as X-ray (referred to as either RTR, radiographic examination, radiometric examination, or nondestructive examination (NDE)), and intrusive visual examination consisting of opening the container and recording the contents. The use of Acceptable Knowledge information is presented in the WAP and the CH-TRU WAC.

4.4.1.1 Acceptable Knowledge

The following discusses compliance with criteria at Section 194.24(c)(3).

Acceptable knowledge is defined in the EPA Guidance Manual (EPA 1994). Acceptable knowledge includes information regarding the physical form of the waste, the base materials composing the waste, and the process that generated the waste. Waste characterization will be used to confirm acceptable knowledge information. The WAP and the CH-WAC provide details regarding the application of acceptable knowledge.

Consistency among DOE TRU waste sites in using acceptable knowledge information to characterize TRU waste involves a three-phase process: (1) compiling the minimum acceptable knowledge documentation in an auditable record, (2) confirming acceptable knowledge information, and (3) auditing acceptable knowledge records.

Acceptable knowledge documentation provides qualitative information that cannot be assessed according to specific data quality objectives that are used for analytical techniques. QAOs for analytical results are described in terms of precision, accuracy, completeness, comparability, and representativeness. Analytical results will be used to confirm the characterization of wastes based on acceptable knowledge.

The acceptable knowledge process and waste stream documentation must be evaluated through internal assessments by QA organizations and assessments by auditors external to the organization (that is, the CBFO).

The CBFO has conducted and will continue to conduct an initial audit of each TRU waste site prior to certifying the TRU waste site for shipment of TRU waste to the WIPP facility (see the Hazardous Waste Facility Permit [NMED 2002] Attachment B through B6, including Figure B4-3). This initial audit will establish an approved baseline that will be reassessed annually.

4.4.1.2 Nondestructive Examination

NDE is a qualitative technique that involves the use of X-rays examination of waste containers to identify and verify the contents. NDE is used to verify the absence of prohibited items and to determine the appropriate methodologies to be used for waste characterization. NDE is not required for newly generated waste because controls exist to verify compatibility of the matrix material(s) and the absence of prohibited items prior to and during waste packaging.

All activities required to achieve the radiography objectives must be described in TRU waste site QAPjPs and SOPs. Retrievably stored containers will have this type of permanent record on file throughout the life of the WIPP project. As a quality control check on NDE, a statistically determined number of retrievably stored containers within the population subjected to NDE will be randomly selected and visually examined.

4.4.1.3 Visual Examination

Visual examination is used by DOE to provide an acceptable level of confidence in NDE. There is no equivalent method in the EPA sampling and analysis guidance documents. TRU waste site personnel develop training programs that are based on waste form and waste management operations. These training programs are used to assess operator performance. The QAPjPs and supporting SOPs specify the training requirements and other activities required to achieve the visual examination objectives. The visual examination expert must be familiar with the waste generating processes that have taken place at that TRU waste site and also with the types of waste being characterized at the site. For an explanation of the hypergeometric approach used in determining the number of containers to be statistically sampled by visual examination, see the WAP.

4.4.2 Quantitative Methodologies

To minimize exposure, the quantitative methodology used to determine the radionuclide inventory of the waste is NDA. The nonintrusive methodology of NDA employs radiation detection techniques for determining the waste's isotopic content and activity. This is the preferred approach because of the safety hazards involved in opening waste containers having radioactive contaminants. Although the data generated by radioassay serve many functions including the calculation of the ^{239}Pu equivalent activity, the ^{239}Pu fissile gram equivalent, and the decay heat of waste containers, the purpose of these data relative to long-term regulatory compliance with 40 CFR Part 191 is to provide corroborative data relating to the radionuclide inventory reported in the CRA-2004 and furnish radionuclide information on a container basis to maintain a running inventory of TRU waste emplaced in the WIPP disposal system.

TRU nuclides emit both ionizing radiation (including alpha particles, beta particles, and gamma rays) and nonionizing radiation (neutrons). Based on detection of these emissions, several technologies have been developed to measure one or more of these radiations as they emerge from the waste container. Although most of the ionizing radiation (alpha and beta particles) are not able to penetrate the walls of the waste container, both gamma rays and neutrons can penetrate the waste matrix as well as the waste container to varying degrees. Combining gamma ray measurements, other advanced particle detection techniques specific to neutrons, and acceptable knowledge provides the precision and accuracy required by the QAOs contained in the CH-TRU WAC Appendix A. Mass spectroscopy and radiochemistry also provide the precision and accuracy to meet the QAO requirements in the CH-TRU WAC Appendix A.

Special techniques, instrumentation, and detectors have been developed to measure the gamma ray energies. Because there are many different gamma rays originating from any one radionuclide with each gamma ray having a unique energy and rate of occurrence characteristic of the radionuclide from which it originated, the resulting distribution or spectrum of gamma ray energies provides a fingerprint or signature of that particular radionuclide. In practice, with the application of appropriate correction factors and the utilization of acceptable knowledge, gamma ray and neutron NDA systems provide radioisotope inventory information about the waste without the need for opening the container.

All radioassay systems must be calibrated using a variety of matrix and source standards to simulate the various waste compositions, source distributions, and interferences common to the waste streams originating from a particular TRU waste site. By applying the resulting correction factors to the measurements, an accurate assessment of the radionuclide inventory within the waste container is feasible. NDA methods appropriate to a particular waste stream profile are used in the radionuclide analysis.

4.4.2.1 <u>Nondestructive Assay</u>

A variety of NDA methodologies are effective in meeting the requirements of the CH-TRU WAC Appendix A. NDA instruments can be classified as belonging to one or more of the four categories listed below:

- gamma ray measurements

  - low- and high-resolution spectroscopy using a sodium iodide and intrinsic germanium detector,
  - transmission-corrected gamma ray measurement using a segmented gamma ray scanner, and
  - transmission-corrected gamma ray measurement using a computed tomographic gamma ray scanner.
- passive neutron measurements
  - passive neutron coincidence counter,
  - advanced matrix-corrected passive neutron counter (add-a-source), and
  - shielded neutron-assay probe totals counter.
- passive and active neutron measurements
  - Am-lithium source-driven coincident counter,
  - californium delayed-neutron counter (shuffler),
  - neutron generator differential die-away counter, and
  - combined thermal and epithermal neutron counter.
- thermal neutron capture
  - californium delayed-neutron counter,
  - neutron generator differential die-away counter, and
  - combined thermal and epithermal neutron counter.

The list is neither complete nor limiting and is meant to illustrate the breadth of choice available. QAOs may be met with the listed systems or by modifications, functionally equivalent alternatives, multiple combinations, or hybrids of the systems.

For each of the radionuclide components identified in Table 4-11 as being significant to PA and requiring assay, any of the above NDA methodologies, either singularly or in combination, may be used in determining the activity and corresponding uncertainty. In the case of 100-percent sampling, these measurements are performed on a container basis. For the case of less than 100-percent sampling, the reported values are on a waste stream basis. Upon receipt of the waste at the WIPP, the measured activity of these significant radionuclide components, plus their associated uncertainty, are accumulated by the WWIS in order to ensure that the volume and activity limits of the repository are not exceeded.

4.4.3 Additional Change to the Waste Characterization Program

Since the certification of the WIPP, an additional change related to the waste characterization program has occurred. In the past, DOE planned to declassify any classified materials in waste before shipment to WIPP. In 2002, the RFETS proposed sending waste containing classified shapes to WIPP, where the associated radiography and VE records would be classified and require a DOE security clearance for review and audit. In 2003, the EPA determined that classified waste may be shipped to WIPP provided DOE meets certain specified requirements (EPA letter of February 11, 2003, to DOE CBFO).

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