REMOTE-HANDLED

TRANSURANIC

SYSTEM ASSESSMENT

APPENDICES

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Appendices

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REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX A

Inventory and Generation of Remote-Handled Transuranic Waste

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ACRONYMS AND ABBREVIATIONS

ANL-E	Argonne National Laboratory - East
ANL-W	Argonne National Laboratory - West
CAO	Carlsbad Area Office
C&C	Consultation and Cooperation Agreement - State of New Mexico
CH	contact handled
D&D	decontamination and decommissioning
DOE	Department of Energy
FEIS	Final Environmental Impact Statement
IDB	Integrated Data Base
INEL	Idaho National Engineering Laboratory
KAPL	Knolls Atomic Power Laboratory - Schenectady
LANL	Los Alamos National Laboratory
LWA	WIPP Land Withdrawal Act
m^3	cubic meters
MTRU	mixed transuranic
NG	Newly Generated
NRF	Nuclear Reactors Facilities
ORNL	Oak Ridge National Laboratory
R&D	research and development
rem	Roentgen Equivalent Man
RH	remote handled
RS	Retrievably Stored
SRS	Savannah River Site
TRA	Test Reactor Area
TRU	transuranic
WIPP	Waste Isolation Pilot Plant
WTWBIR	Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report

RH-TRU WASTE INVENTORY AND GENERATION

1.0 INTRODUCTION

This document provides a summarization of existing information on the current inventory and anticipated future generation rates of remote handled transuranic (RH-TRU) waste throughout the Department of Energy (DOE) Complex.

The amounts of existing and projected RH-TRU waste in the National TRU system are discussed in this Appendix. Sites with identified existing or future RH-TRU inventories and included in this study are:

- Argonne National Laboratory-West (ANL-W),
- Battelle Columbus Laboratory Decommissioning Project (Battelle),
- Bettis Atomic Power Laboratory (Bettis),
- Hanford Reservation (Hanford),
- Idaho National Engineering Laboratory (INEL),
- Knolls Atomic Power Laboratory (KAPL),
- Los Alamos National Laboratory (LANL),
- Oak Ridge National Laboratory (ORNL), and
- Savannah River Site (SRS);

1.1 Regulatory Requirements Affecting RH-TRU Waste

Public Law 96-164, which authorized WIPP, restricted the waste being sent to WIPP to defense waste. Specifically, the WIPP was authorized to "demonstrate the safe disposal of radioactive waste resulting from defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission" (U.S. Congress, 1980). Subsequently, and in conjunction with the limits on disposal of contact-handled transuranic (CH-TRU) waste at WIPP, the amount of RH-TRU waste which could eventually be disposed of at WIPP was limited to approximately 7,080 m^3 (250,000 ft^3). This was first established in the Record of Decision for the WIPP Final Environmental Impact Statement (FEIS) (DOE, 1981), and is also the authorized limit specified in the Final Supplement Environmental Impact Statement (FSEIS) (DOE, 1990a) and the First Modification to the July 1, 1981 Agreement for Consultation and Cooperation with the State of New Mexico (New Mexico, 1984).

In 1992, Congress issued Public Law 102-579, the *Waste Isolation Pilot Plant Land Withdrawal Act* (LWA), which withdrew the land designated for WIPP use from public land laws and transferred jurisdiction of the 16-square mile area to the Department of

Energy. In addition, the LWA contained limitations on the RH-TRU waste to be sent to WIPP that were nearly identical to those originally set forth in the First Modification to the Consultation & Cooperation (C&C) Agreement with the state. The primary difference is that the C&C Modification limits the maximum amount of RH-TRU waste that can be shipped to WIPP to 7,080 m^3 (250,000 ft^3), while the LWA does not set a specific limit on WIPP's RH-TRU waste capacity. The LWA sets forth the total capacity of WIPP, by volume, as "6.2 million cubic feet of transuranic waste" and does not differentiate between CH-TRU and RH-TRU waste (U.S. Congress, 1992). The LWA contains the following dose rate and curie limits:

- No transuranic waste received at WIPP may have a surface dose rate in excess of 1,000 rems per hour.

- No more than 5 percent by volume of the remote-handled transuranic waste received at WIPP may have a surface dose rate in excess of 100 rems per hour.

- Remote-handled transuranic waste received at WIPP shall not exceed 23 curies per liter maximum activity level (averaged over the volume of the canister)

- The total curies of the remote-handled transuranic waste received at WIPP shall not exceed 5,100,000 curies.

These limits basically mirror those contained in the C&C modification, except that the Modification sets a limit of 354 m^3 (12,500 ft^3) on the maximum volume of waste over 100 rem/hr that can be shipped to WIPP, as follows:

- No more than 5% of the total volume *of 250,000 cubic feet (or 12,500 cubic feet maximum)* of defense RH-TRU shipped to WIPP will exceed 100 rem per hour surface dose rate. (emphasis added)

1.2 Data Sources

Revision 1 of the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report* (WTWBIR), (DOE, 1995a), served as the primary data source for this report. Other data sources included the *Mixed Waste Inventory Report* (DOE, 1993) and the *Integrated Data Base* (IDB) (DOE, 1994).

2.0 RH-TRU WASTE INVENTORY

2.1 Current Inventory

The current inventory of RH-TRU waste totals 1,170 m^3 (41,314 ft^3) and is found at six DOE sites (DOE, 1995a). However, most of this waste is found at one site, the ORNL, which stores approximately 85% of the total current RH-TRU waste inventory. The five remaining sites are LANL, with approximately 8% of the total inventory; Hanford and INEL, each with less than 3%; and KAPL and ANL-W, each with less than 1%. Specific quantities are presented on a site-by-site basis in Table 1. In most cases, the waste has been generated, but it has not yet been packaged in accordance with the WIPP Waste Acceptance Criteria.

An additional 43,000 m^3 (1,518,362 ft^3) of "suspect" mixed RH-TRU waste has been reported by Hanford in previous data submittals; however, insufficient information has been available about the waste to allow it to be categorized as RH-TRU in Revision 1 of the WTWBIR (DOE, 1995a). Data to be provided by Hanford for the Revision 2 of the WTWBIR will provide additional information on how much of this waste can be defined as RH-TRU.

2.2 Projected Inventory

The WTWBIR (Revision 1) projects that a total of 3,620 m^3 (127,825 ft^3) of RH-TRU waste will be generated by the nine DOE sites (DOE, 1995a). The Hanford site accounts for about 80% of this, with a projected generation of about 3,000 m^3 (105,932 ft^3). ORNL is second in projected RH-TRU waste generation with about 10% or 360 m^3 (12,712 ft^3). Bettis projects the smallest quantity—less than 2 m^3 (71 ft^3). The remaining six sites represent only 8% of the total projected inventory. These projected inventories represent the estimated amounts of RH-TRU waste to be generated through the year 2022.

Table 1. RH-TRU Waste Disposal Inventory by Site[1]

SITE	STORED WASTE	PROJECTED WASTE	TOTAL WASTE
ANL-W	9 m^3 (307 ft^3)	28 m^3 (132 ft^3)	36 m^3 (1282 ft^3)
BATTELLE	0.0	71 m^3 (2507 ft^3)	71 m^3 (2507 ft^3)
BETTIS	0.0	2 m^3 (56.5 ft^3)	2 m^3 (56.5 ft^3)
HANFORD	33 m^3 (1165 ft^3)	2974 m^3 (105,004 ft^3)	3007 m^3 (106,169 ft^3)
INEL	31 m^3 (1095 ft^3)	17 m^3 (593 ft^3)	48 m^3 (1688 ft^3)
KAPL	11 m^3 (395 ft^3)	25 m^3 (889.83 ft^3)	36 m^3 (1285 ft^3)
LANL	91 m^3 (3224 ft^3)	83 m^3 (2920 ft^3)	174 m^3 (6145 ft^3)
ORNL	994 m^3 (35,092 ft^3)	357 m^3 (12,592 ft^3)	1351 m^3 (47,687 ft^3)
SRS	0.0	64 m^3 (2256 ft^3)	64 m^3 (2256 ft^3)
TOTAL RH-TRU VOLUMES	1169 m^3 (41,282 ft^3)	3619 m^3 (127,797 ft^3)	4788 m^3 (169,078 ft^3)

[1] Source: WTWBIR (DOE, 1995b), Tables 3-16 through 3-23

2.3 RH-TRU Waste Curie Content

RH-TRU radioactivity estimates for the stored RH-TRU waste inventory as of the end of 1993 are shown in Table 2. This table shows the total curie content of waste stored, by site, for five of the major sites. This information was obtained from Revision 10 of the IDB (DOE, 1994), which did not specifically address both volume and curie content for ANL-W, Battelle, Bettis, and SRS. Of the five sites with complete IDB information, ORNL accounts for the greatest estimated total number of curies (290,000), as well as the highest average curie content per liter (0.51 curies per liter). ORNL's total curie estimate represents about 83% of all radioactivity of RH-TRU waste at the sites. Although Hanford, at 38,000 curies, is the next highest in total curie content, its average curie content per cubic meter is only 0.19 curies per liter. The lowest average of the five sites is INEL, at 0.01 curies per liter. Detailed radionuclide distribution information on a site-by-site basis may be found in the WTWBIR (DOE, 1995a). These values show that the total RH-TRU activity is projected to be well below the 5.1 million curie limit in the Land Withdrawal Act.

2.4 RH-TRU Waste Estimated Dose Rates

Estimates of RH-TRU dose rates have been provided for selected DOE facilities. These dose rate estimates are provided as ranges and are segregated between projected RH-TRU waste and existing retrievably-stored RH-TRU waste. Table 3 summarizes these dose rate ranges and the estimated percentage of RH-TRU waste within each range. Percentages of containers in each surface dose interval have also been provided.

2.5 RH-TRU Waste Origins

RH-TRU waste for disposal at WIPP is limited to radioactive waste resulting from defense activities and defense programs of the United States Government exempted from regulation by the United States Nuclear Regulatory Commission. The term excludes any radioactive waste generated by the commercial nuclear power industry.

RH-TRU defense waste has a variety of origins. The origin of most of the RH-TRU waste is designated as either research and development (R&D), or production operations. Additionally, a considerable amount of waste is classified as decontamination and decommissioning (D&D). RH-TRU waste at the major DOE sites originated or will be generated by one of the above activities. Production operations and/or R&D account for all of the stored and projected RH-TRU waste at Hanford (DOE, 1995a).

Table 2. Radioactivity of RH-TRU Waste[1]

SITE	TOTAL CURIES[1]	STORED VOLUME ESTIMATE[2]	AVERAGE CURIES/LITER[3]
HANFORD	38,400	201 m^3 (7,097 ft^3)	0.19
INEL	7,790	80 m^3 (2,825 ft^3)	0.01
KAPL	103	2 m^3 (71 ft^3)	0.04
LANL	11,800	91 m^3 (3,213 ft^3)	0.13
ORNL	290,000	564 m^3 (19,915 ft^3)	0.51
TOTALS	349,000	938 m^3 (33,121 ft^3)	

[1] Total Curies from the Integrated Data Base (DOE, 1994)
[2] Stored Volume Estimates are from the Integrated Data Base (DOE, 1994)
[3] Conversion based on 1000 liters per cubic meter.

Table 3. Estimation of Surface Dose Rates for RH-TRU Waste Containers[1]

Site	Projected[2] or Stored[3]	Container	Dose Rate (rem/hr)					
			0.2-1.0	1 - 10	10 - 50	50 - 100	>100	Quantity[6]
INEL[4]	Stored	Drums	2%	56%	40%	1%	0%	335
INEL[5]	Projected	Drums	0%	0%	100%	0%	0%	N/A
ANL-W	Stored	Inserts	0%	0%	31%	69%	0%	16
ANL-W	Projected	Others	0%	0%	0%	0%	100%	N/A
LANL	Stored	Canisters	0%	18%	27%	55%	0%	22
LANL	Projected	Canisters	0%	0%	38%	19%	43%	N/A
ORNL	Stored	Canisters	3%	18%	6%	73%	<1%	2138
ORNL	Projected	Canisters	0%	31%	12%	32%	25%	243
Hanford	Stored	Canisters	40%	34%	1%	25%	0%	368
Hanford	Projected	Canisters	N/A	N/A	N/A	N/A	N/A	N/A

[1] Source: 1991 Integrated Data Base Data Submittal and Engineering Judgement

[2] Projected - Projected or future waste inventories

[3] Stored - Retrievably stored or existing waste inventory

[4] Includes ANL-E, ANL-W, TRA (Test Reactor Area), and NRF (Nuclear Reactors Facilities)

[5] Includes ANL-W, Bettis, and NRF.

[6] These values were derived from the original Integrated Data Base Data Submittal for the purpose of estimating RH-TRU dose rates and their potential impact on related activities such as characterization. These values represent the equivalent number of containers based on the assumed containerization method shown under the "Container" column. Volumes and container numbers are not consistent with the current WTWBIR, Rev. 1. These data are provided as reference only.

N/A - Not Available

The RH-TRU defense-waste inventory can be further subdivided into TRU waste and mixed TRU (MTRU) waste. The majority of the RH-TRU waste is classified as MTRU. All of the ORNL RH-TRU waste and most of the Hanford waste is in this category. However, 1,246 m^3 (43,997 ft^3) of projected waste at Hanford is classified as TRU and not as MTRU. Table 4 lists stored and projected RH-TRU and MTRU defense waste for each of the generator sites.

3.0 WIPP RH-TRU WASTE PROFILES FOR FINAL WASTE FORM

Table 5 groups waste into generalized categories based on similar characteristics. This table presents data for the sites in seven categories. The heterogenous category accounts for 78% of the RH-TRU generated waste. The solidified inorganic category indicates waste that is in non-solid form, such as sludge, which requires further treatment. About 16% of the RH-TRU waste is in this category and essentially all of it is found at ORNL.

4.0 RH-TRU WASTE REQUIRING TREATMENT AND/OR REPACKAGING

Estimates provided in Table 6 regarding the amount of waste requiring either treatment, repackaging, or both are based on site-specific knowledge and/or process knowledge of the waste at each site; knowledge of what would be required for shipment of the waste to WIPP; and assumptions about which types of RH-TRU waste would require repackaging or treatment. These estimates were made from data in the WTWBIR (DOE, 1995a).

4.1 Waste Requiring Repackaging

All of ORNL's RH-TRU waste, and about 50% of the RH-TRU waste at Hanford, INEL, ANL-W, KAPL, and LANL must be repackaged based on current understanding. Therefore from Table 6, approximately 93% or 1,081 m^3 (38,171 ft^3) of all stored RH-TRU waste needs repackaging.

4.2 Waste Requiring Treatment

Table 6 shows the percentage of stored and projected waste at each of the major sites that must be treated. Approximately 16% or 790 m^3 (27,895 ft^3), of the total stored and projected RH-TRU waste will require treatment. All solidified inorganic waste (i.e., sludges) at ORNL, which constitutes approximately 58% of all their RH-TRU waste, needs treatment. About 4.4% of the INEL waste is classified as solidified inorganic waste and will require treatment.

Table 4. RH-TRU Mixed Waste Inventories[1]

SITE	TYPE	VOLUME (m^3) AT END OF 1993	PROJECTED VOLUME (m^3)
ANL-W	MTRU	8.65	3.89
	TRU	0	23.74
BATTELLE	MTRU	0	0
	TRU	0	71
BETTIS	MTRU	0	0
	TRU	0	1.57
HANFORD	MTRU	0	1727.71
	TRU	33.16	1246
INEL	MTRU	17.34	16.8
	TRU	13.63	0
KAPL	MTRU	11.23	25.23
	TRU	0	0
LANL	MTRU	14.97	67.66
	TRU	76.33	15
ORNL	MTRU	993.81	356.7
	TRU	0	0
SRS	MTRU	0	0
	TRU	0	63.92
TOTAL	MTRU	1046	2197.99
	TRU	123.12	1421.23

[1] Source: WTWBIR, (DOE, 1995a)

Table 5. WIPP RH-TRU Waste Profiles for Final Waste Form[1]

Site	Waste Group (All Volumes in Cubic Meters)							
	Combustible	Filter	Heterogeneous	Lead/ Cadmium Metal	Salt Waste	Solidified Inorganic	Uncategorized Metal	Unknown
ANL-W								
Current[2]		0.89	0.59	0.00			7.17	0.00
Projected		2.09	0.08	0.36			1.36	23.74
Combined		2.98	0.67	0.36			8.53	23.74
Battelle								
Current			0.00					
Projected			71					
Combined			71					
Bettis								
Current			0.00					
Projected			1.57					
Combined			1.57					

Site	Waste Group (All Volumes in Cubic Meters)							
	Combustible	Filter	Heterogeneous	Lead/ Cadmium Metal	Salt Waste	Solidified Inorganic	Uncategorized Metal	Unknown
Hanford								
Current			33.16					
Projected			2973.71					
Combined			3006.87					
INEL								
Current			13.63	0.00	0.00	2.10	4.11	11.13
Projected			2.80	5.60	2.80	0.00	5.60	0.00
Combined			16.43	5.60	2.80	2.10	9.71	11.13
KAPL								
Current			11.23					
Projected			25.23					
Combined			36.46					

Site	Waste Group (All Volumes in Cubic Meters)							
	Combustible	Filter	Heterogeneous	Lead/ Cadmium Metal	Salt Waste	Solidified Inorganic	Uncategorized Metal	Unknown
LANL								
Current	14.84						76.46	
Projected	3.16						79.50	
Combined	18.00						155.95	
ORNL								
Current			382.81			611.00		
Projected			182.70			174.00		
Combined			565.51			785.00		
SRS								
Current			0.00					
Projected			63.92					
Combined			63.92					

Site	Waste Group (All Volumes in Cubic Meters)							
	Combustible	Filter	Heterogeneous	Lead/ Cadmium Metal	Salt Waste	Solidified Inorganic	Uncategorized Metal	Unknown
TOTAL RH-TRU VOLUMES								
Current	14.84	0.89	441.43	0.00	0.00	613.10	87.74	11.13
Projected	3.16	2.09	3321.00	5.96	2.80	174.00	86.46	23.74
Combined	18.00	2.98	3762.42	5.96	2.80	787.10	174.20	34.87

[1] Source: WTWBIR (DOE, 1995a)
[2] Current is retrievably stored waste
[3] Volumes in cubic meters

Table 6. Percentage of RH-TRU Waste Requiring Treatment and/or Repackaging[1]

Site	Retrievably Stored Waste[2]	Percentage of Stored Waste Requiring Repackaging[3]	Projected Waste[2]	Total Waste[2]	Percentage of Total Waste Requiring Treatment[3]
ANL-W	8.7	50[4]	27.6	36.3	0
BATTELLE	0	N/A	71	71	0
BETTIS	0	N/A	1.6	1.6	0
HANFORD	33.2	50[4]	2973.7	3006.9	0
INEL	31	50[4]	16.8	47.8	4.4[6]
KAPL	11.2	50[4]	25.2	36.4	0
LANL	91.3	50[4]	82.7	174	0
ORNL	993.8	100[5]	356.7	1350.5	58[6]
SRS	0	N/A	63.9	63.9	0

[1]Data Source: WTWBIR (DOE, 1995a)
[2]All Volumes in Cubic Meters
[3]Estimates of Waste Requiring Treatment/Repackaging from Process Knowledge
[4]It is assumed that 50% of Stored Waste Needs Repackaging
[5]All of the stored waste at ORNL will need repackaging because no waste is currently in certifiable packaging.
[6]58% of the ORNL total waste is categorized as solidified inorganic (sludge) and will require treatment prior to shipment to WIPP. About 4.4% of the INEL waste is classified as solidified inorganic.

5.0 RH-TRU WASTE NOT MEETING WIPP WASTE ACCEPTANCE CRITERIA

Most of the RH-TRU waste currently not meeting the WIPP Waste Acceptance Criteria exceeds either the allowable surface dose rates or total curie limits. Some of these wastes can be made acceptable for disposal through repackaging. For example, various RH-TRU waste canisters which exceed 1,000 rem per hour could be made eligible by repackaging to an acceptable radiation level. The amount of waste which would fall in this category is unknown at this time.

However, some RH-TRU waste with dose rates above 1,000 rem per hour, in excess of acceptable neutron dose rate limits, or in excess of acceptable curie limits may remain ineligible for shipment due to inherent characteristics which would not be significantly affected by repackaging. Also current revisions on the estimated volumes of RH-TRU waste available for disposal at WIPP indicate that these volumes greatly exceed the current legal capacity limit for WIPP.

Issues concerning the ineligibility of wastes for disposal at WIPP are currently being addressed by the DOE. A report, entitled "*Recommendation For Disposal Of All TRU Waste*" is being prepared as mandated in Section (7)(b)5 of the LWA. This report, which will be sent to Congress, addresses disposal alternatives for wastes not eligible for shipment to WIPP. A draft of the report will be submitted to Congress by the end of 1997.

6.0 SUGGESTIONS FOR FUTURE DATA COLLECTION ON RH-TRU WASTE INVENTORIES AND GENERATION

Effective RH-TRU waste management planning is highly dependent on the type of data available for analysis. These data form the basis for decisions on such matters as characterization, treatment, storage, and transportation. The following are additional data needed to develop a future revision to the overall RH-TRU waste management plan:

- data on RH-TRU waste origins and acceptable knowledge of generation,
- data on the dose rate for RH-TRU waste, specifically on waste which could be shielded down to 200 millirem per hour,
- data on the characteristics of waste between 100 and 1,000 rem per hour,
- data on the characteristics of waste exceeding 1,000 rem per hour or otherwise exceeding WIPP Waste Acceptance Criteria, and
- data on the type of packaging or treatment required for projected waste.

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REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX B

Remote-Handled Transuranic Waste Site Storage

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ACRONYM LIST

ALARA	as low as reasonably achievable
ANL-W	Argonne National Laboratory - West
cm^2	square centimeters
DOE	Department of Energy
dpm	disintegrations per minute
FMEF	Fuels Materials Examination Facility
INEL	Idaho National Engineering Laboratory
KAPL	Knolls Atomic Power Laboratory
LANL	Los Alamos National Laboratory
m^3	cubic meters
mrem	millirem
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
RH	remote handled
SRS	Savannah River Site
TRU	transuranic
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant
WTWBIR	WIPP Transuranic Waste Baseline Inventory Report

RH-TRU WASTE SITE STORAGE

1.0 INTRODUCTION

This report examines the need for temporary site storage of remote handled transuranic (RH-TRU) waste throughout the Department of Energy (DOE) complex. It provides an assessment of potential alternatives, and presents recommendations for providing site storage.

1.1 Scope

Temporary site storage is defined as storage for characterized waste ready for shipment to the Waste Isolation Pilot Plant (WIPP) but pending final certification for transport and disposal at WIPP. At this time, the WIPP is the only identified disposal option for RH-TRU waste; however, no RH-TRU waste has been certified to meet the WIPP Waste Acceptance Criteria (WAC), Revision 4, (DOE, 1991). Therefore, this type of storage of RH-TRU waste does not currently exist at the generator sites. A site storage facility at WIPP was not considered due to Resource Conservation and Recovery Act (RCRA) permitting constraints.

Data for this report came primarily from Revision 1 of the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report* (WTWBIR) (DOE, 1995).

1.2 Background

At the nine generator sites, 1169.1 cubic meters (m^3) of waste is currently stored, and 3619.2 m^3 is projected to be generated by the year 2022. The four major sites, Oak Ridge National Laboratory (ORNL), Los Alamos National Laboratory (LANL), Idaho National Engineering Laboratory (INEL), and the Hanford Reservation (Hanford), represent more than 98% (1149 m^3) of the RH-TRU waste currently stored. The four major generator sites examined in this report also represent about 95% (3,430 m^3) of the projected RH-TRU waste to be generated by 2022 (DOE, 1995). For the purpose of this report, the relatively small quantity sites are assumed to ship on an "as-generated" basis and therefore do not require site storage capacity. As identified in the Inventory and Generation report, the Hanford Reservation is expected to reclassify approximately 5,000 m^3 of "suspect" waste as RH-TRU waste in Revision 2 of the WTWBIR.

1.3 Methodology

To determine the site-specific needs for site storage, the following five-step methodology was followed in the preparation of this report:

1. Determine site storage capacity requirements for each of the four major sites.
2. Determine the existing and proposed storage facilities that are suitable for site storage.
3. Determine the shortfall in potential RH-TRU waste site storage space at each generator site.
4. Determine the alternatives for providing site storage.
5. Provide recommendations for site storage.

2.0 SITE STORAGE REQUIREMENTS

2.1 Capacity Requirements

Requirements for site storage capacity are based on the amount of waste that should be kept in storage in order to ensure that waste is shipped to WIPP at a sustainable, steady rate. Without sufficient site storage, a disruption in operations at the generator sites could stop the flow of waste to WIPP. Conversely, an operations shutdown at WIPP could require generator sites to discontinue waste shipments and subsequently affect treatment and processing activities. Therefore, without site storage capability, an operational disruption at either the generator site or WIPP could lead to a slowdown or cessation of systemwide operations.

For estimation purposes, it is assumed that the amount of time required to restart a facility, either the site or "WIPP", is four months. This includes time to prepare new procedures and conduct an operational readiness review. Therefore, a total storage time of eight months is required to cover both an interruption at WIPP and an interruption at the generator sites.

This report focuses on the sites with the largest likely demand for RH-TRU waste storage: Hanford, INEL, Oak Ridge National Laboratory (ORNL), and Los Alamos National Laboratory (LANL). Table 1 shows the assumed shipping schedules and associated storage needs for these sites. This draft shipping schedule was developed to be used as an initial basis for assessing site storage needs at each generator site.

Table 1. Shipping Schedules and RH-TRU Waste Site Storage Needs for Generator Sites (canisters/yr)[1]

Shipment Dates	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OAK RIDGE NATIONAL LABORATORY											
Shipments per year[2]	0	0	24	24	24	24	24	24	24	24	24
Site storage required at site[3]	0	0	16	16	16	16	16	16	16	16	16
IDAHO NATIONAL ENGINEERING LABORATORY											
Shipments per year	6	6	6	6	6	6	6	1	1	1	0
Site storage required at site	4	4	4	4	4	4	4	0	0	0	0
LOS ALAMOS NATIONAL LABORATORY											
Shipments per year	12	12	12	12	12	12	12	12	12	12	12
Site storage required at site	8	8	8	8	8	8	8	8	8	8	8
HANFORD RESERVATION											
Shipments per year	12	12	24	24	48	48	96	96	144	144	144
Site storage required at site	8	8	16	16	32	32	64	64	96	96	96

[1]Data from the RH-TRU Waste Work-off Schedule in equivalent number of canisters
[2]Based on 0.89 m^3 per RH-TRU 72B packaging
[3]Based on site storage for eight months of shipments

Table 1 Shipping Schedules and RH-TRU Waste Site Storage Needs for Generator Sites (canisters/yr)[1] (continued)

Shipment Dates	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
OAK RIDGE NATIONAL LABORATORY														
Shipments per year[2]	24	24	48	48	96	96	120	120	121	121	121	121	121	121
Site storage required at site[3]	16	16	32	32	64	64	80	80	80	80	80	80	80	80
IDAHO NATIONAL ENGINEERING LABORATORY														
Shipments per year	1	0	1	1	0	1	0	1	0	1	1	0	1	1
Site storage required at site	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOS ALAMOS NATIONAL LABORATORY														
Shipments per year	12	12	6	4	3	3	3	3	3	3	3	3	3	3
Site storage required at site	8	8	4	3	2	2	2	2	2	2	2	2	2	2
HANFORD RESERVATION														
Shipments per year	144	144	192	192	192	192	192	192	192	192	192	192	192	187
Site storage required at site	96	96	128	128	128	128	128	128	128	128	128	128	128	125

[1]Data from the RH-TRU Waste Work-off Schedule in cubic meters
[2]Based on 0.89 m^3 per RH-TRU 72B packaging
[3]Based on site storage for eight months of shipments

As shown in the Table, the required amount of site storage varies considerably among the four major sites. For example, Idaho National Engineering Laboratory (INEL) will require a peak capacity of 4 canisters (about 3.6 m^3), while the Hanford Reservation (Hanford) will need about 128 canisters (114 m^3) of storage capacity. Hanford's needs are the most variable, ranging from a start-up capacity of about 8 canisters (7.1 m^3) and then reaching a peak requirement of approximately 128 canisters (114 m^3), where it essentially remains throughout the emplacement campaign. ORNL and LANL peak at 80 canisters (71 m^3) and 8 canisters (7.1 m^3) respectively.

The small quantity generator sites, including Bettis Atomic Power Laboratory (Bettis), Battelle Columbus Laboratory Decommissioning Project (Battelle), Knolls Atomic Power Laboratory (KAPL), Savannah River Site (SRS), and Argonne National Laboratory-West (ANL-W) are not anticipated to require a significant amount of storage because each of these sites has relatively small amounts of waste. In most cases, their shipments will be made shortly after their waste has been characterized and certified, or on an "as-generated" basis. If a shutdown occurs at WIPP, storage would not be needed at these sites to accommodate the continued operations of a significant facility or set of operations. Similarly, if a shutdown occurred at the small quantity site, the loss to WIPP of those shipments would not be significant.

2.2 Suitability Criteria For Site Storage Facilities

The suitability of a facility to provide RH-TRU waste site storage depends on a number of criteria and characteristics, such as:

1. Space must be available as required to meet site storage needs; however, a facility does not have to be designated exclusively for site storage.

2. The site storage facility must be sized to accommodate the waste canisters that will be used in the RH-72B shipping cask. These waste containers are 3.1 meters (10 feet, 1 inch) long by 0.66 meters (26 inches) in diameter. However, if an alternative to the RH-72B packaging was used, such as a new shielded packaging, the waste containers would most likely be designed to have similar dimensions to those of a standard 55-gallon drum, 83-gallon drum, or Standard Waste Box.

3. Internally, the facility used for site storage must be radiologically clean. This is defined as having alpha contamination of less than 20 disintegrations per minute per 100 square centimeters (20 dpm/100 cm^2) and beta or gamma contamination of less than 1,000 dpm/100 cm^2. Externally, there should be sufficient shielding, designed to "as low as reasonably achievable" (ALARA) standards, to protect the health and

safety of workers. Access to the structure should be controlled so that workers are not exposed to more than 500 millirem per year (mrem/yr).

4. The facility should be currently permitted under RCRA, be in the permitting process, or have the ability to be permitted without extensive renovation or modification. The facility should also have the ability to meet RCRA inspection and sampling requirements if the RH-TRU waste is classified as mixed waste. (Note: If dose rates are high, inspections will be conducted remotely.)

5. The facility should have an adequate design life. In no case will use of the facility exceed its design life (i.e., the operational life as specified in design plans).

6. The facility must be accessible by road and accommodate handling systems for RH-TRU casks.

3.0 ALTERNATIVES FOR PROVIDING SITE STORAGE

Storage requirements at the generator sites can be satisfied by multiple alternatives, as described below:

- Utilize existing waste storage in its present configuration and condition.
- Modify or qualify an existing waste storage facility for storage, including modifications to RCRA permitting conditions and/or adding additional shielding or decontamination.
- Construct new facilities to provide storage.
- Utilize some combination of these alternatives.

4.0 ALTERNATIVE EVALUATION

This section presents a survey of existing and proposed RH-TRU waste storage facilities that have the potential to be used for RH-TRU waste storage at the four major generator sites. Facilities such as tanks for sludge storage, unlined trenches containing RH-TRU solid waste, or heavily contaminated shielded structures were considered unsuitable and thus were eliminated. Table 2 provides a summary of existing and proposed facilities that could potentially be used for site storage of RH-TRU waste.

Table 2 Existing and Proposed RH-TRU Storage Facilities with Potential for RH-TRU Site Storage[1]

Building	Configuration	Status	Storage Capacity	Space Previously Committed	Waste Type	Additional Capacity	RCRA Permit	Radiologically Clean
OAK RIDGE NATIONAL LABORATORY								
7885	Concrete block structure, bunker	operational	108 concrete containers (65 m^3)	100%	Solid debris	No	Yes	Yes
7883	Concrete block, bunker	Proposed, to be operational in 1997	108 containers (65 m^3 of waste)	37%	Solid	Yes (40 m^3)	Yes	Yes
7884	Concrete	Proposed for future	300 containers	67%	Solid	Yes (60 m^3)	Yes	Yes

Building	Configuration	Status	Storage Capacity	Space Previously Committed	Waste Type	Additional Capacity	RCRA Permit	Radiologically Clean
HANFORD RESERVATION								
218-W-4B caissons	Concrete lined cylindrical vault	Operational	Storage halted	Unknown	Unknown	No	Interim status	Unknown
Fuels Materials Examination Facility (FMEF)	Concrete building	Unused (built for the Fast Flux Test Facility)	Unknown	Unknown	Unused	Unused	None	Yes
IDAHO NATIONAL ENGINEERING LABORATORY								
714, 720 Intermediate level TRU waste storage facility	Carbon steel subsurface vaults	Operational	170 m^3		Solid	Yes	3 vaults have RCRA-approved liners, room for 10 drums	Yes

Building	Configuration	Status	Storage Capacity	Space Previously Committed	Waste Type	Additional Capacity	RCRA Permit	Radiologically Clean
LOS ALAMOS NATIONAL LABORATORY								
Burial site- shafts	Augured vertical shafts	Operational	90.7 m^3, 20 shafts with characterized waste		Solid	New holes to be added	No[2]	Yes

[1]Source: TRU Facility Matrix Data Base
[2]Not needed because waste is not mixed

4.1 Oak Ridge National Laboratory

The ORNL site inventory of retrievably stored RH-TRU waste is approximately 994 m^3 and its projected waste generation is approximately 357 m^3 (DOE, 1995). ORNL has one operational facility (7885) and two proposed facilities (7883 and 7884) that could potentially be used for site storage. These facilities are more completely described below.

Storage facility 7885 is a concrete block, earth-covered bunker, which is permitted by RCRA and is radiologically clean. The facility could potentially be used for site storage without any modifications. However, it is currently almost completely filled with RH-TRU solid debris waste that has not been characterized. If this material is removed, characterized, and certified for shipment to WIPP, the facility could serve as a storage facility.

Proposed storage facility 7883, which also will be a concrete, earth-covered building, is scheduled for completion in 1997. This facility is intended for storage of newly generated RH-TRU waste and 37% of its capacity is accounted for. Consequently, about 60% of its capacity (40 m^3) would be available for site storage in 2002.

Proposed storage facility 7884 is being designed for 300 containers of waste. The structure has been reserved for approximately 200 containers of existing RH-TRU waste, which will be retrieved from its current burial place in unlined trenches. Based on this commitment, building 7884 would have space available for approximately 60 m^3 of storage when it is constructed.

According to Table 1, ORNL will require an increasing amount of storage from 2004, when storage space for only 16 canisters (14.2 m^3) will be needed, until 2019, when its requirement peaks at about 80 canisters (71 m^3). Storage requirements then remain constant through 2026. Assuming that facility 7883 is completed as planned, its 40 m^3 of storage space will be sufficient to meet ORNL's storage requirements until the year 2017, when 64 canisters or approximately 57 m^3 of storage space will be required. Storage building 7884, if constructed, will provide an additional 60 m^3 of potential storage space, bringing ORNL's storage capacity to 100 m^3. This will be adequate to meet ORNL's peak storage requirements of 80 canisters (about 71 m^3) and provide a buffer for unanticipated storage requirements. These existing and proposed RH-TRU storage facilities are described in Table 2.

4.2 Hanford Reservation

Hanford's inventory of stored RH-TRU waste is described in the WTWBIR as approximately 33 m^3 with projected generated volumes of waste to be about 3,033 m^3 (DOE, 1995). As shown in Table 2, Hanford has one existing RH-TRU storage facility, which is currently full and one existing facility, which is unused and could provide for storage. Projections for Hanford indicate a reassignment of waste previously labeled as "suspect" TRU into the TRU waste category. Approximately 5,000 m^3 of waste is now expected to be RH-TRU.

Storage facility 218-W-4B encompasses caissons, which are earth-covered and are no longer being used to store newly generated RH-TRU waste. Investigation revealed that these caissons are inaccessible and thus would probably not be suitable for additional storage.

The Fuels Materials Examination Facility (FMEF) is a large shielded structure that was built for another project and never used. The FMEF would make an excellent storage facility for RH-TRU waste since it is large, shielded, and could be used to load packagings remotely. However, a number of other parties are also interested in using this facility.

Hanford's requirements for storage varies, as shown in Table 1, from a low of 8 canisters (7.1 m^3) during the first year to a peak of 128 canisters (114 m^3) from 2015 through 2020. At present, there is no existing facility or proposed facility that is likely to offer the potential to be used for storage. This information is summarized in Table 2. The FMEF provides one possibility but additional information would have to be collected concerning its design and its other potential uses.

4.3 Idaho National Engineering Laboratory

INEL's inventory of retrievably stored RH-TRU waste is approximately 31 m^3 with a projected waste generation of about 17 m^3 (DOE, 1995). According to Table 1, the requirement for site storage will be about 4 canisters (3.6 m^3) in 2002 until 2008. After 2008, shipments are assumed to be on an "as-generated" basis. Table 2 provides a summary of the major characteristics for the existing RH-TRU waste storage facility. Among the current storage facilities, the three storage vaults that are RCRA permitted could potentially be used for storage and would accommodate approximately 5 m^3 of RH-TRU storage. This would cover INEL's storage needs for all years. Other vaults could be converted for waste storage purposes by including them in the RCRA permit.

An INEL task force is currently investigating its RH-TRU waste storage facilities and determining long-term storage potential. This will include the potential for storage. The evaluation will be completed by the end of fiscal year 1995. However, initial findings indicate that there appears to be ample storage capacity for RH-TRU waste.

4.4 Los Alamos National Laboratory

LANL's inventory of retrievably stored RH-TRU waste is approximately 91 m^3, and the projected waste generation is estimated to be about 83 m^3. According to Table 1, 8 canisters (7.1 m^3) of storage will be required by LANL in 2002 through 2014. This storage requirement will begin to decrease in 2015.

As shown in Table 2, there are 20 burial-site shafts that contain waste already characterized and certified to WIPP WAC, Revision 3. As these shafts are emptied, they could potentially be reused as storage.

5.0 ALTERNATIVE RANKINGS AND RECOMMENDATIONS

5.1 Oak Ridge National Laboratory

As indicated in Section 4.1, ORNL has only one existing facility (Building 7885) that can potentially be used for storage. In addition, one facility (Building 7883) will be built in two years and could be used for storage. A third facility (Building 7884) would supplement storage capacity for those years when storage demand increases.

5.1.1 Preferred Alternative

Portions of planned RH-TRU waste storage facilities should be used to meet storage needs in the future. This alternative is superior to the secondary alternative because it satisfies the need for 80 canisters (71 m^3) of RH-TRU waste storage and utilizes proposed facilities 7883 and 7884.

5.1.2 Secondary Alternative

A new facility that accommodates, in one location, the anticipated 80 canisters (71 m^3) peak demand for RH-TRU waste storage could be designed and constructed at ORNL. This structure would have the advantage of centralizing RH-TRU waste storage in one location. However, costs would be increased considerably since existing and currently proposed facilities would not be used.

5.2 Hanford Reservation

Hanford does not have an existing RH-TRU waste storage facility that will serve for storage purposes. Although the FMEF has the potential to provide storage space, there is a strong demand among other groups to use the facility for other purposes. Thus, its use as a storage facility is unlikely. Furthermore, additional information is necessary to determine the characteristics of the FMEF and assess its suitability for storage.

5.2.1 Preferred Alternative

The preferred alternative is to investigate the use of the FMEF by collecting information about its design and capabilities. If it proves to be adequate, a campaign could be initiated to obtain the rights to use the facility. Use of this facility would eliminate the need to build a new storage facility, although some modifications would be necessary.

5.2.2 Secondary Alternative

The secondary alternative is to plan and develop a new RH-TRU storage facility at Hanford. Plans should be developed to construct a facility to accommodate an approximate maximum of 128 canisters (114 m^3) of storage after 2015. Less storage capability would be needed before that date. The storage should be constructed in phases, with one module being constructed at a time.

5.3 Idaho National Engineering Laboratory

INEL has two buildings, with a total of three RCRA-permitted vaults, that have the potential to be used for site storage.

5.3.1 Preferred Alternative

The preferred alternative for INEL is to utilize the current storage facilities. The three vaults permitted under RCRA would provide about 5 m^3 of storage. This preferred alternative has the advantage of utilizing existing facilities, being accomplished at relatively low cost, and accommodating all identified RH-TRU wastes at INEL.

5.3.2 Secondary Alternative

Due to the relatively small amount of RH-TRU waste identified at this time, no secondary alternative is considered at this time.

5.4 Los Alamos National Laboratory

LANL currently has 20 augured vertical shafts that could provide RH-TRU waste storage needs. These shafts currently contain waste that is characterized and certifiable to Revision 3 of the WIPP-WAC.

5.4.1 Preferred Alternative

The preferred alternative for LANL is to utilize existing RH-TRU waste storage facilities for site storage. LANL's facilities do not have to be permitted under RCRA because the RH-TRU waste is not mixed. Ample space is available for the 8 canisters (7.1 m^3) of RH-TRU waste required to be in storage during the peak years.

5.4.2 Secondary Alternative

Due to the relatively small amount of RH-TRU waste identified at this time, no secondary alternative is considered at this time.

6.0 REFERENCES

DOE, 1995. *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report*, CAO-94-1005, Revision 1, U.S. Department of Energy-Carlsbad Area Office, Carlsbad, New Mexico, February 1995.

DOE, 1991, *Waste Isolation Pilot Plant Waste Acceptance Criteria*, WIPP/DOE-069, Revision 4, December 1991.

REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX C

Characterization of Remote-Handled Transuranic Waste

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ACRONYM LIST

AEA	Atomic Energy Act
ANL-E	Argonne National Laboratory, East
ANL-W	Argonne National Laboratory, West
CH-TRU	contact handled
CTEN	Combined Thermal/Epithermal Neutron
CY	calendar year
DOE	Department of Energy
EPA	Environmental Protection Agency
FTIR	Fourier Transform Infrared
HFEF	Hot Fuel Examination Facility
IDB	Integrated Data Base
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
LINAC	linear accelerator
m^3	cubic meters
NDA	non-destructive assay
NDE	non-destructive examination
NG	newly generated
NMD	No-Migration Determination
NMED	New Mexico Environment Department
NMVP	No-Migration Variance Petition
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OSW	Office of Solid Waste
PAN	Passive-Active Neutron
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Program Plan
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RH-TRU	remote handled
RS	retrievably stored
RTR	real-time radiography
SARP	Safety Analysis Report for Packaging
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter, Model II
WAC	waste acceptance criteria
WAP	waste analysis plan
WIPP	Waste Isolation Pilot Plant
WTWBIR	WIPP TRU Waste Baseline Inventory Report

WASTE CHARACTERIZATION

1.0 INTRODUCTION

The purpose of this chapter is to discuss the status of technology development within the Department of Energy (DOE) transuranic (TRU) waste complex for characterization of remote-handled (RH-TRU) TRU waste and to summarize the availability of existing or planned equipment and facilities at the major sites that either have RH-TRU waste in storage and/or plan to generate waste in the future.

An synopsis is also presented of the percentage of RH-TRU waste that might fall outside the capabilities of existing waste characterization systems. This synopsis will allow areas to be pinpointed for which additional, future funding should be allocated.

2.0 STATUS OF TECHNOLOGY DEVELOPMENT

Before one can evaluate the status of technology development for characterization of RH-TRU waste, a comprehensive set of waste characterization requirements/criteria must be developed. Although the results from Performance Assessment calculations have not been finished (other than in draft form) and provided to state and federal regulatory agencies for review, and although a certification statement has not yet been issued by regulatory agencies, it is still possible to develop reasonable assumptions as to what the waste characterization requirements will be based on past and present requirements that have been imposed on DOE.

2.1 Determination of Existing RH-TRU Waste Characterization Requirements/Criteria

The basis of the comparison presented is from the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC), Revision 4, issued in December 1991 (DOE, 1991). All sites are expected to be operating and packaging waste according to Revision 4. Revision 4 of the WIPP-WAC identified and consolidated existing criteria and requirements which regulate the safe handling and preparation of TRU waste packages for transportation to and emplacement in the WIPP. The criteria/requirements originated from four sources:

- <u>WIPP Operations and Safety Criteria</u>

  These are the criteria developed to ensure safe handling of wastes at the WIPP. They were previously issued in WIPP-DOE-069, Revision 3 (DOE, 1989).

- Transportation: Waste Package Requirements

  Waste package requirements for transportation of RH-TRU wastes will not be finalized until the RH-TRU Cask Safety Analysis Report for Packaging (SARP) is approved by the Nuclear Regulatory Commission (NRC) and a Certificate of Compliance is issued. Preliminary criteria are included in Table 4-1 from the draft RH-TRU Cask SARP currently under review by the DOE prior to submittal to the NRC (VECTRA, 1994).

- RCRA Requirements

  TRU waste is categorized as TRU-mixed waste if it contains hazardous waste as defined in 40 CFR Part 261, the Resource Conservation and Recovery Act (RCRA) (EPA, 1986). Because of the presence of hazardous waste, mixed waste is subject to dual regulation under the Atomic Energy Act (AEA) (U.S. Congress, 1954) and the RCRA (U.S. Congress, 1976). The requirements/criteria listed in Table 4-1 are summarized from those listed in the WIPP RCRA Part A and Part B Permit Applications (DOE/Westinghouse, 1991; DOE/Westinghouse, 1993).

  The DOE submitted a No-Migration Variance Petition (NMVP) (DOE, 1990) to the Environmental Protection Agency (EPA) Office of Solid Waste (OSW) in 1990 and has been granted a conditional No-Migration Determination (NMD) (EPA, 1990) for a period of ten years for testing and experimentation purposes. In the NMD, the EPA OSW has suggested additional waste characterization to support a petition for disposal operations. The NMD requirements have been included in the WIPP RCRA Part B Permit Application, submitted to the New Mexico Environment Department (NMED), and are included in Table 1.

  The primary reference document for establishing the RCRA waste characterization requirements included in the WAC is the WIPP Waste Analysis Plan (WAP). The DOE provided information in the WAP to the EPA OSW and the NMED on available characterization data for the waste to be emplaced in the WIPP. These data were used in the NMVP and subsequently in the WIPP RCRA Part B Permit Application. Sites may use sampling and analysis, or acceptable knowledge to identify the hazardous component of their wastes. In addition, each site must characterize a statistically representative sample of its waste to demonstrate that it meets the requirements of the NMD (EPA, 1990). Sampling and analysis activities are to be described in the site Quality Assurance Project Plans (QAPjPs). Acceptable knowledge as used by the Environmental Protection Agency (EPA) includes process knowledge and results from previous testing, sampling, and analysis associated with the waste. Acceptable knowledge includes information regarding the raw materials used in a process or operation, the process description, the products produced, and the associated wastes. Acceptable knowledge documentation may include the site history and mission, site-specific processes or operations, administrative building controls, and all previous and current activities that generate a specific waste.

- Performance Assessment Criteria

  The Performance Assessment waste characterization criteria were incorporated in WIPP WAC Rev. 4 from activities supporting the Test Phase at WIPP. The Test Phase has been cancelled at WIPP, but those criteria that are still included in the WIPP Quality Assurance Program Plan (QAPP) (DOE, 1995a) have been included as part of this evaluation.

Table 1 represents a modification of Table ES-1 from Revision 4 of the WIPP WAC (DOE, 1991). This table has been modified and updated in order to more accurately reflect the currently known requirements/criteria for RH-TRU waste. These modifications include:

- Criteria from the WIPP Test Phase that were not retained in the QAPP have been dropped from the list (DOE, 1995a)

- Requirements have been added based on the current draft of the RH-TRU Cask SARP (VECTRA, 1994).

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	**LIMITING PARAMETER(S)**	**CH-TRU WASTE**	**LOWER SURFACE DOSE RATE RH-TRU WASTE**	**HIGHER SURFACE DOSE RATE RH-TRU WASTE**
WASTE CONTAINER REQUIREMENTS/CRITERIA				
Waste Containers 3.2.1	• Containers shall be noncombustible and meet DOT Type A packaging requirements. • Current RH-TRU cask requirements limit acceptable containers to a WIPP RH-TRU canister or 3 drums overpacked in a WIPP RH-TRU canister.	Procurement/Administrative Controls Inspection		
Waste Package Size 3.2.2	• RH-TRU cask allows only a WIPP RH-TRU canister.	Administrative Controls Inspection		
Waste Package Handling 3.2.3	• All WIPP RH-TRU canisters shall be configured with an axial lifting pintle (see 3.2.2 above).	Procurement/Administrative Controls Inspection		
WASTE FORM REQUIREMENTS/CRITERIA				
Immobilization 3.3.1	• Waste materials shall be immobilized if >1% by weight is particulate material < 10 microns in diameter, or if >15% by weight is particulate material < 200 microns in diameter.	Process Controls/Knowledge		
Liquids 3.3.2	• Only residual liquids; as a guideline, residual liquid in well-drained internal containers to be restricted to approximately 1 volume % of the internal container; aggregate amount of residual liquid < 1 volume % of external container.	RTR (shielded containers, if allowed, will require visual)	RTR with some equipment modification (will require visual, if shielded)	Visual New Technology?

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	LIMITING PARAMETER(S)	CH-TRU WASTE	LOWER SURFACE DOSE RATE RH-TRU WASTE	HIGHER SURFACE DOSE RATE RH-TRU WASTE
Pyrophoric Materials 3.3.3	• No non-radionuclide pyrophorics permitted. Radionuclides in pyrophoric form are limited to <1% by weight in each waste package.	Process Controls/Knowledge Oxidation Process Criticality/Wattage Limitations		
Explosives 3.3.4	• No explosives (49 CFR Part 173, Subpart C) are permitted.	Procurement/Administrative Controls Process Controls/Knowledge		
Compressed Gases 3.3.4	• No compressed gases are permitted.	RTR Visual		Visual New Technology?
TRU Mixed Waste 3.3.5	• TRU wastes shall contain no hazardous wastes unless they exist as co-contaminants with transuranics. • Waste generators must determine if their waste is regulated by RCRA, and meet the requirements in the WIPP RCRA Part A and Part B Permit Applications.	Administrative Controls Process Controls/Knowledge Supplemented with Sampling and Analysis, if necessary		
	• Generators must document procedures for sampling, analytical protocols, QA/QC guidelines, and other information called for in 40 CFR § 265.13 and 264.13 in a site-specific QAPjP.	Administrative /Document Controls		
	• Characteristic ignitable (D001), corrosive (D002), and reactive (D003) wastes are not acceptable at WIPP. • Sludges shall be analyzed for total VOCs and toxic metals specified in the NMD.	Process Controls/Knowledge Supplemented with Sampling and Analysis, if necessary		Same, but these characteristics may not be demonstrable in a hot cell.

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	**LIMITING PARAMETER(S)**	**CH-TRU WASTE**	**LOWER SURFACE DOSE RATE RH-TRU WASTE**	**HIGHER SURFACE DOSE RATE RH-TRU WASTE**
TRU Mixed Waste 3.3.5 (Con't.)	• Any waste container sent to WIPP must meet the two times (2X) the maximum comparability requirement for 5 nonflammable VOCs as specified in the NMD. • Any waste container sent to WIPP must meet the ten times (10X) the average comparability requirement for 3 nonflammable VOCs as specified in the NMD.	Sampling and Analysis		
Specific Activity of Waste 3.3.6	• Waste shall be greater than 100 nanocuries of TRU per gram of waste, exclusive of added shielding, rigid liners, and the waste containers, including alpha contaminated wastes handled as TRU under DOE Order 5820.2A.	Nondestructive Assay (NDA) System or Radiochemical Analysis (for solidified waste forms)		New Technology?
Waste Package Weight 3.4.1	• Current waste package limits are 8000 lbs per WIPP RH-TRU canister.	Using Calibrated Equipment, in a heavily shielded environment, if necessary		
Nuclear Criticality (Pu-239 FGE) 3.4.2	• Accepted package limits, including two times the error, are: - < 325FGE/WIPP RH-TRU canister	Use Techniques Documented in RH-TRU Cask SARP		New Technology?
Pu-239 Activity 3.4.3	• Waste packages shall not exceed 1000 Ci of Pu-239 equivalent activity (PE-Ci).	Calculation		

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	**LIMITING PARAMETER(S)**	**CH-TRU WASTE**	**LOWER SURFACE DOSE RATE RH-TRU WASTE**	**HIGHER SURFACE DOSE RATE RH-TRU WASTE**
Surface Dose Rate 3.4.4	• RH-TRU Canister shall have a surface dose rate of ≤1000 rem/hr. - 95% canisters ≤100 rem/hr - 5% canisters >100 rem/hr but ≤ 1000 rem/hr. • Shielded containers are allowed for ALARA purposes only. • Neutron contributions of ≤270 mrem/hr. • External dose rates on the loaded RH-TRU Cask shall not exceed 200 mrem/hr surface, or 10 mrem/hr at 2 m.	Use Techniques Documented in RH-TRU Cask SARP		
Surface Contamination 3.4.5	• Removable package surface contamination shall not be >20 dpm/100 cm^2 alpha, and not >100 dpm/100 cm^2 beta/gamma. [NOTE: This is a change to bring the WIPP WAC into compliance with the DOE Radiological Control Manual]	Measured at TRU Waste Generator/Storage Site and Provided in Documentation		
Thermal Power 3.4.6	• Thermal (wattage) limits for individual waste packages, including the error, are contained in the RH-TRU Cask SARP. • RH-TRU Cask design limit is 300 watts.	NRC approved techniques, currently used for CH-TRU should be useable for RH-TRU		New Technology?
Gas Generation 3.4.7	• No sealed containers >1 gallon may be in the waste	Real-time radiography or visual examination.		

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	LIMITING PARAMETER(S)	CH-TRU WASTE	LOWER SURFACE DOSE RATE RH-TRU WASTE	HIGHER SURFACE DOSE RATE RH-TRU WASTE
Gas Generation 3.4.7 (Con't.)	• Waste packages emplaced in WIPP during the experimental period shall not exceed 50% of the lower explosive limit in any layer of confinement for hydrogen and methane. • Total flammable VOCs are limited to 500 ppm in the headspace gas of waste packages. • If total flammable VOCs are >500 ppm in headspace, a flame test must be performed prior to emplacement in the WIPP. • If total flammable VOCs are >500 ppm in headspace, a Le Chatelier calculation is necessary.	Test (on nonradioactive gas samples assumed)		
	• All chemicals/materials >1% by weight must be evaluated for compatibility within the waste form and with TRUPACT-II materials of construction. • Trace chemicals (<1 weight % limit) must total < 5% by weight of the waste in any package. • Chemicals/materials present in concentrations greater than one weight percent, shall conform to the allowable chemicals in each waste material type.	Process Controls/Knowledge		

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	**LIMITING PARAMETER(S)**	**CH-TRU WASTE**	**LOWER SURFACE DOSE RATE RH-TRU WASTE**	**HIGHER SURFACE DOSE RATE RH-TRU WASTE**
Gas Generation 3.4.7 (Cont.)	• The maximum number of confinement layers shall be known. • All confinement layers, such as bags, shall be closed only by a twist-and-tape or fold-and-tape method.	Process Controls/Knowledge		
	• Total alpha activity of waste on a container basis	Calculation according to methodology listed in the WIPP QAPP		
	• Visual characterization of solid waste for 10 waste material categories listed in QAPP.	Visual Examination		
	• All WIPP RH-TRU canisters and internal closed drums shipped in RH-TRU Cask shall be vented with one or more filters that meet specifications listed in the RH-TRU Cask SARP.	Visual Examination Administrative Controls		
DATA PACKAGE REQUIREMENTS/CRITERIA				
Labeling 3.4.8	• A unique identification number shall be permanently attached to the RH-TRU Canister in a conspicuous location using characters at least 2 inches high and should reasonably be expected to last 10 years. • Each package shall have appropriate DOT labels (outside of cask).	Labelling Affixed by TRU Waste Generator/Storage Sites		

Table 1. Comparison of CH-TRU and RH-TRU Characterization Methodologies for WIPP WAC, Rev. 4 with Modified RH-TRU Requirements/Criteria

SUMMARY OF WAC LIMITING PARAMETERS FOR RH-TRU WASTE		COMPLIANCE METHODOLOGY*		
CRITERION/ REQUIREMENT AND SECTION	**LIMITING PARAMETER(S)**	**CH-TRU WASTE**	**LOWER SURFACE DOSE RATE RH-TRU WASTE**	**HIGHER SURFACE DOSE RATE RH-TRU WASTE**
Data Package Certification 3.5.1	• A data package with certification shall be transmitted prior to shipment. • Documentation for certification of a WIPP RH-TRU canister for shipment in each RH-TRU Cask shall be submitted. • A hazardous waste manifest shall be utilized for each shipment of TRU mixed waste.	Documentation Provided by TRU Waste Generator/Storage Sites		
OTHER REQUIREMENTS/CRITERIA				
Additional Requirements 3.6.1	• Each package shipped shall belong to one of the content codes defined in RH-TRUCON. • Retrievably stored waste that has been unvented shall be vented and aspirated per the RH-TRU Cask SARP. • Payload control procedures outlined in the RH-TRU Cask SARP shall be followed.	Documentation Provided by TRU Waste Generator/Storage Sites		

2.2 Application of CH-TRU Waste Characterization Technologies to RH-TRU Waste Characterization

The DOE has implemented waste characterization programs for contact-handled (CH)-TRU waste at the TRU waste generator/storage sites. Specific technologies have been developed (e.g., Real-Time Radiography [RTR], Gas Sampling and Analysis Systems, and Passive-Active Neutron [PAN] Assay Systems) for the characterization of CH-TRU waste that can contribute to the overall technology for characterization of RH-TRU waste. Some of these systems can be applied to all RH-TRU waste (i.e., Gas Sampling and Analysis) and others can only be applied to a part of the RH-TRU waste inventory, applicability is limited by the more intense radiations emitted by some RH-TRU waste containers which interfere with the mechanism of non-destructive examination (i.e., RTR and PAN systems).

In order the maximize the utilization of existing CH-TRU technologies for the characterization of RH-TRU waste, the waste inventory has been divided into two groupings based on surface dose rates, a "Low Surface Dose Rate" group and a "High Surface Dose Rate" group. These groupings were defined based on informal discussions with DOE/contractor personnel at several RH-TRU waste generator/storage sites. The surface radiation dose rates quoted below are thought to be the thresholds above which the existing CH-TRU instrumentation becomes unsuitable for characterization of RH-TRU wastes. The grouping of RH-TRU wastes is different for the two technologies for non-destructive examination of RH-TRU wastes:

- RTR
  10 rem/hr gamma; 1 rem/hr neutron at surface of waste container

- PAN Assay Systems
  1 rem/hr gamma; 0.1 rem/hr neutron at surface of waste container.

2.3 Potential New Technologies Needed for RH-TRU Waste Characterization

Table 1 lists each of the waste characterization requirements/criteria under "Limiting Parameters" and provides a general list of methodologies used by the TRU waste generator/storage sites for characterization of CH-TRU wastes under "Compliance Methodology - CH-TRU Waste." It should be noted that *This list of compliance methodologies is not meant to be a totally encompassing list of techniques used by the sites for characterization, but represents commonly used techniques for TRU wastes.* Many of the waste characterization requirements/criteria are achieved through existing process controls/knowledge, administrative controls, procurement controls, or by calculations based on existing data. Three technologies dominate the methodologies that are used to obtain quantitative/qualitative measurements:

- Real-Time Radiography (RTR)
- Gas (Headspace) Sampling and Analysis Systems
- Passive Active Neutron (PAN) Assay Systems

The remainder of this section will discuss the applicability of these systems to characterization of RH-TRU wastes of varying surface dose rates. The comparisons and determined applicability of the systems listed above are based on the division of RH-TRU wastes into two surface dose rate categories, as described in Section 2.2.

- Real-Time Radiography

Most CH-TRU waste sites currently use RTR to perform an examination of waste containers for compliance with several WAC requirements (e.g., pressurized containers, free liquids). Currently, shielded CH-TRU containers cannot be examined by this technique because the interrogation radiation cannot penetrate the waste container shielding and still provide definition of waste materials inside the waste container. This does not significantly impact shipment of CH-TRU waste, since shielded CH-TRU waste containers are currently not allowed in the TRU Package Transporter, Model II (TRUPACT-II) (DOE, 1991). This inability for radiation from an RTR system to penetrate a waste container (with shielding) also makes this system unsatisfactory for use with shielded RH-TRU waste packages.

However, there is another concern with utilization of this system for examination of RH-TRU wastes. The presence of intense gamma radiation emitting from the waste within RH-TRU waste containers nullifies the effectiveness of the RTR interrogation of the waste container, making the system unsatisfactory for RH-TRU waste characterization for waste containers with "High Surface Dose Rates," as indicated in Table 1. It is estimated that RH-TRU wastes with "Low Surface Dose Rates" (<10 rem/hr gamma; <1 rem/hr neutron) can be adequately characterized by existing RTR systems with some minor modification of equipment.

Therefore, there exists in the DOE RH-TRU system a need to modify existing technology or to develop new technology to replace the RTR system for examination of waste containers with internal lead shielding and/or the occurrence of "high surface dose rate" radiation. A discussion of systems under development may be found in Section 4.0.

- Gas Sampling and Analysis Systems

Several of the criteria/requirements listed in Table 1 require sampling and analysis of headspace gases from within waste containers for inorganic and/or organic gases. A system has been developed by Idaho National Engineering Laboratory (INEL) and emplaced at Argonne National Laboratory-West (ANL-W) for sampling and analysis of headspace gases from CH-TRU waste containers under the Quality Assurance/Quality Control (QA/QC) requirements of the WIPP QAPP (DOE, 1995a).

The sampling design of this system allows the remote collection of a gas sample from the waste container headspace that is nonradioactive and can be analyzed in any qualified laboratory. This system should be easily adapted to sampling RH-TRU waste which has been properly shielded to protect worker safety. *No new technology needs to be developed to apply this technique to characterization of RH-TRU wastes.*

- Passive Active Neutron (PAN) Assay Systems

Most CH-TRU waste sites currently used PAN Assay Systems to perform a remote examination of waste containers for compliance with some WAC requirements (e.g., criticality, wattage determination). These systems are commonly used to determine radionuclide inventories (radionuclides present and quantity of each) for waste containers which contain radionuclide mixtures known from process records. Gamma spectroscopy instrumentation is needed in addition to the PAN system for those waste containers where the radionuclide mixture is not known prior to examination of the waste container.

It is estimated that for RH-TRU wastes with "Low Surface Dose Rates" (<1 rem/hr gamma; <0.1 rem/hr neutron), existing PAN systems can be used with some equipment modifications. However, the increased gamma and neutron fields of "High Surface Dose Rates" RH-TRU waste cause unsatisfactory results for these wastes if assayed with existing CH-TRU PAN systems, even with the modifications for the "Low Surface Dose Rate" RH-TRU wastes.

Therefore, there exists in the RH-TRU system a need to modify existing technology or develop new technology to replace the PAN systems for assay of waste containers that have "high surface dose rate" radiation. A discussion of systems under development may be found in Section 4.0..

3.0 TECHNOLOGY DEVELOPMENT FOR WASTE CHARACTERIZATION REQUIREMENTS

The report on Inventory and Generation provides the best estimate of DOE's RH-TRU stored and projected waste inventories. These estimates are based on data provided by the sites during 1994 (DOE, 1995b). However, the sites have not provided surface dose rate estimates with these inventories. Previous Integrated Data Base (IDB) submittals have included background data on estimated does rates, which were not published in the final report (DOE, 1992). The TRU waste site IDB submittals summarizing the waste inventories at the end of calendar year (CY) 1991 (DOE, 1992) were the last instance in which these data were collected by DOE. Table 2 presents a summary of the information provided by the TRU waste sites for waste in storage at the end of CY 1991 and projected waste generation until 2018.

Data have been provided from five RH-TRU facilities and divided in separate groups of newly-generated or projected RH-TRU waste and retrievably-stored RH-TRU waste. For stored RH-TRU waste, the existing containers as of the end of CY 1991 have been divided into percentages for the different surface dose intervals. The total number of containers currently in storage is provided in the last column. For the projected RH-TRU waste, only percentages of waste containers in each surface dose interval have been provided. The estimates of the amount of containers projected in the CY 1991 IDB submittals is significantly different in many cases than those projected in the WIPP TRU-Waste Baseline Inventory Report (WTWBIR), Rev. 1. The reviewers are referred to the report on Inventory and Generation for a summary of the WTWBIR Rev. 1 data.

Examination of Table 2 demonstrates that, based on the CY 1991 data, almost all RH-TRU waste scheduled for eventual shipment to WIPP for disposal exceeds the 1 rem/hr limit for modified assay equipment, mentioned in Section 2.2. Since dose rates are not available for each individual container and data for containers at a site are only available for each discrete range (e.g., 5 containers in the 10 to 50 rem/hr range), it is not possible to make precise calculations from Table 2 as to what percent of the stored volume would occur within a given dose rate (e.g., 20 rem/hr).

However, this can be estimated from Table 2 by making the assumption that the volume of waste is linearly distributed within each dose rate range. This assumption implies that, for a given site, the total volume of RH-TRU waste having a dose rate of less than 20 rem/hr will be the sum of the waste volumes in the ranges 0.2 to 1 rem/hr, 1 to 10 rem/hr, and 25 percent of the waste volume from 10 to 50 rem/hr. Thus, if a site has 4 cubic meter (m^3) of stored waste in the 10 to 50 rem/hr range, it would have 1 m^3 of waste (i.e., 25 percent of 4 m^3) for every 10 rem/hr increment within this range. Based on this assumption and the total waste volume provided by the sites, it is estimated that approximately 30 percent of the total stored RH-TRU waste by volume may have dose rates less than 10 rem/hr (i.e., 70 percent may have dose rates greater than 10 rem/hr) and up to 35 percent may have dose rates less than 20 rem/hr.

Since Table 2 shows that a large percentage of the RH-TRU waste scheduled for emplacement in WIPP has dose rates greater than 10 rem/hr, this indicates the need for improved assay technology.

4.0 RH-TRU WASTE CHARACTERIZATION CAPABILITIES

Tables 3 and 4 summarize the existing and planned waste characterization equipment and facilities at six DOE TRU sites which either have RH-TRU waste in storage and/or project future generation. There are additional RH-TRU waste sites identified in Revision 1 of the WTWBIR (DOE, 1995b), but these sites were not included at the time of this survey. The discussions that follow are summarized by equipment/facility needs.

4.1 Real-Time Radiography Equipment

All RH-TRU sites listed in Table 3 have an RTR unit available for characterization of CH-TRU waste, except ANL-E which plans to do 100% visual examination. These RTR units could possibly be modified to characterize "Low Surface Dose Rate" RH-TRU. Based on the percentages of waste provided in Table 2 (< 10 rem/hr), these modifications would provide benefit to the DOE TRU waste system for characterization of RH-TRU waste. In addition, the development of a "new" technology or modification of an existing technology is needed to provide a technique for characterizing RH-TRU waste with "High Surface Dose Rates" for those characteristics presently done by RTR for CH-TRU wastes. Otherwise, a large number of RH-TRU waste containers will have to be opened in a hot cell and visually characterized. None of the sites listed in Table 4 have plans for developing an RH-TRU system for examining "High Surface Dose Rate" RH-TRU waste similar to RTR for CH-TRU. Hanford has identified a need to develop a system in conjunction with an RH-TRU repackaging facility, but development of the system has not started.

Table 2. Estimation of Surface Dose Rates for RH-TRU Waste Containers[1]

Site	Projected[2] or Stored[3]	Container	Dose Rates (rem/hr)					
			0.2-1.0	1 - 10	10 - 50	50 - 100	>100	Quantity[6]
INEL[4]	Stored	Drums	2%	56%	40%	1%	0%	335
INEL[5]	Projected	Drums	0%	0%	100%	0%	0%	N/A
ANL-W	Stored	Inserts	0%	0%	31%	69%	0%	16
ANL-W	Projected	Others	0%	0%	0%	0%	100%	N/A
LANL	Stored	Canisters	0%	18%	27%	55%	0%	22
LANL	Projected	Canisters	0%	0%	38%	19%	43%	N/A
ORNL	Stored	Canisters	3%	18%	6%	73%	<1%	2138
ORNL	Projected	Canisters	0%	31%	12%	32%	25%	243
Hanford	Stored	Canisters	40%	34%	1%	25%	0%	368
Hanford	Projected	Canisters	N/A	N/A	N/A	N/A	N/A	N/A

[1] Source: 1991 Integrated Data Base Data Submittal and Engineering Judgement
[2] Projected - Projected or future waste inventories
[3] Stored - Retrievably stored or existing waste inventory
[4] Includes ANL-E, ANL-W, TRA (Test Reactor Area), and NRF (Nuclear Reactors Facilities)
[5] Includes ANL-W, Bettis, and NRF.
[6] These values were derived from the original Integrated Data Base Data Submittal for the purpose of estimating RH-TRU dose rates and their potential impact on related activities such as characterization. These values represent the equivalent number of containers based on the assumed containerization method shown under the "Container" column. Volumes and container numbers are not consistent with the current WTWBIR, Rev. 1. These data are provided as reference only.
N/A - Not Available

4.2 Passive Active Neutron and other Assay Equipment

As shown in Table 3, most RH-TRU facilities have a CH-TRU PAN system for radionuclide inventory determinations on CH-TRU wastes. ANL-E and ANL-W both have Segmented Gamma Scanners for RH-TRU, but these may be insufficient for determining radionuclide inventories for meeting WIPP WAC Revision 4 requirements/criteria. For "Low Surface Dose Rates" (<1 rem/hr gamma; <0.1 rem/hr neutron), the existing CH-TRU systems could be modified to characterize the radionuclide inventories. However, examination of Table 2, indicates that very small quantities of RH-TRU waste will occur below these thresholds.

Therefore, there is a need to develop "new" or modify an existing technology to achieve a system which can meet the WIPP WAC Revision 4 requirements for radionuclide characterization. Two promising systems are under development: a linear accelerator (LINAC) PAN type system at Oak Ridge National Laboratory (ORNL) and a Combined Thermal/Epithermal Neutron (CTEN) Interrogation radioassay system at Los Alamos National Laboratory (LANL). Both of these systems show promise for radioassay of RH-TRU waste containers with "High Surface Dose Rates," and should be pursued in the future to support RH-TRU waste characterization activities.

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ANL-E	Visual characterization is planned	Segmented gamma scanner consisting of a 4,096 channel plus-height analyzer, germanium detector, and computerized data collection is available in the Alpha-Gamma Hot Cell Facility (AGHCF).[1]	Fission gas analysis and collection system and micro-sampling equipment are available in the AGHCF.	AGHCF - The 11'x32' AGHCF consists of a multicurie hot cell, a small machine shop, a decontamination/repair area, surrounding open areas, and the Electron Beam Laboratory (EBL) which contains a shielded electron microprobe, a glovebox for specimen preparation, a scanning electron microscope, and a scanning Auger microprobe. The cell is capable of handling fuel elements up to 6-ft nominal length, although longer lengths can be accommodated. The AGHCF has been previously used to examine and repackage 30-gallon drums of RH-TRU waste. Building 200 Hot Cell Facility - The complex houses 12 isolated hot cells. Shielding capabilities of the cells for gamma radiation are a minimum of 30 Ci for five cells, 1000 Ci for three cells, 50,000 Ci for one cell, and 1 million Ci of 1 MeV of gamma radiation for the remaining three cells. A system of radio-controlled carts can be remotely operated from outside the shielded areas for access to any of the 12 cells. Small cranes are capable of moving up to 2 tons within the cells. The largest cells, two on each floor, can accommodate specimens up to 11-ft-long.

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ANL-W	Irradiated specimens can be examined in the HFEF/North[1] main cell using neutron radiography techniques. A second neutron radiography station, outside of the argon gas main cell, also enables radiography to be conducted without introducing the unirradiated or irradiated specimens into the HFEF/N main hot cell.	Segmented gamma scanner available in the HFEF/N[1]	FTIR system installed in the Waste Characterization Area of the HFEF/N[1]	Hot Fuel Examination Facility/North - This facility comprises two adjacent, shielded hot cells designed for long-term, permanent, remote operations without requiring personnel entry. Much of the in-cell examination equipment for fuel elements is automated or semi-automated. In-cell examinations include detailed viewing and photography, weighing, precision dimensional surveys, precision gamma-ray scanning, electrical eddy-current cladding testing, and fuel element fission-gas puncturing and sampling.
INEL	Real-time radiography for CH-TRU waste drums and boxes[1]	PAN assay for 55-gal CH-TRU TRU waste drums[1]	Prototype headspace gas sampling system, not in use[1]	Test Area North Hot Cells and Test Reactor Area Hot Cells may both have potential application for visual characterization and direct sampling of RH-TRU wastes.
HANF	RTR for CH-TRU waste drums and boxes[1]	PAN assay for 55-gal CH-TRU waste drums[1]	None	Unknown

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
LANL	RTR for CH-TRU waste	PAN assay for 55-gal CH-TRU waste drums;[1] PAN assay for 1-gal RH-TRU waste cans[2]	None	<u>LANL Chemical and Metallurgy Hot Cell Facility</u> - This facility is a complex of 16 cells (6'W x 12'H x 12' or 14'L). Each bank of eight hot cells has a central corridor and hydraulic-actuated doors for isolation of each cell. The central corridor has enough space to easily accommodate 55-gal drums, shielded waste casks, or larger overpacks. The hot cells are designed for 100,000 Ci loading with ^{60}Co. Ample room and flexibility is available to provide space for shielded gloveboxes in the hot cell corridor or as stand-alone systems. There are hot cell penetrations that are straight-through, bent-angle, and cell-to-cell.

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ORNL	RTR for CH-TRU waste drums and boxes[1]	PAN assay for CH-TRU 55-drums;[1] segmented gamma scanner[1]	None	Building 3517 Fission Products Development Laboratory - Building 3517 is a two-story structure with a metal-sided high bay area over the cell bank. The cell roof has removable plugs for access to each cell. The cell bank consists of two rows that consist of 17 cells with overall dimensions of 28.5-ft wide by 89-ft-long by 18-ft-high. The interiors of the hot cells are highly contaminated from past operations. The soil surrounding this structure is also highly contaminated with fission products and requires remediation. Building 3525 High Radiation-Level Examination Laboratory - Building 3525 is a basic two-story brick building that includes a shielded-cell complex which has a working area of 950 ft^2 shielded for high-gamma activity. The building structure outside the hot cells is completely protected by an automatic wet-pipe sprinkler system, while the hot cells are equipped with heat detectors. Items up to 4 x 4 x 6 ft in size and weighing up to 10 tons may be transferred through a shielded airlock door system. Structural provisions have been made for installation of heavy-duty manipulation equipment if needed.

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ORNL (contd.)				Building 7860 (Hydrofracture Facility) - Building 7860 is a L-shaped single-story structure with overall dimensions of 56'x 79.5'. Building 7860 was formerly used to inject liquid waste and grout into underground shale formations, a disposal technique that is no longer allowable. Therefore, the building is no longer in use. The liquid waste had a radionuclide concentration of one curie per gallon consisting of primarily ^{137}Cs and ^{90}Sr, which are the primary cell contaminants. The Tennessee Department of Health and Environment will not permit any further use of this disposal technique; therefore Building 7860 is no longer in use. The liquid waste had a radionuclide concentration of one curie per gallon consisting of primarily ^{137}Cs and ^{90}Sr. Hence, the equipment within the hot cells, and probably the cells themselves, are contaminated with these and other radionuclides.

Table 3. Summary of DOE Site Characterization Capabilities for RH-TRU Waste (Existing Capabilities)

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ORNL (contd.)				Building 7930 (Thorium-Uranium Recycle Facility) - The second floor of this three-story building provides space for sampling of radioactive materials, a development laboratory, a shop for handling slightly contaminated material, a maintenance area, and mechanical and electrical service equipment rooms. The shielded cells have a gross floor area of 5,740 ft^2. The bulk of the shielding is normal concrete, 5-1/2-thick up to the second floor level around the cells and 4-1/2-ft-thick above the second floor. Currently, two of the cells are used for the ORNL ^{252}Cf production program. The antiquated building fire alarm system is in critical need of upgrading or replacement because of the unavailability of replacement parts.

[1] Requires modification for use on RH-TRU waste and containers.
[2] Limited for use on certain LANL-generated RH-TRU waste streams.

Table 4. Summary of DOE Site Characterization Capabilities for RH-TRU Waste - Projected Future Capabilities

Site	Radiography	Radioassay	Gas Sampling/Chemical Analysis	Visual Examination
ANL-E	None planned	None planned	None planned	None planned
ANL-W	None planned	PAN assay for RH wastes	Working in conjunction with the INEL in the development of a portable gas sampling and analysis system	None planned
INEL	None planned	Selected site for testing the CTEN Assay system being developed by LANL[1]	Portable chemical analysis system for TRU waste drum headspace gas sampling system; installation of a FTIR at-line sampler in the INEL Drum Venting Facility[1]	None planned
HANF	"Enhanced" RTR for RH-TRU	"Enhanced" Assay system for RH-TRU	None planned	Undetermined facility planned.
LANL	None planned	CTEN Assay for 55- and 83-gal drums	None planned	None planned
ORNL	None planned	Linear accelerator-based PAN assay	None planned	None planned

[1] Would require further modification for use on RH-TRU waste.

4.3 Gas Sampling and Analysis Equipment

As discussed in Section 2.3, Gas Sampling and Analysis Units produce gas samples that are nonradioactive and can be analyzed outside a glovebox/hot cell environment. Therefore, the issues of sampling for headspace gases and analysis by a qualified laboratory can be separate activities. Presently, ANL-W, ANL-E, INEL, and the Rocky Flats Environmental Technology Site (RFETS) have qualified under the Performance Demonstration Program for gas analysis. Sites that sample for gases can send a gas sample offsite, if needed, for analysis. This allows greater flexibility in the DOE system for analysis of headspace gases from RH-TRU waste containers.

A Fourier Transform Infrared (FTIR) system (for organic gases) has been installed in the Waste Characterization Area of the Hot Fuel Examination Facility (HFEF) at ANL-W. This unit allows analysis at the site of sampling, without the collection of gases in sample containers. A portable version of the FTIR with a Residual Gas System for inorganic gases (FTIR/RGS) is being worked on by ANL-W/INEL. This system, when it is operational, can be used throughout the entire RH-TRU system for sampling and analysis of headspace gases. The individual sites would only have to supply the area for placement of the RH-TRU container and insertion of the sampling apparatus into the container. Generally, this would be done in a hot cell similar to that described in the next section on "Visual Examination." The one drawback to use of FTIR at this time is that FTIR is not yet an EPA- approved sampling method.

4.4 Visual Examination Facilities

Most existing RH-TRU waste was originally generated in a hot cell at the various DOE sites. Therefore, most sites should have facilities available, after modification, where visual examination of waste could occur as well as providing an area for sampling of gases prior to opening the waste container. Table 3 provides a brief description of facilities at several sites that are candidates for utilization of visual examination (and headspace sampling). Although Hanford is listed as "unknown," further examination should reveal facilities that could be modified for such activities.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This study has provided a preliminary assessment of technology available for RH-TRU characterization and the present and near-future capabilities to characterize RH-TRU waste currently stored at several DOE sites. This assessment is necessary to identify capability needs and to develop appropriate plans for their development and implementation.

Based on the preliminary assessment, there appears to be limited characterization capabilities specifically designed for "High Surface Dose Rate" RH-TRU waste at the sites identified. In fact, it is unlikely that the current infrastructure for RH-TRU waste characterization would support certification to the WIPP-WAC.

Considerable progress needs to be made to improve current capabilities for RH-TRU waste characterization, particularly for non-destructive assay (NDA) and non-destructive examination (NDE), where there is currently little or no capability. For example a system previously used for the neutron assay of RH-TRU waste was a small PAN device located at the LANL. While capable of assaying certain waste streams generated at LANL, the system is currently inoperable and would require system upgrades. Application of this technique to other off-site RH-TRU waste streams would require extensive system modifications. Although there are new neutron system technologies under development at LANL (CTEN) and the ORNL (LINAC), these systems are unproven and are probably years from potential use in an operating environment.

Current capabilities for RTR of RH-TRU waste are essentially nonexistent. RTR systems located at the sites identified in Table 3 are currently capable of examining CH-TRU wastes only. Application to RH-TRU wastes would require the installation of shielding to allow examination of "Low Surface Dose Rate" RH-TRU waste. "New" technology or modification of some existing technology needs to be developed to allow an "RTR-equivalent" examination of RH-TRU wastes with "High Surface Dose Rates." Therefore, the primary characterization method for RH-TRU waste across the complex is visual examination within a hot cell. At Hanford, additional data gathering is needed to identify potential facilities for visual examination. In general, the operation and maintenance of hot cell facilities is costly, particularly if used for the destructive examination of radioactive waste. Other problems may also arise from cross-contamination between the wastes and the hot cells themselves, further complicating the characterization process.

Analytical capabilities for gas analysis exists at ANL-W, ANL-E, RFETS and INEL. These are presently fixed systems that are used for CH-TRU wastes. Only the ANL-W system, which is located in the Waste Characterization Area of the HFEF, is also capable of accepting RH-TRU wastes. A portable system currently under development at the INEL (FTIR/RGS) could have potential application to RH-TRU wastes across the DOE system. The system will be cart-mounted and will be capable of real-time analysis of waste container headspace gas. The system is still under development, however, and is presently unproven in the field.

The use of any of the facilities discussed above for characterization of off-site RH-TRU wastes would obviously necessitate transportation of the waste. Transportation of RH-TRU wastes would require the use of an NRC-approved Type B shielded cask. These casks, are built to maintain integrity under a variety of severe accident conditions and are therefore costly to construct. To utilize a Type B shipping container, some "up-front" characterization is in order to ensure the waste shipment complies with the allowable Certification of Compliance requirements of the container Safety Analysis Report for Packaging (SARP). This "up-front" characterization for packaging and transportation would therefore require some level of on-site capability to demonstrate compliance. The degree of characterization capability would be dependent on the amount of compliance requirements for the shipping container.

RH-TRU waste characterization capabilities at the five DOE sites are not sufficient to support final certification to the current WIPP-WAC. DOE will need to develop additional capabilities to support the necessary characterization activities to enable shipment to WIPP. Key developments in characterization capabilities, particularly for both NDA and NDE, will need to be realized in the near future. Without these capabilities, certification of these wastes for shipment and subsequent disposal at WIPP will be severely hampered.

Several activities must therefore be performed to assure that RH-TRU waste can be initially shipped and that RH-TRU waste shipments can be sustained over a lengthy period. These activities include:

- The Waste Acceptance Criteria for RH-TRU wastes must be clearly defined.
- A Quality Assurance Program Plan with clearly defined data requirements and subsequent site-specific Quality Assurance Project Plans must be developed
- The current technological capabilities of existing characterization equipment must be identified for RH-TRU waste.
- The reasonable technological improvements or modifications in existing characterization equipment must be identified in regard to extending the operating range of the equipment.
- The technological capabilities necessary to allow characterization of currently uncharacterizable RH-TRU waste must be identified and developed.
- The role of "acceptable knowledge" needs to be clearly defined.

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REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX D

RH-TRU Waste Treatment Alternatives System Analysis

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Carlsbad Area Office
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RH-TRU WASTE
TREATMENT ALTERNATIVES
SYSTEM ANALYSIS

prepared by

Sandia National Laboratories

October 1995

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List of Acronyms

ADS	Activity Data Sheets
ANL-W	Argonne National Laboratory-West
BCLDP	Battelle Columbus Laboratory Decommissioning Project
BIR	Baseline Inventory Report
CH	contact handled
DOE	Department of Energy
FFCA	Federal Facilities Compliance Act
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Laboratory
IWPF	Idaho Waste Processing Facility
KAPL	Knolls Atomic Power Laboratory
LANL	Los Alamos National Laboratory
LDR	land disposal restriction
LLW	low level waste
ORNL	Oak Ridge National Laboratory
PEIS	programmatic environmental impact statement
PSTP	Proposed Site Treatment Plan
RH	remote handled
SRS	Savannah River Site
STP	Site Treatment Plan
TPF	TRU Processing Facility
TRU	transuranic
TSFC	total system future cost
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant

Executive Summary

The U.S Department of Energy (DOE) is currently planning for the disposal of transuranic (TRU) waste at the Waste Isolation Pilot Plant (WIPP). Although contact handled (CH) TRU waste disposal is scheduled to begin in 1998, remote handled (RH) TRU waste disposal will not begin until about 2002. Treatment of most of the RH-TRU waste will be required to achieve compliance with the WIPP waste acceptance criteria (WAC). Treatment will include a variety of processes depending on the waste form. The current inventory of RH-TRU waste is relatively small, about 1000 m^3, but large volumes (more than 8,000 m^3) are projected for the next 25 years as the DOE sites are decontaminated and dismantled.

Most of the RH-TRU waste presently in storage will require repackaging, and a large part of the currently stored waste is liquid or sludge that will require solidification. Approximately one half of the newly generated waste will be made WIPP WAC compliant at the generator facilities; the other half will require some form of treatment in a separate facility. DOE's plans for the treatment of RH-TRU waste are being developed in cooperation with the generator sites and their regulators, and many of these treatment plans include facilities to prepare the RH-TRU waste for shipment directly to WIPP. The possibility of alternative type of treatment is being considered, and some of the impacts of this alternative treatment are evaluated in this report.

Three treatment alternatives were considered. One with the elements necessary to meet the WIPP WAC and two others that were postulated in the draft programmatic environmental impact statement (PEIS) that is being developed by DOE. One of the PEIS treatment options for RH-TRU waste is to establish a waste form that is less likely to generate gas during decomposition in the repository. The other, more thorough treatment option considered in the PEIS eliminates the hazardous components of the waste making it compliant with the land disposal restrictions (LDRs) specified in 40CFR268. The option to treat the RH-TRU waste at each site or at regional facility locations is also an important variable considered in the analysis. The desirability of each of these treatment options was evaluated in combination with the preferred options for transportation and packaging and disposal in WIPP as determined in separate RH-TRU waste management studies.

The packaging options included a shielded drum that allows a fraction of the RH-TRU waste to be shipped and disposed as CH waste. Another packaging option included was the new design packaging which, because of its smaller volume, allows greater flexibility and greater volumes to be emplaced at WIPP. The transportation options considered were all truck and truck plus rail shipment from the regional treatment plants. The disposal options considered included the design basis plan for RH-72B canisters emplaced in the walls of some disposal rooms, use of the new design packaging emplaced in the walls of the disposal rooms and the main drifts, and combinations of each with shielded drums emplaced as CH waste.

The evaluation of the options was conducted as a series of system analyses. The current RH-TRU waste management plan (the Design Basis) and five alternative plans were analyzed for total system costs, annual cost, waste volume disposed and disposal rates. The results are summarized in Table ES-1 and Figures ES-1 and ES-2. Each alternative to the Design Basis offers a greater volume of RH-TRU waste disposed. The alternatives that included shielded drums (Alternatives 1, 4, and 5) appear to be more desirable because of the larger amount of RH-TRU waste removed from the generator sites and the lower cost per unit waste disposed over the operating life of WIPP. The alternative that assumed treatment to LDR (Alternative 3) was most expensive on a per unit of RH-TRU waste basis, but when used in combination with shipment of part of the waste in shielded drums (Alternative 5), the cost per unit RH-TRU waste was low and comparable to the lowest cost alternative.

Table ES-1. Summary of Treatment Alternatives System Analysis

	Design Basis	Altern. 1	Altern. 2	Altern. 3	Altern. 4	Altern. 5
Facilities Configuration	Decentral	Decentral	Regional	Regional	Decentral	Decentral / Regional
Treatment Option	WIPP WAC	WIPP WAC	Reduced Gas	LDR	WIPP WAC	WIPP WAC / LDR
Transport Option	Truck	Truck	Truck + Rail	Truck + Rail	Truck	Truck + Rail
Packaging / Disposal	RH-72B	RH-72B + Sh. Drum	New Packaging	New Packaging	Sh. Drum + New Packaging	Sh. Drum + New Packaging
Waste Removed	4280 m^3	14225 m^3	7080 m^3	7080 m^3	16840 m^3	16474 m^3
Waste Disposed	4280 m^3	4280 m^3	7080 m^3	7080 m^3	7080 m^3	7080 m^3
System Cost $\$10^9$	3540	5310	3820	4350	5410	6330
Unit Cost. $\$10^6/m^3$	0.8	0.4	0.5	0.6	0.3	0.4

The analysis suggests that a better alternative might be created by improving the design and payload of the shielded drum package. If each shielded drum could contain more than the 0.03 m^3 as assumed for the current analysis, a lower cost and more efficient RH-TRU waste management option might be created. The benefits of this hybrid alternative could be determined by further analysis.

Figure ES-1. Total Waste Disposed

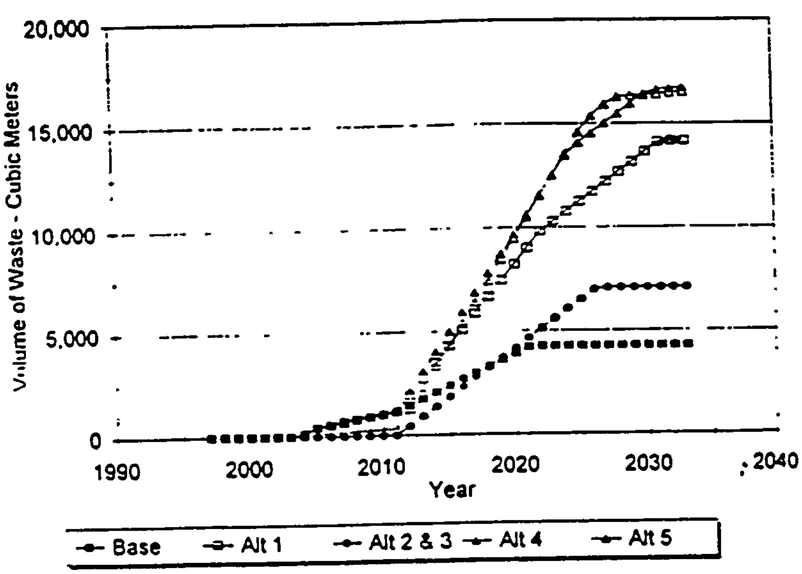
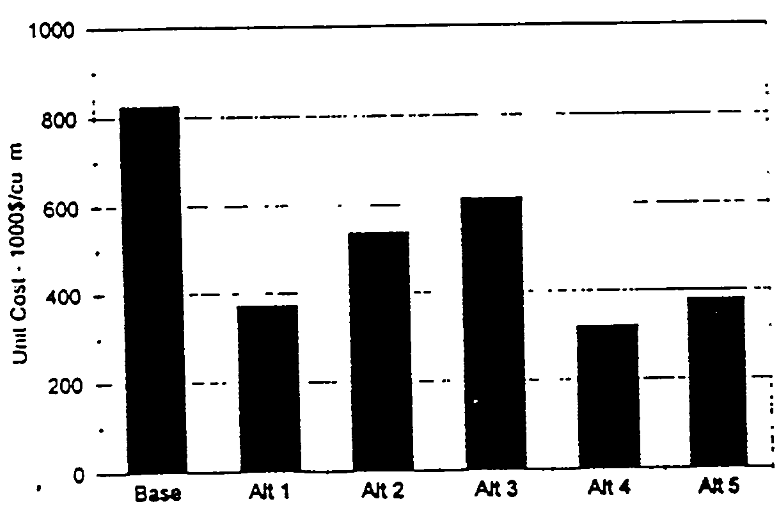


Figure ES-2. Unit Cost of Disposal



RH-TRU Waste Treatment Alternatives System Analysis

1.0 INTRODUCTION AND BACKGROUND

This report examines the U.S. Department of Energy's (DOE's) current plans for the treatment of remote handled (RH) transuranic (TRU) waste, and evaluates the effects that these plans will have on the RH-TRU waste management system. Some alternatives to the treatment plans that offer potential improvements to the overall waste management system are also presented and evaluated. The evaluation includes consideration of the currently planned Design Basis and leading alternatives for the transportation, packaging , and disposal of RH-TRU waste in the Waste Isolation Pilot Plant (WIPP).

Various aspects of DOE's plans for RH-TRU waste management are noted in several different documents (ref. 1-3), some of which are drafts and subject to change. This study will use the RH-TRU waste disposal technical design basis (Design Basis) which is a compilation of best estimate system information based on current plans. The alternatives to the Design Basis that are considered here reflect options for treatment, transportation, and packaging, and disposal configurations that are derived from the same documents and other draft studies undertaken for RH-TRU system planning (ref. 4-5).

It is DOE policy that treatment of TRU waste will be only that necessary to meet the WIPP Waste Acceptance Criteria (WAC) (ref. 6), and to seek a no migration variance from the EPA to allow disposal in WIPP of mixed TRU waste. Thus current plans for RH-TRU waste treatment will not necessarily include techniques that ensure the final waste forms meet land disposal restrictions (LDRs) as specified in 40CFR268. However where cost savings or risk reductions can be realized through LDR treatment, such changes to the Design Basis plans will be considered.

A large fraction of the RH-TRU waste in storage at the DOE sites is considered to be mixed waste and, therefore, subject to the Federal Facilities Compliance Act (FFCA). The Site Treatment Plans (STPs) (ref. 2) that are being prepared to meet the requirements of the FFCA are scheduled to be completed in October 1995. Thus a large part of DOE's plans for RH-TRU waste treatment is somewhat uncertain and subject to change until the Site Treatment Plans are reviewed and approved.

The inventory of RH-TRU waste in storage and projected for the next 25 years has been documented in the WIPP TRU Waste Baseline Inventory Report (BIR) (ref. 7). The BIR identifies 1170 m^3 of RH-TRU waste that will be available for shipment to WIPP as a result of preparing the currently stored RH-TRU waste. The volume of projected RH-TRU waste to be generated in the future is uncertain and estimates are currently being developed. The BIR Rev. 1 estimated that an additional 3,650 m^3 will be generated by the year 2022; however preliminary estimates for the BIR Rev. 2 indicate that the projected volumes will be much greater. Since the WIPP limit for RH-TRU waste has been established at 7,080 m^3 (ref. 11), the analysis will use this limit as the assumed volume of RH-TRU waste that can be disposed in WIPP. The waste in excess of the BIR Rev. 1 volumes is assumed to be projected waste from Hanford.

The projected generation rates for RH-TRU waste for the period 2002 to 2022 are estimated from BIR Rev. 1. For the period beyond 2022, the annual generation rates are assumed to be the same as the BIR Rev.1 values specified for the year 2022. The Hanford rate, however, has been adjusted upward to reflect the additional projected waste expected to be included in future BIR estimates This assumed generation history establishes a total inventory estimate in excess of 16,000 m^3 by the year 2033. Since the currently planned end date for RH-TRU waste operations at WIPP is 2026, and 2033 for contact handled (CH) operations, the assumed generation history ensures that the system analysis will not be limited by availability of waste.

Some of this waste can be shipped to WIPP with little additional processing, some will require repackaging, and some will require various types of treatment to meet the WIPP WAC. The RH-TRU waste inventory and generation appendix (ref. 8) describes the breakdown of the RH-TRU inventory into each of these categories. Table 1 presents these estimated waste volumes that are used in the analysis of the RH-TRU waste management system Design Basis and postulated alternatives.

Table 1. Estimated RH-TRU Waste That Will Require Repackaging or Treatment[1]

Site	*Stored m^3*			*Projected m^3*	
	Shippable	Needs Repack	Needs Treatment	Shippable	Needs Packing or Treatment
Hanford		33.2		8500[2]	4000[2]
ORNL		382.8	611.0	182.7	174
LANL	16.0	75.3		41.3	41.3
INEL		31.0		8.4	8.4
ANL-W		1.5	7.2	13.8	13.8
BCLDP					71.0
SRS					63.9
KAPL		11.2		12.6	12.6
Bettis					1.6
Total	16.0	535.0	618.2	>4000	>4000

Notes: [1] All volumes except Hanford are taken from the BIR Rev. 1.
[2] The Hanford volumes are estimated based on preliminary BIR Rev. 2 data.

Very little of the stored RH-TRU waste can be shipped directly to WIPP in its present form. The 16 m^3 of shippable waste noted in Table 1 at Los Alamos National Laboratory (LANL) represent canisters of RH-TRU waste that have been previously prepared and are essentially ready for final certification and shipment to WIPP. These canisters were packaged to meet an early version of the WAC, and may require some additional sampling and/or analysis to demonstrate compliance to the current WAC. No repackaging or treatment is planned for this waste.

The 535 m^3 of stored waste noted in Table 1 as "needs repack" represents RH-TRU waste that is in storage but does not meet the packaging or WIPP acceptance criteria as presently configured. This waste must be transferred to an appropriate facility for repackaging in compliant containers and certification to the WAC.

The remainder of the RH-TRU waste in storage (618 m^3) is in a form that will require repackaging and some form of special processing to meet WIPP WAC. Plans for this waste include retrieval from storage, transfer to a hot cell for characterization, treatment, packaging, certification, and shipment. The treatment may include simple physical processing such as sorting and size reduction that most of the solid non-mixed waste will require, or it may be more complex such as evaporation and solidification that the liquid and sludge waste will require.

The volume of RH-TRU waste that is projected to be generated is not certain. The BIR has identified all the waste streams that are expected to generate RH-TRU waste through the year 2022, but the volume estimates are subject to site plans and schedules for cleanup projects. The Hanford site has projected that its future cleanup activities will generate large volumes of RH-TRU waste, but the project schedules have changed recently. Although the BIR Rev. 1 does not project most of this volume, recent estimates that will be included in BIR Rev. 2 put the volume of Hanford's future RH-TRU waste at approximately 27,000 m^3 through the year 2022. Because the analysis included here encompasses the period out to 2033, an additional 2000 m^3 has been included in the estimated RH-TRU waste inventory.

The RH-TRU waste generation and inventory appendix (ref. 8), has estimated that the projected waste will be either shippable directly from the generator facilities or will require some processing in different facilities. The estimated split is about 50% in each of the two categories. The Table 1 volumes reflect these estimates and are used in the system analysis.

DOE's plans for the preparation of RH-TRU waste for disposal in WIPP are reflected in the RH-TRU Design Basis. Although the Design Basis is generally consistent with the Proposed Site Treatment Plans (PSTPs) that are being prepared in response to the FFCA, the PSTPs are not final. Some changes may occur as the iterative review process continues and additional analysis shows ways to improve the plans. The RH-TRU Design Basis is consistent with the PSTPs and describes the treatment plans for each RH-TRU waste site in terms of both facilities configuration and operations schedules. Additional details beyond that provided in the PSTPs about the cost, capabilities and capacities of the treatment facilities have been developed from best available information, site contacts and engineering judgment, and are used here in the analysis of the Design Basis and evaluation of the Alternatives.

> ***Note:***
> *Since the PSTPs were drafted, the Idaho National Engineering Laboratory (INEL) has developed plans to build a treatment plant that will process all the alpha low level waste (LLW) and much of the TRU waste at INEL to LDR standards. However it will probably not handle RH-TRU waste, therefore, the Baseline should include use of the Argonne National Laboratory-West (ANL-W) hot cell facility for initial preparation of RH-TRU at a low throughput rate, and the use of the INEL's high-level waste treatment plant for any additional RH-TRU waste treatment needed in later years. The proposed plant, referred to as the Idaho Waste Processing Facility (IWPF), would also be capable of accepting TRU waste from other sites for treatment and the processed waste would be returned to the supplier or sent directly to WIPP. If the IWPF is designed to be capable of RH-TRU waste treatment, some of the alternatives will change and the evaluations will need to be repeated. For the RH-TRU Design Basis configuration, the IWPF was not included since it is assumed to be intended for CH waste only.*

The DOE is presently preparing a Programmatic Environmental Impact Statement (PEIS) that will address the management of all DOE waste. The PEIS includes an evaluation of different TRU waste treatment scenarios that will be documented in an official report due out in 1995. The RH-TRU waste treatment alternatives considered in the current draft of the PEIS include two facility configurations and three treatment options. The configurations are designated Decentralized and Regionalized (the PEIS also considered a third configuration, centralized, but it applies only to CH waste, so it is not considered here). The Decentralized configuration included five sites (the current Baseline includes nine RH-TRU waste sites). The Regionalized configuration includes only two sites, Hanford and Oak Ridge National Laboratory (ORNL). The Decentralized configuration is very similar to the current Design Basis scenario, and therefore is not considered separately in this evaluation.

The three treatment options included in the PEIS are 1) treat to WIPP WAC, 2) treat to reduce gas generation, and 3) treat to LDRs. Both the regionalized configuration for reduced gas generation treatment and LDR treatment are evaluated for comparison to the Design Basis. Details about the Design Basis and the alternatives are described in the following sections.

2.0 DESIGN BASIS

The Disposal Technical Design Basis defines the DOE's current approach to RH-TRU waste disposal in terms of the three primary systems identified in the "*WIPP Remote-Handled Transuranic Waste Disposal Strategy*" (ref. 9). These three systems are 1) the generator/ storage sites' waste management system, 2) the transportation system, and 3) the WIPP disposal system. Analysis of the Design Basis will define the estimated waste work-off schedule, the total system costs for future activities, and provide other data that can be used in relative comparisons to other system configurations and alternatives. By analyzing the impacts that each postulated alternative may have on the risk, cost, and waste volume throughput of the RH-TRU system, desirable aspects of RH-TRU waste management can be identified and incorporated into DOE's RH-TRU waste management plans.

In addition to the Strategy, the Design Basis is developed from the "*WIPP TRU Waste Baseline Inventory Report*" (ref. 7) and site-specific plans for RH-TRU waste management as documented in site logic diagrams, Activity Data Sheets (referred to as ADSs) and other relevant sources. The Design Basis will be updated periodically as improvements in the RH-TRU waste management system are identified.

Each site that currently stores or generates RH-TRU waste will require facilities for retrieving, repackaging, characterizing and certifying, and loading RH-TRU waste for shipment. At the large quantity sites, most of the required facilities will be located on-site near the waste storage or generating facilities. At the small quantity sites, existing facilities or mobile capabilities will often be the most desirable means to process the waste. The Design Basis configuration does not currently include any mobile capabilities.

The Design Basis configuration and operations schedule is presented in Figure 1. In the RH-TRU waste Design Basis scenario, all sites will strive to use existing facilities as much as is practical to prepare their RH-TRU waste for certification and shipment to WIPP. The RH-TRU waste at most sites is heterogeneous solid waste; therefore, these sites will limit treatment to basic repackaging operations (open, dump, sort, repack, certify and ship) to meet WIPP WAC. At a few sites (e.g., ORNL and ANL-W) a fraction of the waste is in the form of liquid or sludge and will require special treatment such as evaporation/solidification. Two new major treatment facilities are included in the Design

Basis plan, a TRU waste treatment plant at Hanford and the TRU Processing Facility (TPF) at ORNL. The Hanford plant will include capability to receive large boxes and most RH-TRU waste, and treat as necessary to meet the WIPP WAC. Treatment may include liquid and sludge solidification. The TPF at ORNL will include special treatment to evaporate and/or solidify liquids and sludge. Sites that cannot treat their waste as necessary using existing facilities will rely on shipment to one of the large plants at Hanford or ORNL.

In the Design Basis, all shipments will be in the RH-72B casks, and all RH-TRU waste will be emplaced at WIPP using the existing equipment and procedures that rely on horizontal emplacement in the walls on 8-foot centers. This WIPP emplacement configuration limits the total RH-TRU waste volume that can be disposed to about 4780 m^3 (5371 boreholes), and limits the RH-TRU waste throughput rate to 350 canisters per year. RH-TRU disposal operations will begin in the year 2002, 4 years after CH waste emplacement begins. During this 4-year period approximately 500 m^3 of RH-TRU waste disposal capacity will become unavailable as a result of CH emplacement in the first few rooms. Thus the total RH-TRU capacity at WIPP using the Design Basis scenario is only about 4280 m^3. RH-TRU disposal operations could continue until the end of 2026, 7 years before CH operations are scheduled to cease. This 7-year period allows for emplacement of CH waste into the WIPP main drifts, a location where no RH-TRU emplacement is possible without facility or equipment design changes. Based on preliminary work-off plans, the WIPP will reach its capacity of 4280 m^3 before the year 2022. Thus in the Design Basis scenario, a large volume of RH-TRU waste will remain in storage at the generator sites following WIPP closure.

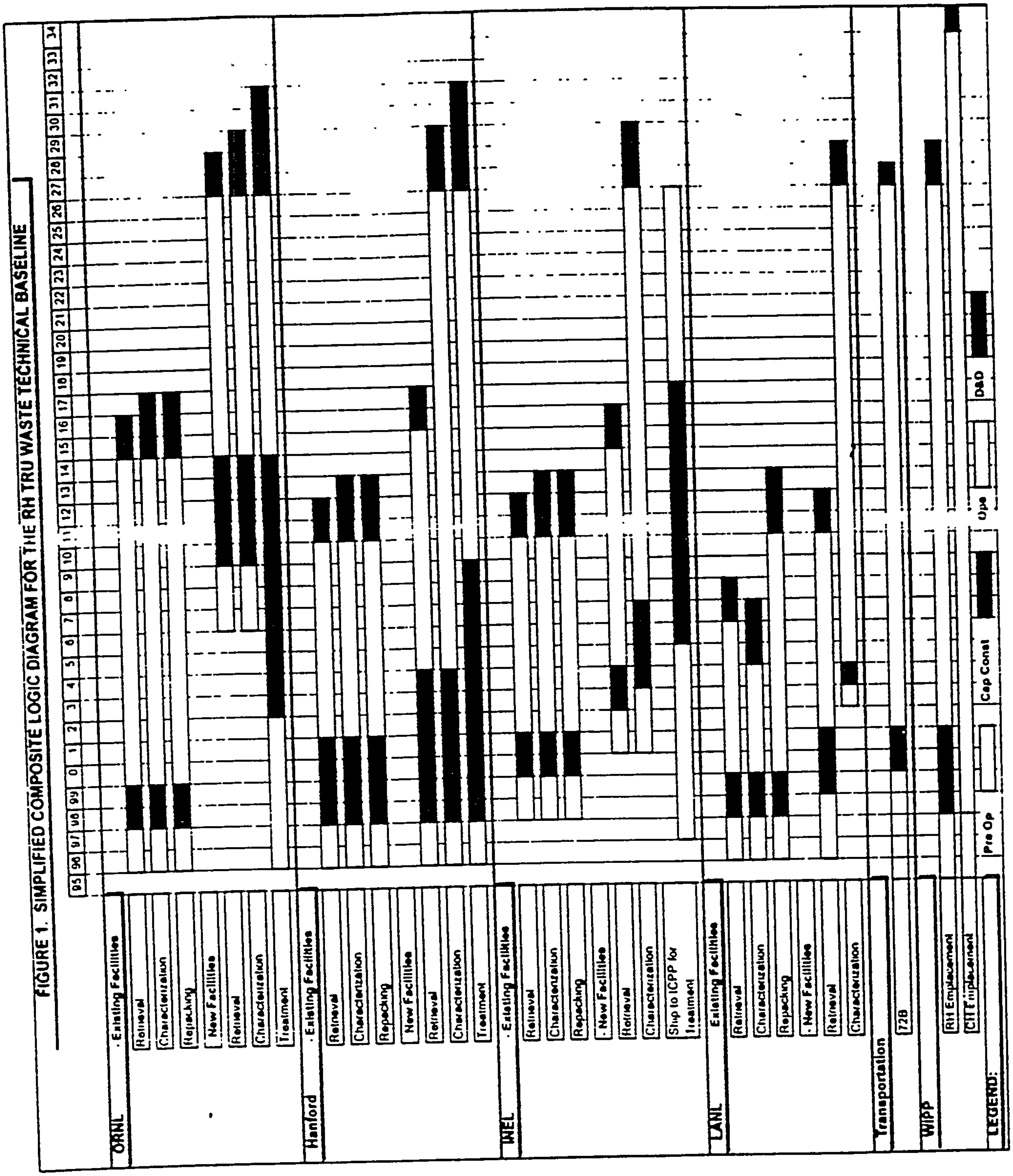


FIGURE 1. SIMPLIFIED COMPOSITE LOGIC DIAGRAM FOR THE RH TRU WASTE TECHNICAL BASELINE

ORNL Retrieval operations for stored RH-TRU waste at ORNL will begin in the year 2000. Waste will be packaged or repackaged using existing facilities to comply with the WIPP WAC or placed in storage pending treatment in the TPF (or equivalent). The TPF will become operational in the year 2015 and process the liquid and sludge RH-TRU waste until WIPP RH-TRU operations cease in 2020. Prior to 2015, ORNL will prepare their solid RH-TRU waste in existing hot cell facilities.

The rate of RH-TRU waste retrieval, preparation, certification, and shipment at ORNL was estimated to be 35 m^3 per year during the period from 2002 to 2015 when existing facilities are being used. When the TPF becomes operational in 2015 the shipping rate is assumed to increase to 100 m^3 per year. In this Design Basis scenario, all currently stored waste and most of the projected newly generated waste from ORNL would be sent to WIPP by 2020. RH-TRU waste generated between 2020 and 2033 would remain in storage at ORNL.

HANFORD Cleanup activities at the Hanford site are expected to generate large volumes (up to 27,000 m^3) of RH-TRU waste over the next 25 years. Hanford will begin retrieval of solid RH-TRU waste from storage in 2002 and use existing facilities to prepare as much as possible for certification and shipment to WIPP. Waste that cannot be certified will be stored pending the opening of new facilities. New facilities at Hanford will be readied for retrieval and characterization of RH-TRU waste in 2005 and treatment in the new Hanford treatment plant will begin in 2010. Hanford waste work-off rates are assumed to be limited initially to 70 m^3/yr between 2002 and 2010, and to increase to ~225 m^3/yr between 2010 and 2020 when the treatment plant is in full operation. Hanford will ship all of its stored RH-TRU waste and part of its projected RH-TRU waste to WIPP by the end of 2020 when WIPP reaches its capacity for RH-TRU waste. All RH-TRU waste generated between 2020 and 2033 would remain in storage at Hanford.

LANL There are 16 canisters of RH-TRU waste already packaged at LANL that must be certified to the WIPP WAC. Other RH-TRU waste in storage will be retrieved beginning in 2000 and treated, packaged, and certified at LANL's existing Wing-9 hot cell facilities. LANL will begin shipment to WIPP in 2002 and complete retrieval and shipment of all currently stored RH-TRU waste by 2012. Beyond the year 2012, half of the newly generated waste will be packaged and certified at the generating facilities and half will be sent to the Wing-9 facility for processing. LANL will ship about 122 m^3 of RH-TRU waste to WIPP by 2020 with an average shipping rate of 6.5 m^3/yr. RH-TRU waste generated after 2020 would remain in storage at LANL.

INEL/ANL-W The INEL will begin retrieval of stored RH-TRU waste in 2002, and package, certify, and ship as much as possible to WIPP. RH-TRU waste that cannot be certified will be stored until it can be sent to ANL-W for processing or to the new high-level waste treatment plant at the Idaho Chemical Processing Plant (ICPP). The ANL-W facilities at Idaho include an existing hot cell facility that will be used to prepare about 30 m^3 of ANL-W-generated RH-TRU waste for WIPP through the year 2020. The INEL will ship about 17 m^3/yr. of RH-TRU waste in 2003 and a cumulative total of about 63 m^3 by 2020. A small amount (~20 m^3) of RH-TRU will remain in storage at INEL in 2033.

BCLDP The decontamination and decommissioning of the hot cell at Battelle Columbus Laboratory Decommissioning Project (BCLDP) will generate a total of 71 m^3 of RH-TRU waste. All of this waste will be packaged and certified using the existing hot cell and shipped to WIPP by 2010. The peak shipping rate is assumed to be 12 m^3/yr.

SRS A total of ~54 m^3 of RH-TRU waste will be shipped from the Savannah River Site (SRS) from 2003 to 2019. The waste will be packaged to WIPP WAC as it is generated and sent directly to WIPP in RH-72B canisters. No special treatment is anticipated. RH-TRU waste generated at SRS after 2019 will remain in storage. The peak shipping rate is assumed to be 2.5 m^3/yr.

Other RH-TRU Sites The laboratory at Bettis will package 1.6 m^3 of RH-TRU waste using existing facilities and ship to WIPP in 2003. The Knolls Atomic Power Laboratory (KAPL) will continuously generate and ship RH-TRU waste to WIPP over the entire RH-TRU operating period. A total of 28.5 m^3 is estimated to be sent from KAPL to WIPP in the Design Basis scenario. As other sites are identified in the future, they may have to rely on mobile systems for their waste treatment, packaging, certification, and shipment to WIPP. If necessary, mobile systems will be included in the Design Basis system model. The Design Basis analyzed here does not include any mobile capabilities. If necessary some of the waste will be sent to the large treatment plants at either Hanford or ORNL before being sent to WIPP for disposal. The Design Basis analyzed here does not include any intersite shipment for treatment; all sites package their RH-TRU waste and ship directly to WIPP.

Summary In the Design Basis scenario, a total of 4280 m^3 of RH-TRU waste is disposed in WIPP between the years 2002 and 2020. All RH-TRU waste generated between 2020 and 2033 is left in storage at the generator sites, because WIPP capacity for RH-TRU waste (4280 m^3) is exceeded in the year 2020 using the current WIPP design and work-off plan. Nearly all of the RH-TRU waste that is disposed requires some form of processing or treatment to meet the WIPP WAC. All sites prepare their own waste for certification and shipment to WIPP, although the bulk of the waste resides at Hanford and ORNL, and will be treated at these two sites. Results of the analysis of the Design Basis are presented in Section 5 with the results of the other Alternatives analysis.

3.0 ALTERNATIVES

Several alternatives to the RH-TRU waste management design basis plan are possible that offer the potential to remove larger amounts of waste from the sites for disposal and possibly reduce future system costs and health and safety risk. Those alternatives that appear feasible and potentially beneficial are described here and evaluated for comparison to the Design Basis. Among the leading alternatives for RH-TRU waste treatment are those considered in the draft PEIS (ref. 1) which include decentralized, regional, and centralized TRU waste treatment facility configurations, and waste treatment options that go beyond that required for compliance to the WIPP WAC Rev. 4.. The PEIS alternatives in combination with the leading packaging, transportation, and disposal configuration options are used in this evaluation. The packaging and transportation options were taken from reference 5, the disposal configuration options were taken from reference 4.

The centralized configuration described in the PEIS is not considered practical for RH-TRU waste treatment; therefore, it was not included as an RH-TRU waste treatment option in the PEIS, and it is not included in this evaluation. The PEIS also used RH-TRU waste inventory information that has changed recently. However, this study includes current inventory information and evaluates several RH-TRU waste management alternatives that are based on the decentralized and regional treatment facility configurations as well as options for transportation and packaging and disposal configuration as described in the other RH-TRU waste alternative studies (refs. 4 & 5).

A regional configuration for treatment to WIPP WAC is not considered, because most sites are already capable of treatment to WIPP WAC or are planning facilities to accomplish such. Further, the preparation required to ship RH-TRU waste off-site is likely to be nearly as complex as preparation to meet the WAC. Thus the expense of large regional treatment plants and the associated costs of transporting waste from several sites to regional plants for little additional treatment is logically an undesirable scenario. Also no alternatives are included that would place LDR treatment in a decentralized configuration. The expense of providing several special treatment plants at each RH-TRU waste site is, again, logically excluded in favor of other proposed alternatives. Table 2 summarizes the key features of the RH-TRU scenarios evaluated in this study.

Table 2. RH-TRU Waste Management Scenarios Evaluated

Scenario	Facilities Configuration	Treatment Option	Transportation	Packaging, & Disposal
Design Basis	Decentralized	WIPP WAC	Truck	RH-72B
Alternative 1	Decentralized	WIPP WAC	Truck	RH-72B + SD
Alternative 2	Regional	Reduced Gas Generation	Truck + Rail	New Desgn Packaging
Alternative 3	Regional	LDR	Truck + Rail	New Design Packaging
Alternative 4	Decentralized	WIPP WAC	Truck	SD + New Design Packaging
Alternative 5	Decentralized and Regional	WIPP WAC and LDR	Truck + Rail	SD + New Design Packaging

Note: SD is shielded drums.

Alternative 1 The first alternative considered is identical to the Design Basis except that shielded drums are used as the packaging option for about 30% of the RH-TRU waste. This option ranked very high in the disposal alternatives evaluation (ref. 4), and offers a potential to increase the total amount of RH-TRU waste removed from the sites and disposed in WIPP. The shielded drums would be transported in a new design packaging system called HalfPack and placed in the CH stacks, avoiding the special WIPP operations problems associated with the placement of RH-TRU canisters in the walls before beginning CH emplacement in the rooms.

The volume of RH-TRU waste removed from the sites will increase in this scenario by the amount that can be packaged and shipped in shielded drums; the amount packaged and shipped in RH-72B canisters will remain the same (4280 m^3). The cost associated with implementation of shielded drums is included in the evaluation, and the cost associated with the canisters and RH-72B casks are maintained the same. The throughput rate at WIPP is maintained the same for the RH-72B canisters (350 per year), but the net RH-TRU waste disposal rate is greater since the shielded drums are handled as CH waste packages and are not throughput-rate limited at WIPP.

The amount of RH-TRU waste that can be packaged in shielded drums is limited by the dose rate of the waste materials. Based on the estimates in the RH-TRU waste inventory and generation appendix (ref. 8), about one third of the RH-TRU waste can be packaged in the shielded drums and remain below the 200 mrem/hr surface-dose-rate limit on CH packages. The balance of the RH-TRU waste that cannot be packaged in shielded drums is assumed to be handled as in the Design Basis--packaged in canisters, shipped in RH-72B casks, and emplaced in the disposal room walls at WIPP--as long as space is available.

Alternative 2 The next alternative considers a regional configuration for the treatment facilities, RH-TRU waste treatment for reduced gas generation, and new design packaging that meets the requirements of reduced gas generation. This special treatment process includes a shred and grout process that is expected to reduce the rate at which the waste will decompose in the repository, thus reducing the gas generation rate and thereby minimizing the potential for long-term facility pressurization. The new design packaging is also assumed to be constructed of a non-corroding or special material that results in greatly reduced gas generation rates in the repository.

In Alternative 2, the RH-72B canister-cask system is replaced with the new design packaging (described in ref. 5, section 4.1.6) that eases handling at WIPP and potentially at some of the RH-TRU generator/storage sites. The throughput for the new design packaging system is assumed to be 50% faster than the RH-72B system, based on system simulation studies. Even more importantly, the new packaging design allows for greater volume capacity at WIPP. More boreholes of varying depths can be provided, and most of the horizontal boreholes can each accommodate a greater volume of waste than the 0.89 m^3 of a RH-72B canister. Additionally the smaller package eases handling at WIPP such that boreholes can be provided and used for additional waste disposal in the walls of the drifts.

The cost of development and implementation of the new design packaging system is included in the evaluation, as well as any cost and time savings realized over the life of RH-TRU disposal operations.

Alternative 2 uses combined truck and rail shipment to WIPP; rail is used only from the regional treatment plants.. The treatment plants were assumed to be sized for the RH-TRU waste inventory estimates in the Design Basis and have an operating life of at least 10 years. Since the treatment plants are not available until 2010 or later, no RH-TRU waste is sent to WIPP until 2010. Although this delay results in cost savings in the early years, it forces increased throughput rates and increased operations costs during the RH-TRU disposal period in later years.

Alternatives 3 The third alternative evaluated includes special treatment of all RH-TRU waste to LDR standards. The treatment process is assumed to be vitrification, or other robust process with similar cost (e.g., a combination of incineration, neutralization, deactivation, and shredding). After treatment, the waste is packaged for shipment and disposal. Alternative 3 uses a combination of truck and rail transportation, and includes the use of the new design packaging and cask design and emplacement procedure. The treatment plant size was assumed to be the same as in Alternative 2. As with Alternative 2, this scenario results in delayed RH-TRU disposal until 2010.

Alternative 4 This alternative is intended to increase the total volume of RH-TRU waste disposed, if possible, to the 7080 m^3 limit. All assumptions are similar to the Design Basis and Alternative 1 except the package configuration. RH-TRU waste is processed at each site to meet the WIPP WAC and shipped by truck to WIPP. However in this scenario, the waste is packaged in either the new design packaging or in shielded drums. Thus, waste can be packaged and shipped early (i.e., in 2002) and a higher RH-TRU waste throughput rate can be achieved at WIPP by replacing the RH-72B system with the new design packaging system.

Alternative 5 The last alternative included in this evaluation is similar to Alternative 3 in that it includes LDR treatment of the waste at regional plants, but in this scenario 20% of the waste is assumed to be processed at the sites and shipped to WIPP. This assumption is based on the fact that some of the waste in storage and to be generated is non-mixed waste and can be disposed without LDR treatment. Further, some of the waste can be sorted at the sites while it is being prepared for shipment to the regional treatment plants, and the sorting can generate additional non-mixed waste for shipment to WIPP from the regional plants. The 20% non-mixed waste is packaged in either shielded drums or the new design packaging and shipped to WIPP beginning in 2002. The remainder of the waste is shipped to the regional plants, treated to LDR, and shipped to WIPP beginning in 2010.

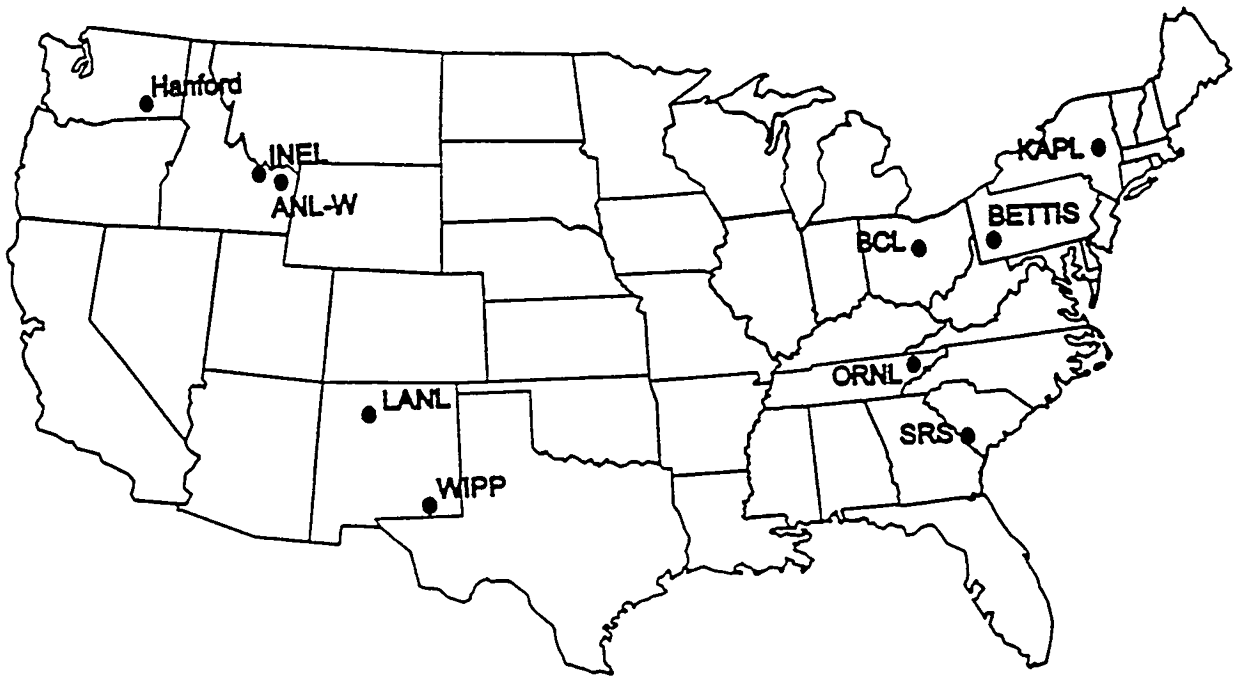
The waste throughput at WIPP is the same as in Alternative 4, and the treatment plants are assumed to be sized to accommodate the WIPP throughput.

4.0 EVALUATION PROCESS

Each alternative was analyzed using a system simulation model that tracks all interdependent system parameters. The results of the analyses can be compared to allow evaluation of each alternative and the relative merits of each. Among the principal parameters of interest are the relative costs, risks, and waste disposal histories of the Design Basis and each alternative.

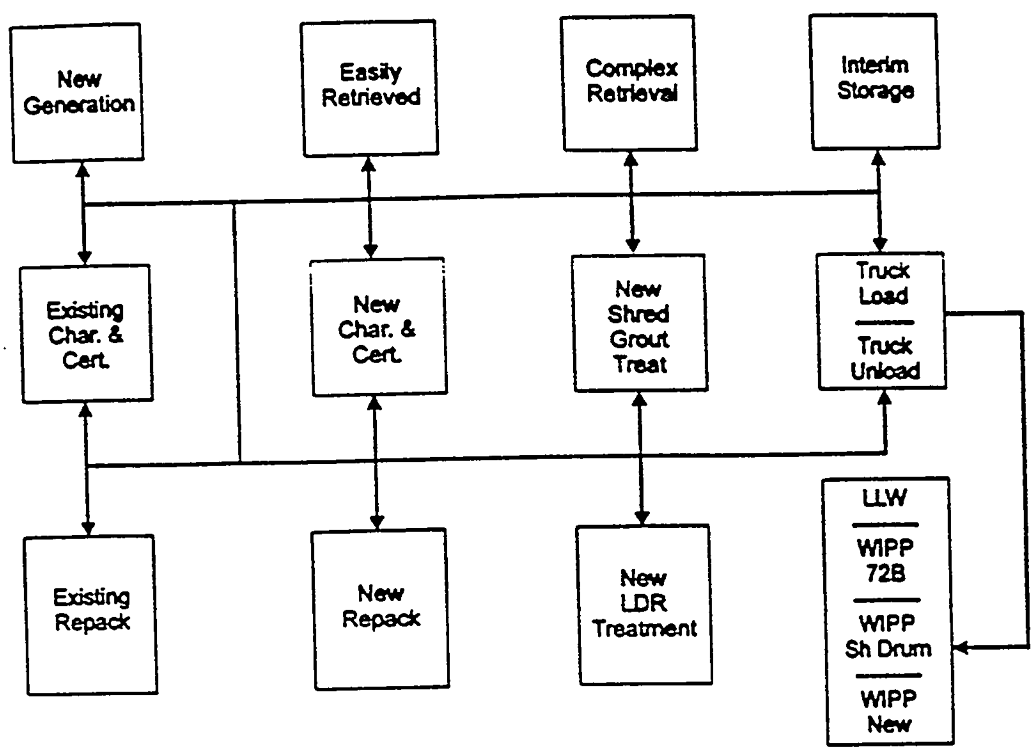
The system simulation model uses a commercial software package, ProModel, supplemented by a detailed spreadsheet for input of all system characteristics. The entire RH-TRU waste management system configuration was included in the analysis model. It consists of the nine generator/storage sites listed in Table 1 (with INEL and ANL-W combined), and one additional site that represents the WIPP. The transportation system is represented as a set of transportation routes between all sites and WIPP; one, two, or three types of packaging can be selected. Thus, the RH-72B, the new unshielded HalfPack packaging for shielded drums, and the new design packaging can all be included as desired. Figure 2 illustrates the site location representation used in the analysis. Distances between sites and WIPP are specified and transport mileage is tracked automatically in the analysis.

Figure 2. Locations of RH-TRU Waste Sites



Each site modeled includes several RH-TRU waste management facilities and operations. Figure 3 shows a typical layout for these facilities and their linkages as employed in the system simulation analysis.

Figure 3. Representation of Facilities at Each Site for RH-TRU Operations



For analysis of the Design Basis, the input spreadsheet was set up to reflect the system configuration and facilities operations schedule as described above and summarized in Figure 1. The cost associated with each facility or operation was similar to that used in the PEIS, or was developed from other relevant sources. For example, the generic treatment facilities costs are taken from EGG-WM-11274 (ref. 10), and the cost associated with the new design packaging was taken from the RH-TRU Transportation appendix (ref. 5). Only total system future costs (commonly referred to as TSFC) were accrued, not total system life cycle costs which would include the addition of sunk costs. The cost of WIPP operations was assumed to be that associated only with RH-TRU waste handling; and the assumed fraction for RH-TRU was taken to be 8% of the total operating cost, slightly more than the ratio of RH-to-total waste volume.

The input information also includes estimates of the processing rates for each facility or operation. These rates were determined from the waste volume inventories in Table 1 and the facility or operation durations shown in Figure 1. The waste volume handled by each operation was adjusted if necessary to account for splits in the process stream that are known to be important. For example, 70% of the waste processed in Alternative 1 was packaged for shipment in the RH-72B canister/cask transporter and 30% was packaged in shielded drums for shipment in the TRUPACT-II transporter. A summary of input parameters and the associated assumptions for all the scenarios analyzed is presented in Attachment A: Simulating the RH-TRU Waste Management System.

5.0 EVALUATION RESULTS

The Design Basis and five Alternatives have been analyzed using the system simulation model. A comparison of analysis results is presented in Table 3, and selected results of each calculation are provided in Figures 4 through 27. Some relevant details of each analysis are discussed in the following sections.

Table 3. Summary Results of Options Analysis

	RH-TRU Waste (m^3) Removed	*RH-TRU Waste (m^3) Disposed*[1]	*RH-TRU Waste (m^3) in Storage*[2]	*TSF Cost Billions*	*RH-TRU Disposal Operations*	*Cost per m^3 Removed & Disposed $M*
Design Basis	4,280	4280	25,700	$3.54	2002-2020	0.83
Alternative 1	14,225	4280	15,770	$5.31	2002-2033	0.37
Alternative 2	7,080	7080	22,920	$3.82	2010-2033	0.53
Alternative 3	7,080	7080	22,920	$4.35	2010-2033	0.60
Alternative 4	16,840	7080	13,160	$5.41	2002-2033	0.32
Alternative 5	16,474	7080	13,520	$6.33	2002-2033	0.38

Notes: [1] The *volume removed* includes both RH-TRU waste in RH-TRU packaging and RH-TRU waste in shielded drums.

[2] Based on the preliminary BIR Rev. 2 volume of ~28,000 m^3 through 2022 and ~2000 m^3 generated between 2022 and 2033.

Design Basis The results of the analysis of the Design Basis configuration are shown in Figures 4 through 7, and the calculated waste work-off schedule for the Design Basis scenario is presented in Table 4. In Table 4, the waste quantities shipped from Hanford for the years 2010 and 2011 were adjusted slightly from the values produced by the model as described in Attachment A: Simulating the RH-TRU Waste Management System. This change was made to minimize a shipping peak in the year 2010. The sum of waste shipped in 2010 plus 2011 remains the same. This scenario disposes of 4280 m^3 of the RH-TRU waste when the limit is reached in the year 2020, and it leaves more than 25,000 m^3 of RH-TRU waste in storage at the sites when WIPP is scheduled to close in 2033. The obvious disadvantage of the Design Basis scenario is that it provides no capacity at WIPP for RH-TRU waste in excess of the 4280 m^3 that can be emplaced in the room walls using the RH-72B system. Since RH-TRU waste operations must cease at WIPP after 2020 due to the lack of available space for the RH-72B canisters, RH-TRU disposal costs are terminated at that time. Thus, total system future costs appear to be low for this scenario, but the volume of RH-TRU waste disposed is also low, and the cost per unit waste disposed is highest.

Figure 4. Cumulative Waste Disposed
Baseline

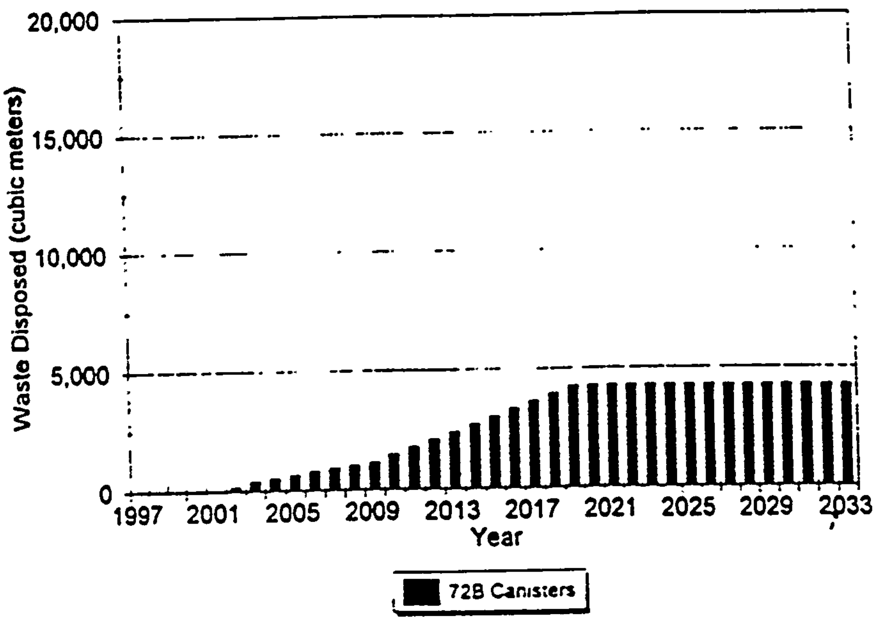


Figure 5. Annual Waste Disposed
Baseline

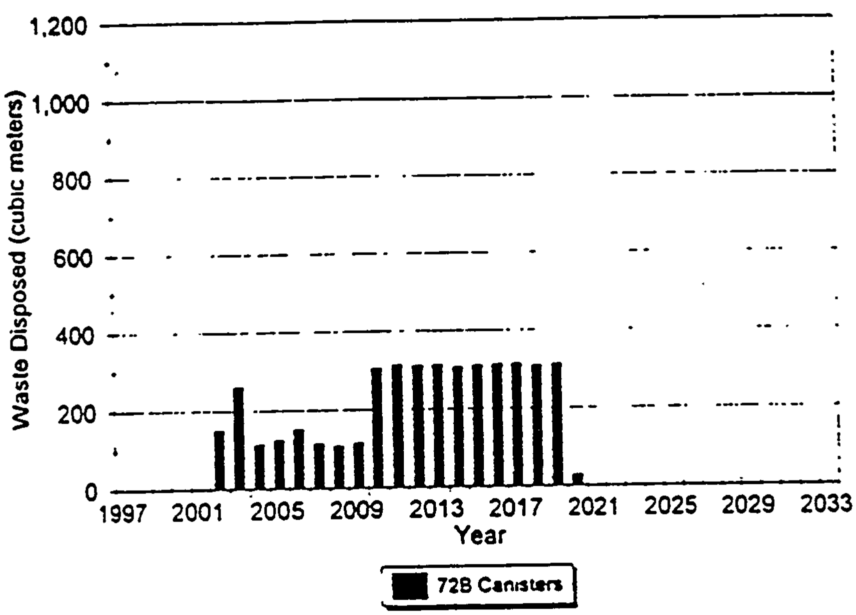


Figure 6. Cost Components
Baseline

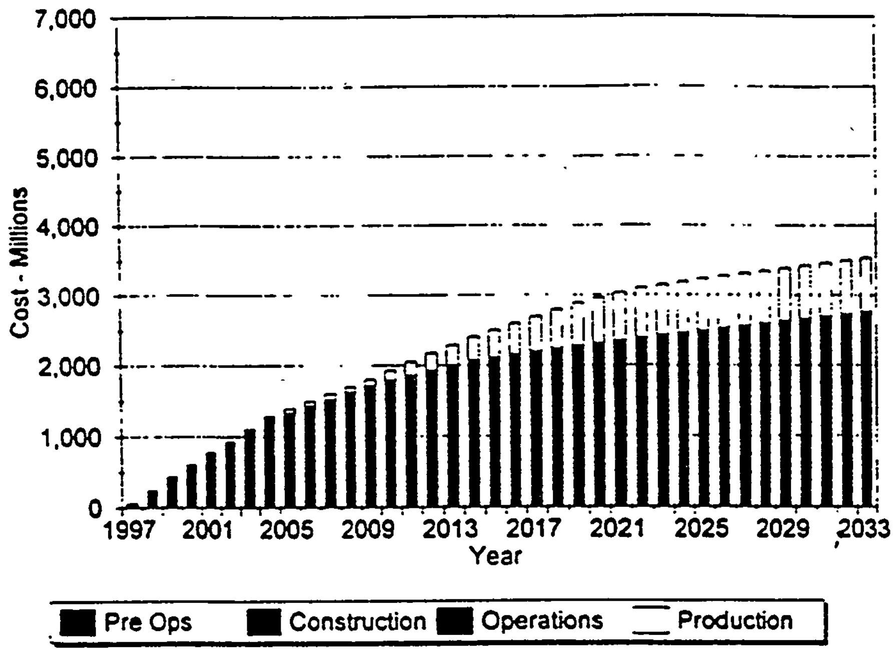


Figure 7. Annual Costs
Baseline

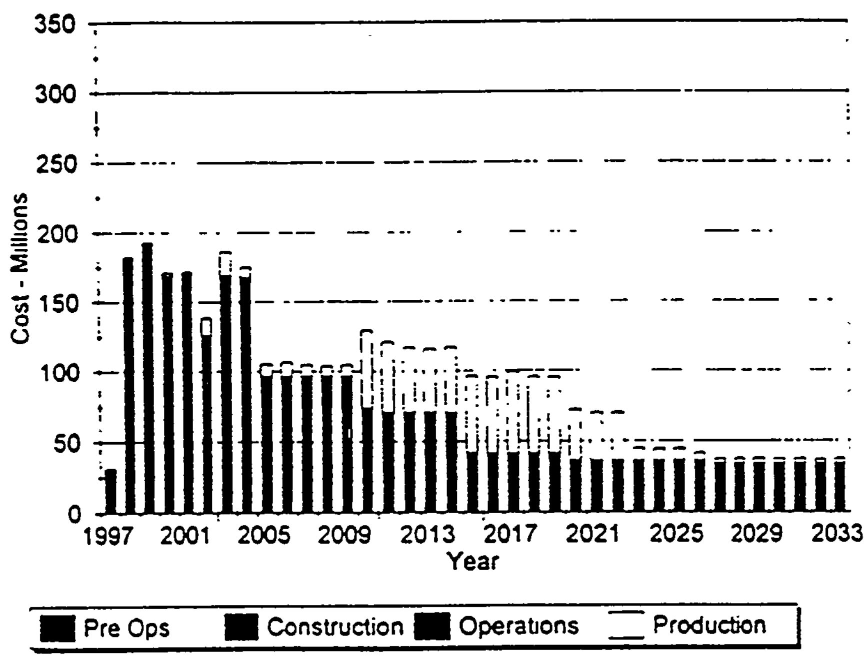


Table 4. RH-TRU Waste Shipping Schedule (cubic meters) - Baseline Case

Year	To WIPP								Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0
2002	0	121	29	0	0	0	0	0	150	150
2003	151	34	11	17	21	19	6	2	261	411
2004	53	36	4	4	12	3	2	0	114	525
2005	71	33	5	4	11	2	1	0	127	652
2006	89	36	5	4	12	3	2	0	151	803
2007	71	33	4	6	6	3	1	0	124	927
2008	45	35	6	6	4	2	2	0	100	1027
2009	62	34	6	6	5	3	2	0	118	1145
2010	328	16	2	4	0	1	0	0	351	1496
2011	269	28	4	4	0	2	1	0	308	1804
2012	258	34	5	2	0	3	2	0	304	2108
2013	285	32	6	1	0	2	2	0	328	2436
2014	267	31	4	0	0	3	2	0	307	2743
2015	249	37	4	0	0	3	1	0	294	3037
2016	214	80	6	1	0	2	2	0	305	3342
2017	214	98	5	2	0	2	2	0	323	3665
2018	205	94	5	0	0	3	2	0	309	3974
2019	196	99	4	1	0	3	1	0	304	4278
2020	27	7	2	1	0	0	0	0	37	4315
2021	0	0	0	0	0	0	0	0	0	4315
2022	0	0	0	0	0	0	0	0	0	4315
2023	0	0	0	0	0	0	0	0	0	4315
2024	0	0	0	0	0	0	0	0	0	4315
2025	0	0	0	0	0	0	0	0	0	4315
2026	0	0	0	0	0	0	0	0	0	4315
2027	0	0	0	0	0	0	0	0	0	4315
2028	0	0	0	0	0	0	0	0	0	4315
2029	0	0	0	0	0	0	0	0	0	4315
2030	0	0	0	0	0	0	0	0	0	4315
2031	0	0	0	0	0	0	0	0	0	4315
2032	0	0	0	0	0	0	0	0	0	4315
2033	0	0	0	0	0	0	0	0	0	4315
Totals	3054	918	117	63	71	59	31	2	4315	

Note: Differences between the totals shown in this table and those discussed in the text and contained in other tables in the report represent waste processed but not shipped.

Alternative 1 The results of the analysis of Alternative 1 are shown in Figures 8 through 11, and the calculated work-off schedule is presented in Table 5. The most striking feature of the Alternative 1 results is that 14,231 m^3 of the RH-TRU waste stored and projected through the year 2033 can be disposed in WIPP. This alternative puts nearly 10,000 m^3 of the RH-TRU waste into shielded drums in the CH stacks and it uses all of the available wall space for RH-TRU canisters at WIPP (4280 m^3). The peak shipping rate to WIPP reaches 800 m^3, most of which is shielded drums. The estimated total system future cost for this Alternative is considerable more than that for the Design Basis; but more importantly, the cost per unit waste disposed is much lower, less than half the unit cost of the Design Basis.

Figure 8. Cumulative Waste Disposed
Alternative 1

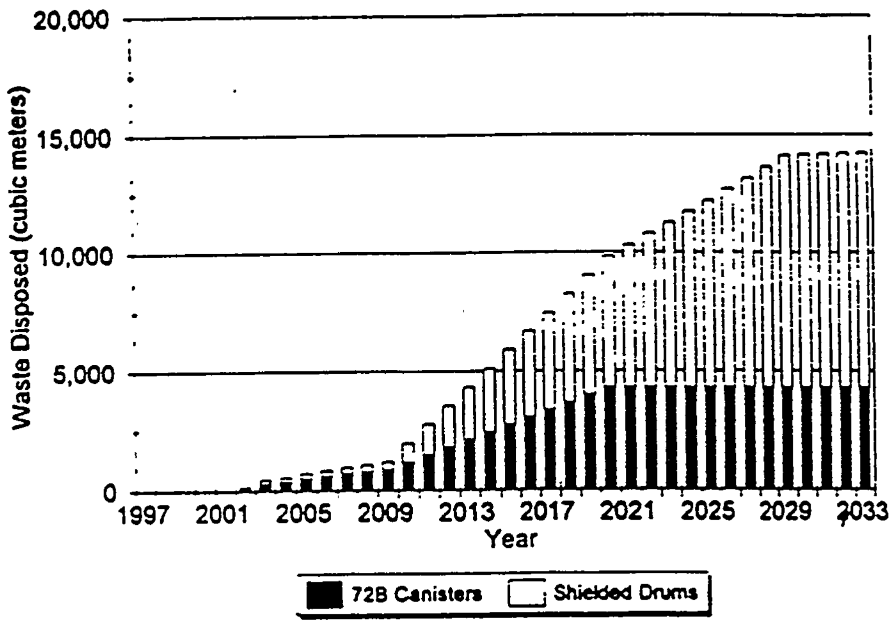
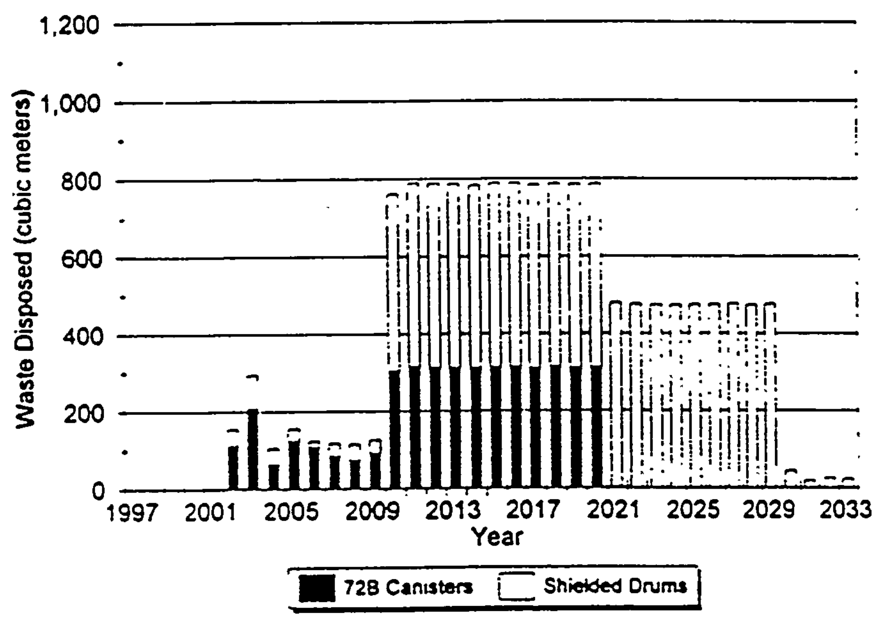


Figure 9. Annual Waste Disposed
Alternative1



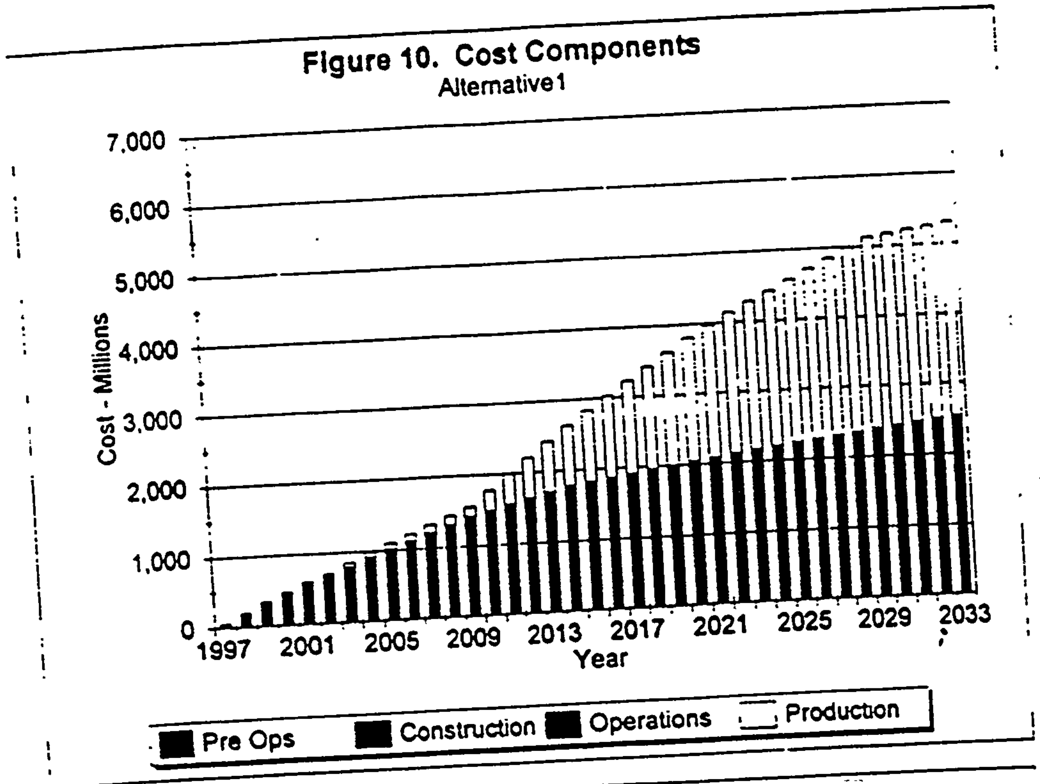


Figure 10. Cost Components
Alternative1
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Cost - Millions
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
Year
Pre Ops
Construction
Operations
Production

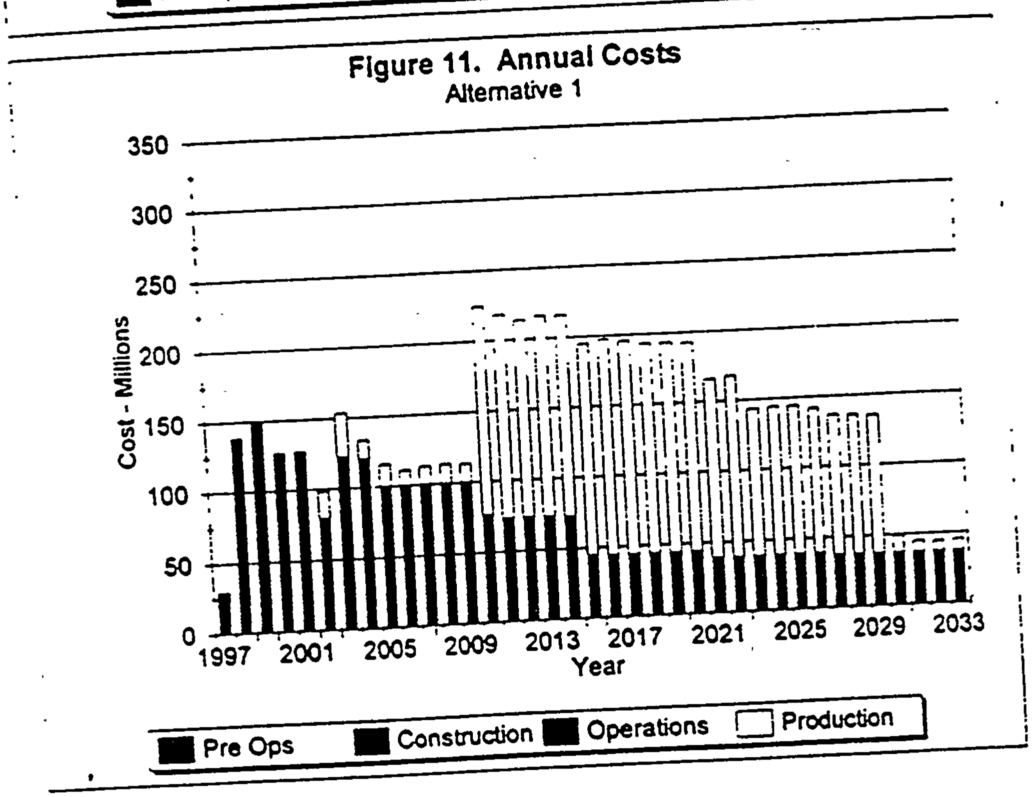


Figure 11. Annual Costs
Alternative 1
350
300
250
200
150
100
50
0
Cost - Millions
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
Year
Pre Ops
Construction
Operations
Production

Table 5. RH-TRU Waste Shipping Schedule (cubic meters) - Alternative 1

Year	To WIPP								Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0
2002	0	122	32	0	0	0	0	0	154	154
2003	187	33	11	17	22	18	4	1	293	447
2004	45	35	5	5	11	2	1	0	104	551
2005	107	33	5	6	11	2	2	0	166	717
2006	53	34	5	7	11	3	1	0	114	831
2007	62	32	6	7	6	2	2	0	117	948
2008	62	33	5	7	5	3	1	0	116	1,064
2009	71	34	6	5	5	3	2	0	126	1,190
2010	769	30	4	4	0	2	1	0	810	2,000
2011	754	31	6	2	0	2	1	0	796	2,796
2012	748	31	5	0	0	2	1	0	787	3,583
2013	734	33	5	0	0	2	2	0	776	4,359
2014	784	25	6	2	0	3	1	0	821	5,180
2015	653	77	5	1	0	3	1	0	740	5,920
2016	683	98	6	1	0	2	1	0	791	6,711
2017	692	97	6	0	0	2	1	0	798	7,509
2018	659	95	5	2	0	3	1	0	765	8,274
2019	713	80	4	3	0	2	1	0	803	9,077
2020	701	64	6	1	0	2	2	0	776	9,853
2021	448	21	2	0	0	1	1	0	473	10,326
2022	460	18	1	1	0	1	1	0	482	10,808
2023	448	20	1	1	0	0	1	0	471	11,279
2024	460	18	1	0	0	0	0	0	479	11,758
2025	448	23	1	1	0	1	0	0	474	12,232
2026	463	14	1	0	0	1	1	0	480	12,712
2027	466	5	2	0	0	1	0	0	474	13,186
2028	466	3	1	0	0	0	1	0	471	13,657
2029	448	5	1	1	0	0	0	0	455	14,112
2030	36	3	2	0	0	2	1	0	44	14,156
2031	18	2	1	0	0	1	0	0	22	14,178
2032	18	3	0	0	0	1	1	0	23	14,201
2033	18	4	1	1	0	0	0	0	24	14,225
Totals	12,674	1,156	148	75	71	67	33	1	14,225	

Alternative 2 The results of Alternative 2 are presented in Figures 12 through 15, and the calculated work-off schedule is given in Table 6. This Alternative is able to dispose of enough RH-TRU waste to reach the 7080 m^3 limit, because it allows for emplacement of the new design packaging in the walls of the main WIPP drifts as well as in the room walls. This feature allows RH-TRU waste emplacement to continue through the last year of WIPP operations, 2033. A key feature of this Alternative is the lack of RH-TRU waste shipments to WIPP until the treatment plants are operational and begin to package and certify waste for WIPP in 2010. However, CH waste emplacement operations during the period up to 2010 will likely eliminate an additional 800 m^3 of room wall locations for the RH-TRU package emplacement. To verify the impact of this lost disposal space, a CH work-off plan would be required or a combined RH-CH system analysis would be needed.

In the Alternative 2 analysis, RH-TRU waste shipments from all sites to the ORNL and Hanford treatment plants are assumed to begin in 2000. ORNL begins shipment of treated RH-TRU waste to WIPP beginning in 2015 and ending in 2025 when the WIPP volume limit for RH-TRU is reached. Hanford ships a total of 5748 m^3 or about 80% of the waste; ORNL ships 1440 m^3 or about 20% of the RH-TRU waste. Other sites continue to ship to the regional plants; resulting in large accumulations of stored waste at Hanford and ORNL.

The estimated total system future cost for this Alternative is low (only the Design Basis is lower), but the unit cost of waste disposal is high. To realize the low cost, it was assumed that no RH-72B casks or canisters were needed and the new design packaging had a lower net cost (see ref. 5). This Alternative also had a net total cost for the regional treatment plants that is about the same as the net total costs of the decentralized treatment that takes place at each generator site in the Design Basis and Alternative 1 cases.

Figure 12. Cumulative Waste Disposed
Alternative 2

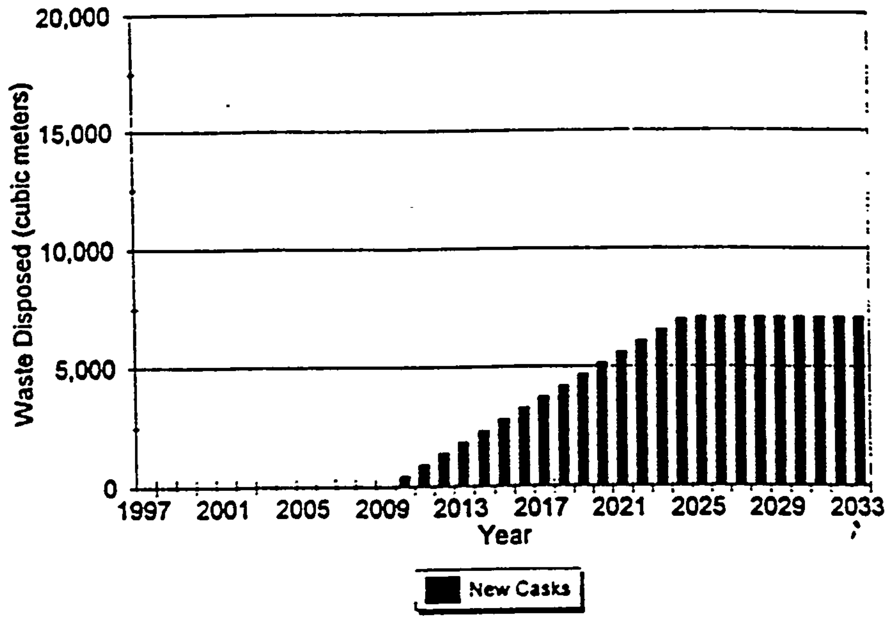


Figure 13. Annual Waste Disposed
Alternative 2

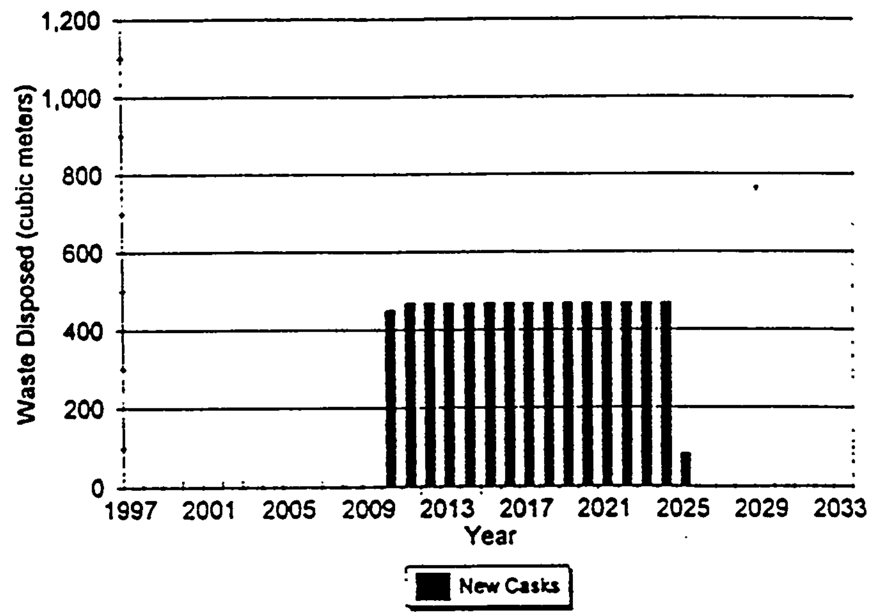


Figure 14. Cost Components
Alternative 2

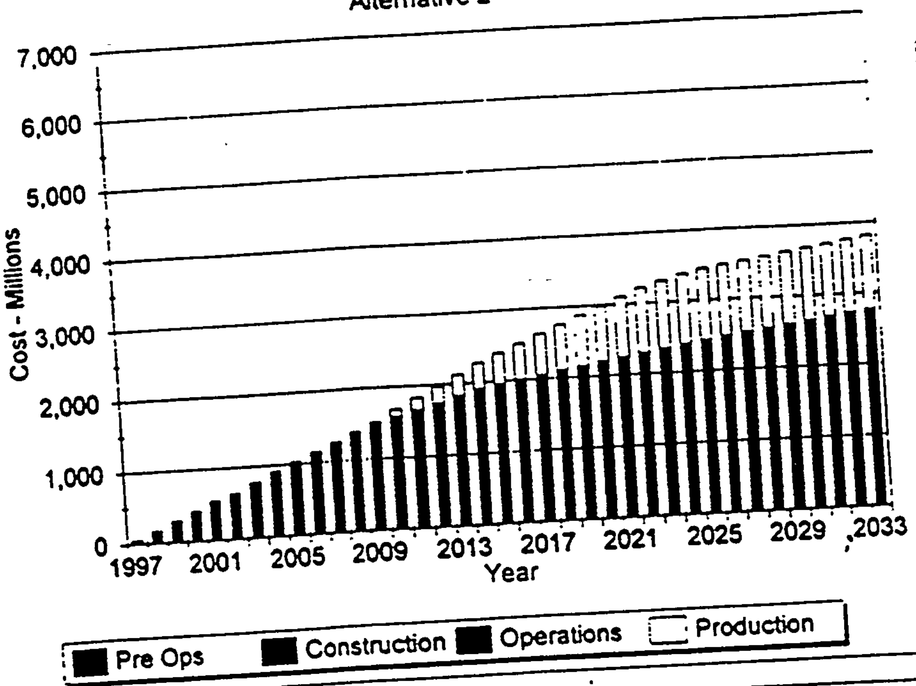


Figure 15. Annual Costs
Alternative 2

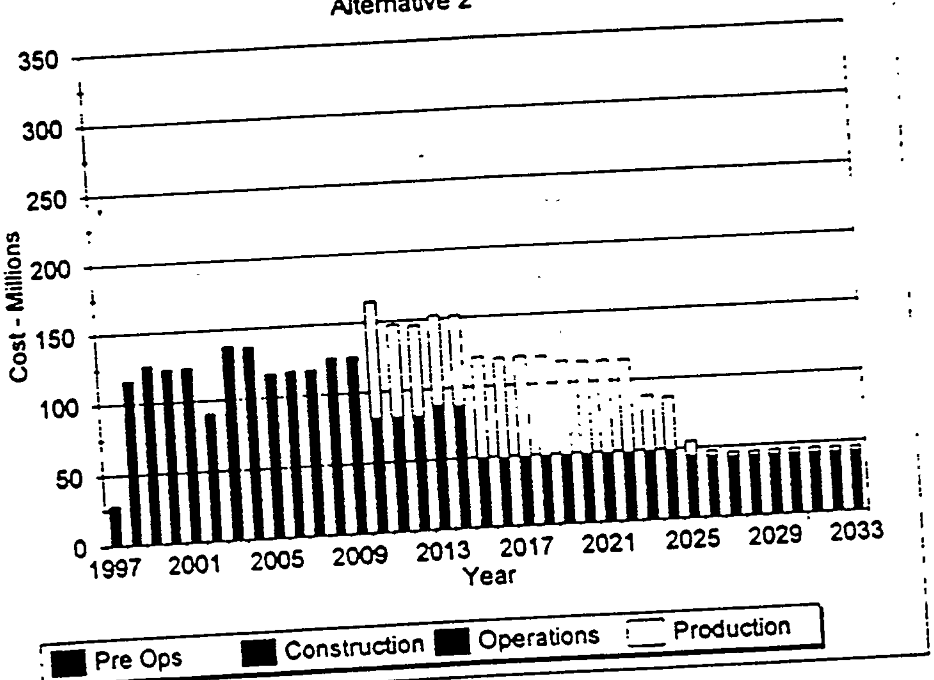


Table 6. RH-TRU Waste Shipping Schedule (cubic meters) - Alternative 2

Year	To WIPP		To Hanford		To ORNL				Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	5	0	0	0	0	0	0	0
2001	0	0	5	0	0	0	0	0	0	0
2002	0	0	5	3	9	2	1	0	0	0
2003	0	0	6	3	9	3	1	0	0	0
2004	0	0	5	3	10	3	2	0	0	0
2005	0	0	6	3	10	2	1	0	0	0
2006	0	0	5	3	10	3	2	0	0	0
2007	0	0	6	3	10	3	1	0	0	0
2008	0	0	5	3	9	2	2	0	0	0
2009	0	0	6	3	5	3	1	0	0	0
2010	593	0	5	3	0	3	2	2	593	593
2011	468	0	5	3	0	3	2	0	468	1061
2012	468	0	6	3	0	2	1	0	468	1529
2013	468	0	5	3	0	3	2	0	468	1997
2014	468	0	6	3	0	3	1	0	468	2465
2015	364	72	5	3	0	2	2	0	436	2901
2016	249	204	6	3	0	3	1	0	453	3354
2017	239	237	5	3	0	3	2	0	476	3830
2018	229	231	5	3	0	3	1	0	460	4290
2019	229	240	6	3	0	2	2	0	469	4759
2020	333	162	5	3	0	3	1	0	495	5254
2021	395	73	6	3	0	3	2	0	468	5722
2022	395	71	5	3	0	3	1	0	466	6188
2023	405	71	6	3	0	2	2	0	476	6664
2024	385	68	5	3	0	3	1	0	453	7117
2025	62	12	5	3	0	3	2	0	74	7191
2026	0	0	6	3	0	2	1	0	0	7191
2027	0	0	5	3	0	3	2	0	0	7191
2028	0	0	6	3	0	3	1	0	0	7191
2029	0	0	5	3	0	3	2	0	0	7191
2030	0	0	6	3	0	2	1	0	0	7191
2031	0	0	5	3	0	2	2	0	0	7191
2032	0	0	5	3	0	2	1	0	0	7191
2033	0	0	4	2	0	2	2	0	0	7191
Totals	5750	1441	182	95	72	84	48	2	7191	

Note: Differences between the totals shown in this table and those discussed in the text and contained in other tables in the report represent waste processed but not shipped.

Alternative 3 The results of Alternative 3 are presented in Figures 16 through 19, and the calculated work-off schedule is given in Table 7. This Alternative yields a waste work-off schedule that is nearly identical to Alternative 2, because the treatment plant is assumed to operate similarly. Thus, this Alternative can dispose of all 7080 m^3 allowed, but the impacts of delayed RH-TRU shipments to WIPP must be considered. The analysis suggests that Alternative 3 would cost less than Alternative 1, but more than Alternative 2. The principal cost difference between Alternative 3 and the other options is the expense associated with the LDR treatment. A secondary cost factor was the elimination of the RH-72B casks and canisters.

Figure 16. Cumulative Waste Disposed
Alternative 3

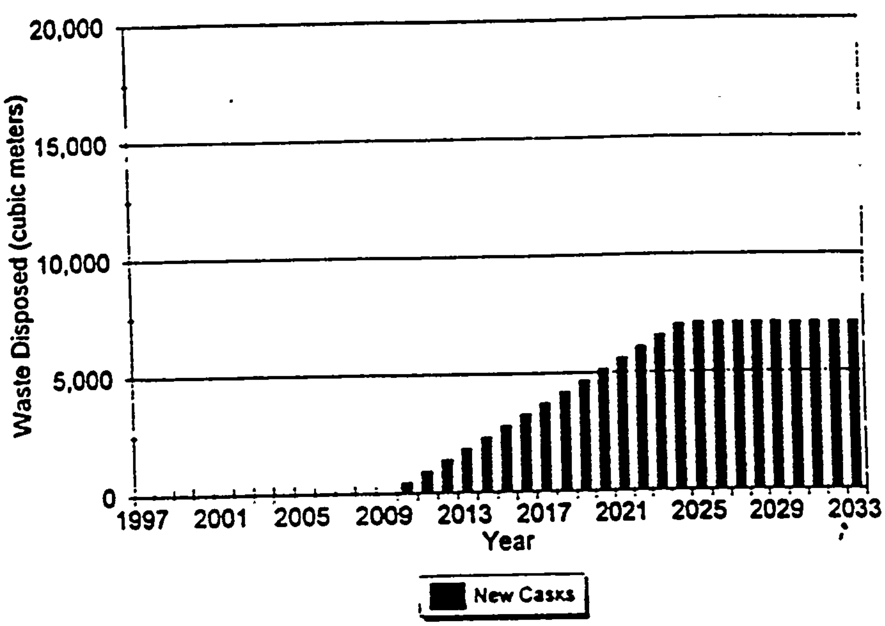


Figure 17. Annual Waste Disposed
Alternative 3

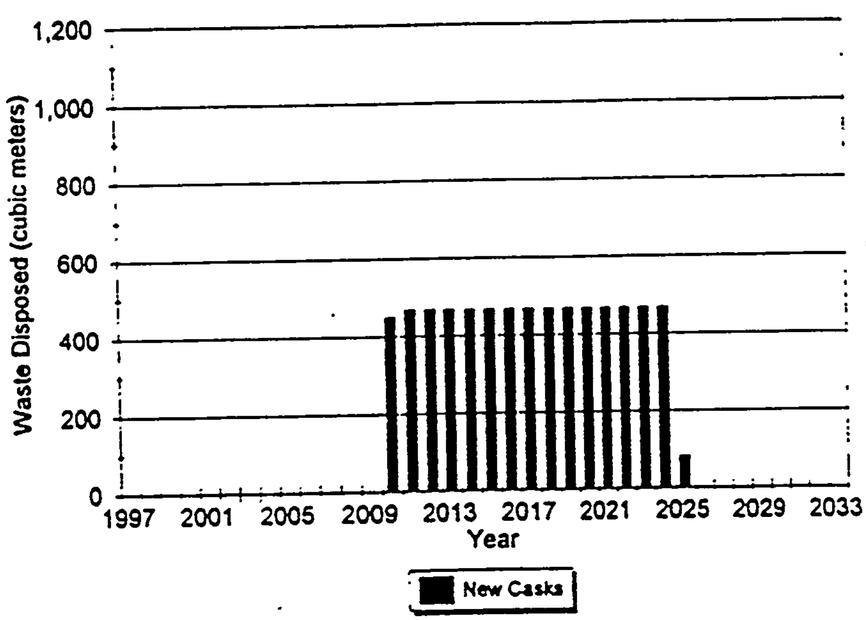


Figure 18. Cost Components
Alternative 3

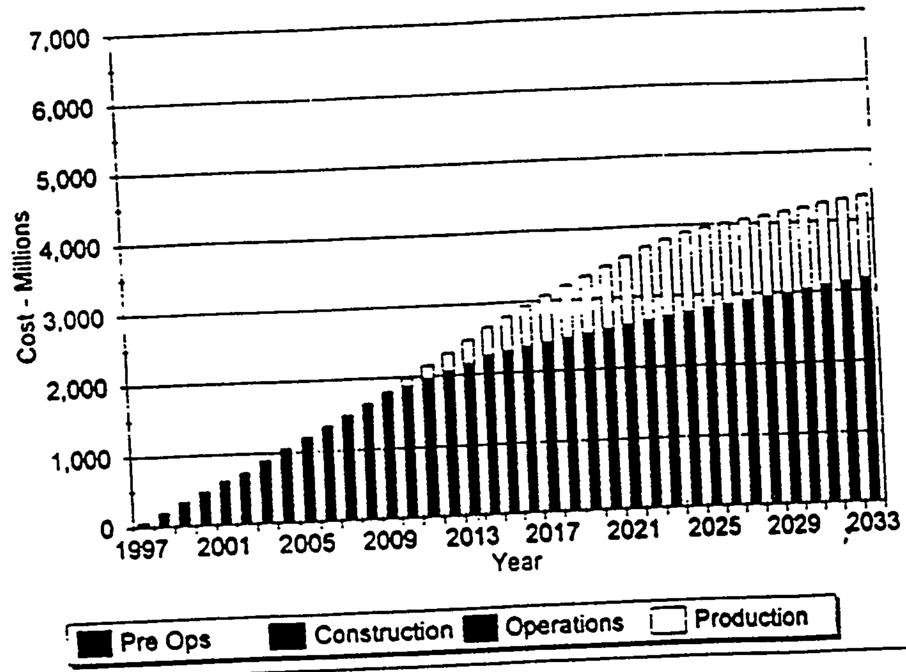


Figure 19. Annual Costs
Alternative 3

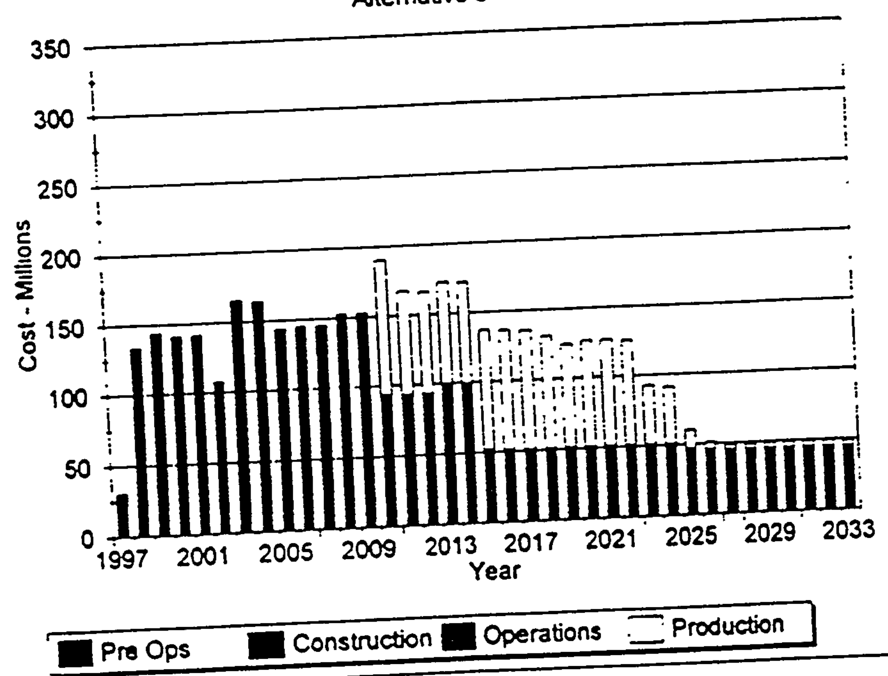


Table 7. RH-TRU Waste Shipping Schedule (cubic meters) - Alternative 3

Year	To WIPP		To Hanford		To ORNL				Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	5	0	0	0	0	0	0	0
2001	0	0	5	0	0	0	0	0	0	0
2002	0	0	5	3	9	2	1	0	0	0
2003	0	0	6	3	9	3	1	0	0	0
2004	0	0	5	3	10	3	2	0	0	0
2005	0	0	6	3	10	2	1	0	0	0
2006	0	0	5	3	10	3	2	0	0	0
2007	0	0	6	3	10	3	1	0	0	0
2008	0	0	5	3	9	2	2	0	0	0
2009	0	0	6	3	5	3	1	0	0	0
2010	593	0	5	3	0	3	2	2	593	593
2011	468	0	5	3	0	3	2	0	488	1061
2012	468	0	6	3	0	2	1	0	468	1529
2013	468	0	5	3	0	3	2	0	468	1997
2014	468	0	6	3	0	3	1	0	468	2465
2015	353	77	5	3	0	2	2	0	430	2895
2016	239	229	6	3	0	3	1	0	468	3363
2017	208	255	5	3	0	3	2	0	463	3826
2018	198	266	5	3	0	3	1	0	464	4290
2019	249	230	6	3	0	2	2	0	479	4769
2020	385	90	5	3	0	3	1	0	475	5244
2021	405	72	6	3	0	3	2	0	477	5721
2022	385	70	5	3	0	3	1	0	455	6176
2023	416	72	6	3	0	2	2	0	488	6664
2024	385	68	5	3	0	3	1	0	453	7117
2025	83	12	5	3	0	3	2	0	95	7212
2026	0	0	6	3	0	2	1	0	0	7212
2027	0	0	5	3	0	3	2	0	0	7212
2028	0	0	6	3	0	3	1	0	0	7212
2029	0	0	5	3	0	3	2	0	0	7212
2030	0	0	6	3	0	2	1	0	0	7212
2031	0	0	5	3	0	2	2	0	0	7212
2032	0	0	5	3	0	2	1	0	0	7212
2033	0	0	4	2	0	2	2	0	0	7212
Totals	5771	1441	182	95	72	84	48	2	7212	

Note: Differences between the totals shown in this table and those discussed in the text and contained in other tables in the report represent waste processed but not shipped.

Alternative 4 The results of Alternative 4 are presented in Figures 20 through 23, and the calculated work-off schedule is given in Table 8. This Alternative yields a greater volume of RH-TRU waste removed from the sites than any of the alternatives analyzed. The RH-TRU limit of 7,080 m^3 is achieved and an additional 9,748 m^3 is packaged in shielded drums and disposed at WIPP. The total cost of this alternative is high, but the unit cost is lowest of all options considered. A large part of the cost is associated with the shielded drums and their shipping and disposal.

Figure 20. Cumulative Waste Disposed
Alternative 4

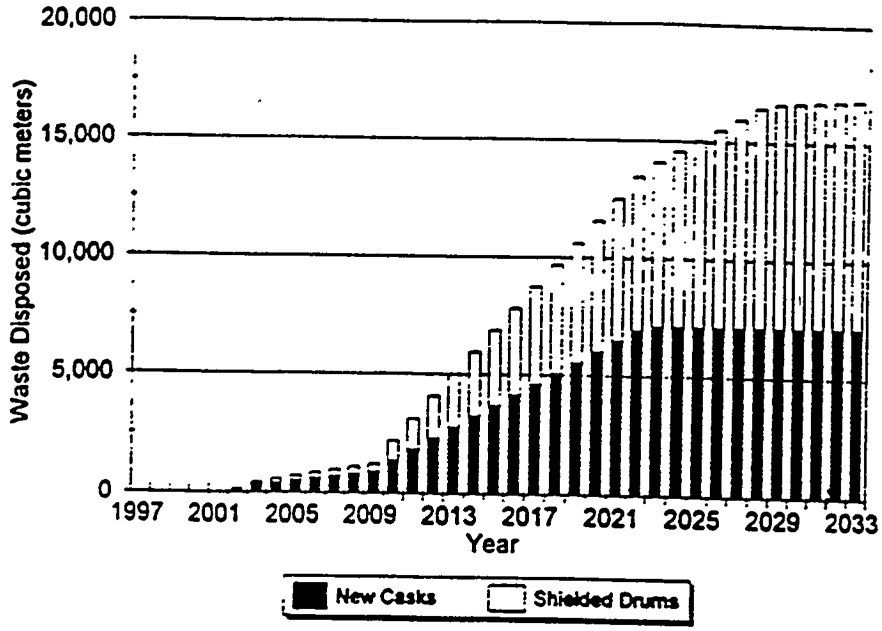


Figure 21. Annual Waste Disposed
Alternative 4

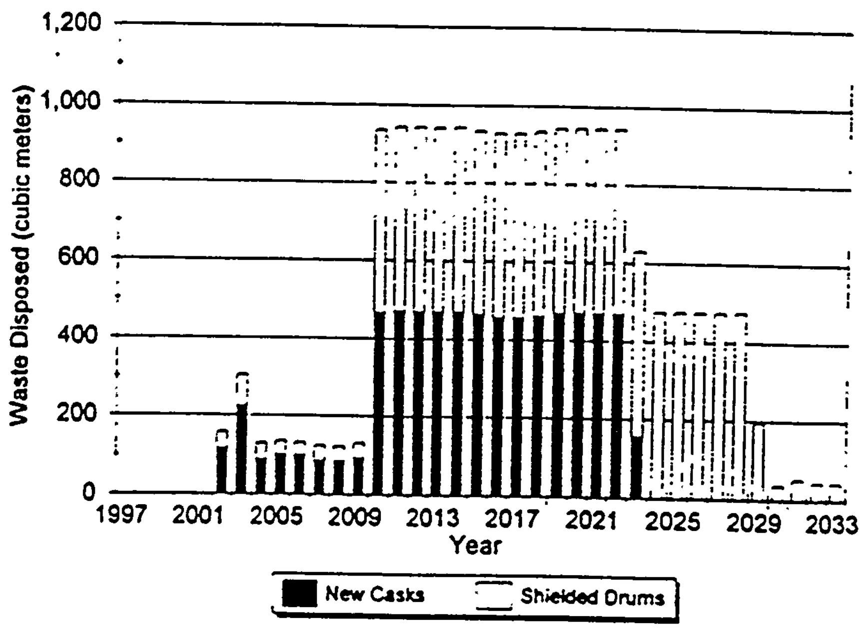


Figure 22. Cost Components
Alternative 4

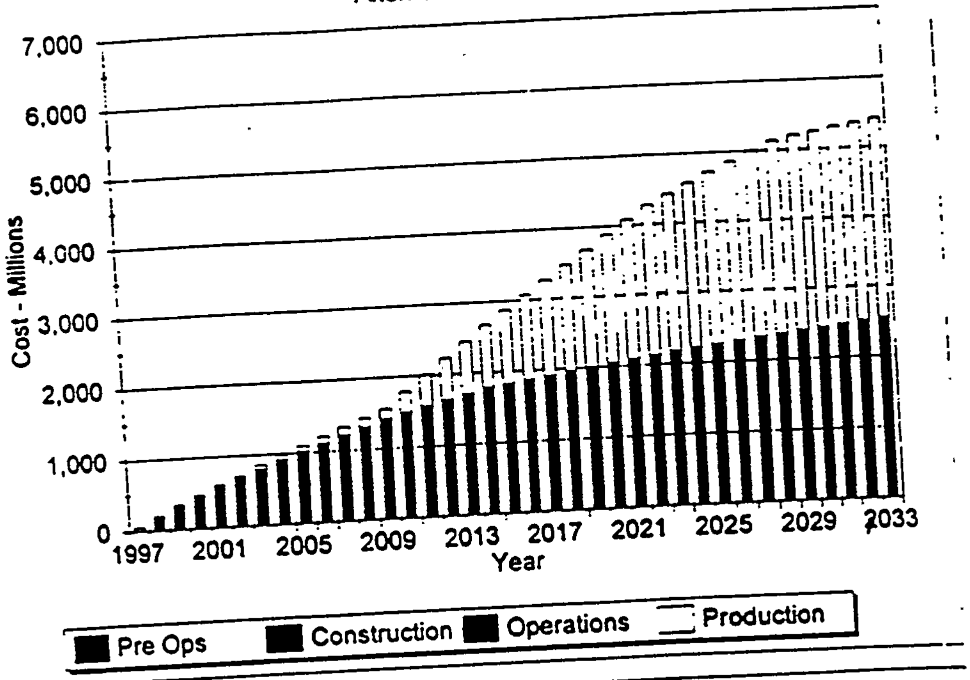


Figure 23. Annual Costs
Alternative 4

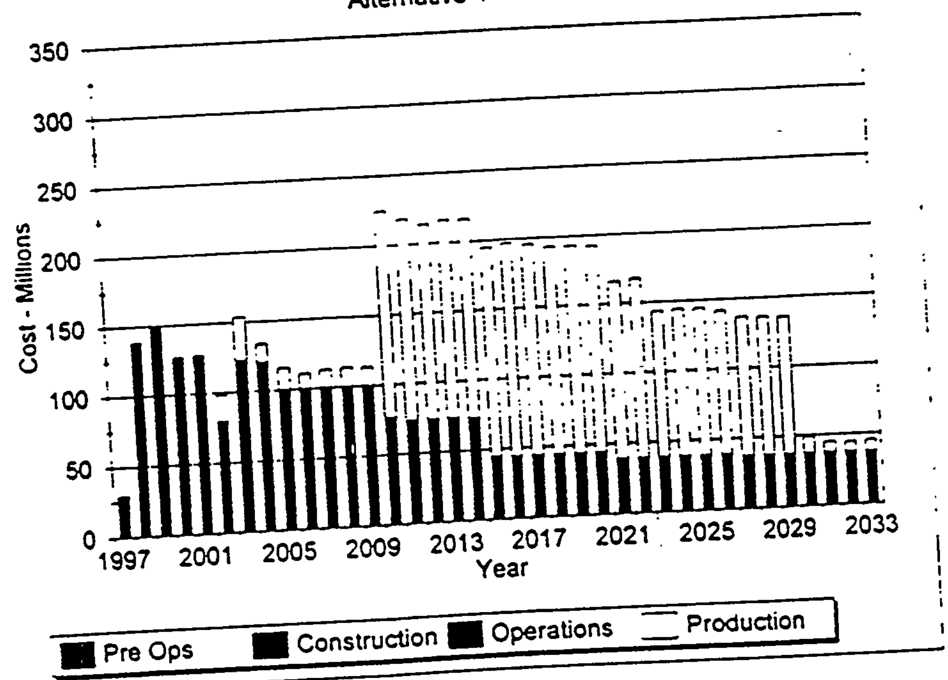


Table 8. RH-TRU Waste Shipping Schedule (cubic meters) - Alternative 4

Year	To WIPP								Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0
2002	0	126	32	0	0	0	0	0	158	158
2003	196	33	11	18	22	18	5	2	305	463
2004	69	34	6	5	11	3	2	0	130	593
2005	76	34	5	6	11	2	2	0	136	729
2006	73	34	6	6	11	2	1	0	133	862
2007	74	33	5	6	6	2	1	0	127	989
2008	71	34	5	6	5	2	1	0	124	1,113
2009	78	34	5	6	5	3	2	0	133	1,246
2010	908	32	5	5	0	2	1	0	953	2,199
2011	896	34	6	1	0	3	2	0	942	3,141
2012	904	33	5	1	0	2	1	0	946	4,087
2013	897	33	5	0	0	2	2	0	939	5,026
2014	918	21	5	1	0	2	1	0	948	5,974
2015	811	93	6	0	0	3	2	0	915	6,889
2016	829	97	5	1	0	2	2	0	936	7,825
2017	825	97	5	1	0	3	1	0	932	8,757
2018	828	96	5	2	0	2	1	0	934	9,691
2019	863	67	5	3	0	2	2	0	942	10,633
2020	870	67	5	1	0	2	1	0	946	11,579
2021	863	66	6	3	0	2	1	0	941	12,520
2022	867	66	5	1	0	3	2	0	944	13,464
2023	586	35	2	2	0	1	1	0	627	14,091
2024	454	20	1	1	0	1	0	0	477	14,568
2025	451	21	2	0	0	1	0	0	475	15,043
2026	466	12	1	0	0	0	0	0	479	15,522
2027	469	4	1	0	0	1	0	0	475	15,997
2028	463	4	2	1	0	1	0	0	471	16,468
2029	181	4	1	0	0	1	1	0	188	16,656
2030	33	5	1	0	0	1	1	0	41	16,697
2031	45	4	1	1	0	1	0	0	52	16,749
2032	39	4	1	0	0	1	1	0	46	16,795
2033	39	4	1	0	0	1	0	0	45	16,840
Totals	15,142	1,281	157	78	71	72	37	2	16,840	

Alternative 5 The results of Alternative 5 are presented in Figures 24 through 27, and the calculated work-off schedule is given in Table 9. This Alternative yields a waste shipping schedule that is nearly identical to that of Alternative 4. The slight difference is the result of the assumed LDR treatment requirement for Alternative 5. Because the RH-TRU waste must be treated to LDR at a regional treatment plant, no waste is packaged at the sites into shielded drums. Any waste that is non-mixed and can be sent directly from the sites to WIPP is assumed to be packaged into the new design packaging. Thus, no shielded drum waste is shipped until 2010 when the first regional plant begins operation. The total cost of Alternative 5 is the highest, about 15% higher than Alternative 4 and about 45% higher than the Design Basis. The unit cost of waste disposed, however is very good; nearly as low as Alternatives 1 and 4. The largest component of the cost is that associated with the large regional LDR treatment facilities.

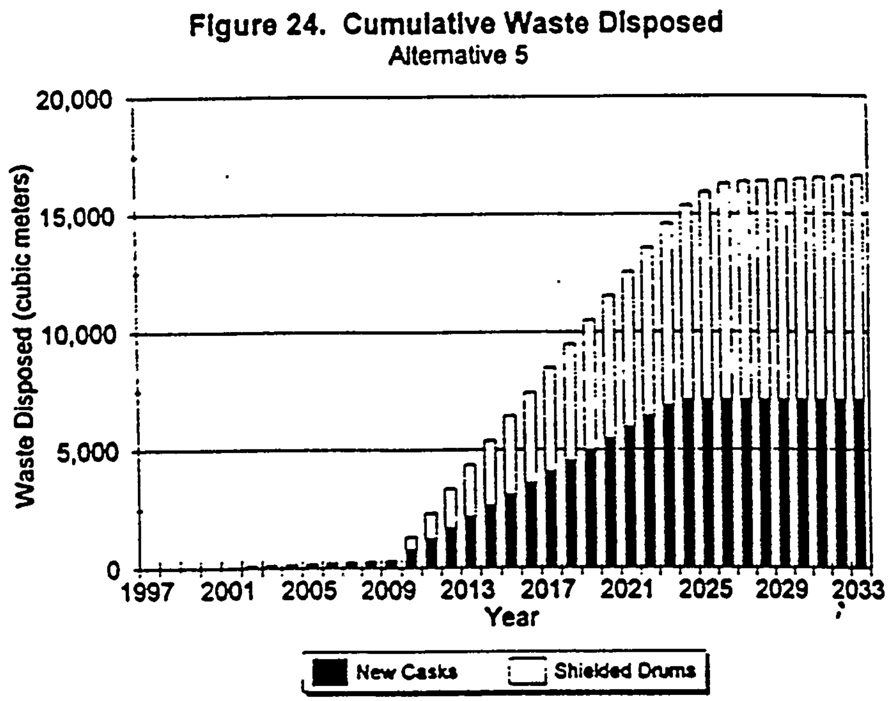


Figure 24. Cumulative Waste Disposed
Alternative 5
Waste Disposed (cubic meters)
20,000
15,000
10,000
5,000
0
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
Year
New Casks
Shielded Drums

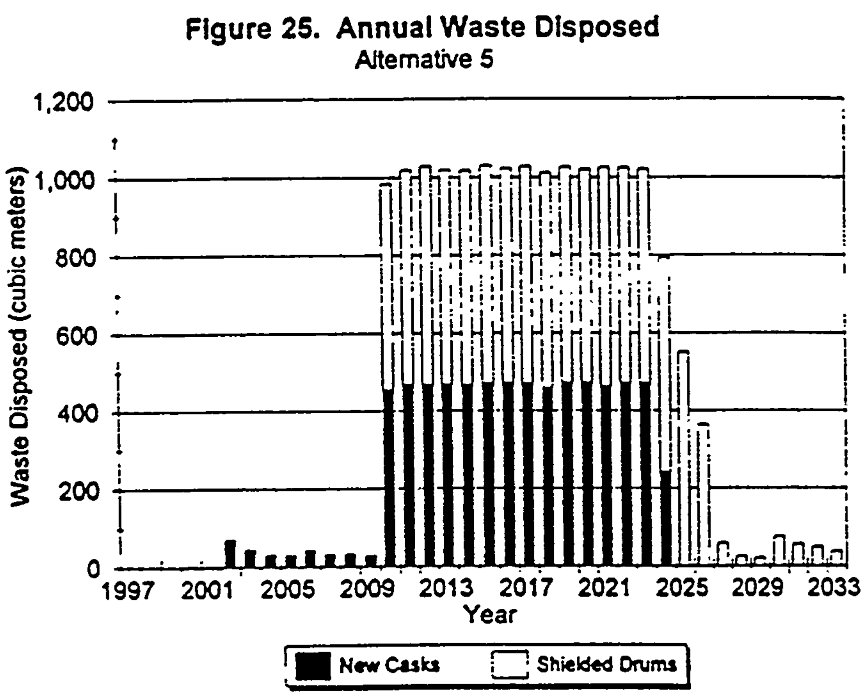


Figure 25. Annual Waste Disposed
Alternative 5
Waste Disposed (cubic meters)
1,200
1,000
800
600
400
200
0
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
Year
New Casks
Shielded Drums

Figure 26. Cost Components
Alternative 5

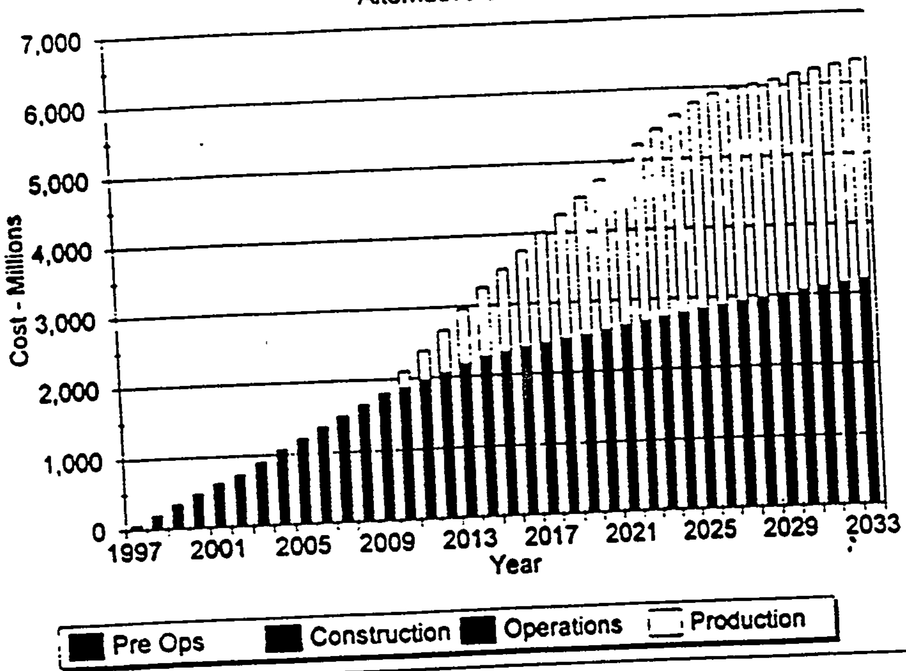


Figure 27. Annual Costs
Alternative 5

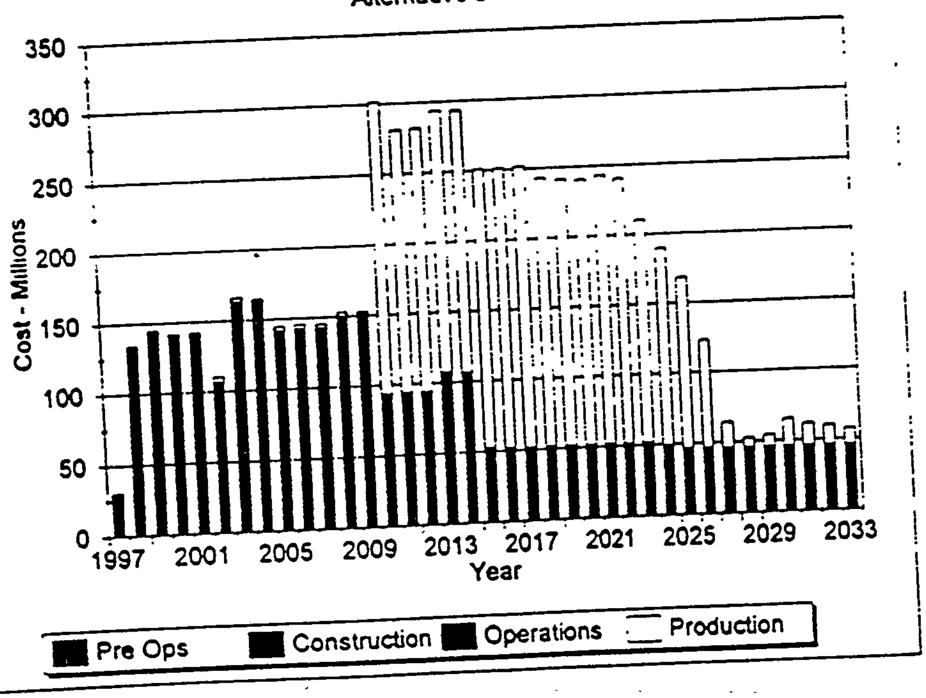


Table 9. RH-TRU Waste Shipping Schedule (cubic meters) - Alternative 5

Year	To WIPP		To Hanford		To ORNL				Totals to WIPP	
	Hanford	ORNL	LANL	INEL/ ANL-W	BCLDP	SRS	KAPL	Bettis	Annual Total	Cumulative Total
2000	0	0	5	0	0	0	0	0	0	0
2001	0	0	5	0	0	0	0	0	0	0
2002	17	10	5	3	9	2	1	0	27	27
2003	12	2	6	3	9	3	1	2	14	41
2004	8	3	5	3	10	3	2	0	11	52
2005	8	2	6	3	10	2	1	0	10	62
2006	12	2	5	3	10	3	2	0	14	76
2007	8	2	6	3	10	3	1	0	10	86
2008	8	4	5	3	9	2	2	0	12	98
2009	8	2	6	3	5	3	1	0	10	108
2010	1,216	2	5	3	0	3	2	0	1,218	1,326
2011	1,008	3	5	3	0	3	2	0	1,011	2,337
2012	998	3	6	3	0	2	1	0	1,001	3,338
2013	1,029	3	5	3	0	3	2	0	1,032	4,370
2014	1,008	1	6	3	0	3	1	0	1,009	5,379
2015	821	101	5	3	0	2	2	0	922	6,301
2016	759	272	6	3	0	3	1	0	1,031	7,332
2017	769	256	5	3	0	3	2	0	1,025	8,357
2018	852	231	5	3	0	3	1	0	1,083	9,440
2019	925	80	6	3	0	2	2	0	1,005	10,445
2020	936	67	5	3	0	3	1	0	1,003	11,448
2021	946	72	6	3	0	3	2	0	1,018	12,466
2022	946	70	5	3	0	3	1	0	1,016	13,482
2023	967	65	6	3	0	2	2	0	1,032	14,514
2024	759	42	5	3	0	3	1	0	801	15,315
2025	520	23	3	2	0	3	1	0	543	15,858
2026	270	18	4	2	0	2	1	0	288	16,146
2027	62	8	4	2	0	3	1	0	70	16,216
2028	10	5	5	3	0	3	1	0	15	16,231
2029	21	1	5	3	0	3	1	0	22	16,253
2030	73	3	6	2	0	2	1	0	76	16,329
2031	52	5	5	2	0	1	1	0	57	16,386
2032	42	8	4	3	0	2	1	0	50	16,436
2033	31	7	3	2	0	2	1	0	38	16,474
Totals	15,101	1,373	174	90	72	83	43	2	16,474	

6.0 SUMMARY OF RESULTS

Comparisons of total system costs over the operating life of WIPP and volume of waste disposed for the Design Basis and the five alternatives are presented in Figures 28 and 29. It is clear that all alternatives offer an improvement to RH-TRU waste management over the Design Basis, because each of the alternatives can each dispose much more stored and projected waste than the Design Basis

Although there is a large uncertainty associated with the absolute cost estimates determined in this evaluation, relative cost comparisons can be useful and informative. Therefore, selection of a preferred option should not be based on these numbers alone. Figure 30 compares the unit costs for all the Design Basis and all Alternatives. Since Alternatives 1 and 4 both have very low unit costs, the decision to use shielded drums to enhance DOE's RH-TRU waste management plans seems to be appropriate.. A remaining uncertainty in the analyses results is the ability of WIPP to accommodate the new design packaging in the manner assumed in the system simulation. The availability of sufficient wall space or other emplacement method should be verified through more thorough analysis and WIPP design evaluations. Additionally, the assumption that shielded drums can be managed at WIPP with no adverse operational impact should be further evaluated before shielded drums are selected as an option.

The analysis suggests that a better alternative might be created by improving the design and payload of the shielded drum package. If each shielded drum could contain more than the 0.03 m^3 as assumed for the current analysis, a lower cost and more efficient RH-TRU waste management option might be created. By initiating RH-TRU waste disposal in WIPP using Alternative 4 and later (about 2010) replacing the 0.03 m^3 shielded package with, for example, an 83-gallon size package that shields 0.05 m^3 of RH-TRU waste, total system costs could be lowered and the total amount of RH-TRU waste removed from the generator sites could be increased while maintaining RH-TRU emplacement operations continuous from 2002 to 2033. The benefits of this hybrid alternative could be determined by further analysis.

Additional details about the analysis methodology and the results of the analyses are given in Attachment A: Simulating the Waste Management System.

Figure 28. Total Costs

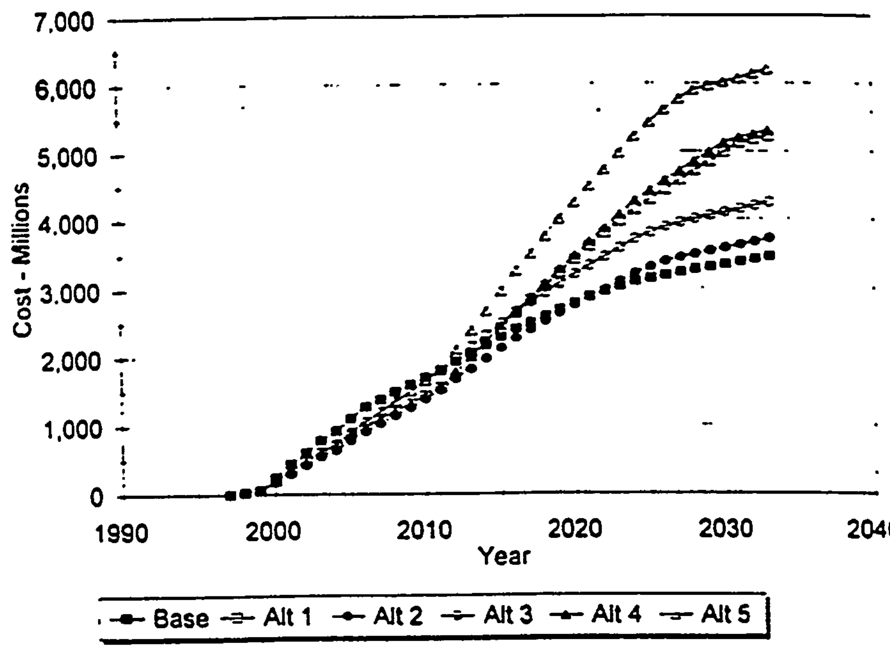


Figure 29. Total Waste Disposed

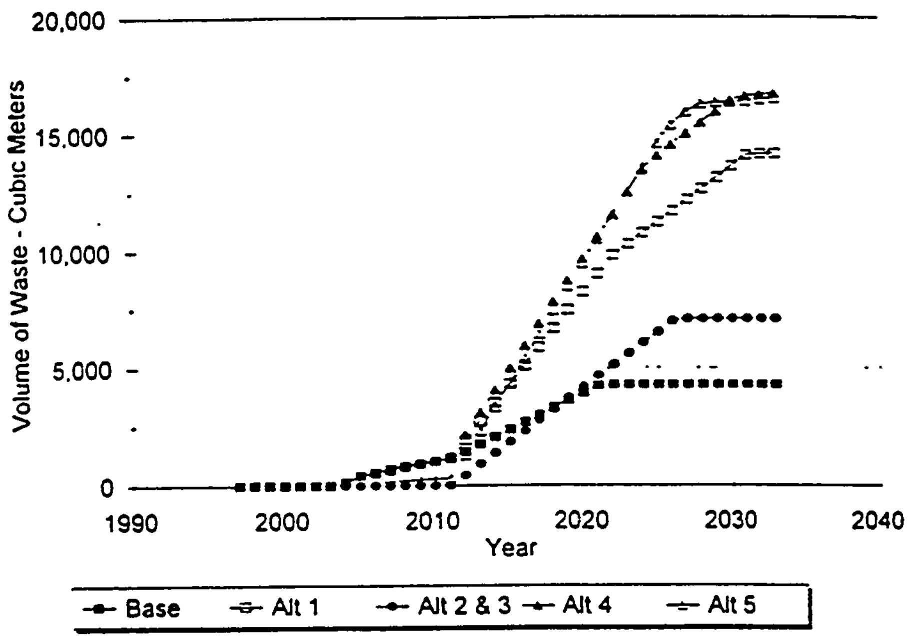
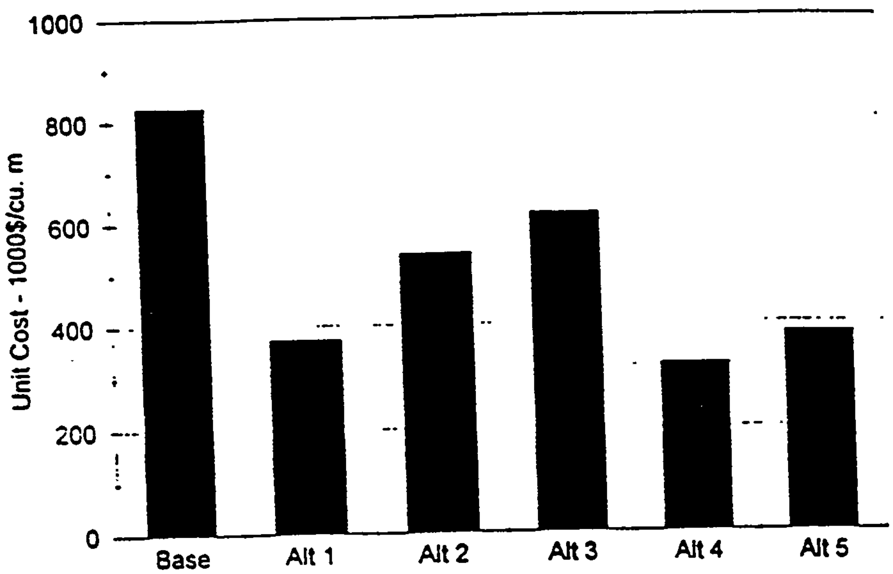


Figure 30. Unit Cost of Disposal



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2. "Overview of Proposed Site Treatment Plans (PSTPs)," U. S. DOE, March 31,1995.

3. "Estimating the Cold War Mortgage - The 1995 Baseline Environmental Management Report (BEMR)," U. S. DOE Office of Environmental Management, DOE/EM-0232, March 1995.

4. "Remote Handled TRU Waste Disposal Alternatives," Appendix F, DOE/CAO-95-1143, Volume 2, November 1995.

5. "Remote Handled TRU Waste Packaging and Transportation Study," Appendix E, DOE/CAO-95-1143, Volume 2, November 1995.

6. "Waste Acceptance Criteria for the Waste Isolation Pilot Plant," WIPP/DOE-069 Revision 4, December 1991.

7. "Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report," CAO-94-1005 Revision 1., February 1995.

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9. "Waste Isolation Pilot Plant Remote-Handled Transuranic Waste Disposal Strategy," DOE/WIPP-95-1090, March 31, 1995.

10. "Interim Report: Waste Management Facilities Cost Information for Transuranic Waste," EGG-WM-11274, June 1994.

11. Department of Energy and The State of New Mexico, *Agreement for Consultation and Cooperation on the WIPP*, Update April 18, 1988.

ATTACHMENT A

Simulating the RH Waste Management System

ATTACHMENT A: SIMULATING THE RH WASTE MANAGEMENT SYSTEM

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Acronyms

ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
BCLDP	Battelle Columbus Laboratory Decommissioning Project
BIR	Baseline Inventory Report
CH	contact handled
D&D	decontamination and decommissioning
DOE	Department of Energy
INEL	Idaho National Engineering Laboratory
KAPL	Knolls Atomic Power Laboratory
LANL	Los Alamos National Laboratory
LDR	land disposal restriction
LLW	low-level waste
ORNL	Oak Ridge National Laboratory
ProModel	Production Modeler
R&D	research and development
RH	remote handled
SRS	Savannah River Site
SNL	Sandia National Laboratories
TPF	TRU Processing Facility
TRU	transuranic
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant

Attachment A
Simulating the RH Waste Management System

A1.0 Introduction

The remote handled (RH) waste management system proposed by the U.S. Department of Energy (DOE) was simulated using a computer model to provide information needed to support the RH Alternatives Analysis. Six different treatment scenarios--a Baseline and five Alternatives--were evaluated using a variety of shipping methods. The RH system was simulated using a model developed jointly by the Sandia National Laboratories, New Mexico (SNL), and Los Alamos Technical Associates, Inc. Some of the capabilities of the model and how it was utilized in the RH analysis, as well as the RH scenarios analyzed, are briefly discussed in this section. A detailed description of the model is presented in Section A2.0.

A1.1 Summary of Model Capabilities

The System Simulation model consists of three parts: input data, the simulation program, and output data. The heart of the model is a commercially available simulation software system, Production Modeler (ProModel). The simulation program is written in the language provided by that system. Input to the simulation program is provided by a series of ASCII (text) files that can be edited by a word processor. By using this technique, no major software support is required unless the system configuration needs to be changed. For the RH system, the input information was generated by a spreadsheet-driven program that created the ASCII input files and served as the front-end of the model. Program output is in the form of numeric tables and graphics. Output data are incremented annually so that evaluation can be based on both annual and total values. The following paragraphs summarize the kinds of output data available and how these data were utilized for the RH Alternatives Analysis.

Costs

The simulation program as configured is capable of compiling fixed costs in five different categories. Each category may be defined by the user and can be either one-time costs or annual costs. Operating costs for processing waste are compiled by the simulation program in the following four categories: cost for storage on a per unit-volume-hour basis; processing costs per unit-volume; processing costs per hour; and processing labor costs per hour. Because of the way costs are incremented by the simulation program, it is possible to project annual funding requirements by facility, by site, and by program over the desired time segment.

Dose and Risk
While the simulation program is capable of summing dose and evaluating risk, this feature was not used in the RH analysis reported. This information can be added at a later time.

Volume of Waste Generated and Processed
The simulation program increments the volume of waste passing through the system in much the same way that costs are incremented so that annual and total waste volumes can be compiled. For the RH analysis, two sources of waste were identified: waste generated prior to the start year, referred to as stored waste; and waste generated during the time period studied, referred to as projected waste or newly generated waste.

Volume Changes During Processing
The simulation program is capable of creating or destroying waste during processing in order to simulate actual treatment processes. For the RH analysis, it was assumed that no volume changes occurred during processing. Information on volume change during processing can also be added at a later date.

Shipping and Disposal
As presently configured, the simulation program can accommodate as many as three different shipping and disposal options each with a different shipping rate and/or rate of disposal at the Waste Isolation Pilot Plant (WIPP). All three were utilized in the RH analysis.

A1.2 RH Analysis Scenarios

The six scenarios that were modeled for the RH analysis were designated as Baseline, Alternative 1, Alternative 2, Alternative 3, Alternative 4, and Alternative 5. Table A-1 summarizes the key features of each RH scenario. A more detailed description is given in the paragraphs that follow the table.

Table A-1. RH Waste Management Scenarios Modeled

Scenario	Treatment Location	Treatment Option	Transport Method	Packaging and Disposal
Baseline	Decentralized	WIPP WAC	Truck to WIPP	RH-72B
Alternative 1	Decentralized	WIPP WAC	Truck to WIPP	RH-72B and Shielded Drum
Alternative 2	Regional	Reduced Gas Generation	Truck to Regional Train to WIPP	New Design Packaging
Alternative 3	Regional	LDR	Truck to Regional Train to WIPP	New Design Packaging
Alternative 4	Decentralized	WIPP WAC	Truck to WIPP	New Design Packaging and Shielded Drum
Alternative 5	Decentralized	WIPP WAC	Truck to Regional	New Design Packaging
	Regional	LDR	Train to WIPP	New Design Packaging and Shielded Drum

LDR: land disposal restriction WAC: waste acceptance criteria

Design Basis

In the Baseline, scenario shipments to WIPP were assumed to start in 2002. All sites were assumed to initially use existing facilities to treat their RH waste for certification and shipment to WIPP. Treatment in existing facilities was limited to basic repackaging operations (open, dump, sort, repack, certify, and ship) to meet WIPP WAC. At a few sites (Hanford, Oak Ridge National Laboratory (ORNL), and Argonne National Laboratory-West (ANL-W)) a fraction of the waste was assumed to be liquid or sludge requiring special treatment such as evaporation/solidification. Two new major treatment facilities are included in the Baseline modeled, a transuranic (TRU) waste treatment plant at Hanford and the TRU Processing Facility (TPF) at

ORNL. Treatment in the new plants at Hanford and ORNL was assumed to include liquid waste treatment. Liquid waste at ANL-W was assumed to be treated on-site in existing facilities. All shipments to WIPP were assumed to be in RH-72B casks. Transport to WIPP was assumed to be by truck, one RH-72B cask and canister to a truck. The WIPP emplacement configuration for RH-72B canisters and the space available in 2002, when RH shipments start, limit the total RH TRU waste volume that can be disposed to 4280 cubic meters and limit the RH waste throughput rate to 350 canisters per year, so these limits were used in the Baseline. RH disposal operations were assumed to continue until the end of 2026, when disposal operations for RH-72B canisters must end, or when the 4280 m^3 limit was reached, whichever occurred first.

Alternative 1

The first alternative modeled was identical to the Baseline except that in addition to RH-72B canisters, shielded drums were used for packaging 30% of the RH waste. The use of shielded drums has the potential to increase the total amount of RH TRU waste removed from the sites and disposed in WIPP because the shielded drums can be disposed as contact handled (CH) waste. Shielded drums were assumed to be the same size as a standard 55-gallon drum with a capacity of one-seventh of a standard drum. It was assumed that the shielded drums would be transported in a new packaging design called HalfPack that could hold seven drums. Because of weight limitations, the number of shielded drums that could be transported in 3 HalfPacks was assumed to be 10 shielded drums of RH waste and 11 drums of CH waste. The cost associated with implementation of shielded drums is included in the input to the simulation program. The cost for disposal of a shielded drum was assumed to be the same as for a CH drum. It was also assumed that all waste packaged in shielded drums could be disposed at WIPP until the end of 2033. The cost used for RH-72B casks and canisters was the same as the Baseline. The throughput rate at WIPP for RH-72B canisters was the same as used in the Baseline (350 per year) with identical limits on total volume (4280 cubic meters) and cut-off date (end of 2026).

Alternative 2

The second alternative provides regional plants at Hanford and ORNL to treat all waste for reduced gas generation. In addition to aqueous waste treatment, a shred and grout process is provided. The shred and grout process is expected to reduce the rate at which the waste will decompose in the repository, thus reducing the gas generation rate. In addition, all waste is assumed to be packaged in the new design packaging constructed of a non-corroding or special material, resulting in greatly reduced gas generation rates in the repository. In Alternative 2, the RH-72B canister-cask system is replaced with the new design packaging. The dimensions and capacity of the new packaging were assumed to be the same as a standard 55-gallon drum. The throughput at WIPP for the new design packaging system was assumed to be 50% faster than the RH-72B system, i.e, 50% more RH waste could be emplaced in a year than in the Baseline scenario. The volume limit at WIPP was assumed to be the regulatory limit, 7080 cubic meters, and the cut-off limit was assumed to be the end of 2033, the same as for CH waste. The reason that these limits were raised is that the smaller drums can be emplaced in drift walls as well as in room walls. The cost of development and implementation of the new design packaging system is included in the evaluation, as well as any cost and time savings realized over the life of RH disposal operations. Alternative 2 assumed combined truck and rail shipment to WIPP. Trucks are used to ship waste from each site to the regional plants, two casks to a truck, and rail is used only from the regional plants to WIPP, five casks to a train. The treatment plants were assumed to be sized for the RH waste inventory estimates in the Baseline and an operating life of at least 10 years. Since the treatment plants are not available until 2010 or later, no RH TRU waste is sent to WIPP until 2010.

Alternative 3

The third alternative modeled was identical to Alternative 2 except it was assumed that all RH waste would be treated to meet LDR standards. The treatment process is assumed to be vitrification, or other robust process with similar cost (e.g., a combination of incineration, neutralization, deactivation, and shredding). Aqueous treatment was also assumed to be required with residues from the treatment receiving the same robust treatment as the rest of the waste. Waste was assumed to be processed and shipped to the regional plants in the same manner as for Alternative 2. After treatment the waste was assumed to be packaged in the same manner described in Alternative 2 and shipped and disposed in an identically. The treatment plant size was assumed to be the same as in Alternative 2. As with Alternative 2, this scenario results in delayed RH disposal until 2010.

Alternative 4

This alternative, a variation on Alternative 1, is intended to increase the total volume of RH waste disposed, if possible, to the 7080 cubic meters limit. All assumptions are the same as for Alternative 1, except the package/shipping system is the new design packaging system described in Alternative 2. RH waste is processed at each site to meet the WIPP WAC and shipped by truck to WIPP. In this scenario, the waste is packaged in either the new design packaging or in shielded drums. Thus, waste can be packaged and shipped early (i.e., in 2002) and a higher RH waste throughput rate can be achieved at WIPP by replacing the RH-72B system with the new design packaging system.

Alternative 5

The final alternative modeled in this evaluation is similar to Alternative 3 in that it includes LDR treatment of the waste at regional plants, but in this scenario 20% of the waste is assumed to be processed at the sites and shipped to WIPP. This assumption is based on the fact that some of the waste in storage and to be generated is non-mixed waste and can be disposed without LDR treatment. Further, some of the waste can be sorted at the sites while it is being prepared for shipment to the regional treatment plants, and the sorting can generate additional non-mixed waste for shipment to WIPP. The 20% non-mixed waste is assumed to be in the new design packaging and shipped to WIPP from the regional plants beginning in 2002. The remainder of the waste is shipped to the regional plants, treated to LDR, and shipped to WIPP beginning in 2010 in either new design packaging or shielded drums by rail. For shipping shielded drums, each rail shipment was assumed to consist of nine HalfPacks containing 35 shielded RH drums and 28 CH drums.

A2.0 RH Waste Management System Model

The RH Waste Management System Model consists of three major components: the simulation program that is written in ProModel's language, input data made up of ASCII files that are read by the program when it compiles, and the output data. The remainder of this section describes how these elements were configured to make the model.

A2.1 The Simulation Program

The waste management system as configured in the simulation program consist of eleven modules: ten representing generator sites and one representing a disposal site. The number of modules that can be used to make up any waste management system is only limited by computer memory and by run time. For the RH analysis, eight of the generator site modules were used. The eight individual generator sites, each represented as a module, are the Hanford Site, the ORNL, the Los Alamos National Laboratory (LANL), the Idaho National Engineering Laboratory (INEL) and ANL-W combined in one module, Battelle Columbus Laboratory Decommissioning Project (BCLDP), the Savannah River Site (SRS), Knolls Atomic Power Laboratory (KAPL), and Bettis. A module was also identified for Argonne National Laboratory-East (ANL-E) but was not used as no waste was reported at that site in the Baseline Inventory Report (BIR) Rev. 1 (DOE 1995). WIPP represents the disposal module.

Each module in the simulation program contains identical elements that represent facilities as follows:

- Three sources of waste from fixed inventories (i.e., stored waste) designated GN1, GN2, and GN3.

- One source of time-dependent waste arrivals that can vary over ten different time periods. This element is used to represent newly generated waste.

- A waste storage facility designated IS.

- Three processing (e.g., repackaging, characterization, etc.) facilities designated SP1, SP2, and SP3. These can be used as desired.

- Three waste treatment (e.g., shred and grout, vitrification, incineration, etc.) facilities designated TP1, TP2, and TP3. The treatment processes to be used are established by means of the input files and will be described in the next subsection.

- Three packaging loading and unloading facilities designated TL1, TL2, and TL3 and UL1, UL2, and UL3 respectively. This provides a means of shipping and/or receiving waste to or from other sites.

- Five elements, designated Exits, provide the means for waste to leave the system. One is used to represent disposal of low-level waste on-site, designated LLW; three are used to represent on-site TRU waste disposal, designated DS1, DS2, and DS3 (the input files are set up so that these are only active for the WIPP site), and one is used to represent waste that exits the system because of volume reduction achieved by treating waste.

- Provisions are also provided for generating (spawning) waste within any element. This allows volume increases through waste treatment.

Local trucks are used to move waste between elements within a module, and highway or rail packaging is used to move waste between modules.

A2.2 Input File Preparation

For each site module in the RH model, spreadsheet files were created so that site-specific variables could be input, flow of waste through the site could be calculated, process times estimated, and cost data could be calculated. The spreadsheet files thus developed were linked to master files that can provide input common to all sites including cost and schedule data, waste sources and destinations, etc.

One of the master files is a spreadsheet that contains cost data based on information in the EG&G "Interim Report: Waste Management Facilities Cost Information for Transuranic Waste" (Feizollahi and Shropshire, 1994). The cost information in that report is provided as a series of curves for a wide variety of waste processing modules. In order to make the information on the curves more useful, curve fitting techniques were used to convert the information on the curves to equations of the form,

$$y = C_1x^n + C_2 ,$$

where y is cost, x is throughput, and C_1, C_2, and n are constants. Values for the constants are stored in the master spreadsheet file, throughput is calculated within the site spreadsheet, and the link to the master provides the information to calculate the facility costs. The cost information is in turn printed to the proper input file for the simulation program. Specific costs can also be input to override calculated costs. The calculated costs can also be modified by applying a multiplier. Because of the small quantities of RH waste at most of the sites, the calculated throughput may fall below the specified range in the EG&G interim report. In that case, the low limit specified in the report is used. Although realistic, this assumption results in facilities with a much larger capacity than needed with a corresponding high construction cost and high maintenance cost. For example, a sorting hot cell with one operating station might be capable of processing 1000 units of waste a year. If only 10 units a year are to be processed, it is not possible to build a cell with a tenth of an operating station. In these cases, it was assumed that these facilities would only be operated as needed so processing costs are calculated based on actual throughput. Table 1-1 from the EG&G interim report lists the different modules for which costs are provided and the range of throughputs over which the costs are applicable.

Three of the five fixed cost categories available were used in the RH analysis. They were defined as: pre-operation costs (this includes research and development (R&D) costs and construction operating costs) as a one-time cost; capital construction costs as a one-time cost; and facility operation and maintenance costs as an annual cost. Construction operating costs were combined with R&D in order to comply with the cost breakdown in the interim report. Decontamination and decommissioning (known as D&D) costs were not included because it was felt the these costs would be approximately the same for all six cases evaluated. Further, RH waste will continue to be produced at several of the sites even after WIPP ceases operation; therefore, the need to process waste will continue. For the RH analysis, fixed costs and waste processing costs per unit-volume were supplied by the front-end program. The variety of cost categories available made it possible to compare the total cost of the different treatment and shipping scenarios requiring evaluation.

More than 20 input files are required by the simulation model. Many of these only require occasional modification. Ten of the input files, however, are subject to some degree of modification for each alternative analyzed. These ten are created by the spreadsheet program. A list of files so created and their titles follow.

File 01 - Fixed Inventory & Storage/Queue Parameters
File 02 - Facility Production and Cost Data
File 04 - Facility Schedule & Cost Code
File 05 - Entity Destination Information
File 09 - Newly Generated Entity Arrival Data
File 10 - Off-Site Processing
File 13 - Spawn Split Information
File 14 - Site Transport Systems
File 15 - Site-to-Site Mileage
File 0L - Bundle Sizes

A2.3 Output File Interpretation

ProModel produces graphics that can be used directly for analysis and evaluation. However, the ProModel files that are in the form of numeric tables generally need to be processed so that the data can more easily be interpreted. Because of the large amount of detail produced by each simulation, graphic representations and side-by-side comparison of output are the easiest way to evaluate results. Options available include graphics and tabular data produced by a FORTRAN program directly from ProModel tables; and graphics produced by importing ProModel tables from multiple simulations into a spreadsheet for comparison on a single figure or for presentation in tabular form.

A3.0 Summary

The Waste Management System model is a useful tool for simulating the RH TRU waste management system and analyzing and evaluating alternatives. Because the model is designed to operate by using user-supplied input in the form of text files for controlling the simulation program, it can easily be modified to accommodate changes to the alternatives. The model uses a commercially available program for performing simulations. Computer-based systems have been developed for generating input files so that multiple alternatives of complex systems can be simulated. Techniques have also been developed for analyzing output from the model.

The model is a total-system model that simulates and analyzes waste management activities such as generation, retrieval, storage, characterization, treatment, transportation, and disposal. Output data from the model make available both annual and total values. Depending on the input data provided, the output data can include operating and capital costs; radioactive dose and risk; hazardous risk including injuries and deaths; chemical dose and risk; volume of waste disposed, both on-site and off-site; volume reduction achieved by treatment; and number of highway trips and total mileage. This information provides management with the tools required to allocate funding and manpower. More detailed data are also available if needed for complete evaluation.

A4.0 References

U.S. Department of Energy (DOE), "Integrated Data Base for 1993: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics," DOE/RW-0006, Rev. 9, prepared by Oak Ridge National Laboratory for DOE, March 1994.

DOE, "Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report," CAO-94-1005 Revision 1, February 1995.

Feizollahi, Fred and David Shropshire, "Interim Report: Waste Management Facilities Cost Information for Transuranic Waste," EGG-WM-11274, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Published June 1994.

Hand, F.R, and G.W. Barr, "TRU Waste System Models," *Proceedings of 1994 Winter Simulation Conference*, Lake Buena Vista, Florida, December 1994.

Exhibit - ProModel Data Input and Output Files

This Exhibit contains descriptions of Production Modeler (ProModel) files used to model the RH waste management system. A key to understanding the some of the labels used in the files is also included.

AA-1 Sample Input Files

The following are input files for the Baseline - Hanford.

File 01 - Fixed Inventory & Storage/Queue Parameters
File 02 - Facility Production and Cost Data
File 04 - Facility Schedule & Cost Code
File 05 - Entity Destination Information
File 09 - Newly Generated Entity Arrival Data
File 13 - Spawn Split Information

The following are input files for all sites, Baseline.

File 10 - Off-Site Processing
File 14 - Site Transport Systems
File 13 - Spawn Split Information
File 15 - Site-to-Site Mileage
File 0L - Bundle Sizes

AA-2 Key to ProModel Files

Year numbers and equivalent calendar year:

Year #	Cal.	#	Cal.	#	Cal.	#	Cal.
0	1995	10	2005	20	2015	30	2025
1	1996	11	2006	21	2016	31	2026
2	1997	12	2007	22	2017	32	2027
3	1998	13	2008	23	2018	33	2028
4	1999	14	2009	24	2019	34	2029
5	2000	15	2010	25	2020	35	2030
6	2001	16	2011	26	2021	36	2031
7	2002	17	2012	27	2022	37	2032
8	2003	18	2013	28	2023	38	2033
9	2004	19	2014	29	2024		

Site numbers and name:

1	WIPP	6	BCLDP
2	Hanford	7	SRS
3	ORNL	8	ANL-E
4	LANL	9	KAPL
5	INEL/ANL-W	10	Bettis

Facility numbers, designation, and description:

1	GN1	Existing Retrieval Facilities
2	GN2	New Retrieval Facilities
3	GN3	Other Retrieval
4	SP1	Special Processing 1
5	SP2	Special Processing 2
6	SP3	Special Processing 3
7	TP1	Existing Treatment Facilities
8	TP2	New Treatment Facilities
9	TP3	Special Treatment Facilities
10	IS	Storage Facilities
11	TL1	Transport Loading 1
12	TL2	Transport Loading 2
13	TL3	Transport Loading 3
14	LLW	Low Level Waste Disposal
15	DS1	WIPP Disposal 1

16	DS2	WIPP Disposal 2
17	DS3	WIPP Disposal 3
18	UL1	Transporter Unloading 1
19	UL2	Transporter Unloading 2
20	UL3	Transporter Unloading 3
21	LT	Local Truck
22	HT1	Transporter 1
23	HT2	Transporter 2
24	HT3	Transporter 3
25	AD	Administration Facilities

REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX E

Packaging and Transportation Study

DOE/CAO-95-1143
Volume 2

November 1995

U. S. Department of Energy
Carlsbad Area Office
National TRU Program

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Packaging and Transportation Study

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for managing the disposition of transuranic (TRU) waste resulting from nuclear weapons production activities of the United States. This waste is temporarily stored nationwide at several of the DOE's waste generating/storage sites. The goal is to eliminate interim waste storage and achieve environmentally and institutionally acceptable permanent disposal of TRU waste.

Transuranic waste is waste contaminated with alpha-emitting radionuclides with an atomic number greater than 92 and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram. Remote-handled (RH) TRU waste is packaged TRU waste whose external surface dose rate exceeds 200 millirem per hour (mrem/hr). For the Waste Isolation Pilot Plant (WIPP), there is an upper limit of 1,000 rem per hour (rem/hr). Contact-handled (CH) TRU waste is waste whose external surface dose rate does not exceed 200 mrem/hr. DOE 5820.2A, Radioactive Waste Management, defines TRU waste and allows the heads of DOE field offices to classify other wastes that must be managed as TRU waste.

The mission of the WIPP as established by Congress in 1979 (Public Law 96-164) is to provide "...a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission." Authorized solely as a defense research and development facility by Congress, the WIPP will receive stored and newly-generated defense TRU waste. The regulated capacity of the WIPP is 175,584 m^3 (6.2 million ft^3) of waste as cited by the Land Withdrawal Act (Public Law 102-579). Of this amount, up to 7,080 m^3 (250,000 ft^3) may be RH TRU waste.

Safety, economy, reliability, and efficiency are the primary goals of any system for packaging and transporting RH TRU waste to the WIPP. The system must also comply with applicable regulatory requirements while supporting the DOE's National TRU Program. At WIPP, a surface facility is available for unloading incoming shipping containers. An underground mined area is provided for the permanent disposal of RH and CH TRU waste. The disposal area is located 650 meters (2,150 ft) below the surface in a bedded salt formation. The WIPP site provides the equipment to emplace a RH TRU package in the underground disposal area.

1.1 Purpose

This report presents the results of a detailed assessment of RH TRU waste packaging and transportation (P&T) alternatives and recommends the most cost-, schedule-, and safe-effective RH TRU waste P&T alternatives. The alternatives were included in this study on the basis of their potential to optimize RH TRU waste P&T. Also included are the current requirements used as key parameters to establish the logic of the decision-making process. All alternatives examined are consistent with currently planned facility operations and with the DOE mandate to meet requirements for conducting P&T operations in a technically sound, economical, and safe manner. None of the alternatives were eliminated as impossible to implement. They were ranked as the best-to-least choice likely to meet the goals of optimizing RH TRU P&T.

This assessment of the RH TRU waste P&T is part of the DOE's strategy for sustained disposal as described in the WIPP Remote-Handled Transuranic Waste Disposal Strategy. It considers the waste P&T capability to comply with all applicable regulatory requirements and supports the DOE's National TRU Program.

As used in this report, "packaging" is defined in accordance with 10 CFR 71.4: *"Packaging means the assembly of components necessary to ensure compliance with the packaging requirements of this part. ...The vehicle, tie-down system and auxiliary equipment may be designated as part of the packaging."* A "package" as defined by 10 CFR 71.4 is *the packaging together with its radioactive contents as presented for transport.* In the following sections, vehicle tie-downs and auxiliary equipment are included as part of the packaging.

RH TRU waste containers will meet the structural requirements and design conditions for Department of Transportation (DOT) Type A packaging. Past experience in the TRU waste program has shown that Type A packaging provides adequate assurance of worker health and safety under the normal conditions of waste package handling and storage. Type A packaging could be a shielded drum, canister (design basis package), 3.8 liter (1-gallon) can, or some new configuration. From a P&T perspective, there is little difference between what model of Type A packaging is transported. However, to the generator or WIPP, Type A packaging may have significant impacts on handling, risk, cost, or throughput. The reusable shipping containers used to transport RH TRU waste to the WIPP will meet the requirements of NRC-certified Type B packaging. Type B packaging could be a road cask, such as the RH-72B cask (design basis) or a TRUPACT-II.

The latest inventory data shows existing RH TRU waste at nine sites (see Table 1). Argonne National Laboratory-West (ANL-W) has been combined with the Idaho National Engineering Laboratory (INEL) for packaging and transportation purposes. Four of the identified sites do not have rail transportation directly available. Bettis (BT), Knolls Atomic Power Laboratory (KAPL), Los Alamos National Laboratory (LANL), and Battelle Columbus Decommissioning Project (BCLDP) all have various distances on public roads that must be traveled to get to rail transportation. The other RH TRU waste sites have both truck and rail access.

The following table is the amount of waste used for calculating transportation costs for the different alternatives. The table is based on the information from CAO-94-1005, Revision 1, dated February 1995, Table 6-2: *Remote Handled Transuranic Waste Disposal Inventory by*

Site (DOE,1995). This document contains the most current information on the RH TRU waste inventory. To convert cubic meters to cubic feet divide by 0.02832.

Table 1. Estimated Volumes of RH TRU Waste Shipped From Each Generator

Generator Site	Currently Available Waste in Cubic Meters	Total Projected Volumes to Ship in Cubic Meters
INEL combined with ANL-W (Idaho)	39.7	84.0
Hanford	33.0	3000 (5299.4[1])
LANL (Los Alamos)	91.0	174.0
ORNL (Oak Ridge)	990.0	1350.0
Other Generators		
BCLDP (Battelle)	0.0	71.0
BT (Bettis)	0.0	1.6
KAPL (Knolls)	11.0	36.0
SRS (Savannah River)	0.0	64.0
Current Projected + Stored		4780.6
TOTALS	1164.7	7080[2]

[1] Currently, the projected amount of RH TRU waste is less than the design limit of 7,080^{3}m . The amount of waste necessary to make up the difference was all assumed to come from the Hanford Site.
[2] WIPP is currently authorized by the C and C (DOE,1987), and FSEIS (DOE,1990) to dispose of 7,080 m^3.

1.2 Packaging and Transportation Scope

The RH TRU waste P&T alternatives in this study are evaluated against the proposed RH-72B cask and associated canister. The RH-72B cask and canister are therefore referred to as the design basis case. In addition, the schedule and rates outlined in the *WIPP Disposal Decision Plan* (DOE, 1995b) are assumed as part of the design basis. Treatment of the waste form is not discussed in this study. Figure 1 tabulates the types and permutations of alternatives. The matrix has two sections: one for the packaging and one for the transportation.

NRC-CERTIFIED TYPE B PACKAGING	DOT-CERTIFIED TYPE A WASTE PACKAGING	
	SHIELDED PACKAGING	UNSHIELDED PACKAGING
SHIELDED PACKAGING (e.g.,RH-72B)	X	X
UNSHIELDED PACKAGING (e.g.,TRUPACT-II)	X	N/A[1]

NRC-CERTIFIED TYPE B PACKAGING	MODE of TRANSPORTATION	
	TRUCK	RAIL
SHIELDED PACKAGING (e.g., RH-72B)	X	X
UNSHIELDED PACKAGING (e.g.,TRUPACT-II)	X	X

[1] To meet the transportation surface dose rate limits, either the container or package must be shielded.

Figure 1. RH TRU Waste Packaging & Transportation Alternatives

Assumptions were necessary in the development of P&T alternatives. The assumptions are as follows:

- The system must be capable of transporting 7,080 m^3 (250,000 ft^3) of RH TRU waste. This is the largest amount of RH TRU waste that can be disposed of at the WIPP per current agreements.

- The volume of RH TRU waste transported is assumed to be 7,080 m^3 (250,000 ft^3). This is the current design limit specified in the Final Supplement Environmental Impact Statement (FSEIS) (DOE, 1990) and state of New Mexico *Agreement for Consultation and Cooperation* (DOE, 1987). Volume of the emplaced package is not considered.

- A waste package is assumed to be full of waste; partially filled volumes are not contemplated.

- Some truck capability is required because not all sites have rail capability.

- Table 2 and 3 are assumed schedules of where and when waste becomes available. Two different operational periods were assumed. A 25-year schedule and a 35-year schedule are assumed.

- Waste is certified to the approved Waste Acceptance Criteria (WAC). Waste certified to the approved WAC meets the WIPP disposal requirements for the waste form.

- For a normal road shipment, the gross vehicle weight must not exceed 36,288 kilograms (80,000 lbs). No special road permits are required. For trucks with gross vehicle weights greater than 36,288 kg (80,000 lbs), special road permits are required.

- Unless otherwise noted, packaging is assumed to be transportable by truck or rail. With rail, a minimum of three packages was assumed to be transported per shipment. The size of rail shipments is limited only by the amount of packaging available and the ability to handle the waste at both the generator and WIPP.

Table 2. 25-Year Waste Receipt Period Schedule

Shipment Dates	Site	Number of Shipments per Year	Remarks
Year 1	LANL	66	Truck
Year 2	LANL ORNL	25 (total of 168) 143	Truck, w/Rail possible from ORNL
Year 3	ORNL	264	Truck or Rail
Year 5	ORNL INEL	348	Truck or Rail
Year 6	INEL ORNL HANFORD	85 (total of 348) 113 150	Truck or Rail
Year 7-23	Combination of all sites: ORNL,INEL, SRS,HANFORD, KAPL,BCLDP,BT, LANL	348	Truck and Rail (not all of the waste is currently available)
Year 24	HANFORD	264	Truck or Rail
Year 25	HANFORD	233	Truck or Rail
Total		**7,955**	

Note: The schedule for small-quantity generator sites could be moved forward if they have adequate facilities to characterize and package the waste. It is assumed that each shipment is 0.89 m^3 (31 ft^3) of waste. This is the volume of the RH-72B. Use of rail should result in a greater volume of waste shipped per shipment. The total number of shipments would be between 4,000 and 7,955. The schedule emplaces 7,080 m^3 (250,000 ft^3). Schedule/Work-off plan would be revised annually.

Table 3. 35-Year Waste Receipt Period Schedule

Shipment Dates	Site	Number of Shipments	Remarks
Year 1	LANL	30	Truck
Year 2	LANL	125	Truck
Year 3	ORNL	150	Rail Available
Year 4	ORNL	150	Truck or Rail
Year 5	ORNL	200	Truck or Rail
Year 6-35	Combination of all generator sites: ORNL,INEL,SRS, KAPL,BT,BCLDP, HANFORD,LANL	250 per year	Truck required from some sites; Rail could be used from larger sites
Total		**7,955**	

Note: The schedule for small-quantity generators could be moved forward if they have adequate facilities to characterize and package the waste. It is assumed that each shipment is 0.89 m^3 (31 ft^3) of waste. Use of rail should result in a greater volume of waste shipped per shipment. The total number of shipments would be between 4,000 and 7,955. Schedules/Work-off plans would be revised annually.

The transportation cost data are taken from DOE/WIPP 93-058, *Comparative Study Waste Isolation Pilot Plant (WIPP) Transportation Alternatives* (DOE, 1994b), and EGG-WM-10877, Revision 1, *Waste Management Facilities Cost Information for Transportation of Radioactive and Hazardous Materials* (DOE 1994c). Table 4 contains the data used for mileage and cost. Life-cycle costs were based on the per trip costs along with the various stated assumptions. This study does not look at any alternatives other than shipping waste certified for long-term disposal to WIPP. The approved WAC will be used to determine the waste forms which can be stored at WIPP. The use of the above information was deemed appropriate because it is the information that will be referenced in the RCRA Part B disposal permit application, which will be initially submitted 6/95. Once the permit application is submitted, changes cannot be submitted until a permit is issued/approved approximately 12/97.

Table 4. Transportation Input Table

Generator Site	One-way Mileage to or from WIPP[1] by Truck	Round-trip Transportation Cost per Shipment Rail[2]	Round-trip Transportation Cost per Shipment Truck[3]
ANL-E	1,478 miles	$26,234	$8,163
BT(Bettis)	1,596 miles	N/A[4]	$9,800
Hanford	1,753 miles	$44,966	$9,649
INEL and ANL-W	1,336 miles	$31,522	$7,441
KAPL(Knolls)	2,230 miles	N/A	$9,700
LANL	394 miles	N/A	$2,469
ORNL	1,543 miles	$25,568	$8,389
SRS	1,807 miles	$30,561[5]	$9,755
BCLDP (Battelle)	1,608 miles	N/A	$9,800

[1] Mileage numbers came from EEG-WM-10877, Revision 1, September 1994.
[2] Rail cost data taken from Table 7-5, "Class Rates for Regular Train Service," using three RH-72B casks per rail shipment, DOE/WIPP 93-058, February 1994.
[3] Cost data for truck come from Table 7-2, DOE/WIPP 93-058, February 1994, "Truck Contract Shipment Costs for Round Trip to Each Site." Where specific data were not in the table, data were extrapolated based on mileage.
[4] N/A was put in some rail costs due to the facility not having direct rail available. Shipments must be transported by truck to a commercial rail head. To change miles to kilometers divide by 0.6214.
[5] Cost data are for CH TRU waste shipments by rail. RH TRU waste data were not calculated due to lack of RH TRU waste inventory.

This report looked at two operational periods: 25 years and 35 years. Due to the CH and RH TRU waste disposal starting at different times, the actual RH TRU waste emplacement is 35 years. Any change on the operational life of the WIPP has little impact on the packaging and transportation system. If throughput is distributed over 35 years, the required fleet size can be reduced, and development of new packaging could be deferred. Additional equipment replacement cycles and maintenance would be encountered. RCRA Part B permits have renewal cycles of ten years and Nuclear Regulatory Commission (NRC) Certificates of Compliance (C of C's) are renewable on five-year cycles. The renewals provide scheduled opportunities for changes.

2.0 PACKAGING AND TRANSPORTATION REQUIREMENTS

Shipping and packaging must meet all the requirements of federal laws and numerous commitments made to the state and local governments by the DOE. Attachment A is a summary of the existing requirements directly related to packaging and transportation. In addition, for the waste to be properly disposed of at the WIPP, the waste must be certified to meet the requirements established in the various disposal permits. In some cases those limits may be more restrictive than the requirements for shipping the waste. Alternatives requiring major changes to the Land Withdrawal Act and other laws were not developed due to the complexities and uncertainties in the political arena. The requirements can be broken down into several major categories as follows:

- Requirements affecting the packaging and its design,
- Requirements that impact the waste form for shipping and transportation,
- Requirements specified by approved permits or agreements, and
- Requirements imposed on transportation.

The major requirement imposed on packaging is the use of a NRC-certified Type B packaging. For certified Type B packaging, the NRC issues a C of C. The C of C specifies the user requirements and the authorized contents for the packaging. To demonstrate compliance with a NRC C of C, there is a minimum amount of knowledge that must be known about the waste form. For example, the PU^{239} fissile gram equivalents, decay heat, hydrogen gas generation rates, and isotopic composition must be known.

3.0 WASTE INVENTORY REQUIREMENTS

The ability of the generator sites to furnish certified waste is one of the major variables. Currently, the design basis scenario requires that the RH TRU waste be emplaced at WIPP prior to the CH TRU waste or the storage capability is irrecoverably lost. CH TRU waste receipt begins in 1998 and ramps up until full throughput is realized. A five-year ramp-up is currently planned. The result is approximately 850,000 208 liter (55-gal) drum equivalents of waste to be emplaced.[1] This results in a need for between 178.0-311.5 m^3 (6285-11,000 ft^3) (200-350 design basis canisters) of RH TRU waste per year when full throughput is realized. If the RH TRU waste shipped is less than this amount, storage capability using the approved design basis in the underground at the WIPP is lost. As of this writing there is no RH TRU waste certified for

[1] 175,584 cubic meters (6.2 million cubic feet) minus the 7,080 cubic meters (250,000 cubic feet) for RH TRU waste.

disposal at the WIPP.[2] The waste must undergo some type of characterization before compliance with the transportation and disposal requirements can be demonstrated. The waste inventory must also be packaged. Most of the existing inventory is not packaged. Shipping requirements for the waste form are specified in NRC-approved certificates of compliance (C of C's) for the container being used. NRC shipping and WIPP storage requirements for the waste are consolidated under the WIPP's waste acceptance criteria (WAC). The WAC, Rev. 4 (DOE, 1991) combines both the WIPP/DOE criteria and NRC C of C requirements.

The first RH TRU waste is assumed to come from Los Alamos and/or Oak Ridge National Laboratory (ORNL). ORNL has the largest inventory of stored RH TRU wastes. The bulk of the waste at ORNL is in the form of a sludge that must be treated in some manner and packaged. ORNL had identified a budgetary line item project to accomplish this. The ORNL treatment facility is scheduled for operation sometime after 2005. ORNL also is evaluating the possibility of using an existing facility. Los Alamos has a hot cell that is available for characterizing and packaging RH TRU waste. The other sites with RH TRU waste have not identified facilities where packaging and characterization activities will take place.

Small quantity generators could be accommodated by the P & T system in the work-off schedule at any time. However, a site must be able to characterize and package the waste as required. The use of mobile characterization and treatment systems is being studied. Details should be available in 1996. If treatment of the waste form is required before the waste can be disposed of at WIPP, the challenge becomes finding NRC-certified Type B packaging. In order to move waste to a treatment facility the generator must be able to demonstrate compliance with a NRC C of C, which requires some level of characterization at the generator site. Attachment B is a list of items required in most NRC C of C's.

4.0 PACKAGING

For the purpose of this study, packaging was grouped into several major categories. Only representative containers in these categories were evaluated. The categories were based upon what type of payload container the WIPP would emplace. Containers could be used to transport large canisters, small canisters, drums, small cans (1-gal), shielded DOT Type A packages, or a new configuration. Within the different categories there were normally several possible packaging selections.

4.1 Alternative Packaging

Several resources were used to develop the list of potential casks for use at the WIPP. First,

[2] LANL has approximately 16 canisters that were certified to an earlier revision of the WAC.

RAMPAC, an acronym for Radioactive Materials Packages, a database maintained for DOE by Analysas Corporation, was searched. This database has approximately 2000 certified packagings listed. The database allows the use of various criteria to do searches. Secondly, using various trade magazines, a list of potential suppliers or users of packaging was developed, and a telephone survey was conducted to identify packaging not previously identified. The survey helped identify packaging under development that is not certified. Lastly, NUREG-0383, Vol 1-3, Revision 17, *Directory of Certificates of Compliance for Licensed Containers* (NRC, 1994), was searched to identify any packaging that may not have been listed.

Several commercially available casks which are in the shielded packaging category of the matrix, Figure 1, were identified. Currently, not all the casks have double containment. Those casks without double containment would be limited to 20 curies of Plutonium or need a modification. The modification in most cases would be a liner that provides another layer of containment. Companies expressed a willingness to process changes to the NRC C of C's and modify existing designs to accommodate RH TRU waste. For brevity, not all the possibilities are listed. The packaging that fit P&T system needs the closest were chosen for further evaluation. The majority of the casks were designed for spent fuel. To transport all the various forms of RH TRU waste, most would require changes to their NRC C of C's. Some of the alternative packaging can transport a portion of the RH TRU waste inventory today. One cask in the special permit[3] area was evaluated, and no rail-only packaging was considered. Rail-only packaging could only be used at five of the nine generator sites having RH TRU waste. Therefore, no rail-only packaging was evaluated. To meet all P & T system requirements, packaging must be transportable by truck. Attachment C shows some of the vendor data available.

New packaging is under development by several companies and should be certified and available prior to RH TRU waste receipt. Assuming a manufacturer has the tooling in place and the packaging has an approved NRC C of C, at least one year should be allowed from the time a manufacturer is given a release to build the packaging until required delivery. The schedules in Figures 2 through 5 show schedules for normal and expedited packaging development and delivery.

[3]The special permit refers to the need to have a special permit when transported by truck. The packaging plus the tractor and the trailer exceeds 36,288 kg (80,000 lbs). The special permits add additional restrictions and requirements. The rules applicable to special road permits vary by state.

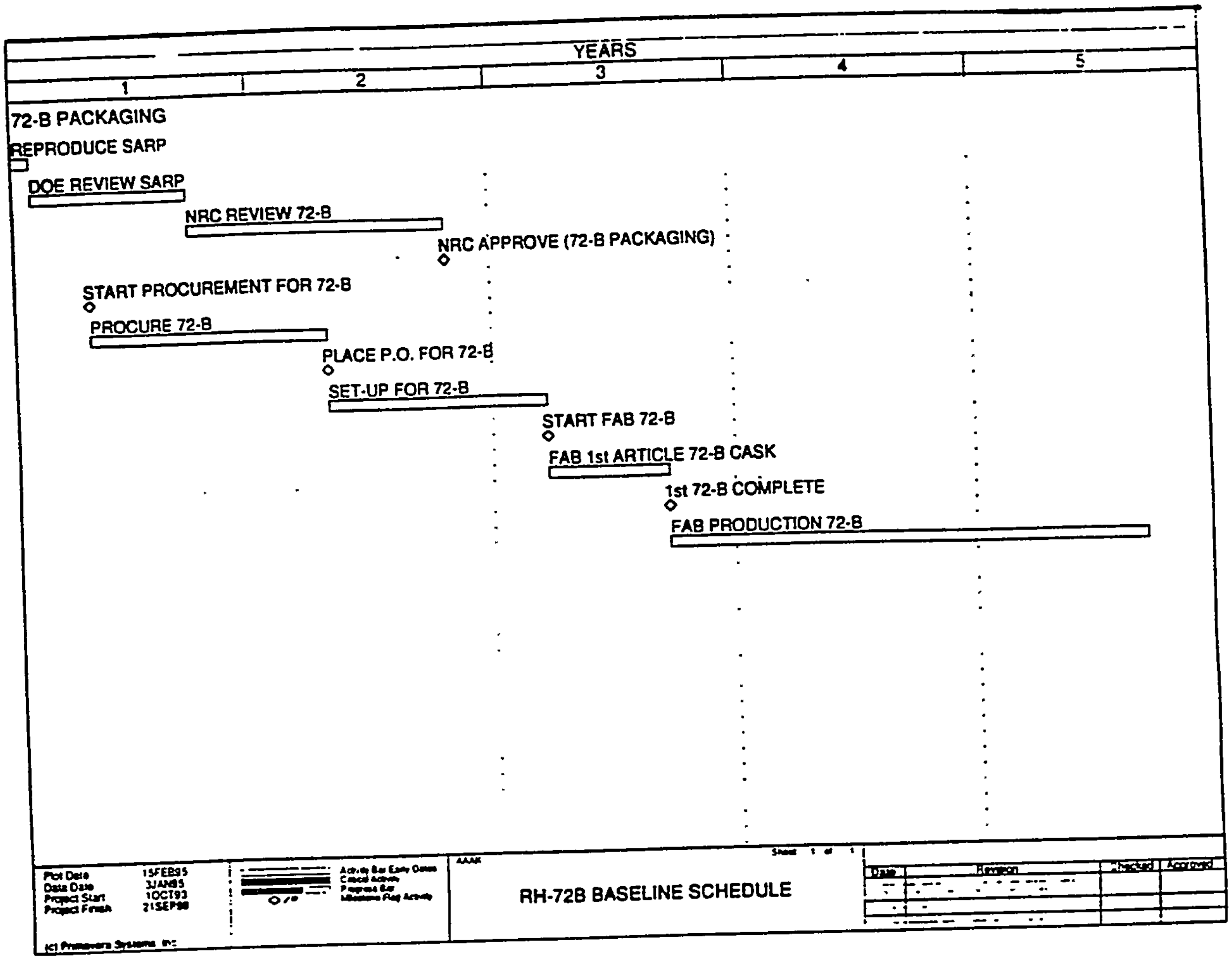

Figure 2. RH-72B Design Basis Schedule

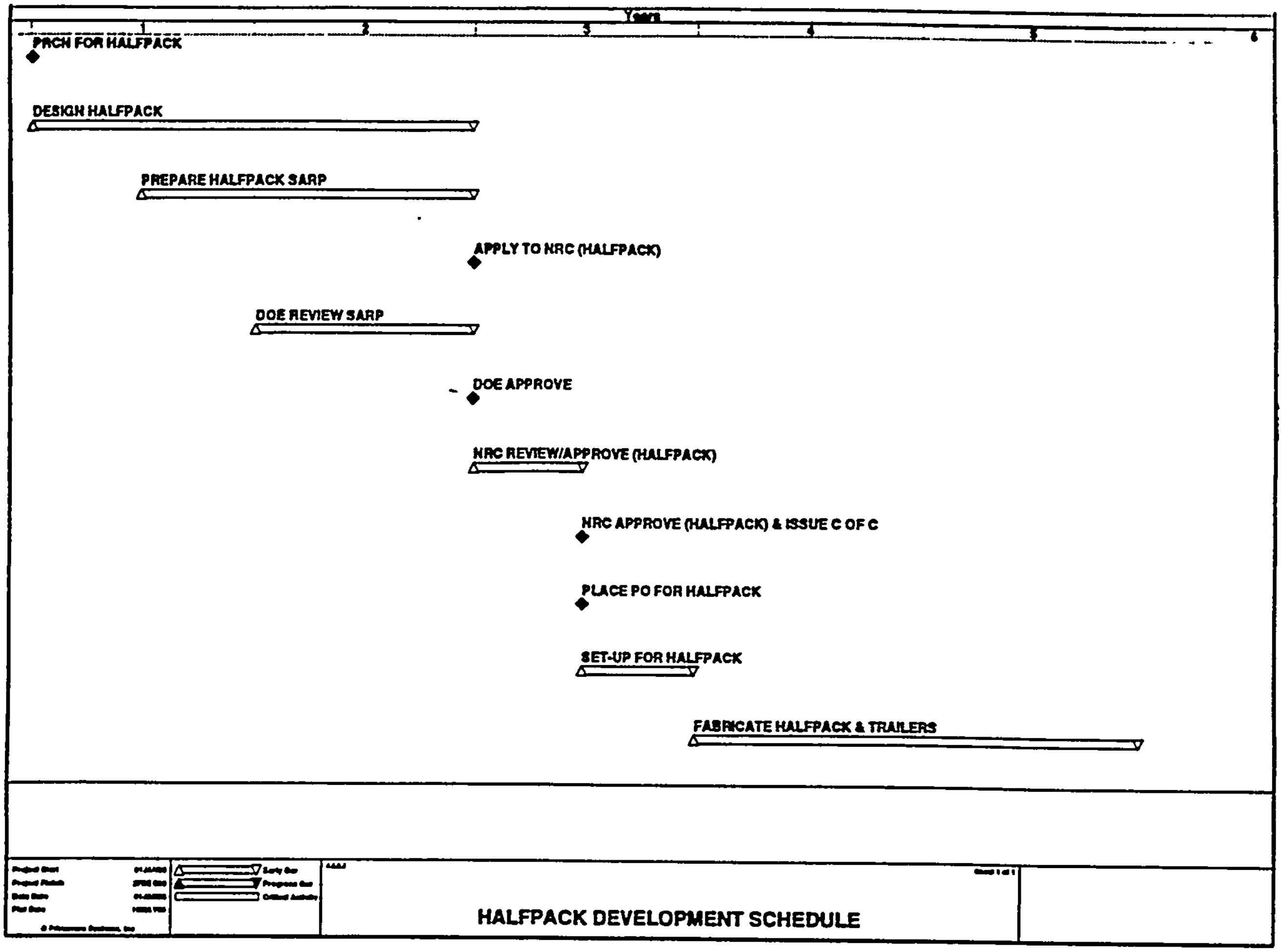

Figure 3. HalfPack Development Schedule

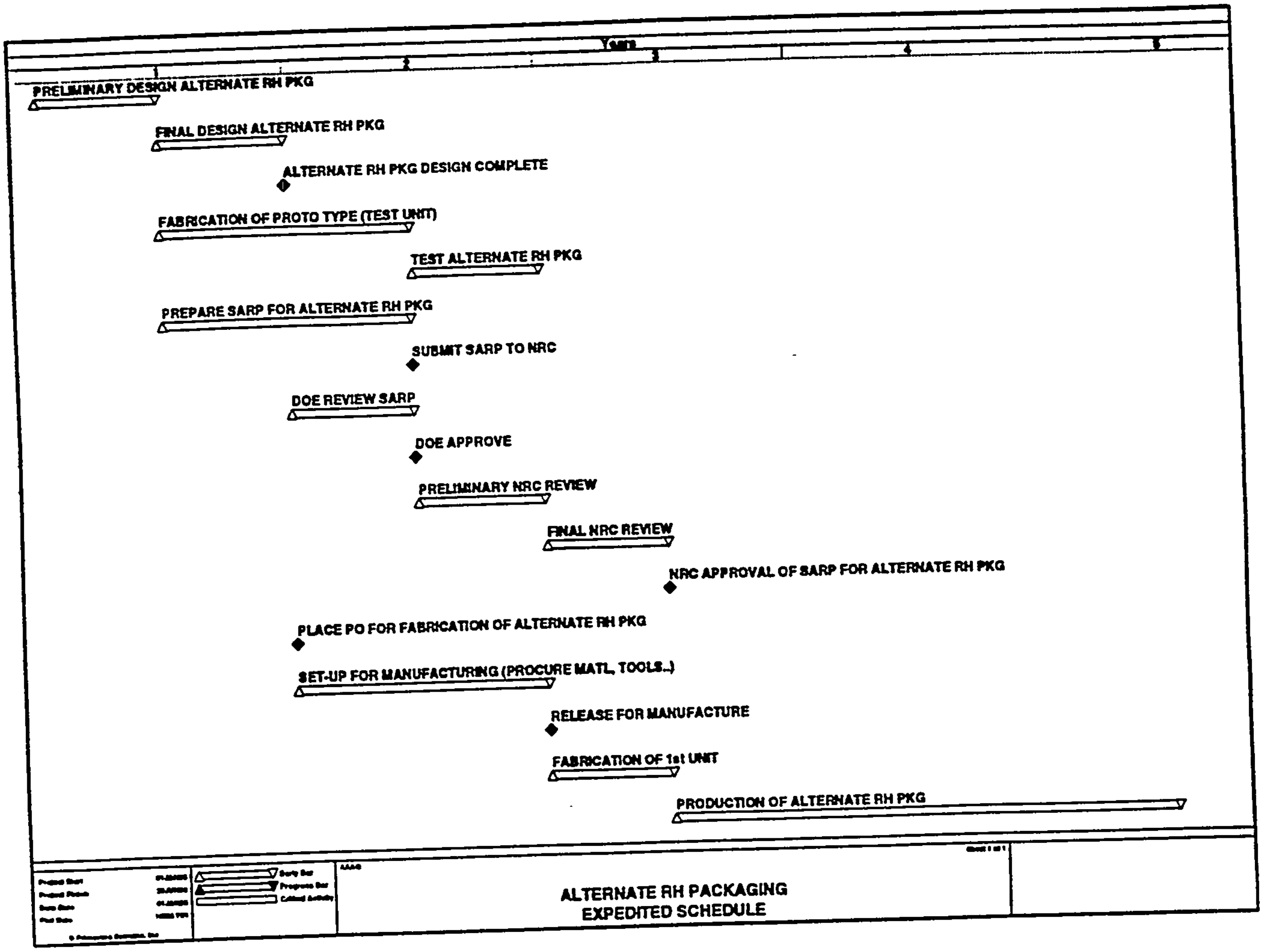

Figure 4. Alternate RH TRU Waste Packaging Expedited Schedule

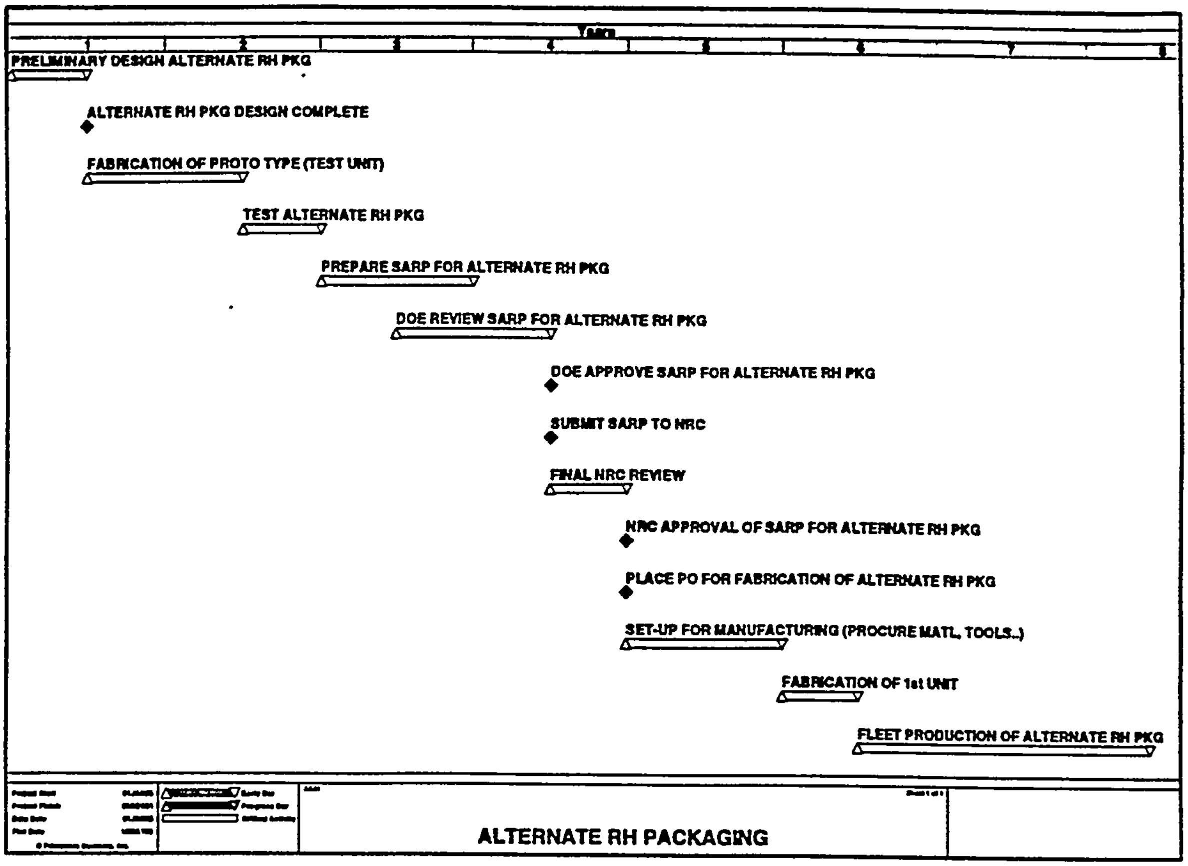

Figure 5. Alternate RH TRU Waste Packaging

New unshielded packaging, primarily spinoffs from the TRUPACT-II which is currently certified, was also considered. Any changes using a Type B packaging other than the RH-72B or a TRUPACT-II and the originally designed handling equipment will require some type of permit/regulatory change for the WIPP. Due to the schedule restraints and the detail required, the RCRA Part B application will be submitted with the original RH TRU waste equipment and designs. As mentioned earlier, changes to the permit can be submitted and acted on once the initial permit is granted.

Several alternatives have been developed to the RH-72B. Additional variations or permutations can be developed using different combinations of packaging. Once generators document additional detail about the waste form and volumes, alternatives can be refined. Over the life of the facility, the P & T system will evolve. Due to variations in the waste form, a one-type packaging system may not be the best alternative. It may be more efficient to use a system with several types of packaging optimized for specific waste forms.

A short narrative description of the alternatives follows. Figure 6 is a summary of alternatives chosen for evaluation.

ALTERNATIVES SHIELDED PACKAGING						
ALTERNATIVE	COST	THROUGHPUT	REGULATORY	IMPACTS	RISK	REMARKS
RH-72B	Baseline	BASECASE 10 UNITS (initially 20 total)	IN RCRA PERMIT; CASK NOT CERTIFIED	REQUIRES CANISTERS; REQ. MOD/EQUIP	BASE	TRUCK /RAIL
GE 2000 CASK	More	20 UNITS	NOT IN PERMIT; CASK CERTIFIED	REQ. MOD/EQUIP	MORE SHIP Worse	TRUCK/RAIL
DRUM CASK	More	40 UNITS	NOT IN PERMIT; CASK CERTIFIED	REQ. MOD/EQUIP	MORE SHIP MORE TYPES OF ACCIDENTS	TRUCK/RAIL
OVERWEIGHT or RAIL CASK (e.g.CNS8-120B)	Less	SUITABLE FOR SPECIAL SHIP	NOT IN PERMIT; CASK CERTIFIED	REQ. MOD/EQUIP	Better (FEWER SHIPMENTS)	REQUIRES SPECIAL ROAD PERMIT
1 GAL CASK	More	120 UNITS	NOT IN PERMIT; CASK CERTIFIED (IN PROCESS)	REQ. MOD/EQUIP	MORE SHIP Worse	TRUCK/RAIL
NEW DESIGN	Less	SCHEDULE DELAYS POSSIBLE	NOT IN PERMIT; CASK NOT CERTIFIED	REQ. MOD/EQUIP	AS GOOD OR BETTER THAN BASE	TRUCK/RAIL
UNSHIELDED PACKAGING						
TRUPACT-II	Less	DOES NOT GET ALL WASTE-20 UNITS	IN RCRA PERMIT; REVISE C OF C	DOES NOT SHIP HIGH "R" WASTE	same	TRUCK/RAIL
NEW (HalfPacks)	Less	DOES NOT GET ALL WASTE-20 UNITS	NOT IN PERMIT; PACKAGING NOT CERTIFIED	DOES NOT SHIP HIGH R WASTE.REQ MOD/EQUIP	same	TRUCK/RAIL
COMBINATIONS						
CASK plus Unshielded Packaging	Less	Better	Not in permit.Packaging not certified	Req Mod/Equip	Fewer Shipments Better	TRUCK /RAIL

Figure 6. Shielded, Unshielded and Combinations of Packaging Alternatives

4.1.1 RH-72B Cask

The RH-72B cask was the alternative chosen for the design basis case against which other alternatives are judged as better or worse. The cask is described in the technical baseline document and the RCRA Part B permit application. A draft Safety Analysis Report for Packaging (SARP) (DOE, 1994d) is currently in review at DOE Headquarters and has not yet been submitted to the NRC. It is believed the cask will be certified by the NRC based on analysis because it is similar in design to the NuPac 125B cask which is certified. The RH-72B cask holds a vented canister which holds approximately 0.89 m^3 (31.4 ft^3) of waste. The payload for the canister is approximately 2,631 kg (5,800 lbs).[4] Canister fabrication costs are relatively high, $12,000-$14,000 each. In addition, the canister lid must be attached with a certified welding process in a shielded facility. The cask is designed for shipment by either rail or truck. The cask is designed for canisters having a maximum surface dose rate of 1,000 R/hr. The canisters are approximately 3.1 meters (10 ft) long by 0.66 meters (2.2 ft) in diameter.

The current schedule calls for the RH-72B SARP (DOE, 1994d) to be submitted to the NRC this year (see Figure 2). Approval and issuance of a C of C would nominally occur about 12 months after SARP submittal to the NRC. After C of C approval, manufacture of the first 10 casks could begin.

The initial fleet size is 10 RH-72B casks with a trailer for each cask (10) and TRU carrier contract tractors to move the casks around the country as required. The cost of 10 trailers and ten casks is estimated at $7,500,000. The CH TRU waste transportation contract could be modified to include the transportation of the RH TRU waste. Attachment D is an estimate of the transportation and hardware costs. (Table 4 data were used to calculate the transportation costs in Attachment D.) Transportation costs are about $72 million over a 25-year period. The cost of the canisters to support this alternative adds an additional $112 million. In order to meet the *WIPP Disposal Decision Plan* (DOE, 1995b) date for receipt of RH waste, a fabrication order for the casks must be in place approximately three years prior to scheduled waste receipt. Delivery of the casks could be spaced out. However, to meet the throughput requirements outlined in the plan, at least five casks would be needed by initial waste receipt dates. To support training and operational readiness reviews, at least two of the casks are needed 12 months prior to waste receipt.

In order to support shipments from multiple sites and maintain a receipt rate of approximately one canister a day (200-350 canisters/year), additional casks would be needed. Additional casks are needed to support shipping schedules or throughput from the facilities located at

[4] The canister weighs approximately 998 kg (2,200 lbs). The canister plus the payload must be less than or equal to 3,629 kg (8,000 lbs).

greater distances from WIPP. A longer WIPP operational period results in a smaller annual throughput and consequently a smaller fleet.

4.1.2 GE 2000 Cask with Short Canister or Drum

The GE 2000 cask, used on previous occasions by DOE, is a currently NRC-certified Type B packaging, ID USA/9228/b(U)F-85, Rev. 6. The cask would require the design of an inner containment vessel to ship greater than 20 curies of Pu. The change to the C of C could probably be done by analysis.[5] The cask is a steel-encased, lead-shielded shipping cask with a payload of 2,472 kg (5,450 lbs). The internal cavity is sized slightly larger than a 208 liter (55-gal) drum. The internal volume of the cask is 0.49 m^3 (17.3 ft^3). A small canister could be designed to more efficiently utilize this volume. The gross weight of the container assembly is 15,218 kg (33,550 lbs). At this weight only one cask per truck shipment is possible. ORNL recently purchased a GE 2000 cask and will use it later this year to ship spent fuel to SRS.

The GE 2000 cask can transport RH TRU waste containers having a surface dose rate of 1000 R/hr and is certified for up to 600 watts of decay heat. The use of this cask would require a change to the RCRA Part B permit to support current schedules. The major drawback of the GE 2000 cask is its small volume and the necessity to modify some of the WIPP facility equipment. Using a newly designed canister, the usable volume could be increased to over 0.40 m^3 (14.1 ft^3). To ship 7,080 m^3 (250,000 ft^3) of waste would take about 16,500 shipments by truck. This is double the number of road shipments using the RH-72B cask.

4.1.3 Shielded Packaging for 208 liter (55-Gallon) Drum

The B-3 cask is a currently certified NRC Type B packaging, ID USA/6058/B( ). The B-3 was originally designed to hold one DOT SPEC 17H steel 208 liter (55-gal) drum. A truck could carry two of these casks for a shipment volume of about 0.42 m^3 (14.8 ft^3) which is comparable to the shipment volume of the GE 2000. The DOE owns several of these units and the design. Los Alamos has four of the B-3 casks to support the Molybdenum-99 medical isotope program. The B-3 is not doubly contained; however, some RH TRU waste could be shipped with the current NRC C of C. In the long term, the C of C would need to be modified. The B-3 cask certification was grandfathered under previous requirements by the NRC; therefore, the building of additional units of this same design is not possible. Modification and further testing would be required and the cost of building new B-3-type units would be comparable to that for a completely new design.

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[5]GE was contacted by phone. The Engineering manager in charge of the licensing activities confirmed the modification was possible. When the packaging was certified, the method and software used for analysis was validated with the NRC.

Several newer one-drum casks are available with some modification or certification efforts. For example, the International Atomic Energy Agency (IAEA) approved cask, Croft design # 2917C, is a suitable design for a single drum. This cask is not NRC-certified; however, licensing in the U.S. could be pursued if a decision was made to utilize this design. The "C" version of this design has double containment.

Using the Croft packaging results in the WIPP site and the generators handling lighter, smaller packages. Handling of drums at WIPP is evaluated in the RH TRU waste disposal alternatives document. Using trucks to transport this type of cask results in about 16,000 road shipments of RH TRU waste, compared to about 8,000 for the design basis. The number of casks involved also increases the handling operations at the generator and at WIPP. The advantage is that the DOE currently has access to the B-3 casks and could be prepared to support initial receipt schedules. Unless additional casks are made available, or this alternative is combined with others, throughput is limited. The biggest advantage in handling drums is the availability of remote/robotics handling equipment. Handling equipment of this type has been thoroughly tested in the hazardous waste arena.

4.1.4 Cask for 3.8 liter (1-gallon) Cans

Several companies have containers which will accept 3.8 liter (1-gal) cans (e.g., Croft design # 2773A, and SAFKEG 2863B). Handling equipment could be developed for this small configuration. It is possible to place several of the SAFKEG-type shielded packages on a standard flatbed truck, due to their small size and light weight. The system is not as volumetrically efficient as other alternatives. The system would accommodate the waste currently packaged in 3.8 liter (1-gal) containers. Three SAFKEG-type designs are in the process of being certified by DOE and the NRC. The number of shipments to WIPP by truck would be at least three times higher than the design basis. Packaging costs are substantially lower for this unit, between $12,000-$50,000 each. More than 100 casks would be needed to have an adequate throughput. This alternative is attractive only if the throughput is initially slow and the budgetary resources for capital equipment are low. However, the alternative impacts the facility because regulatory permit changes, facility changes, and packaging certification would be required.

4.1.5 Shielded Overweight Casks and Rail Casks

The CNS 8-120B and several other similar type casks have been used by the DOE to transport radioactive materials.[6] The CNS 8-120B, a certified Type B packaging, ID USA/9168/B(U), is doubly contained. This specific cask weighs about 33,566 kg (74,000 lbs) with payload,

[6] The NuPac 125-B was not listed. This cask has double containment and has a gross weight of 82,328 kg (181,500 lbs.). This cask is a rail-only cask and could not be used on all sites having RH TRU waste because of rail availability.

and would require a special overweight road permit when shipped by truck. Some of the limitations that usually apply with special road permits are: shipments during daylight hours only, no shipments on weekends or holidays, and special routes due to weight. The restrictions vary by state. DOE Order 1540.1A discourages use of shipments above the legal weight and size. Between 3-5 casks must be processed at the WIPP per week with the use of rail to obtain the required throughput. The restrictions on travel would require holding areas along the transportation corridors. Additionally, the WIPP facility is not configured to handle casks of this size. The generator sites must be configured for handling these types of casks also.

One of the preliminary designs for WIPP used a rail cask transporting multiple canisters. The volumetric efficiencies are 3-5 times better. Between 1.5-5.0 m^3 (53-177 ft^3) of waste could be shipped in an oversized cask. Handling would present several challenges and require WIPP facility modifications. Transportation of this type of unit would need to be by rail to realize efficiencies and minimize the need for special road permits.

The majority of these units were designed to handle irradiated fuel. The inner cavities of the casks are not designed for the types of packages the WIPP site planned to emplace. While it is possible to modify the C of C's on this cask and several others in this category and overcome all the handling and transportation issues, other alternatives are more attractive. This alternative is attractive if 1-2 sites can have large volumes of waste ready for shipment. About 1/3rd as many shipments would be required. If the volume of waste shipped is spread out over periods greater than 25 years, this alternative is less attractive. In conjunction with this alternative the waste could be stockpiled and shipped in a shorter period.

The CNS 10-160B and several other casks are also NRC-certified Type B packaging that could ship a large portion of the RH TRU waste inventory. Shipments could be initiated with no modifications to the NRC C of C's. Costs of the casks in this category are reasonable. Costs range from $400,000-$3,000,000 for a cask depending on the type and certification status.

4.1.6 Design New Shielded Packaging

One alternative is to design entirely new packaging. The limited amount of high dose rate RH TRU waste could be shipped in special road permit casks. Waste could be shipped later in the operational life of the WIPP allowing for the decay of the isotopes resulting in shipping and handling lower dose rate containers. If resources are made available, there is sufficient time to develop new packaging. The RH-72B system was developed based upon canisters having a maximum of 1000 rem/hr surface dose rates. Of the RH TRU waste in the inventory, the majority is less than 100 rem/hr. WIPP can only dispose of a maximum of 354 m^3 (12,500 ft^3) of waste that is between 100 rem/hr and 1000 rem/hr.[7] The criteria for a new design would be based on a lower dose rate resulting in significant savings in shielding. The RH-72B shielding requirements were based on isotopes of Cesium and Cobalt. Reducing the weight of the shielding allows for design of a less expensive cask with a greater payload. Significant long-term cost savings would be derived from the greater payload.

To improve the efficiency of a new design, increased knowledge of the specific isotopes in the high dose rate waste and more specific information on the volume of RH TRU waste at different dose rates is required. Information on RH TRU waste grouped by dose rate such as 200 mrem/hr-20 rem/hr, 20-50 rem/hr, 50-100 rem/hr, and >100 rem/hr would be very useful in developing design criteria. Design options such as removable shield liners will allow for a more efficient packaging when shipping higher dose rate RH TRU waste. Another option would be to hold the shipment of high dose rate RH TRU waste until later in the operational life of the WIPP as radioactive decay will reduce the dose rate of the waste.

WIPP could work with the group designing the packaging and emplacement equipment for Yucca Mountain. The multi-purpose cask could ship all the RH TRU waste and has a large volume. The Yucca Mountain system also utilizes vertical emplacement. Their system could be proof tested at the WIPP. The use of such a system at the WIPP would give the Yucca Mountain group valuable operating experience. The WIPP could benefit by sharing reduced design and development costs for vertical emplacement handling equipment.

Another possible new design alternative would be to develop a system where the road cask and the WIPP facility cask are the same. Potentially many operational steps could be eliminated by transporting the road cask underground. The interior payload container could be emplaced directly from the road cask.

In summary, it is possible to design better packaging if knowledge of the inventory is increased. A longer operational life of the WIPP will result in some decay of isotopes allowing for transport of higher dose rate waste to be scheduled later in the life of the facility so that a lighter cask with less shielding and a greater payload could be used. A new design could also be optimized to ship waste to treatment facilities.

4.1.7 Unshielded Packaging (Shielded drums in TRUPACT-II)

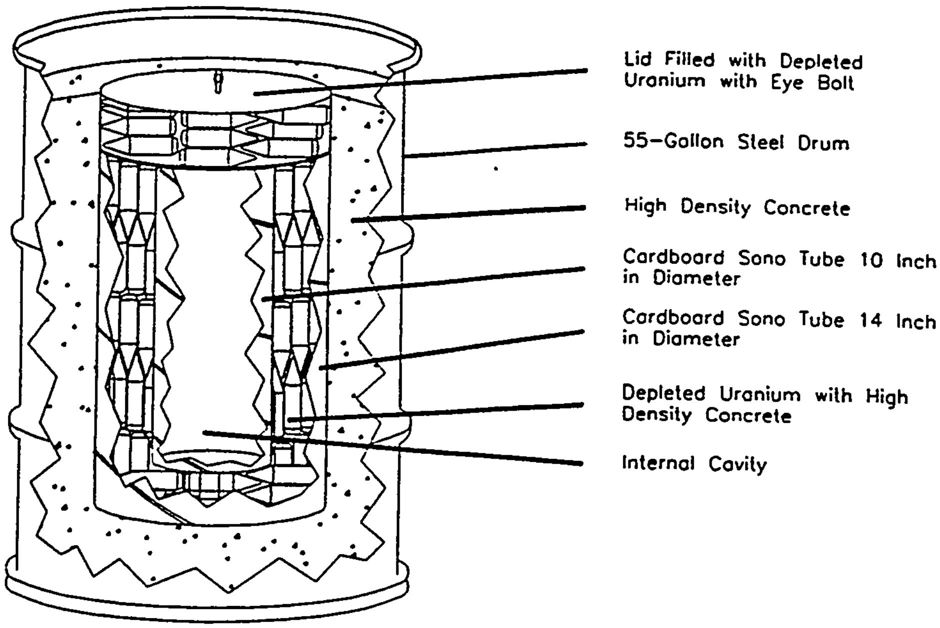
A shielded drum allows the project to remove RH TRU waste from the generator sites and emplace it in the CH TRU waste stacks at WIPP. Because the drums have a surface dose rate of less than 200 mrem/hr, the waste would be considered CH TRU waste and be shipped in TRUPACT-II. Using shielded drums can result in more RH TRU waste being removed from

[7]This number is based upon the 5% limit contained in the Land Withdrawal Act.

the generator sites at earlier dates. The total volume of waste and the curie limits would still remain fixed by the Land Withdrawal Act. The use of steel shielded drums impacts the total mass of steel used in the performance assessment for RH TRU waste. The additional steel could be a contributor to gas generation potential (not rate) in the underground. There is a slight risk that the final performance assessment (PA) could be sensitive to the amount of steel underground. If this sensitivity happens then the amount of RH TRU waste that can be stored underground could be substantially reduced using steel shielded drums. This alternative packaging does not impact the 7,080 m^3 (250,000 ft^3) approved for RH TRU waste disposal. This type of alternative provides greater flexibility in the future when much of the RH TRU waste is being generated through facility decommissioning. If more than 7,080 m^3 (250,000 ft^3) of RH TRU waste is generated, this alternative provides a possible method of disposing of a larger portion of the RH TRU waste inventory.

Steel shielded drums sized to hold 208 liter (55-gal) drums are commercially available for approximately $4,000 each. Attachment C contains a sketch. This price could be reduced if contaminated steel from DOE decommissioning projects was used for a portion of the shielding. The drums are certified Type A payload containers which could be placed in a TRUPACT-II which cost about $350,000 each. The TRUPACT's could be used for CH TRU waste when not being used for shielded RH TRU waste. The drums evaluated have 3.8 cm (1.5 in) of steel shielding. By limiting the waste form, RH TRU waste packed in this drum could be reduced to a surface dose rate of less than 200 mrem/hr. This allows the drum to be handled as CH TRU waste. Only minor changes to the TRUPACT-II NRC C of C are anticipated to accommodate this waste. These changes could be completed in 12 months. All current schedules would be supported. If the drums were placed in standard waste boxes (SWB's) or 10-drum overpacks, no facility permit changes would be anticipated. However, to reduce costs, a permit change would be required allowing direct emplacement of the shielded drums.

In addition to steel shielded drums, drums using depleted uranium and concrete for shielding are available. The depleted uranium drum is available using DOD surplus depleted uranium projectiles (see Figure 7). To take advantage of major cost savings, a commitment to purchase drums would need to be made in the near future. There is sufficient material to provide drums for a good portion of the design limit of RH TRU waste. Drums made of surplus materials would cost between $400-$1000. DOD personnel would ensure the drums are DOT Type A certified. Internal volume on a 208 liter (55-gal) shielded drum would be about 25.4 cm (10 inches) diameter by 60.96 cm (24 inches). This equates to about 0.03 m^3 (1.1 ft^3) per drum or 0.42 m^3 (14.8 ft^3) per truck shipment. The concrete and depleted uranium is preferred from the PA gas generation perspective. Use of these drums also requires limiting the waste form to waste that results in a surface dose rate of less than 200 mrem/hr.



Utilizing DOD surplus Depleted Uranium Projectiles
Cost is estimated between $400 to $1000 per drum
Approximate weight, empty 1400 lbs.

This Illustration is for
Information Purposes only.

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Figure 7. 55-Gallon Depleted Uranium Shielded Container

Other types of shielding are possible and available. Lead shielding could be utilized. However, lead shielded drums were not viable alternatives given cost, regulatory concerns with lead and payload weights. Shielded casks which are not disposed of are better than lead shielded drums which are.

4.1.8 New Design Unshielded Packaging

Based on the TRUPACT-II design, a new shorter version called HalfPack could be developed. The payload cavity of the HalfPack would be 1.8 m diameter by 0.9 m high (6 ft diameter by 3 ft high). The TRUPACT-II cavity is the same diameter but 1.8 m (6 ft) high. The HalfPack would ship drums of RH TRU waste if the contents were shielded to ensure contact-handled dose rates, i.e., less than 200 mrem/hr at the surface of the drum. The HalfPack could use either depleted uranium shielded drums or steel shielded drums. The HalfPack would use the same ICV and OCV lids as the TRUPACT-II and the ICV and OCV bodies would be shortened to one-drum high instead of the current two-drums-high configuration for TRUPACT-II. The current tie-down/trailer interface would be retained and all of the TRUPACT-II handling equipment used. The payload in the HalfPack would be approximately 4,536 kg (10,000 lbs). (The TRUPACT-II maximum payload is 3,295 kg [7,265 lbs].) It is believed that the HalfPack could be certified by the NRC with minimum effort due to the similarities between it and TRUPACT-II. A shipment by truck will carry three HalfPacks with a payload limit of 9,526 kg (21,000 lbs), and a volume limit of between 3 and 21, 208 liter (55-gal) drums per shipment. This packaging alone could not ship all the available RH TRU waste. The waste shipped would have to be limited to that with some lower dose rate. The shielded drum will reduce the surface dose rate to less than 200 mrem/hr. This alternative does not impact the transport of high-dose RH TRU waste by cask. When not being used for shielded RH shipments, this Type B packaging could be used for heavier CH TRU waste packages. See Figure 3 for a development schedule.

This alternative could meet all schedule dates and remove a large portion of the RH TRU waste inventory. The packaging is volumetrically efficient and avoids the use of the hot cell at WIPP, an operational cumbersome path. This alternative also provides operational flexibility. The RH TRU waste removed from the generator is CH TRU waste at WIPP. The 7,080 m^3 (250,000 ft^3) allocated for RH TRU waste would still be available.

In summary, this alternative removes RH TRU waste from the generator sites; however, the waste is counted as CH TRU waste for storage at the WIPP. As stated above, this alternative limits the RH waste to a smaller subset due to dose rate limitations. To transport all the inventory this alternative must be combined with other alternatives.

4.1.9 Combinations of Shielded and Unshielded Packaging

Various alternatives can be developed using different combinations of packaging. The waste form is varied enough and can be packaged many different ways. A single package may not be the best way to transport all waste from various sites. The sites also have different needs. This alternative involves using two different packagings. Higher activity RH TRU waste would be shipped with a certified Type B cask. In parallel, unshielded packaging, e.g., TRUPACT-II, is used to ship the RH TRU waste which has a dose rate that can be safely and economically shielded down to less than 200 mrem/hr. This makes the waste CH TRU waste. These limitations would be highly dependent on the shielding requirements for the isotopes being transported. Greater volumetric or payload efficiencies could be gained by using a new design like the HalfPack. One truck shipment would be able to transport a payload of approximately 9,526 kg (21,000 lbs). The volume of waste transported could be increased to about 2.1 m^3 (74 ft^3) per truck shipment. (This volume is similar to what can be transported in a special permit or rail cask.) The high-dose RH TRU waste, which can only be 5% of the RH TRU waste or a maximum of 354 m^3 (12,500 ft^3), could be transported in shielded casks.[8]

The advantage of using a combination alternative is that WIPP could get low dose rate RH TRU waste from the generators early and in a more volumetrically efficient manner. Higher level RH TRU waste can still be received at any time during the operational life of the facility. The waste in the shielded drums would be considered CH TRU waste at WIPP (as discussed previously). The HalfPacks are useable as CH TRU waste packaging for super-compacted waste or extremely heavy drums thus keeping the overall TRU waste fleet size down.

4.2 Evaluation Process

In order to evaluate the various alternatives and develop a rating scheme, rating criteria were established. Using the criteria, a decision matrix was developed. Next, pairwise comparison was used to evaluate the alternatives. Each criterion of the problem is looked at in isolation. Judgments are made about pairs of alternatives relevant to a criterion. A narrative scale was used to judge the alternatives. Alternatives with respect to a criterion could be equal, moderately preferred, strongly preferred, very strongly preferred or extremely more preferred. A commercially available software for personal computers, *Expert Choice,* was then used to combine all the judgements into a unified whole that ranks alternatives from best to worst. Judgements were based on the consensus of a group of seven evaluators. The evaluators represented Engineering, Operations, and Safety (see Attachment E). The criteria used were:

- Cost. The cost for the various alternatives was broken down into the following components.

- Transportation. This criterion is based upon the volume of the waste packaging and the number which could be shipped by truck the number of shipments was calculated. Rail

[8]The Land Withdrawal Act allows only 5% of the RH TRU waste to have a dose rate between 100-1000 rem/hr.

shipments were normally chosen to carry three times the truck shipments. Table 4 was used for shipment costs. Only a truck shipment number was used for comparison. For the overweight, cask rail shipments were used where possible. In addition, a $2,000 surcharge was added to each special permit shipment. The surcharge was necessary to cover the cost of state special road permits for overweight packaging from those sites that did not have rail access.

The cost of shipments was used to compare the alternatives. Additional information on modes of transportation is contained in the transportation section.

- Hardware. The hardware costs of each alternative can be divided into three parts: the container that the waste is shipped in, which is reused; cost of the payload container, such as a drum or canister, and cost of the trailer or rail car to ship the waste. For sustained throughput it was assumed that the DOE owned the packaging and trailer. Rail cars could be leased or owned. Maintenance costs for the alternatives were considered equal. Therefore, the maintenance costs are not considered in Attachment D.

  Leasing of packaging was evaluated. Leasing of individual packaging averages about $3,500 per day for short-term leases and decreases to about $1,500 per day as the performance period increases. The performance period changed from short-term to long-term at 3-6 months. Leasing is not cost effective over a 25-50 year operational period with a range of 200-350 shipments per year.

  Fewer shipments could make this a cost effective alternative. A contract could be placed with a nuclear waste shipping company to ship specific waste forms. The DOE would not have to own the casks, or be responsible for the maintenance.

  The primary cost differences between alternatives are the number of shipments required to get the desired amount of waste to WIPP.

- Regulatory. This criterion evaluates the anticipated need for changes to permits, laws, DOE orders or agreements. Next, the ability to get a license or permit is evaluated. If the alternative compromises the ability to obtain a permit or delays the schedule, this alternative is deemed worse than the other. Last, the need to revise permit applications is evaluated.

- Technical. This criterion evaluates the ability of available technology to meet the design criteria. Proven technology or modified technology is used in all the alternatives evaluated in this section. Therefore, the alternatives were essentially equal with regards to this criterion. Only in the case of a new design is there a possibility of using high-risk technology. Also, all the packaging must be certified as Type B.

- Throughput. Throughput was evaluated as to which alternative was better or worse. An alternative should support waste receipt per the *WIPP Disposal Decision Plan* (DOE, 1995b) and increase the probability or assurance of emplacing 7,080 m^3 (250,000 ft^3). Alternatives that increase the flexibility or the interface with CH TRU waste emplacement are ranked as better.

- Impacts. Impacts are evaluated based on their impact to WIPP, the Generator Site, and the Stakeholders. Alternatives are ranked as better if they require less work than the other alternative.

- Risk. This criterion looks at the overall safety of the alternative. All of the packaging will be certified. This means that technically the material could be shipped, if the NRC C of C is complied with. However, the frequency of incidents can change, as can the consequences of these incidents, or the types of incidents. Alternatives can have significant differences in the number of shipments.

The Final Supplement Environmental Impact Statement (FSEIS) used a total number of truck shipments of 7,963. The number of rail shipments based on the maximum use of rail was 3,932. The number of rail shipments could vary significantly based upon the volume of waste shipped. Risk was viewed as better than design basis if significantly fewer shipments were required.

The evaluation process was divided into two parts. Shielded packaging was evaluated as a group and unshielded packaging as a group. Combinations of the two groups were not evaluated separately. Selection of the top alternative in either category does not preclude the use of the other. At the end of the evaluation process, a sensitivity analysis was performed.

Prior to finalizing the results, the criteria were weighted. Risk was rated the highest. Throughput was weighted next. Cost and regulatory were weighted essentially the same and ranked third and fourth. Impacts was weighted the least and ranked last. Technical viability was weighted equally for all alternatives. After the initial evaluation it was not carried forward. The sensitivity analysis showed that the ranking of the alternatives was not very sensitive. Changing the criteria weighting factors by 10% did not change the top alternatives.

4.3 Evaluation Results

The combination of a new cask with a HalfPack was the alternative that was preferred. Figures 8 and 9 graphically summarize the results. This alternative combines the top alternatives from each group. This alternative removes the most RH TRU waste from the generator sites. Using this alternative it is possible to get 7,080 m^3 (250,000 ft^3) of RH TRU waste to WIPP and any additional RH TRU waste inventory that can be shielded to CH TRU waste. The limiting factors would be the total curie limit contained in the Land Withdrawal

Act and the amount of RH TRU waste inventory that is low dose rate (can be shielded to CH TRU waste). This alternative has lower life-cycle costs and is not impacted heavily by extending the operational life of the WIPP. This alternative requires higher funding initially to implement than other alternatives. Two new packaging designs must be processed through the DOE and the NRC certification. However, the costs are recovered in the operational phase due to volumetric efficiencies. With more volumetrically efficient packaging the number of shipments can be reduced. This is true whether truck or rail is used. Because 95% of the waste coming to WIPP must be less than 100 rem/hr, a new lighter cask with greater volume is possible. The primary drawback to this alternative is that you must start 5-7 years prior to waste receipt to deliver a NRC-certified Type B packaging fleet.

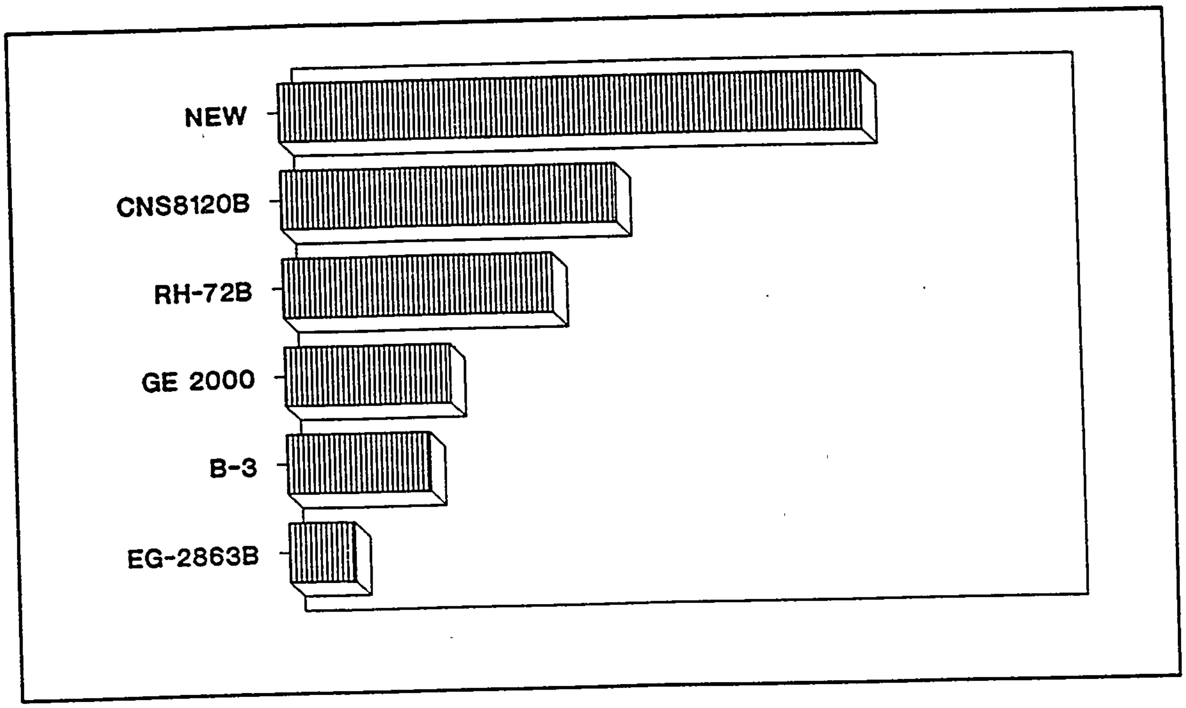

Figure 8. Shielded Packaging Ranking

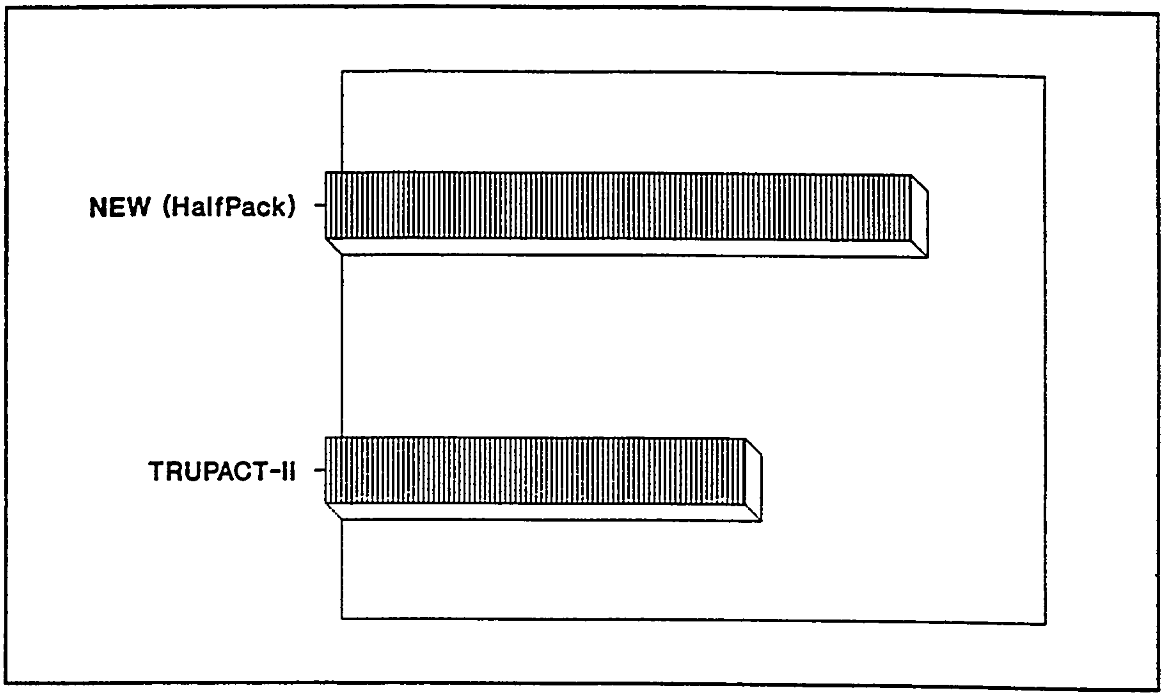

Figure 9. Unshielded Packaging Ranking

The next choice is a special road permit/rail cask in combination with a HalfPack or TRUPACT-II type packaging. Because of the size of the cavity and payload, special permit/rail casks were preferred over other alternatives. The volumetric efficiency and high use of rail greatly reduced the risk. Additionally, the throughput was good. This alternative has limited flexibility. Shipments from small quantity generators would require a different cask or special road permits. This alternative also rates high if centralized RH TRU waste treatment facilities are established. Large rail shipments to the WIPP become easy from two or three central facilities. If necessary, leased casks could be used from small-quantity generators.

In order to optimize packaging further, it is essential to increase knowledge about the RH TRU waste inventory. Additional information should be requested in the Baseline Inventory Report (BIR) about dose rates, repackaging, isotopic content and total volume of TRU waste. The additional data would help in development of packaging design criteria and the mix of packaging required. If the total amount of RH TRU waste coming to the WIPP is less than 7,080 m^3 (250,000 ft^3), a combination alternative may not be necessary. A shielded cask that can be transported by truck or rail becomes a stand-alone alternative. Volumetric efficiencies and the flexibility to remove more than 7,080 m^3 (250,000 ft^3) of RH TRU waste from the generators is not as important. A small fleet of shielded casks could transport all the waste to the WIPP.

4.4 Packaging Recommendation

WID's recommendation is to start shipping RH TRU waste from the generator sites in shielded drums transported in the TRUPACT-II. The recommendation is derived from the analysis and conformance to projected funding. RH TRU waste shipments could then start almost as soon as CH and at the lowest cost. No additional NRC Type B packaging would be required. The HalfPack design should be developed if funding is available or there is more than 7,080 m^3 (250,000 ft^3) of RH TRU waste. The HalfPack is volumetrically more efficient. The HalfPacks could be manufactured if the TRUPACT-II fleet is expanded. This would minimize manufacturing startup costs.

A shielded cask is also required for higher dose rate waste and new cask design with a greater volume is recommended. This is safer and cheaper over the life of the facility. The initial cost is greater. The decision on fleet size should be postponed until the permits are issued. The regulatory agencies could require changes to the WAC that impact the waste work-off plan. Fleet size is also dependent on how much certified waste can be made available by the generator sites.

In addition, based upon the results of the RH TRU waste disposal alternatives study it was determined that the impact on the WIPP facility was reduced if smaller canisters or drums were used for the payload container. Using the smaller payload containers also improved the probability of disposing of 7,080 m^3 (250,000 ft^3) of RH TRU waste. The RH-72B NRC C of C application and SARP (DOE, 1994d) could be modified to use shorter canisters or drums. The major advantages to the WIPP were more of the underground area could be used for RH TRU waste disposal, and handling the payload containers was more efficient.

If the design life of the facility is extended, an evaluation of using more corrosion resistant alloys should be considered. Normally these alloys would add substantially to the initial cost of the packaging. However, if the life of the packaging is extended, the use of more expensive materials may be cost effective.

5.0 TRANSPORTATION SYSTEM

Two general methods of transportation are available for transporting RH TRU waste to the WIPP. These are truck and rail. Air and water were not considered. (These two modes have physical or regulatory constraints that eliminate them from consideration.) In addition, if centralized treatment facilities are established, shipments must be made to the treatment facility and then to WIPP.

Several specific alternatives were evaluated for transportation. The alternatives were required to provide the safe, economical and efficient delivery of RH TRU waste to the WIPP. The alternatives fit into three general categories: 100% Truck, 100% rail, or a combination of truck and rail. Due to lack of rail access at some generator sites, 100% rail is not possible. In addition, the combination alternatives are not mutually exclusive. The system selected must also meet regulatory requirements and deliver the amount of waste scheduled in the work-off plan. The recommendation is divided into two parts: an initial one to provide waste for disposal in the early phases of disposal, and one to provide sustained throughput. Specific alternatives are:

- 100% truck,
- Utilizing rail to the maximum extent possible with trucks from sites where rail is not feasible,
- Rail from large-quantity generators and truck from small-quantity generators,
- Mixed CH and RH TRU waste shipments by rail, and
- Truck shipment initially changing to rail when central treatment facilities become operational.

Regardless of the mode of transportation and the packaging, the NRC is concerned about hydrogen gas generation. The NRC essentially limits the amount of hydrogen that is present in a package to no more than 5% by volume. This criterion must be met over a period of time that is twice the expected shipment time. For a package containing organic substances or water which radiolytically generate combustible gases, testing or analysis is required to show that the criterion of ≤5% hydrogen buildup is met. The shipment time is from the time the package is sealed until the package is opened. The worst-case time in transit and the handling times makeup the shipment time. TRUPACT-II has a 60-day limit. When rail transportation is considered this time period could be greater. Because of this NRC criterion shipping time is a great concern. In the last several years the railroads have made tremendous improvements with just-in-time deliveries. However, there is still a question if they can keep shipping/delivery schedules as reliably as trucks.

5.1 Emergency Response

When selecting a transportation alternative, decision makers must be mindful of ancillary issues such as emergency preparedness response, training the corridor entities, and equipping the response team. If the routes and mode are the same as those used for CH TRU waste transport, then cost and stakeholder impacts are minimized. If two different modes are used from the same generator site, then additional costs are incurred in keeping multiple corridors from the same generator site active. The rail and truck corridors normally differ slightly and involve some different responders.

Training for the Oak Ridge corridor has not been initiated. Training is required approximately one year before waste is shipped from a major site. Table 5 shows the estimated costs of training the additional states that waste would pass through coming from ORNL. The other major corridors have completed initial training oriented towards shipping CH TRU waste. The addition of RH TRU waste results in only minor changes to existing programs. Figure 10 is a map of approved routes. Primarily those sections of the training describing the hazard would need to be changed to include RH TRU waste. The difference between RH and CH TRU waste is the dose rate.

Table 5. States and Tribal Issues Input Table[1]

State	Training	Exercises	Institutional[2]
NEW MEXICO	$14,332	No Additional Cost to Current Program	$24,000
TEXAS	$28,664	$12,100	$120,000
OKLAHOMA	$64,494	$14,900	$175,000
ARKANSAS	$35,830	$18,600	$150,000
TENNESSEE	$71,660	$23,100	$220,000
TOTAL	$214,980	$68,700	$665,000

[1] Assumptions:
- All funding data are expressed in 1995 dollars and not factored for inflation.
- All training and exercise funding is based on 100% truck shipments.
- No additional funding for exercises in New Mexico is anticipated due to existing WIPPTRAX funding provided through existing cooperative agreements.
- Additional funding for tribal-specific exercises is not anticipated at this time.

[2] The funds in the institutional section are used to cover items in the negotiated state cooperative agreements. (e.g., emergency equipment, public information programs, route studies, incident prevention programs, and additional state response personnel)

Only notifications and minimal preparation may be required to ship the limited amounts of waste currently at small-quantity generators.

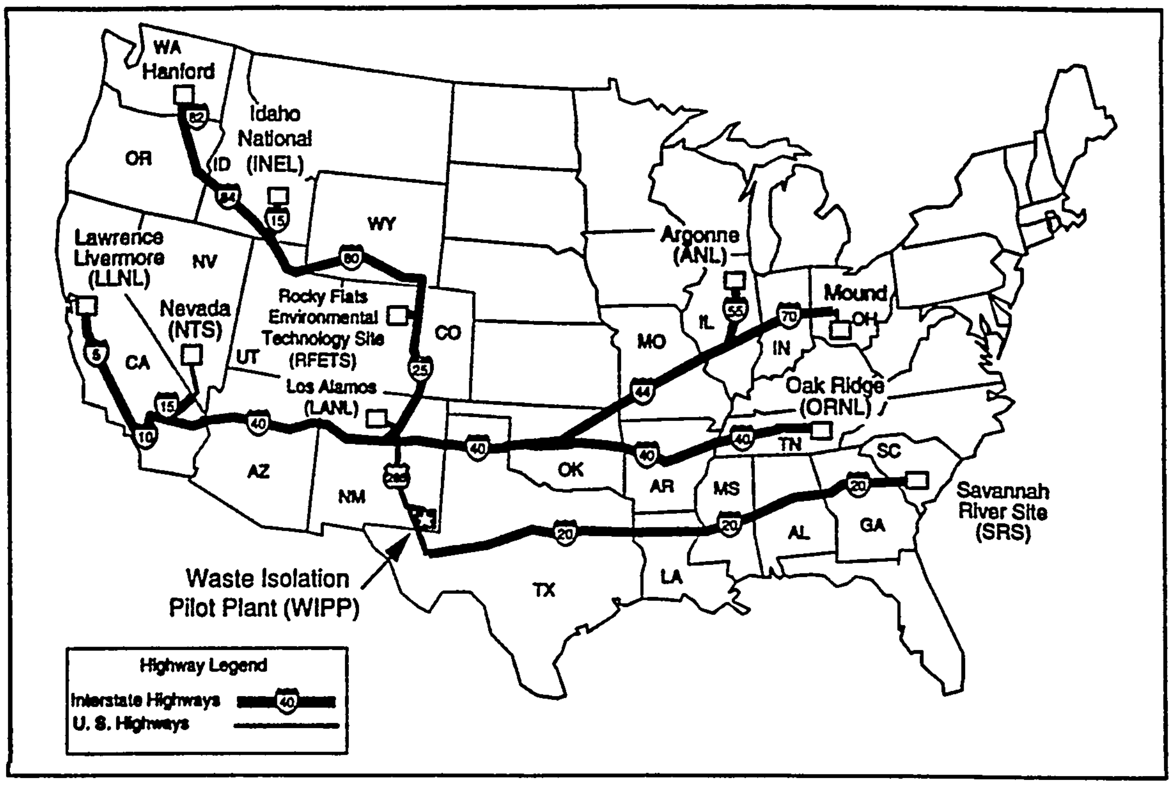

Figure 10. TRU Shipments

In October 1980, with the publication of the Final Environmental Impact Statement (FEIS) for the WIPP, the DOE initially committed to provide the WIPP transportation incident/accident emergency response training on the WIPP transportation routes. The WIPP LWA, Public Law 102-579, identifies requirements for continuation of training programs for emergency response, as well as hospital training. The States Training and Education Program (STEP) started in 1988 to meet this commitment and was modified after the passage of the LWA. The program is offered to local, state, and tribal governments and describes the proper procedures to follow in the event of a WIPP-related transportation incident. The current program was reviewed for compliance with 29 CFR 1910.120 and certified by Occupational Safety and Health Administration (OSHA). Only minor modifications to the existing program are anticipated to prepare for RH TRU waste. The most economical method is to incorporate the RH TRU waste in the next cycle of training.

Emergency response to an incident involving WIPP shipments by train would be similar to that of trucks. County or city personnel would act as first responders to assess the situation and attempt to save lives. State and federal teams would respond if requested. The major difference is that a train runs on privately owned track that is the responsibility of each railroad. The rail carriers would assist in an emergency response. All major rail carriers have emergency plans for hazardous materials incidents.

For emergency response, dedicated trains provide a safer alternative. Because of the absence of other cargo on the train there is less chance that other hazardous materials would be involved in an incident. Involvement of other materials can complicate emergency response and cleanup activities.

5.2 Alternative Transportation Systems

All of the transportation modes, given sufficient resources, are capable of meeting the work-off-plan requirements. All modes are technically viable and can meet regulatory requirements. Due to some of the generator sites not having rail currently available, the system must maintain some truck capability. As a result, the evaluation criteria for transportation modes include cost, flexibility, and risk. The criteria are explained in the section 5.3. Specific cost data for shipping has been detailed in DOE/WIPP 93-058 (DOE 1994b) and EEG-WM-10877, Rev. 1 (DOE,1994c)

In order to process rail shipments at the WIPP, the site must be able to move rail cars around the yard.[9] If a switch engine is obtained or leased for this function, at least $500,000 is added to the annual operational costs for the WIPP. This is partially/wholly offset by savings elsewhere.

5.2.1 100% Truck

The first alternative is to ship all RH TRU waste to WIPP utilizing truck shipments. The major assumption with this alternative is that the packaging is transportable over the highways without special road permits. This places weight and size restrictions on the packaging. For sustained throughput, special road permit shipments are not acceptable. In addition, most of the packaging requiring special permits is of a size that presents handling challenges at WIPP and the generator sites.

Some of the alternatives such as leased trucks, or trucks owned by the DOE, were considered but rejected. Over the extended waste receipt period, the evaluation of these permutations provides no meaningful data.

The proposed system would utilize dedicated trucks and trailers. The trailers are assumed to be furnished by the DOE with the certified packaging ready for shipment.

[9] Switch engines are available surplus from DOE/DOD facilities. Also, other methods could be used to move rail cars.

5.2.2 Utilize rail with truck from sites without rail

This alternative uses the rail capability to the maximum extent feasible and truck where necessary. The truck portion is the same as the 100% truck alternative, only on a smaller scale. The assumption for rail is that at least three casks would be transported per shipment. It is assumed that the DOE furnishes the rail cars to minimize demurrage costs. It is also assumed that the packages are loaded and unloaded in less than 60 days. A maximum of 6,801.4 m^3 (240,162 ft^3) of waste would be available from sites with existing rail capability. Another 278.6 m^3 (9,838 ft^3) of waste is located at sites that need truck shipments. If more than 7,080 m^3 (250,000 ft^3) of waste is shipped, it would probably come from the Hanford Site. Hanford has both truck and rail capability. In Attachment D cost data for the overweight cask were calculated this way using the surcharge for special road permits described in the section 4.2.

5.2.3 Rail from large-quantity generators with truck from small-quantity generators

This alternative combines the economy of scale possible by rail with the necessity to transport waste from multiple sites with small quantities. The truck option portion is the same as the 100% truck section. The rail portion is basically the same as section 5.2.2.

5.2.4 Combined RH and CH TRU Waste Shipments by Rail

The greatest economies and efficiencies are realized when rail shipments of waste destined for WIPP are combined. It also means that the most efficient use of resources can be made in handling ancillary issues, such as emergency preparedness training. Shipments from the same generator site would be combined. The normal shipment would be nine or more TRUPACT-II's with CH TRU waste and three or more packages with RH TRU waste.

5.2.5 Truck Shipments from Sites to Centralized Treatment Point and then Shipped by Rail to WIPP

Several of the alternatives being evaluated in the RH TRU waste treatment area establish centralized treatment facilities at either two or five locations. Waste from other generator sites would be shipped from the generator site to the treatment facility. The majority of these sites would be small-quantity generators. The treatment facilities would be located to optimize RH TRU waste system performance. The treatment facilities could be at ORNL and Hanford or INEL. These sites will either generate or have large inventories of RH TRU waste.

5.3 Evaluation Process

The transportation system was evaluated on the basis of cost, risk, and flexibility criteria. Alternatives were rated as better or worse than the design basis. The design basis is 100%

truck using the RH-72B cask. The criteria are defined as:

- Cost. Cost for transportation is identified as the cost of transporting the waste from the generator site to the WIPP site, plus the cost of hardware. Hardware costs include: the container, the packaging, and the trailer or rail car. Maintenance costs for the packaging for the various alternatives are considered equal and therefore not included. Cost data were developed using the cost-per-shipment information contained in DOE/WIPP 93-058 (DOE, 1994b) and EEG-WM-10877 (DOE, 1994c). These documents were completed in 1994 and allow comparisons. The Santa Fe Railroad was contacted to verify that the rail cost data were still valid. The data for truck shipments are comparable based on actual data obtained from the TRU waste carrier contract. The cost data are in Attachment D.

- Flexibility. Several topics are addressed under the flexibility criterion. First, does the alternative provide greater probability of meeting the work-off plan needs? Does the alternative allow greater flexibility in accommodating delays, or changes in the CH TRU waste work-off plan and RH TRU waste work-off plan? For example, if the site scheduled to ship cannot ship due to unscheduled equipment failures, can other sites be used? Weather, maintenance problems, and budget issues can all produce schedule delays that require P&T system changes. The objective is to maintain the throughput that the WIPP can emplace.

- Risk. Overall risk of the alternative is ranked as better or worse than the design basis. The frequency of shipments, types of incidents, or consequence of incidents may change. Reduced risk results in the alternative being ranked as better than the design basis. Alternatives with fewer shipments were ranked better than other alternatives.

5.4 Evaluation Results

The assumptions used in this area highly impact the outcome of recommendations. Truck, or some combination of truck and rail can all meet the requirements for sustained throughput for the WIPP. Over a 25-year period, life-cycle costs range from $70 million to over $600 million. Actual cost figures were not calculated for a new cask. It was assumed that a more volumetrically efficient cask than the RH-72B could be developed. This would result in costs somewhere between the RH-72B and HalfPack range. Costs for each alternative being shipped primarily by rail were not calculated. Depending on the number of containers made available, actual transportation costs could be reduced to about $50 million over an operating period of 25-40 years. This is $1-4 million per year depending on the alternative. Impacts to the generator site and the WIPP facility become the driving factors. Truck transportation has greater flexibility than rail to respond to various needs. This requires a Type B packaging that does not require special road permits. Truck is better for small waste shipments. Unless dedicated trains are used, hydrogen gas generation adds additional characterization and packaging challenges. These challenges would need to be met to demonstrate compliance with a NRC C of C. Dedicated trains are only cost effective with larger shipments.

5.5 Transportation System Recommendation

WID's initial recommendation is to begin RH TRU waste receipt with 100% truck shipments. This recommendation is made for several reasons, based upon the established criteria in Section 5.3. Note that this recommended mode of transportation does not apply to the full operational period of WIPP. Rather, this recommendation is valid until the treatment facilities at one of the larger generator sites of INEL, Hanford, or ORNL become operational. As the larger sites become fully operational, the recommendation would be reevaluated and probably would be changed. Based upon the current program life-cycle assumptions, the recommendation changes during the life of the facility to include a combination CH and RH TRU waste rail shipments from the larger generator sites.

The reasons for the initial 100% truck recommendation are as follows:

- There is uncertainty about the waste inventory and about when certified waste will be available and in what quantities. Generator site schedules are being developed and are dependent on funding. In addition technical difficulties could be encountered that delay the startup of characterization and treatment operations. Treatment facilities do not become available until after 2005.

- It is expected that the first RH TRU waste shipments will come from Los Alamos. LANL has a hot cell available for RH TRU waste characterization and packaging activities. LANL has only truck capability. Ancillary impacts and costs can be minimized.

- There is an extended ramp-up period projected involving low volumes of RH TRU waste. A ramp-up period of greater than three years is projected. Rail is the best when shipping large volumes from limited sites.

- Unless CH and RH TRU waste shipments are combined, the benefits of rail, such as economy of scale, cannot be fully realized. The sustained throughput should be achieved first before switching to rail. As a minimum one of the major packaging or treatment facilities should be fully operational. ORNL is the first major site that will have a RH TRU waste certification and packaging facility.

- Operational costs at the WIPP site would increase if a switch engine or other devices to move rail cars are required.

- Initially, system reliability and ability to meet the work-off plan will be unknown. The truck alternative has greater flexibility.

- Truck capability must be available for sites without rail and for small-quantity generators.

- Due to gas generation concerns, the time between loading and unloading needs to be less than 60 days. Using commercial rail service, the 60-day time period between loading at the generator site and unloading at the WIPP site has not been proven. Without guarantees from the railways, hydrogen gas generation could be an issue.

The large generator sites are scheduled to have characterization, packaging, and treatment facilities on-line sometime after 2005. When these facilities are operational, the rail alternative for transportation mixed with truck becomes the more attractive alternative. The change in modes should be made when:

- One of the major packaging or treatment facilities is fully operational. A steady, high-volume supply of certified waste is required to make rail effective. The volume should be such that at least three containers are shipped per shipment. ORNL is the first site scheduled.

- Sufficient packaging must be available.

- The transportation corridor emergency responders must be trained.

A change in mode can be implemented in the time it takes to place a carrier contract with the railroad or a transportation company that will handle rail shipments (approximately 12 months). This time period could be reduced. Many third-party transportation companies now handle truck as well as rail. Outsourcing and contracting to a full-service transportation company has provided savings to many corporations. Using a full-service transportation company could provide added flexibility when using a combination mode. Also, additional packaging is needed if rail is used. To sustain throughput, it is necessary to have a certain minimum number of containers to enable the generator to load waste, the site to unload waste, and to have waste in transit. This decision should be postponed or reviewed annually as revised or new information becomes available. Key to refining this recommendation is increased knowledge about when the major generators will have the waste certified and packaged for the WIPP.

6.0 REFERENCES

WIPP Land Withdrawal Act, Public Law 102-579.

Price Anderson Amendments Act of 1988, Public Law 100-408.
10 CFR Part 71, *Packaging and Transportation of Radioactive Materials.*

23 CFR Part 658, *Federal Highway Administration.* Truck Size and Weight.

29 CFR Part 1910, *Occupational Safety and Health Administration*

40 CFR Part 261, *Identification and Listing of Hazardous Waste.*

40 CFR Part 262, *Standards Applicable to Generators of Hazardous Waste.*

49 CFR Part 100-177,200-268 *Hazardous Materials Transportation.*

49 CFR Part 350-399, *Federal Highway Administration, Department of Transportation.*

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DOE (U.S. Department of Energy), DOE Order 5480.3, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes*, Washington D.C. Jul. 9,1985.

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DOE (U.S. Department of Energy), DRAFT, 1994d, *Safety Analysis Report for the RH-TRU 72-B Waste Shipping Package*, prepared by Vectra Technologies, Inc.

DOE (U.S. Department of Energy), 1995b, *WIPP Disposal Decision Plan*, Carlsbad Area Office, March 15,1995.

ATTACHMENT A

Packaging and Transportation Requirements

REQUIREMENT	REFERENCE
Total curies shall not exceed 5.1 Million for RH TRU waste	LWA Sec 7
RH TRU waste shall not exceed 23 curies per liter	LWA Sec 7
No more than 5% of the RH TRU waste will exceed 100 R/hr	LWA Sec 7
All waste must be shipped in NRC-certified packaging	LWA Sec 16
Notification and Training is required for Emergency Preparedness	LWA Sec 16 State NM C and C
Santa Fe Bypass must be completed or administrator can certify shipment	LWA 16
Waste must be certified	WAC, and C of C for packaging
RH TRU waste is limited to 250,000 cubic feet or 7,080 cubic meters	State NM C and C, Record of Decision, FSEIS
No RH waste will have a surface dose rate greater than 1,000 R/hr	LWA Sec 7
Indemnification Liability for Transportation Accidents	Price-Anderson Act
Participate as Observer WAC Audits/certification	state NM C and C
45-day review and comment period prior to waste shipment	State NM C and C
Cost of Transportation Accident Cleanup is DOE's	State NM C and C
60 days notice to state if use federal employees vs contract to transport waste	State NM C and C

Comply All DOT/NRC transportation requirements	State NM C and C
Specific Procedures needed one year in advance	State NM C and C
Packaging design, operation, Maintenance, fabrication and loading	10 CFR 71
Motor carrier safety regulations	49 CFR 350-399 (DOT)
Train Operation	49 CFR 100-177,200-268
Hazardous Waste Shipments/Disposal	40 CFR 191,261,262,263,264,265, 268
Packaging Design/Selection	DOE Order 5480.3A and 1540.3A
Transportation Contracting / Requirements/Safety	DOE Order 1540.1A
Transportation Safety	DOE Order 5480.3
Waste Management, WIPP-Specific Transportation	DOE Order 5820.2A
State of NM can monitor transportation	State NM C and C
Prior to ship by rail state can review, comment or inspect	State NM C and C
Double Confinement if >20 curies of PU	10 CFR 71.63
Data on all waste brought in to state	State NM C and C

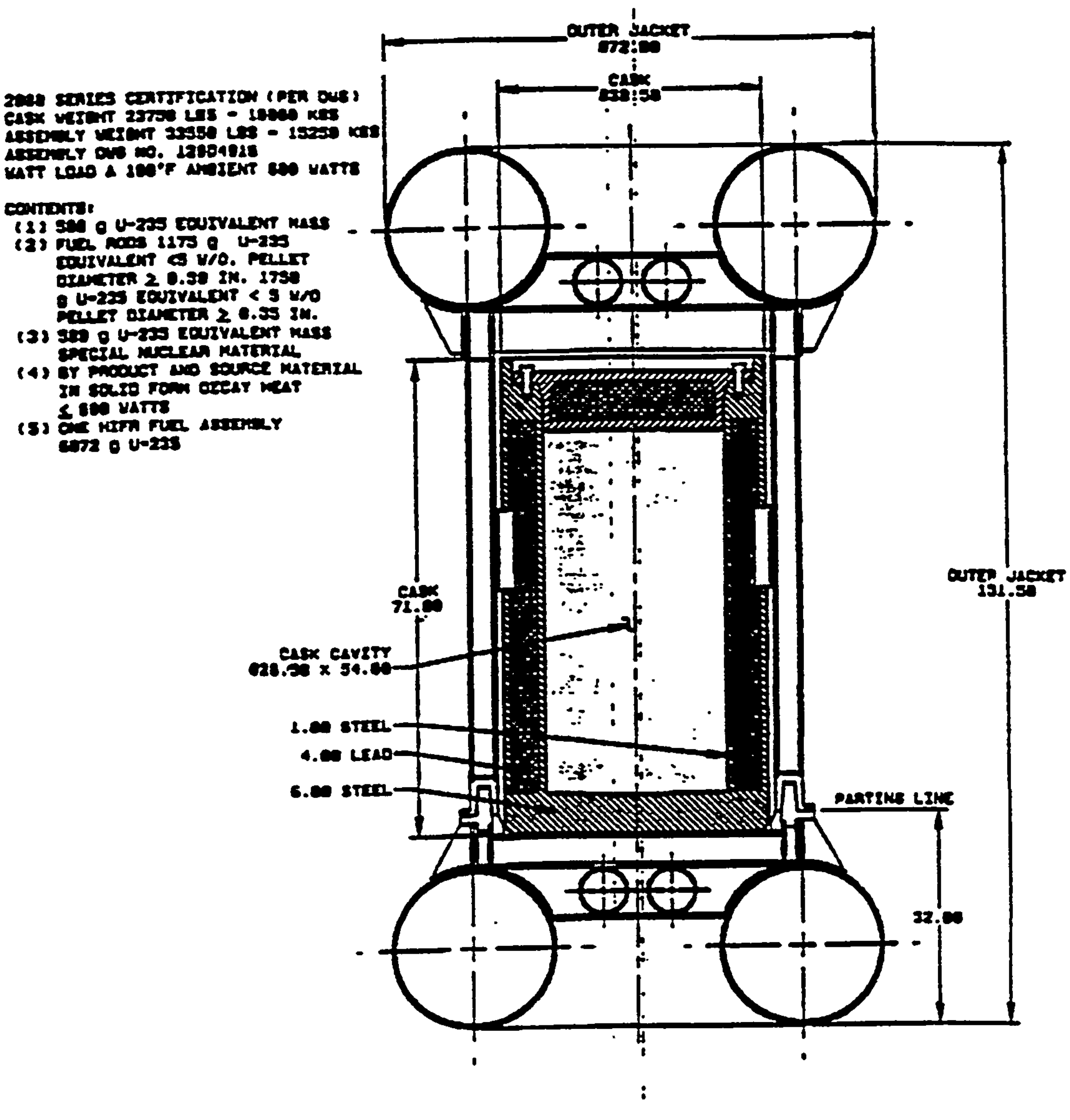
ATTACHMENT B
NRC Type B Packaging Requirements

In order to ship RH TRU waste in NRC Type B packaging, certain information is required about the waste form. The following information is normally required to show compliance with a NRC C of C:

- Waste Description
- Waste Form
- Free Liquids
- Payload Container Venting and Aspiration (Hydrogen Gas Generation)
- Explosives/Compressed Gas
- Chemical Compatibility
- Pyrophorics
- Assay
- Corrosives
- Decay Heat (Thermal Wattage)
- Content Code

ATTACHMENT C

Container Vendor Data



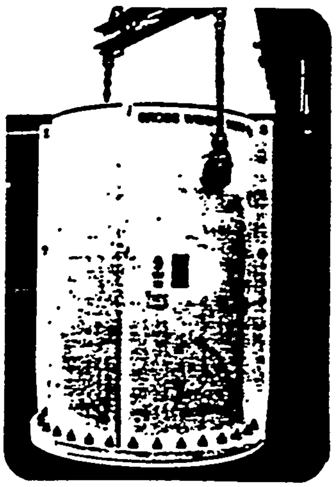
MODEL 2000 SHIELDED CONTAINER

- GE 2000 Cask
- shielded packaging for short canister or drum
- described in Section 4.1.2

Package Design No 2917C

Package Name: Waste Drum Shielded Package

CROFT



Package Type

The 2917C package is a general purpose B(U)F package designed to meet the 10 CFR and IAEA Regulations for the transport of radioactive materials. The package is particularly suitable for α, β & γ emitting waste contained in drums.

Certification

The package has been fully tested and certified to the IAEA regulations by the UK Competent Authority and can be further certified to suit user requirements.

Description

The outer container Casket Design No 2917 is a "double shell" welded cylindrical casket manufactured in low carbon steel with a circular bolted closure at the base. The space between the "shells" is filled with phenolic resin foam and the casket is fitted internally with shock absorbers. The casket provides thermal and mechanical protection to the shielded flask.

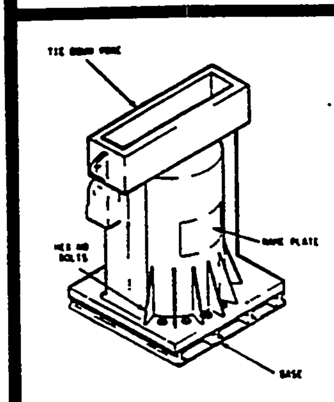
The inner container Design No 2916 is a large cavity shielded flask. The flask is of welded stainless steel construction incorporating lead shielding. Access to the cavity is gained by the removal of a closure flange and a separate shielding plug.

Croft Incorporated
PO Box 488
Middletown
OHIO 45042
USA

Tel
(513) 423 9940

- shielded packaging for 55-gallon drum
- described in Section 4.1.3

CHEM-NUCLEAR SYSTEMS, INC. — CNS 1-13G



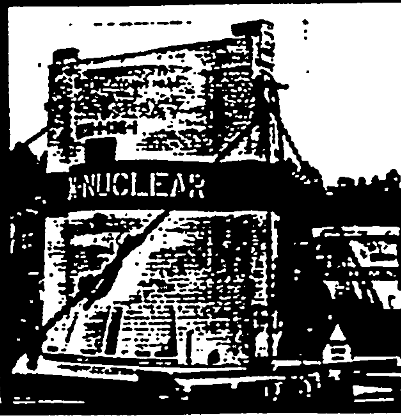
CNS 1-13G

NRC Certificate No. USA/9216/B (   ) F

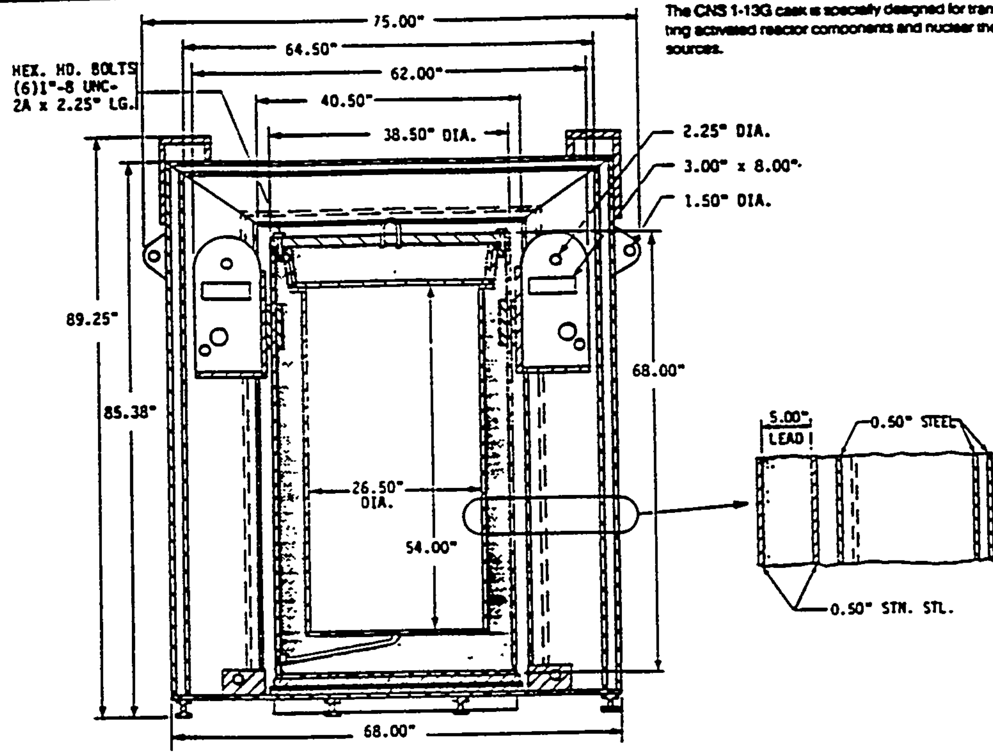
Capacity: (1) 55-gallon drum
(1) 8-17 ft³ liner
Shielding: 6.20" lead equivalent
Dose Rate: 6000 R/hr (approx.)
(Maximum based on Cobalt 60)

Total Empty Package Weight:	25.500#
Empty Cask Weight (with lid):	19.100#
Cask Lid Weight:	2.000#
Overpack with Baseplate:	6.400#

Payload weight not restricted



The CNS 1-13G cask is specially designed for transporting activated reactor components and nuclear therapy sources.



The CNS 1-13G cask is a lead and steel shipping cask for fissile, solid metal, or metal oxides by-product material. The decay heat of the contents must not exceed 600 watts (38,800 curies of Cobalt-60).

Loading: (A) One drum with appropriate lifting sling may be lowered into the cask. (B) A disposable liner may be lowered into the cask while mounted on the transport trailer. (C) Activated reactor components contained in a disposable liner may be loaded into the cask underwater

- shielded packaging for 55-gallon drum
- model requires a modification to provide double containment
- described in Section 4.1.3

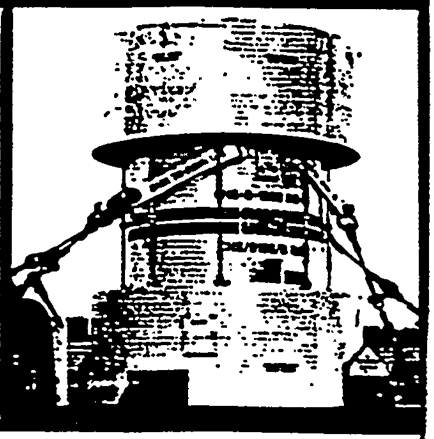
CHEM-NUCLEAR SYSTEMS, INC. — CNS 8-120B

CNS 8-120B

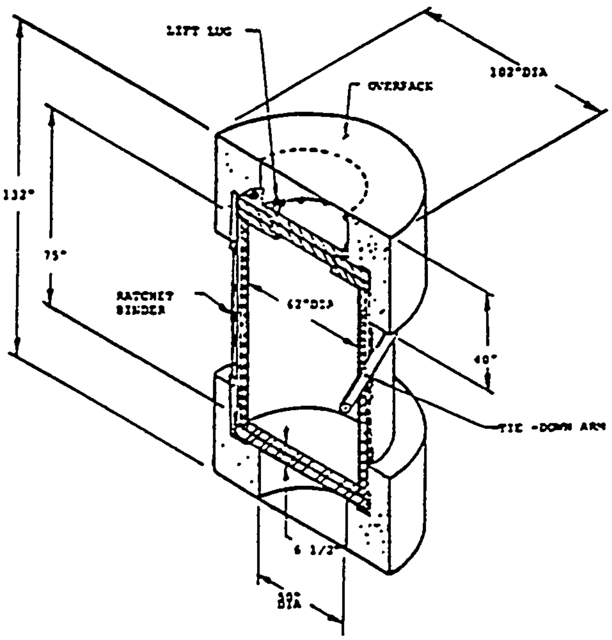
NRC Certificate No USA/9168/B(U)

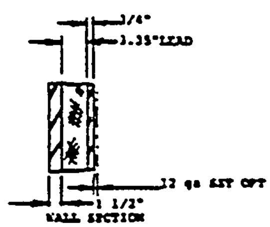
Capacity:	(8) 55-gallon drums
	(1) 120-130 ft^3 liner
	(4) 24" x 72" pressure vessels
Shielding	4.5" lead equivalent
Dose Rate:	880 R/hr (Maximum based on 10% Cobalt 60)

Empty Package Weight (with lids):	49,300#
Primary and Secondary lids:	7,080#
Secondary lid:	1,890#
Payload Weight:	14,680#



The CNS 8-120B cask is specially designed for transporting Type B quantities of dewatered and solidified highly radioactive resin.





The CNS 8-120B cask is a lead and steel shipping cask for dewatered or solidified waste material or activated reactor components contained within secondary container(s). The contents may contain greater than Type A quantities of radioactive material.

Loading: (A) Four drums are placed on each of the two pallets located outside the cask. The pallets are then lowered into the cask. (B) Activated reactor components contained in a disposable liner may be loaded into this cask underwater. The upper right cylinder cask may be loaded while mounted on the transport trailer.

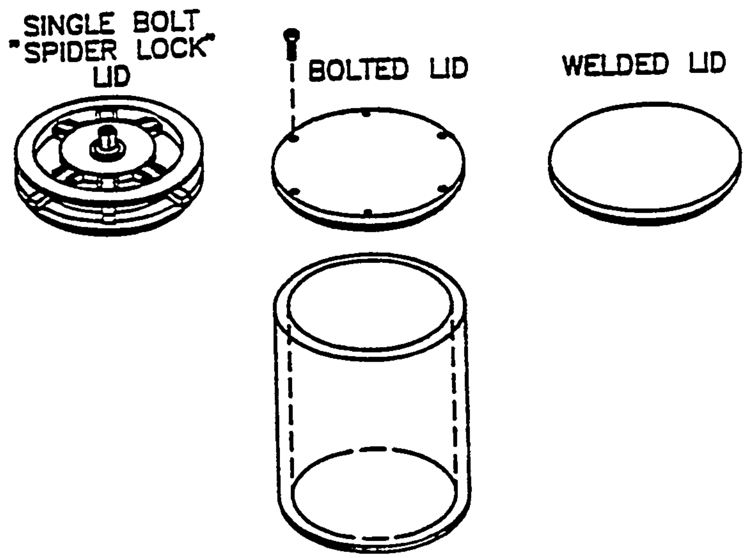
- shielded rail cask and other oversized casks
- described in Section 4.1.5

SCIENTIFIC ECOLOGY GROUP
A Westinghouse Subsidiary

SPINCAST WASTE CONTAINER

DATA SHEET NO. DC-17
REV. NO. 0
SHEET 1 OF 2

Container Functions: Processing, Storage, Transportation, Disposal
Construction Materials: Stainless Steel
Qualifications: DOT Type A



SPINCAST WASTE CONTAINER

SPECIAL FEATURES

- ✓ SIMPLE SINGLE BOLT CLOSURE, BOLTED OR WELDED CLOSURE
- ✓ FULL DIAMETER OPENING
- ✓ STACKABLE - DESIGNED TO SUPPORT FIVE TIMES THE CONTAINER'S GROSS WEIGHT

OPTIONAL FEATURES

- ✓ GRAPPLE RING/FIXTURES
- ✓ PASSIVE VENT
- ✓ WALL THICKNESS CAN BE INCREASED FOR ADDED SHIELDING

- unshielded packaging (shielded drums in TRUPACT-II)
- described in Section 4.1.7

ATTACHMENT D
Alternative Cost Data

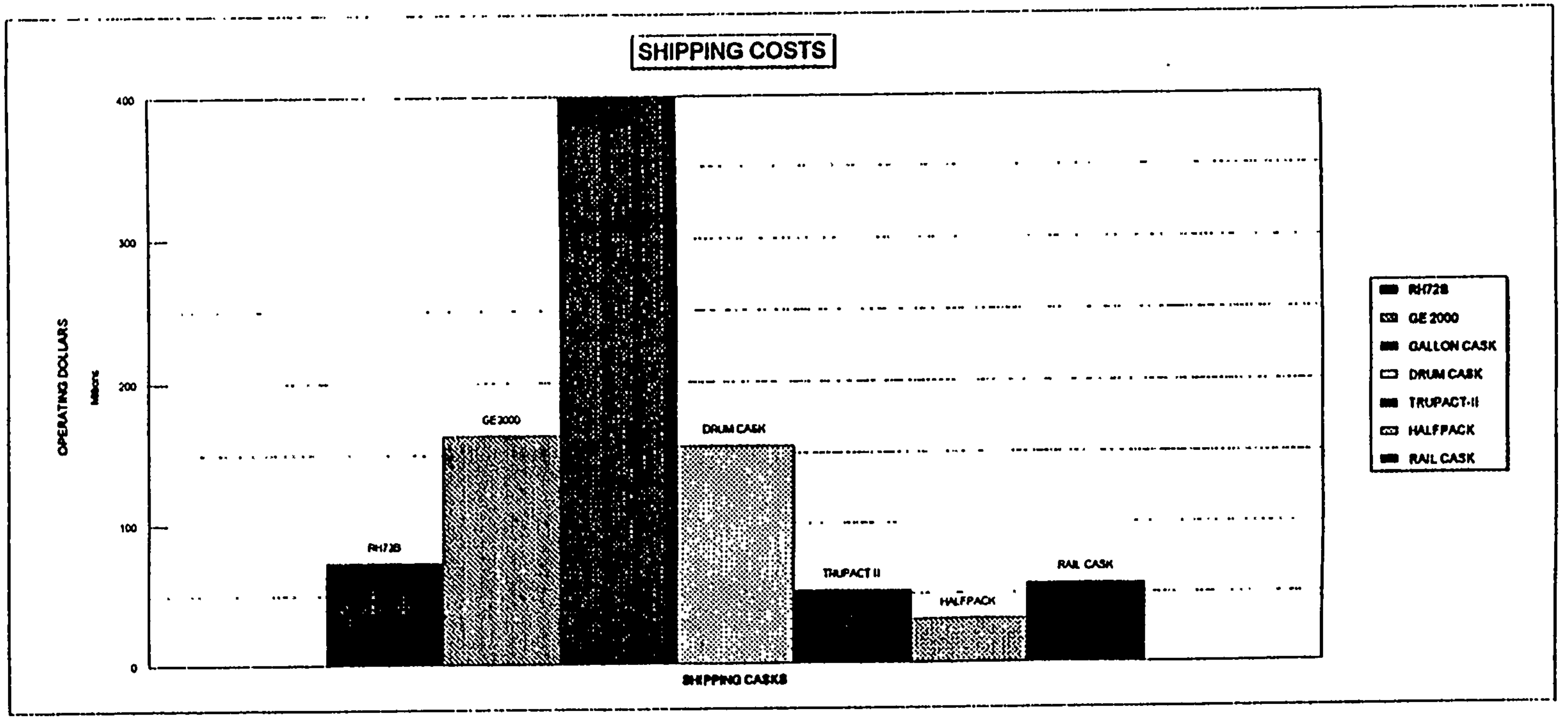
Below is a table showing the major assumptions used in developing the cost data.

ALTERNATIVE COMPARISON CHART

ALTERNATIVES	PACKAGING VOLUME	CAPITAL COST OF PACKAGING	NUMBER OF SHIPMENTS	ASSUMPTIONS
RH-72B	0.89 m^3	$750,000 ea with trailer plus $14,000 per canister	7,955-TRUCK	ASSUMES 1 CASK PER TRUCK.
GE 2000	0.4 m^3	$2,600,000 ea with double containment and trailer, plus $50 per drum	17,770-TRUCK	ASSUMES CARRIES MORE THAN A 55-GAL DRUM; 1 CASK PER TRUCK
DRUM CASK	0.208 m^3 2x=0.42m^3	$350,000 ea plus $50,000 trailer $500,000 to get NRC C of C	16,857-TRUCK	ASSUMES 2 CASKS PER TRUCK; DRUMS ARE HANDLED AT WIPP.
RAIL CASK	1.0-5.0 m^3 8-10 drums	$500,000 ea plus trailer or rail car	6,801 M^3-RAIL, PLUS 279 M^3-TRUCK	NOT ALL WASTE CAN BE SHIPPED BY TRUCK; $2,000 SURCHARGE WHEN SHIPPED BY TRUCK FOR PERMITS
1-GAL CASK	0.1 m^3 8-25 per truck	$50,000 ea plus trailer	70,800	ASSUMES 8 CASKS PER TRAILER
TRUPACT-II	0.42 m^3 1.25 m^3/ shipment	$350,000 ea with trailer plus $4,000 per drum	5,664-TRUCK	ASSUMES AT LEAST 6 55-GAL DRUMS PER SHIPMENT; CANNOT SHIP HIGH R WASTE; 3 TRUPACTS PER TRUCK
NEW SHIELDED	>0.89 m^3	$750,000 ea with trailer	BETWEEN 3,000-7,900	ASSUMES CASK IS BETTER THAN RH-72B
HALFPACK (NEW UNSHIELDED)	2.08 m^3	$350,000 ea with trailer plus $4000 per drum	3,404-TRUCK	ASSUMES 10 55-GAL DRUMS PER SHIPMENT; 3 HALFPACKS PER TRUCK

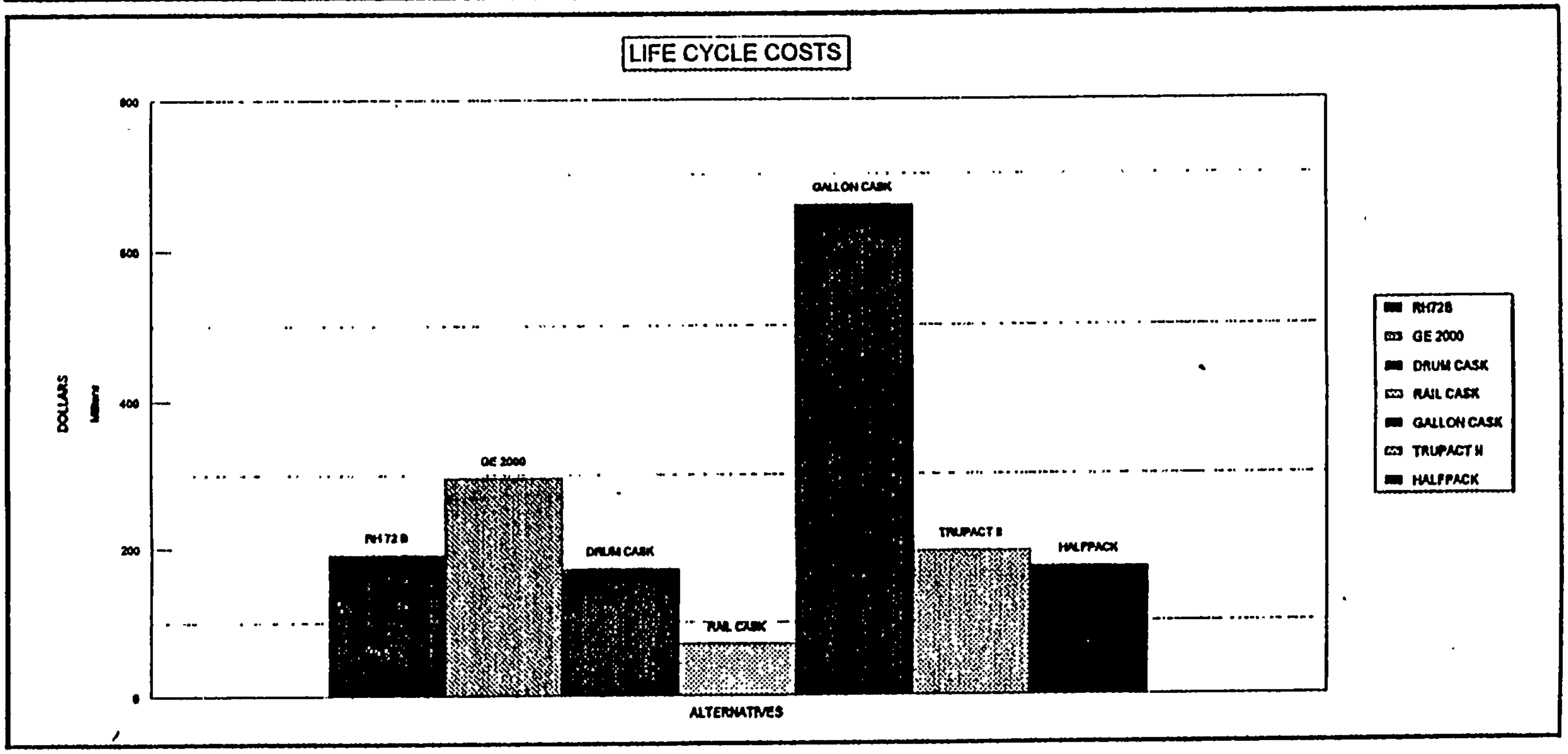
SHIPPING COSTS

SITES	RH72B	GE2000	GALLON CASK	DRUM CASK	TRUPACT II	HALFPACK	RAIL CASK
INEL	$702,296	$1,562,610	$6,250,440	$1,488,200	$500,035	$300,501	$529,569
HANFORD	$57,449,495	$127,825,127	$511,300,510	$121,738,216	$40,904,040	$24,581,755	$47,654,968
LANL	$482,703	$1,074,015	$4,296,060	$1,022,871	$343,684	$206,541	$468,437
ORNL	$12,724,887	$28,312,875	$113,251,500	$26,964,642	$9,060,120	$5,444,783	$6,903,360
BCLDP	$781,797	$1,739,500	$6,958,000	$1,656,666	$556,640	$344,519	$504,698
BT	$22,022	$49,000	$196,000	$46,666	$15,680	$9,423	$14,216
KAPL	$392,359	$873,000	$3,492,000	$831,428	$279,360	$167,884	$253,734
SRS	$701,483	$1,560,800	$6,243,200	$1,486,476	$499,456	$300,153	$391,180
TOTALS	$73,300,000	$163,000,000	$652,000,000	$155,200,000	$52,200,000	$31,400,000	$56,700,000



LIFE CYCLE COSTS

ALTERNATIVES	FLEET SIZE	FLEET CAPITAL COST	TYPE 'A' PACKAGING COST	CAPITAL COST	OPERATING COST	TOTAL COST
RH 72 B	10	$7,500,000	$111,370,000	$118,870,000	$73,260,000	$192,130,000
GE 2000	10	$26,000,000	$106,200,000	$132,200,000	$163,000,000	$295,200,000
DRUM CASK	20	$10,000,000	$6,810,000	$16,810,000	$155,240,000	$172,050,000
RAIL CASK	6	$3,000,000	$10,240,000	$13,240,000	$56,720,000	$69,960,000
GALLON CASK	125	$6,250,000	$0	$6,250,000	$651,990,000	$658,240,000
TRUPACT II	20	$7,000,000	$136,150,000	$143,150,000	$52,160,000	$195,310,000
HALFPACK	20	$7,000,000	$136,150,000	$143,150,000	$31,360,000	$174,510,000



HALF PACK

SITES	PROJECTED WASTE	HALF PACK VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	2.08	40	$7,441	$300,000
HANFORD	5299	2.08	2548	$9,649	$24,580,000
LANL	174	2.08	84	$2,469	$210,000
ORNL	1350	2.08	649	$8,389	$5,440,000
BCLDP	71	2.08	34	$9,800	$330,000
BT	2	2.08	1	$9,800	$10,000
KAPL	36	2.08	17	$9,700	$170,000
SRS	64	2.08	31	$9,755	$300,000
TOTALS	7080		3404		$31,340,000

TRUPACT II

SITES	PROJECTED WASTE VOLUME (M3)	TRUPACT II VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	1.25	67	$7,441	$500,000
HANFORD	5299	1.25	4239	$9,649	$40,900,000
LANL	174	1.25	139	$2,469	$340,000
ORNL	1350	1.25	1080	$8,389	$9,060,000
BCLDP	71	1.25	57	$9,800	$560,000
BT	2	1.25	2	$9,800	$20,000
KAPL	36	1.25	29	$9,700	$280,000
SRS	64	1.25	51	$9,755	$500,000
TOTALS	7080		5664		$52,160,000

DRUM CASK

SITES	PROJECTED WASTE VOLUME (M3)	DRUM CASK VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	0.42	200	$7,441	$1,490,000
HANFORD	5299	0.42	12617	$9,649	$121,740,000
LANL	174	0.42	414	$2,469	$1,020,000
ORNL	1350	0.42	3214	$8,389	$26,960,000
BCLDP	71	0.42	169	$9,800	$1,660,000
BT	2	0.42	5	$9,800	$50,000
KAPL	36	0.42	86	$9,700	$830,000
SRS	64	0.42	152	$9,755	$1,490,000
TOTALS	7080		16857		$155,240,000

GALLON CASK

SITES	PROJECTED WASTE VOLUME (M3)	GALLON CASK VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	0.1	840	$7,441	$6,250,000
HANFORD	5299	0.1	52990	$9,649	$511,300,000
LANL	174	0.1	1740	$2,469	$4,300,000
ORNL	1350	0.1	13500	$8,389	$113,250,000
BCLDP	71	0.1	710	$9,800	$6,960,000
BT	2	0.1	20	$9,800	$200,000
KAPL	36	0.1	360	$9,700	$3,490,000
SRS	64	0.1	640	$9,755	$6,240,000
TOTALS	7080		70800		$651,990,000

GE 2000 CASK

SITES	PROJECTED WASTE VOLUME (M3)	GE 2000 VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	0.4	210	$7,441	$1,560,000
HANFORD	5299	0.4	13248	$9,649	$127,830,000
LANL	174	0.4	435	$2,469	$1,070,000
ORNL	1350	0.4	3375	$8,389	$28,310,000
BCLDP	71	0.4	178	$9,800	$1,740,000
BT	2	0.4	5	$9,800	$50,000
KAPL	36	0.4	90	$9,700	$870,000
SRS	64	0.4	160	$9,755	$1,560,000
TOTALS	7080		17700		$162,990,000

RH 72 B CASK

SITES	PROJECTED WASTE VOLUME (M3)	RH72B VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	0.89	94	$7,441	$700,000
HANFORD	5299	0.89	5954	$9,649	$57,450,000
LANL	174	0.89	196	$2,469	$480,000
ORNL	1350	0.89	1517	$8,389	$12,720,000
BCLDP	71	0.89	80	$9,800	$780,000
BT	2	0.89	2	$9,800	$20,000
KAPL	36	0.89	40	$9,700	$390,000
SRS	64	0.89	72	$9,755	$700,000
TOTALS	7080		7955		$73,240,000

RAIL CASK

SITES	PROJECTED WASTE	RAIL CASK VOLUME (M3)	SHIPMENTS PER SITE	ROUND TRIP COSTS	SHIPPING COST PER SITE
INEL	84	5	17	$31,522	$530,000
HANFORD	5299	5	1060	$44,966	$47,650,000
LANL	174	1.66	105	$4,469	$470,000
ORNL	1350	5	270	$25,568	$6,900,000
BCLDP	71	1.66	43	$11,800	$500,000
BT	2	1.66	1	$11,800	$10,000
KAPL	36	1.66	22	$11,700	$250,000
SRS	64	5	13	$30,561	$390,000
TOTALS	7080		1530		$56,700,000

RAIL CASK
(CONTRACT RAIL)

SITES	PROJECTED	RAIL CASK	SHIPMENT	ROUND	SHIPPING
INEL	84	5	17	$21,409	$364,000
HANFORD	5,299	5	1,060	$25,604	$27,140,000
LANL	174	1.66	105	$4,469	$470,000
ORNL	1,350	5	270	$30,245	$8,166,000
BCLDP	71	1.66	43	$11,800	$500,000
BT	2	1.66	1	$11,800	$10,000
KAPL	36	1.66	22	$11,700	$250,000
SRS	64	5	13	$21,392	$278,000
TOTALS	7,080		1,530		$37,178,000

Transporting RH TRU waste by contract rail instead of commercial rail presents additional transportation cost savings. When using the numbers from Table 7-6, Contract Rates for Regular Train Service (DOE, 1994b), costs are reduced approximately $20 million. If dedicated trans are used, costs are significantly increased.

COMPARISON OF CONTRACT RAIL TO COMMERCIAL RAIL

GENERATOR SITE	CONTRACT ROUND TRIP COST	CONTRACT SHIPPING COST	COMMERCIAL ROUND TRIP COST	COMMERCIAL SHIPPING COST
INEL	$21,409	$364,000	$31,522	$530,000
HANFORD	$25,604	$27,140,000	$44,966	$47,650,000
LANL[1]	$4,469	$470,000	$4,469	$470,000
ORNL	$30,245	$8,166,000	$25,568	$6,900,000
BCLDP[1]	$11,800	$500,000	$11,800	$500,000
BT[1]	$11,800	$11,800	$11,800	$11,800
KAPL[1]	$11,700	$250,000	$11,700	$250,000
SRS	$21,392	$390,000	$30,561	$390,000
TOTAL		$37,300,000		$56,700,000

[1]LANL, BCLDP, BT, and KAPL do not have rail available.

ATTACHMENT E

P&T Study
WIPP Evaluation Group

Packaging & Transportation Study
WIPP Evaluation Group

Name	Experience	Location
Brown, Michael	Operations/ Engineering	Westinghouse Electric Corporation Waste Isolation Division (WID) Carlsbad, New Mexico
Burrington, Tod	Engineering	Westinghouse Electric Corporation (WID)
Johnson, Jack	Regulatory Compliance	Westinghouse Electric Corporation (WID)
Kelley, Clint	Operations	Westinghouse Electric Corporation (WID)
Palanca, Rod	Operations/ Engineering	Westinghouse Electric Corporation (WID)
Porter, Larry	Operations	Westinghouse Electric Corporation (WID)
Rempe, Norbert	Geotechnical	Westinghouse Electric Corporation (WID)
Uptergrove, Joe	Operations	Westinghouse Electric Corporation (WID)
Woolsey, Gerry	Operations	Westinghouse Electric Corporation (WID)

REMOTE-HANDLED TRANSURANIC SYSTEM ASSESSMENT

APPENDIX F

Remote-Handled Transuranic Waste Disposal Alternatives

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Volume 2

November 1995

U. S. Department of Energy
Carlsbad Area Office
National TRU Program

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Attachment B: RH TRU Waste Disposal Alternatives WIPP Evaluation Group

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Remote-Handled Transuranic Waste Disposal Alternatives

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for managing the disposition of transuranic (TRU) waste resulting from nuclear weapons production activities of the United States. This waste is temporarily stored nationwide at several of the DOE's waste generating/storage sites. The goal is to eliminate interim waste storage and achieve environmentally and institutionally acceptable permanent disposal of TRU waste.

Transuranic waste is waste contaminated with alpha-emitting radionuclides with an atomic number greater than 92 and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram. Remote-handled (RH) TRU waste is packaged TRU waste whose external surface dose rate exceeds 200 millirem per hour (mrem/hr). For the Waste Isolation Pilot Plant (WIPP), there is an upper limit of 1,000 rem per hour (rem/hr). Contact-handled (CH) TRU waste is waste whose external surface dose rate does not exceed 200 mrem/hr. DOE 5820.2A, Radioactive Waste Management, defines TRU waste and allows the heads of DOE field offices to classify other wastes that must be managed as TRU waste.

The mission of the WIPP as established by Congress in 1979 (Public Law 96-164) is to provide "...a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission." Authorized solely as a defense research and development facility by Congress, the WIPP will receive stored and newly-generated defense TRU waste.

Safety and efficiency are the primary goals of the waste disposal system at the WIPP. The disposal system must be able to comply with applicable regulatory requirements while supporting the DOE's National TRU Program. The regulated capacity of the WIPP is 175,600 m^3 (6.2 million ft^3) of waste as cited by the Land Withdrawal Act (Public Law 102-579). Of this amount, up to 7,080 m^3 (250,000 ft^3) may be RH TRU waste.

2.0 PURPOSE

This report presents the results of a detailed assessment of 16 RH TRU waste disposal alternatives for the WIPP and recommends two of the most cost-, schedule-, and safe-effective RH TRU waste disposal alternatives. The alternatives were included in this study on the basis of their potential to optimize the RH TRU waste disposal process and to address issues associated with the current RH TRU waste disposal system. Also included are the current disposal requirements used as key parameters to establish the logic of the decision-making process.

All alternatives examined are consistent with currently planned facility operations and with the DOE mandate to meet requirements for conducting disposal operations in a technically sound, economical, and safe manner. None of the 16 alternatives were eliminated as impossible to implement. They were ranked as the best-to-least choice likely to meet the goals of optimizing the RH TRU waste disposal system at the WIPP. Other components of the TRU waste management system, such as RH TRU waste characterization and treatment capabilities, packaging and transportation, and lag storage, should be considered when making the final disposal system decision.

This assessment of the WIPP RH TRU waste disposal system is part of the DOE's strategy for sustained disposal as described in Section 4.0 of the WIPP Remote-Handled Transuranic Waste Disposal Strategy [Ref. 1]. It considers the waste disposal system's capability to comply with all applicable regulatory requirements and supports the DOE's National TRU Program. This assessment did not attempt to provide in-depth engineering designs in order to allow flexibility in the final alternative design considerations.

3.0 DISPOSAL SYSTEM REQUIREMENTS

The RH TRU waste disposal system at the WIPP must comply with a number of requirements designed to ensure safety and efficiency. The major requirements have been established through several administrative actions and records as follows:

- The design-capacity limit of 7,080 m^3 (250,000 ft^3) of RH TRU waste was originally set by the Record of Decision, January 28, 1981. It was later reiterated in the Final Supplemental Environmental Impact Statement (FSEIS) in June 1990 and the Final Safety Analysis Report (FSAR). This volume is equivalent to 7,955 canisters. [Ref. 2]

- A limit of 5.1 million curies of total activity and 23 curies per liter maximum activity (averaged over the volume of a canister) for the RH TRU waste was originally established by the 11/30/84 Modification to the Consultation and Cooperation (C & C) Agreement between the DOE and the State of New Mexico. [Ref. 2]

- Surface dose rates and activity densities for the waste containers were also established by the C & C Agreement modification in 11/30/84. Up to five (5) percent of the RH TRU waste to be certified for emplacement at the WIPP may have surface dose rates between 100 and 1,000 rem/hr. Dose rates at the surface of the remainder of the waste must be less than 100 rem/hr. [Ref. 2]

- The current disposal canister specifications and waste form requirements are contained in the Waste Acceptance Criteria (WAC) for the WIPP [Ref. 3]. The WAC includes the consideration of WIPP operations and safety criteria, transportation waste package requirements, Resource Conservation and Recovery Act (RCRA) requirements, and performance assessment criteria.

4.0 WIPP RH TRU WASTE DISPOSAL SYSTEM BASELINE

The current RH TRU waste disposal system is designed to use the RH-72B cask for waste transportation and an associated canister for waste disposal operations. These components comprise part of the packaging and transportation system. Figure 1 illustrates the RH-72B cask on a transportation trailer.

The RH TRU waste canisters are made of 1/4-inch carbon steel plate. Their outer dimensions are a diameter of 26 inches and a length of slightly over 10 feet. Their inner volume is 0.89 m^3 (31.43 ft^3). Each canister contains either (1) three 55-gallon drums, (2) three 30-gallon drums, (3) a specialized can from Argonne National Laboratory - West Hot Fuels Examination Facility, or (4) loose waste too large for standard drums. [Ref. 2] Figure 2 illustrates the RH TRU waste canister.

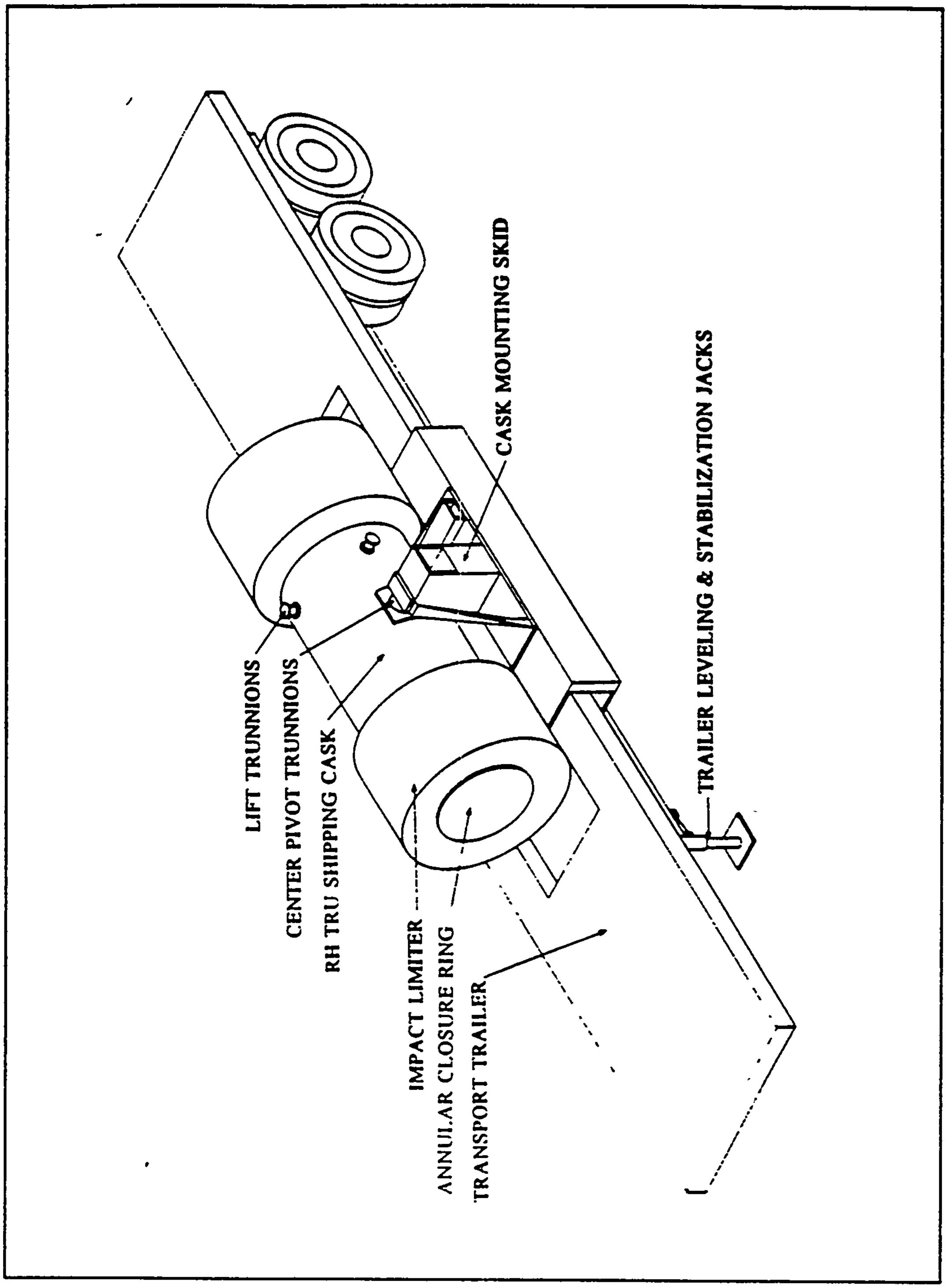

Figure 1. RH TRU Waste Shipping Cask on Trailer

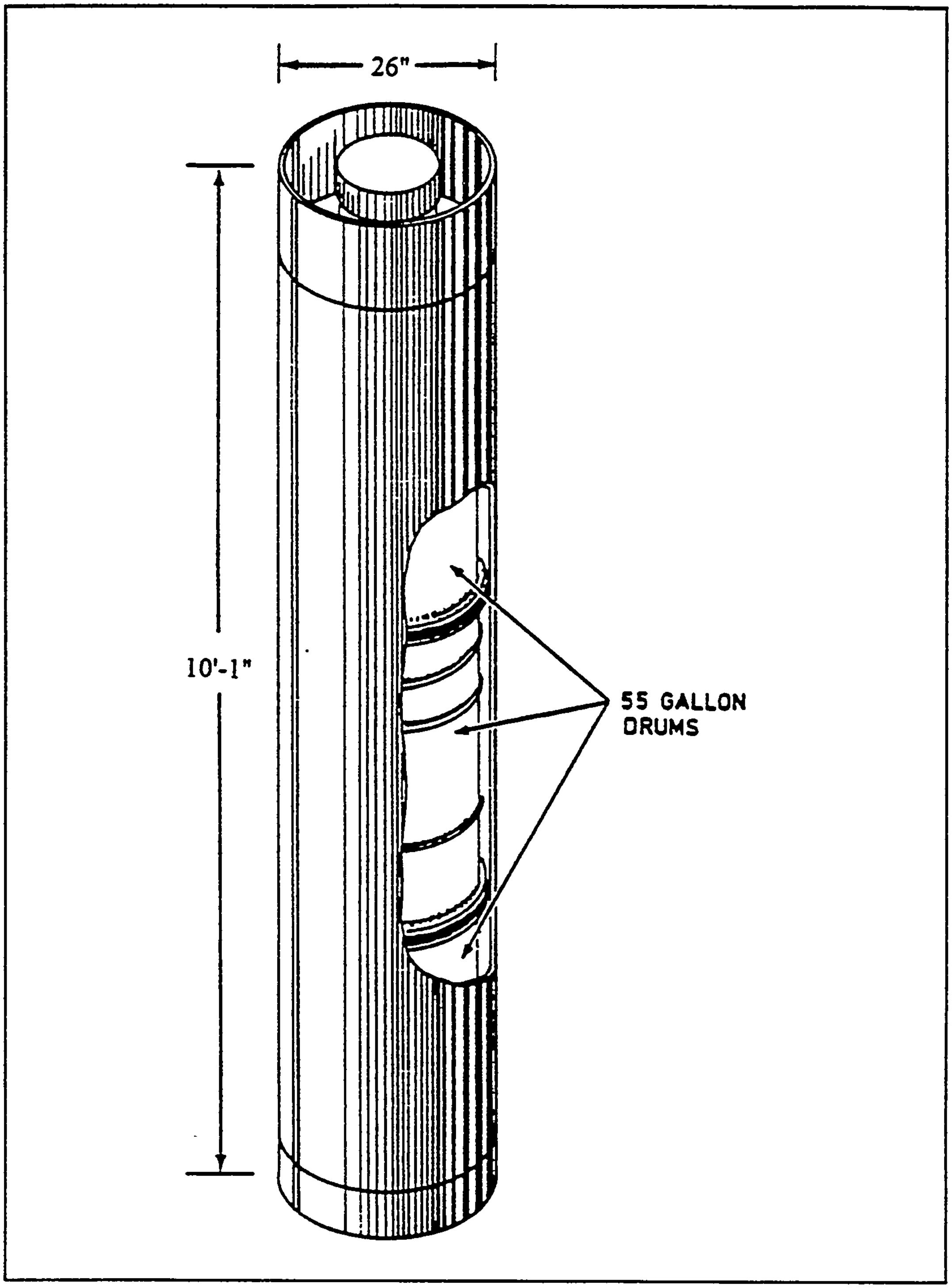

Figure 2. RH TRU Waste Canister

Figure 3 shows the surface facilities and sequence for handling RH TRU waste at the WIPP. When RH TRU waste arrives at the WIPP, the RH-72B shipping cask is removed from the transportation trailer by an overhead crane (1). The cask is transferred to a transfer car and prepared for transfer to the shielded cask unloading room (2). The cask is then mated to the Hot Cell Crane (3). The cask inner lid is removed by remote handling equipment and the canister is transferred into the Hot Cell (4). The canister is inspected for damage and identification. The identification number is verified and contamination and radiation surveys are performed (5). In the unlikely event that contamination is found or the canister is damaged, the canister is placed in an overpack (larger) canister and seal-welded (6). The canister is then loaded into a shuttle car and moved to a position below the Facility Cask (7). The canister is transferred into the Facility Cask. The Facility Cask is used to transfer the canister to the Underground for emplacement (8). The Facility Cask is then rotated to the horizontal position (9). The Facility Cask and transfer car are lowered underground (10). Once underground, the Facility Cask is placed on the Horizontal Emplacement and Retrieval Equipment (H.E.R.E.), which is aligned with a horizontal storage room borehole. The canister is then pushed out of the Facility Cask and a shield plug is installed using the H.E.R.E. (see Figure 4). [Ref. 4]

Boreholes are drilled in the walls of the WIPP disposal rooms and access drifts within the panels. The boreholes are on 8-foot centers and hold one canister. Figure 5 shows the locations of RH TRU waste boreholes in a typical disposal panel configuration [Ref. 5].

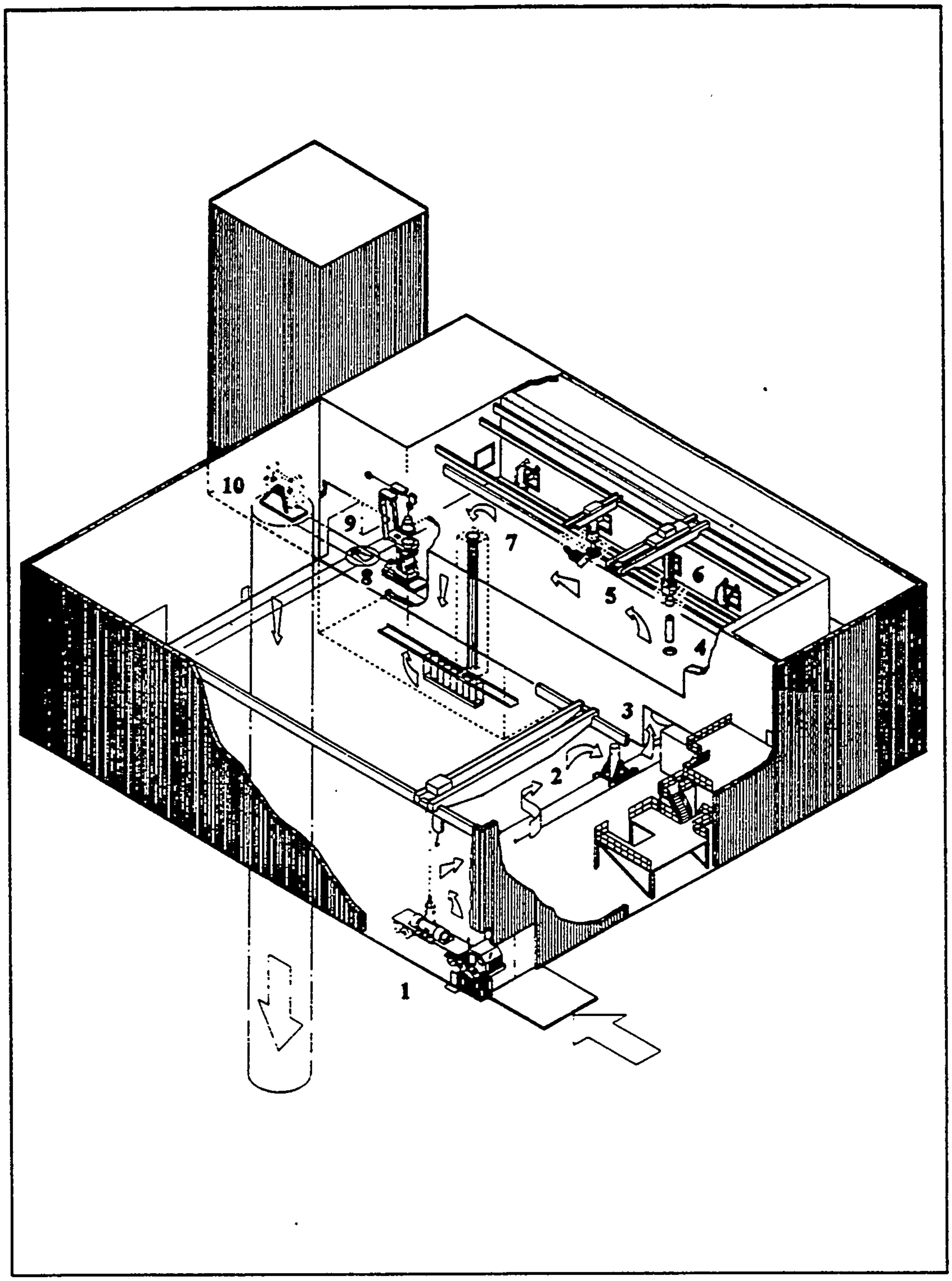

Figure 3. RH TRU Waste Handling Surface Operations

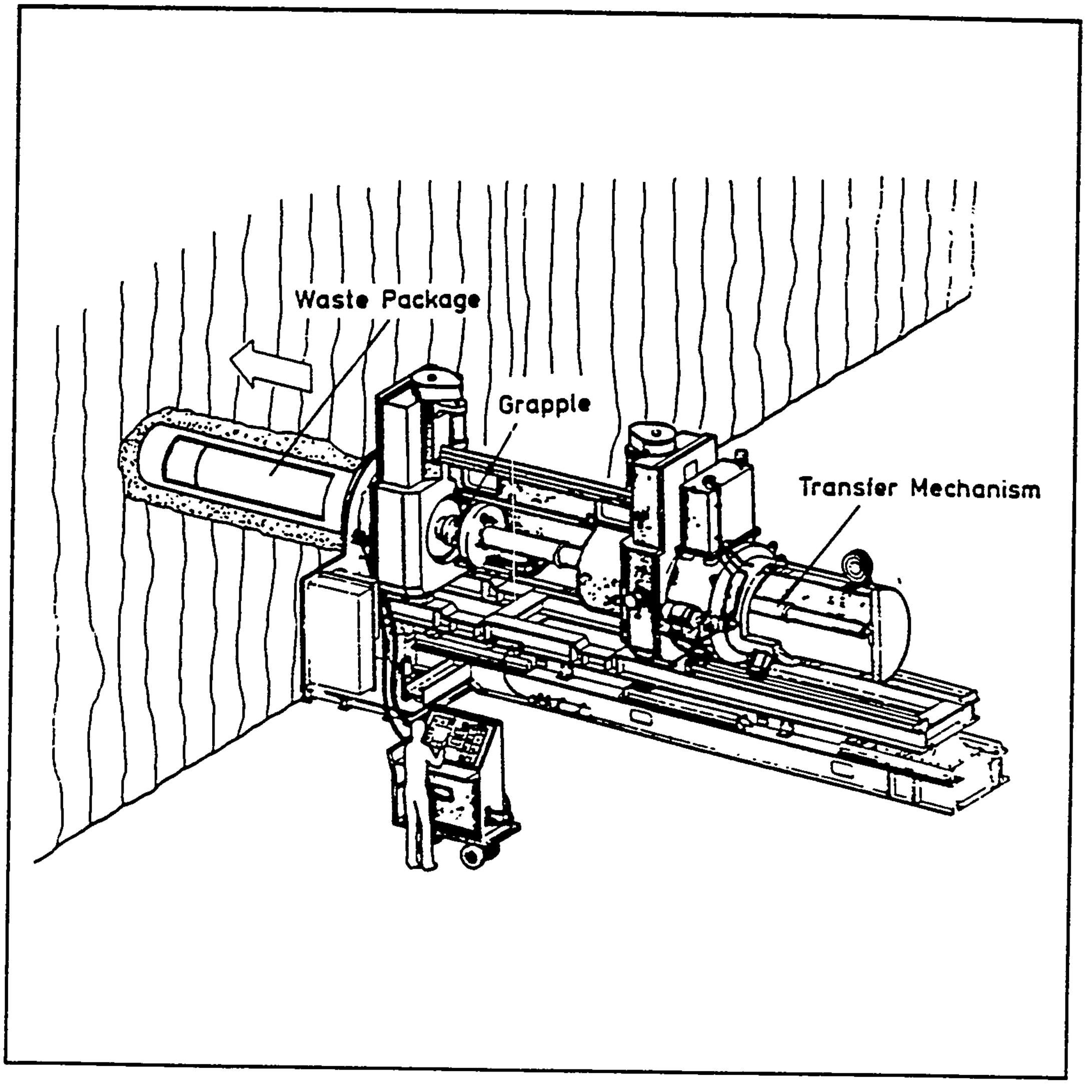

Figure 4. Horizontal Emplacement and Retrieval Equipment

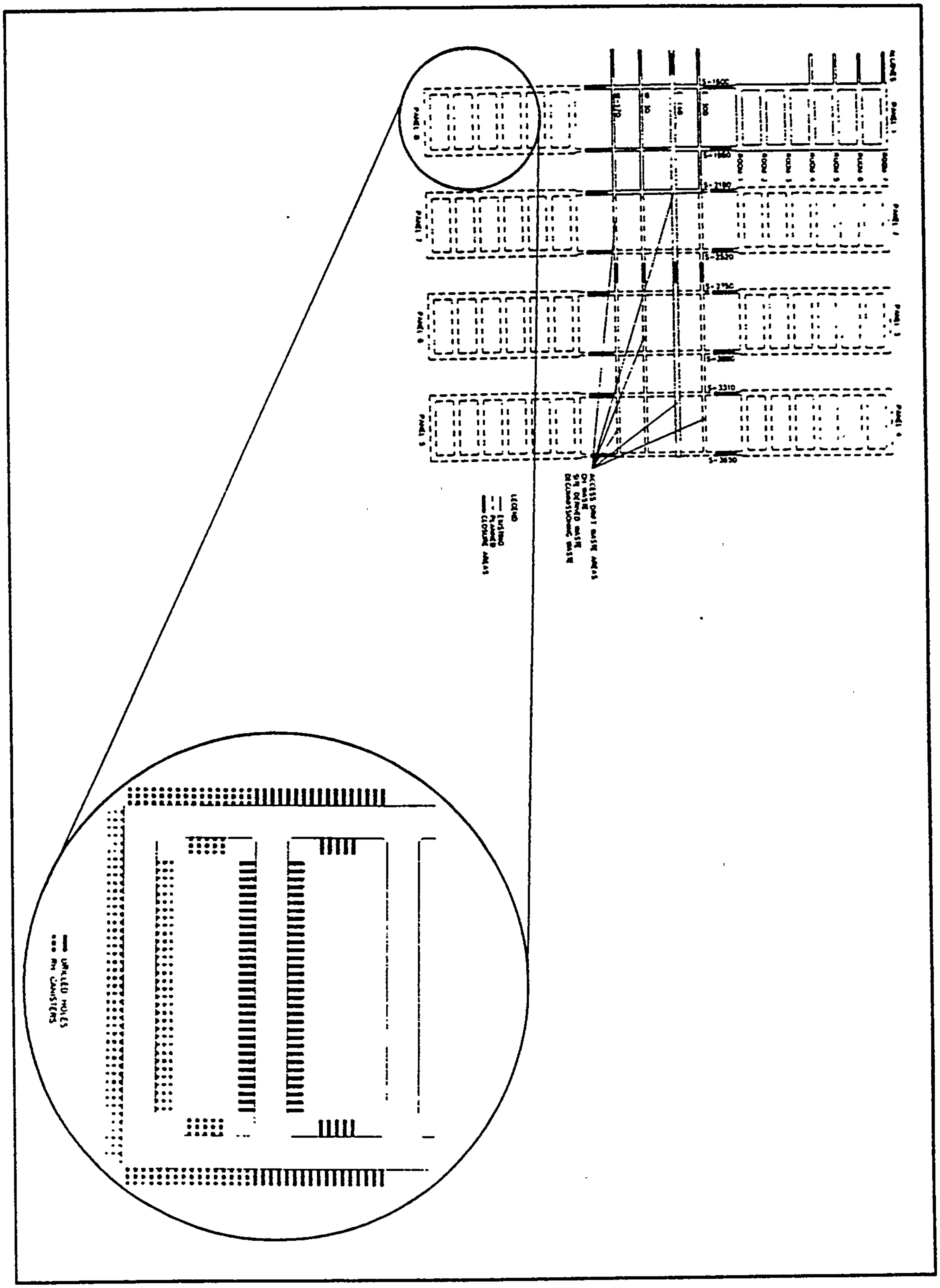

Figure 5. TRU Waste Disposal Areas and Canister Borehole Locations

Figure 5 also illustrates the areas available for TRU waste emplacement. These areas include eight panels and the access drifts leading to the panels. CH TRU waste and site-derived waste will only be emplaced in Panel 1. CH TRU waste, RH TRU waste and site-derived waste will be emplaced in the remaining panels. CH TRU waste, site-derived waste, and decommissioning waste will be emplaced in the access drifts following closure of Panel 8. The WIPP waste disposal system is designed to allow the first waste emplaced in a disposal room or access drift within a panel to be remote-handled. If the RH TRU waste is not emplaced in an area before the CH TRU waste, the opportunity to put RH TRU waste in that area is lost. No RH TRU waste can be emplaced in the access drifts leading to the panels because the H.E.R.E. is too large to be maneuvered in the drifts. [Ref. 5] Conceptually, RH TRU waste would have to be emplaced at a rate of about 1.5 canisters per day, five days a week, over a 25-year period with no delays or shut downs to meet the design capacity of WIPP.

The following is a list of existing RH TRU waste disposal system limitations:

1. The RH TRU waste disposal capacity may be lost.

   - Emplacement of RH TRU waste in room walls must occur before CH TRU waste is placed in the room to permit the operation of the equipment needed to remotely handle the waste.

   - If sufficient RH TRU waste is not available to fill the space available in a given room, the disposal of CH TRU waste in the room will preclude future disposal of RH TRU waste in that room.

   - Currently, only about 70 percent of the allowable RH TRU waste could be disposed of at the WIPP. This is based on the physical limitations of available storage space resulting from the usage of 10-foot canisters, 8-foot centers, and current disposal room and access drift dimensions. [Ref. 5]

2. The disposal system operation is complicated and slow.

   - Emplacement of each canister requires 12 major steps and uses 14 pieces of equipment. The process requires three 8-hour shifts to emplace two canisters, excluding delays.

   - Because of the heavy reliance on specialized emplacement equipment, there are many opportunities for system failure. These failures are expected to result in the interruption of RH TRU waste disposal until the failed component can be fixed. System failures can occur with the Hot Cell Crane, High Bay Crane, Facility Cask Loading Hoist, Facility Cask, H.E.R.E., and Transfer Car/Forklift.

- As part of the initial mission of the WIPP, disposal testing using Defense High Level Waste (DHLW) in bedded salt was planned. This testing is now prohibited. As a result, processing RH TRU waste through the Hot Cell prior to emplacing it in the disposal room walls is no longer required. Also, when waste disposal operations begin, the retrieval of intact RH TRU waste, which would have been required for the test phase (cancelled in 1993), will not be required. In essence, the original DHLW testing imposed several significant restrictions on the facility design.

3. There is a significant amount of work needed on the disposal system to make it operational.

   - There are major deficiencies that must be repaired, upgraded or replaced in the Hot Cell complex, Waste Handling Building, and on underground emplacement equipment. A preliminary list of repairs and procurements needed for the facility, at an estimated cost of $2,061,000, are listed on Table 1.

Table 1. Preliminary List of Repairs/Upgrades Required to Operate RH TRU Waste Handling System

New nuclear coating in the following areas: Hot Cell, Transfer Cell, Cask Unloading Room, Cask Loading Room, and Receiving Bay	127K
Inspect, correct, and conduct Shielding Test	18K
Repair Video system	80K
Upgrade Door Interlock systems	13K
Repair Transfer Cell/Shuttle Car systems	50K
Repair/Upgrade Cask Unloading systems to meet current configuration	195K
Repair Hot Cell Crane	20K
Repair/Modify Cask Loading Room Equipment	75K
Re-develop Facility Grapples	45K
Qualify Overpack Canister Welder	14K
Miscellaneous equipment repair/procurement	79K
Repair RH Ventilation system	112K
Radiation Monitoring Equipment repairs/procurement	504K
Purchase Borehole Drilling Equipment	600K
Refurbish Horizontal Emplacement/Retrieval Equipment (H.E.R.E.)	126K
TOTAL	2,061K

Source: WID, 1995.

5.0 IDENTIFICATION OF ALTERNATIVES FOR RH TRU WASTE DISPOSAL

As described earlier, the WIPP disposal system consists basically of three components: 1) waste receipt, 2) waste transport to the disposal areas, and 3) waste disposal. Early in this study, a determination was made that there are only two parts of the disposal system that are the basis to any disposal system design: the waste package and the emplacement configuration. As a result, alternatives to the design basis RH TRU waste disposal system were generated by identifying emplacement configuration options and waste package options. This fact helped to narrow the list of possible alternatives to 20. In addition, the alternatives were developed and evaluated without in-depth engineering designs applied to allow flexibility in the final alternative design considerations while maintaining the core considerations used in the evaluation process.

The five emplacement configuration options identified are as follows:

1. **CH Stack.** RH TRU waste would be emplaced in the same waste stack as CH waste.

2. **Vertical Boreholes.** Boreholes would be drilled in the floors of the disposal areas soon after the areas were mined. RH TRU waste would be lowered into the boreholes and covered (backfilled) with salt. After the boreholes were filled, CH TRU waste would be stacked over the boreholes. Vertical boreholes include holes drilled diagonally.

3. **Horizontal Boreholes.** Boreholes are drilled in the walls or ribs of the disposal rooms and drifts. RH TRU waste is pushed into the boreholes followed by a shield plug. This emplacement configuration represents the current disposal configuration. Although horizontal boreholes cannot be closer than 8-foot centers, they can be deeper.

4. **Trenches.** Slots or pits would be mined in the floor of the disposal areas. The RH TRU waste packages would be laid into these trenches and covered with salt. After an area was backfilled, CH TRU waste would be stacked on top.

5. **New Mining.** Disposal areas specifically designed to support RH TRU waste disposal would be mined. These areas would be in addition to the disposal areas (rooms and drifts) currently planned for CH TRU waste disposal. The new areas can be on a different horizon or in panels or alcoves mined out of the pillars in the disposal areas.

The four waste package options identified are as follows:

1. **Shielded package.** A waste package composed of materials designed to attenuate the radioactive source within in order to reduce the dose rate to 200 mrem/hr or less on the outside of the waste package. The package has the same dimensions and specifications as a DOT Type A 55-gallon drum or standard waste box used for CH TRU waste disposal.

   Shielded drum packaging is currently available from three potential sources. A drum made from depleted uranium is available through a U.S. Department of Defense (DOD)-sponsored program. Figure 6 shows a cutaway view of this drum. The drum uses depleted uranium and concrete for shielding. Also, packaging designed for TRUPACT-II usage that uses an iron or steel liner inside a 55-gallon DOT 7A drum is being developed for residues at Rocky Flats (see Figure 7). Plus, a drum overpack from the Scientific Ecology Group, shown in Figure 8, could easily be transported in the TRUPACT-II. Future drum designs would be necessary to handle more waste in the overall RH TRU waste inventory.

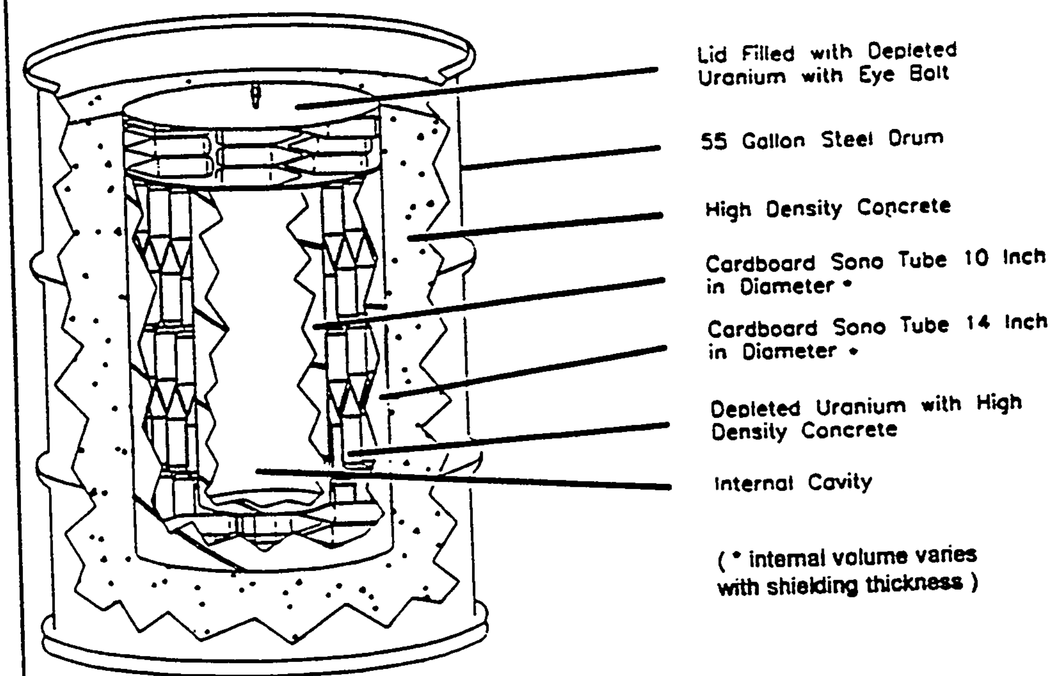

Figure 6. Depleted Uranium Shielded Packaging

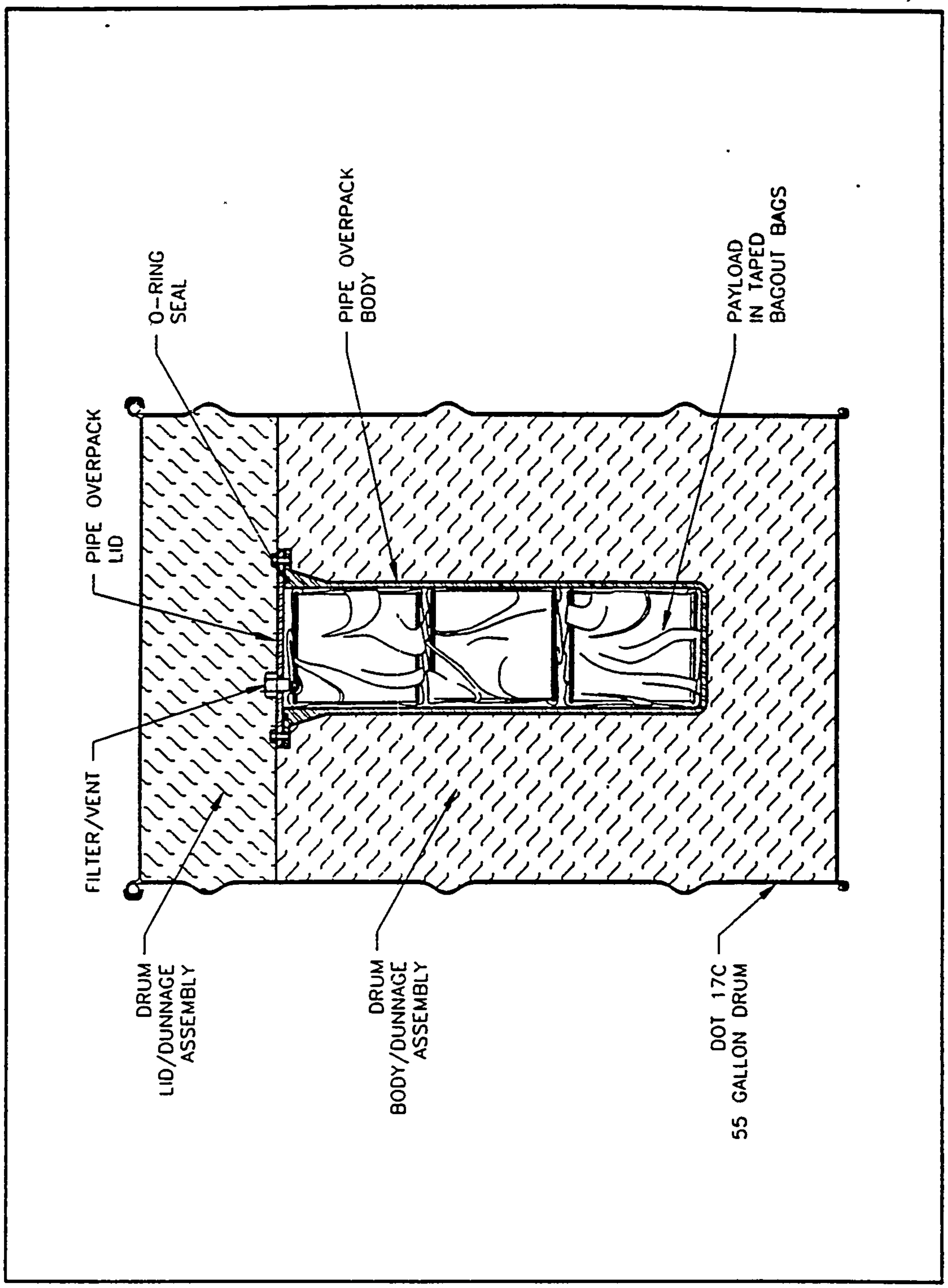

Figure 7. Pipe Overpack in 55-Gallon Drum

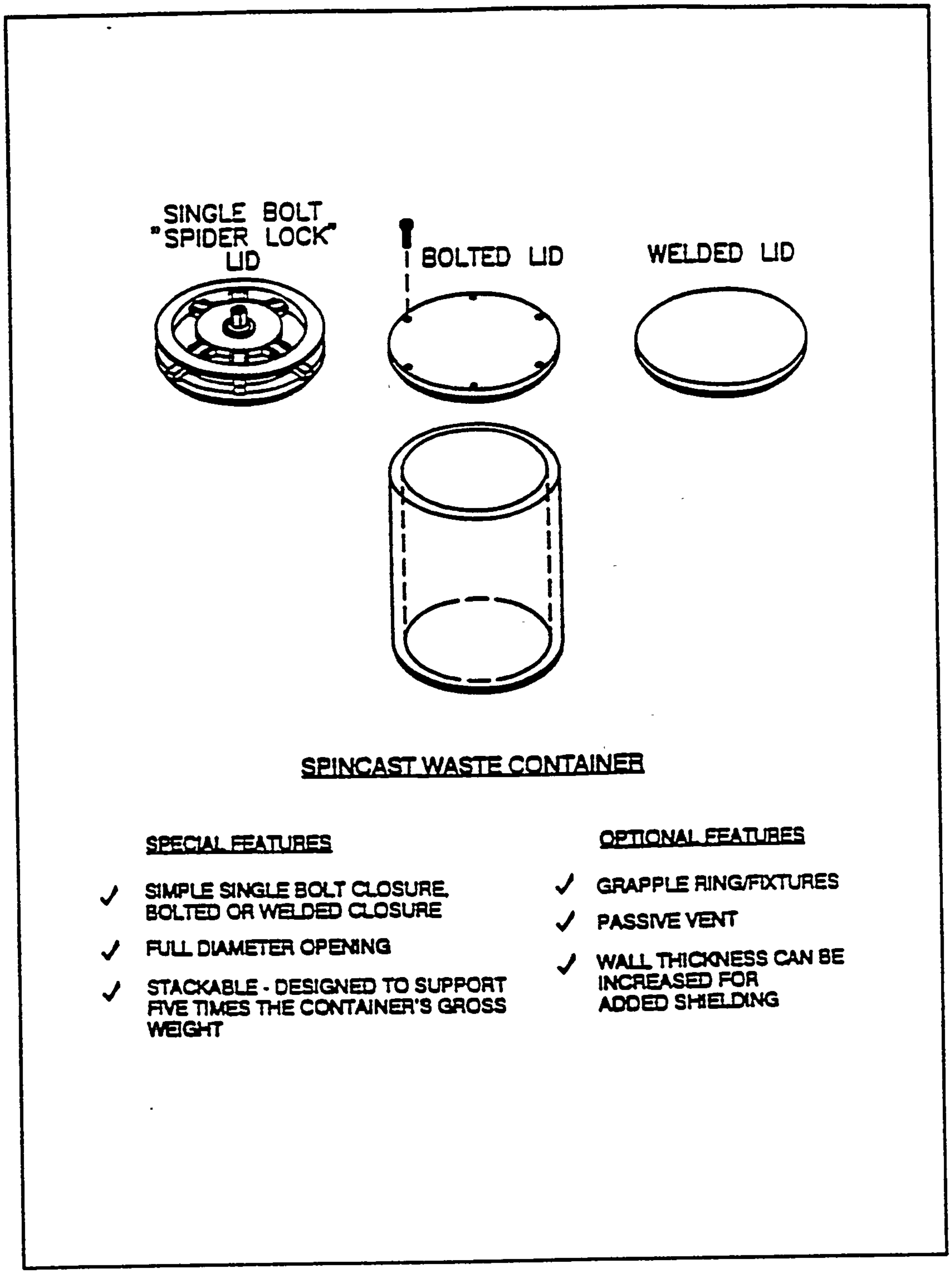

Figure 8. Spincast Waste Packaging

2. **Unshielded package.** A waste package composed of packaging made with the same dimensions and specifications as a DOT Type A 55-gallon drum used for CH TRU waste disposal.

3. **Canister.** The design basis waste package currently designed to be shipped in the RH-72B Cask and handled at WIPP using the Hot Cell, Facility Cask, and H.E.R.E. A canister, approximately 10 feet long, 26 inches in diameter, and weighing up to 3,629 kg (8,000 lbs.) fully loaded, is shown in Figure 2. (The WIPP waste handling system can handle an overpacked canister up to 4,536 kg (10,000 lbs.)).

4. **New Package.** A waste package composed of packaging that is newly designed for waste disposal at the WIPP. This DOT Type A packaging would be more volume efficient than packaging that is currently available and/or have physical dimensions that would allow greater emplacement efficiency in the WIPP disposal areas.

As shown in Figure 9, the five emplacement options and four waste package options were combined to generate 20 alternatives. These alternatives were numbered A-1 through D-5. Four alternatives (A-2, A-3, A-4, and A-5) were immediately rejected because they provided no improvement over the design basis waste handling process. Once a package arrives at the WIPP that can be handled as CH TRU waste, there is no reason to handle it any other way. The 16 remaining alternatives were then evaluated according to the criteria and process described in the following section. These alternatives are described in Attachment FA in terms of surface waste handling aspects (package, transportation mode, and handling mode), underground waste handling aspects (transporter, emplaced package, handling mode, and emplacement configuration), and evaluation considerations.

WASTE PACKAGE EMPLACED		RECEIVED WASTE PACKAGE			
		A	B	C	D
		Shielded Package (CH)	Unshielded Package	Canister	New
1	CH Stack	Page A-2	Page A-4	Page A-14	Page A-24
2	Vertical Boreholes	N/A	Page A-6	Page A-16	Page A-26
3	Horizontal Boreholes	N/A	Page A-8	BASELINE Page A-18	Page A-28
4	Trenches	N/A	Page A-10	Page A-20	Page A-30
5	New Mining (Alcoves, Panels, Horizon)	N/A	Page A-12	Page A-22	Page A-32

Figure 9. Sixteen (16) RH TRU Waste Disposal Alternatives

In most cases, using RH TRU waste disposal alternatives will require modifications to existing written agreements, criticality safety and thermal load limit analyses, performance assessments, policies, and/or descriptive documents. Since preparing and negotiating approvals for these changes will take time, a decision to pursue one or more of them needs to be made well before the WIPP opens.

6.0 EVALUATION PROCESS

To conduct the evaluation of the 16 RH TRU waste disposal alternatives, an evaluation group was assembled that represented the Westinghouse Waste Isolation Division, Sandia National Laboratories and Los Alamos Technical Associates. Collectively, the nine-member evaluation group brought more than 90 years of waste management experience to the task and was exceptionally knowledgeable about the deficiencies and needs of the current TRU waste management system at the WIPP. Attachment B lists the names and affiliations of the evaluation group.

A series of meetings was held by the panel in March 1995 to evaluate RH TRU waste disposal alternatives. Each alternative was collectively evaluated against a weighted criterion that defines its effectiveness and feasibility of implementation at the WIPP. The criteria were (1) environmental, safety, and health risk; (2) operational impact; (3) technical viability; and (4) cost. These criteria are described more fully in the next section.

A computer software program, similar to one used by the Coalition during the Gulf War, was used to support the alternative selection process. The decision support software program, called Expert Choice, is based on the Analytic Hierarchy Process. A ratings model was developed to organize the four criteria and 16 alternatives into a hierarchical structure or tree.

Verbal, qualitative group judgments were integrated into the structure to arrive at the best seven alternatives for the WIPP. Each alternative was collectively rated as a "good", "fair", or "poor" choice in relation to the criterion. The rating labels (good, fair, and poor) were a tool used by the evaluation group to define the relative feasibility of each alternative. Under the technical viability criterion, each alternative was rated as either "proven technology", "proven technology requiring modification", or "new technology". The software program then automatically ranked each of the 16 alternatives to arrive at the seven best alternatives.

Numerical weighting factors for the ratings ("good", "fair", "poor", "proven technology", "proven technology requiring modification", and "new technology") were derived by the computer program through the pairwise comparison process. This is the process of making verbal comparisons between all of the ratings, taken in pairs, in relation to the overall decision goal and in terms of relative importance.

Following the evaluation process, a sensitivity analysis was conducted to investigate how sensitive the alternatives were to changes in criteria importance or weighting. The results of the analysis showed the alternatives were not sensitive to any criterion weighting factor changes within the ±5% range.

7.0 EVALUATION CRITERIA

The following criteria, listed in Table 2, were developed and approved by the evaluation group. The numerical weighting factors for the criteria were derived by utilizing the computer program's pairwise comparison process. During this process, each criterion was collectively compared to the others in relation to the overall decision goal by the panel. The sum of the numerical factors equals one. The numbers are shown here only to provide an indication of the relative importance placed on each of the major criteria by the evaluation group. As stated earlier, a sensitivity analysis indicated that minor changes in the weighting factors did not change the outcome of the rankings. Also included in Table 2 are the major evaluation considerations for each criterion.

Table 2. Evaluation Criteria and Considerations

CRITERIA	DESCRIPTION	MAJOR EVALUATION CONSIDERATIONS
ES&H Risk (.462)		
• Environment	Potential impacts to the environment with respect to system waste inventory and breaches in protective boundaries; includes potential impacts to the Performance Assessment.	Good - potentially improves the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191). Fair - consistent with the current WIPP performance assessment to ensure compliance with 40 CFR 191. Poor - potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).
• Safety & Health	Potential impacts to personnel safety and health with respect to types and frequencies of abnormal events.	Good - potentially reduces the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR). Fair - consistent with the current analyses of the consequences of abnormal events at WIPP (FSAR). Poor - potentially increases the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR).
• Bounding Conditions	Potential impacts to safety parameters established in the FSAR.	Good - potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR). Fair - consistent with the current analyses of the consequences of abnormal events at WIPP (FSAR). Poor - potentially decreases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR).

• Exposure	Potential impacts to maintaining worker exposure as low as reasonably achievable (ALARA).	Good - potentially decreases worker radiation exposure with respect to current design basis projections. Fair - consistent with current projections of worker radiation exposure with respect to the design basis system. Poor - potentially increases worker radiation exposure with respect to current design basis projections.
Operational Impact (.390) • Geotechnical Stability	Geological stability of excavated disposal room with respect to salt deformation and fracturing.	Good - improves disposal room stability. Fair - has little impact on current disposal room stability. Poor - decreases disposal room stability.
• CH Throughput Rate	Rate in which the WIPP disposal system can process CH TRU waste from receipt to disposal.	Good - increases the ability of WIPP to process CH TRU waste. Fair - has little impact on current projections of CH TRU waste disposal rate. Poor - decreases the ability of WIPP to process CH TRU waste.
• RH Throughput Rate	Rate in which the WIPP disposal system can process RH TRU waste from receipt to disposal.	Good - increases the ability of WIPP to process RH TRU waste. Fair - has little impact on current projections of RH TRU waste disposal rate. Poor - decreases the ability of WIPP to process RH TRU waste.
• Support System Requirements	Number of facility systems required to support a disposal system.	Good - less support system requirements. Fair - consistent with current support system needs. Poor - more support system requirements.

• Routine Mine and Equipment Maintenance Functions	Amount of maintenance activities required to support a disposal system.	Good - less maintenance activity requirements. Fair - consistent with current maintenance activities. Poor - more maintenance activity requirements.
• Generator Site	Potential impacts to generator site's ability to ship RH TRU waste to WIPP. Impacts include overall implementation costs, packaging availability, and ease of package handling.	Good - packaging readily available; packaging easily handled; overall implementation costs are low with respect to the current design basis system. Fair - has little impact on generator site's with respect to the current design basis system. Poor - packaging not readily available; packaging not easily handled; overall implementation costs are high with respect to the current design basis system.
Technical Viability (.086) • Proven Technology • Modified Technology • New Technology	 Disposal system technology, including equipment, is readily available. Disposal system technology and/or equipment must be modified to implement at WIPP. Disposal system technology and/or equipment does not exist.	 Proven Technology - Good. Modified Technology - Fair. New Technology - Poor.
Cost (.061) • Facility Modification	 Capital costs associated with modifying the facility in order to implement a waste disposal system.	 Good - less costly with respect to current design basis system modifications. Fair - little cost impact with respect to current design basis system modifications. Poor - more costly with respect to current design basis system modifications.

• System Operation	Costs associated with the operation of the disposal system.	Good - less costly with respect to current design basis system operations. Fair - little cost impact with respect to current design basis system operations. Poor - more costly with respect to current design basis system operations.
• System Maintenance	Costs associated with the maintenance of the disposal system.	Good - less costly with respect to current design basis system maintenance. Fair - little cost impact with respect to current design basis system maintenance. Poor - more costly with respect to current design basis system maintenance.

8.0 EVALUATION RESULTS

The 16 alternatives (Figure 9) were ranked from 1 to 16 by the evaluation group utilizing the analytic hierarchy process utilizing the software Expert Choice. The weighted criteria used (Table 2) were (1) environmental, safety and health risk; (2) operational impact; (3) technical viability; and (4) cost. The listing of alternative rankings is presented below and a detailed evaluation of the rankings is in Table 3.

1. A-1 Shielded Package Emplaced in CH TRU Waste Stack
2. B-3 Unshielded Package Emplaced in Horizontal Boreholes
3. D-3 New Package Emplaced in Horizontal Boreholes
4. B-2 Unshielded Package Emplaced in Vertical Boreholes
5. C-3 Canister Emplaced in Horizontal Boreholes
6. D-1 New Package Emplaced in CH TRU Waste Stack
7. B-5 Unshielded Package Emplaced in New Mined Area
8. C-5 Canister Emplaced in New Mined Area
9. D-2 New Package Emplaced in Vertical Boreholes
10. D-5 New Package Emplaced in New Mined Area
11. C-2 Canister Emplaced in Vertical Boreholes
12. B-1 Unshielded Package Emplaced in CH TRU Waste Stack
13. C-1 Canister Emplaced in CH TRU Waste Stack
14. B-4 Unshielded Package Emplaced in Trenches
15. C-4 Canister Emplaced in Trenches
16. D-4 New Package Emplaced in Trenches

Table 3. Alternatives Ratings and Rankings

Alternative	OpImp Geo (.0776)	OpImp SpSys (.0313)	OpImp Maint (.0329)	OpImp RThru (.1113)	OpImp CThru (.1260)	OpImp GenSt (.0110)	Tech Via (.0665)	Cost Ops (.0348)	Cost Maint (.0174)	Cost Mod (.0087)	Risk SfHlth (.1521)	Risk BadCo (.0334)	Risk Exp (.0668)	Risk Env (.1901)	Total
A-1	Good	Good	Good	Good	Good	Fair	Proven	Good	Good	Good	Fair	Good	Fair	Poor	0.676
B-3	Fair	Fair	Poor	Good	Good	Good	Mod	Poor	Poor	Fair	Poor	Good	Good	Good	0.662
D-3	Fair	Fair	Poor	Good	Good	Poor	Mod	Poor	Poor	Fair	Poor	Good	Good	Good	0.652
B-2	Good	Fair	Poor	Good	Good	Good	Mod	Fair	Poor	Fair	Fair	Good	Good	Fair	0.650
C-3	Fair	Fair	Poor	Fair	Good	Fair	Proven	Poor	Poor	Fair	Poor	Good	Good	Good	0.640
D-1	Good	Good	Good	Fair	Fair	Poor	Mod	Good	Good	Good	Fair	Good	Poor	Good	0.623
B-5	Good	Poor	Poor	Good	Good	Good	Proven	Fair	Fair	Poor	Fair	Fair	Good	Poor	0.618
C-5	Good	Poor	Poor	Good	Good	Fair	Proven	Poor	Poor	Poor	Poor	Good	Good	Poor	0.570
D-2	Poor	Fair	Poor	Good	Good	Poor	Mod	Fair	Poor	Fair	Fair	Good	Good	Fair	0.570
D-5	Good	Poor	Poor	Good	Good	Poor	Mod	Poor	Poor	Poor	Fair	Fair	Good	Poor	0.540
C-2	Poor	Fair	Poor	Good	Good	Fair	Mod	Fair	Poor	Fair	Poor	Good	Good	Fair	0.527
B-1	Good	Fair	Fair	Fair	Fair	Good	Proven	Poor	Fair	Fair	Fair	Fair	Fair	Poor	0.433
C-1	Good	Fair	Fair	Fair	Fair	Fair	Mod	Poor	Poor	Fair	Poor	Good	Fair	Poor	0.343
B-4	Poor	Fair	Poor	Fair	Good	Good	Mod	Poor	Poor	Fair	Poor	Fair	Poor	Poor	0.300
C-4	Poor	Fair	Poor	Fair	Good	Fair	Mod	Poor	Poor	Fair	Poor	Fair	Poor	Poor	0.293
D-4	Poor	Fair	Poor	Fair	Good	Poor	Mod	Poor	Poor	Fair	Poor	Fair	Poor	Poor	0.290

To further refine the ranking of alternatives, the top seven candidates were evaluated under a pairwise comparison process. This second evaluation method allows a sensitivity analysis to be performed showing how any criterion weighing factor changes would effect the outcome of the rankings. This process determined that no ranking status changes occurred when the evaluation criteria values were manipulated in the range of ± 5%. This adds to the confidence of the evaluation outcome. The alternatives evaluated by pairwise comparison are listed below and represented by relative ranking in Figure 10.

1. A-1 Shielded Package Emplaced in CH TRU Waste Stack
2. B-3 Unshielded Package Emplaced in Horizontal Boreholes
3. D-3 New Package Emplaced in Horizontal Boreholes
4. B-2 Unshielded Package Emplaced in Vertical Boreholes
5. C-3 Canister Emplaced in Horizontal Boreholes
6. D-1 New Package Emplaced in CH TRU Waste Stack
7. B-5 Unshielded Package Emplaced in New Mined Area

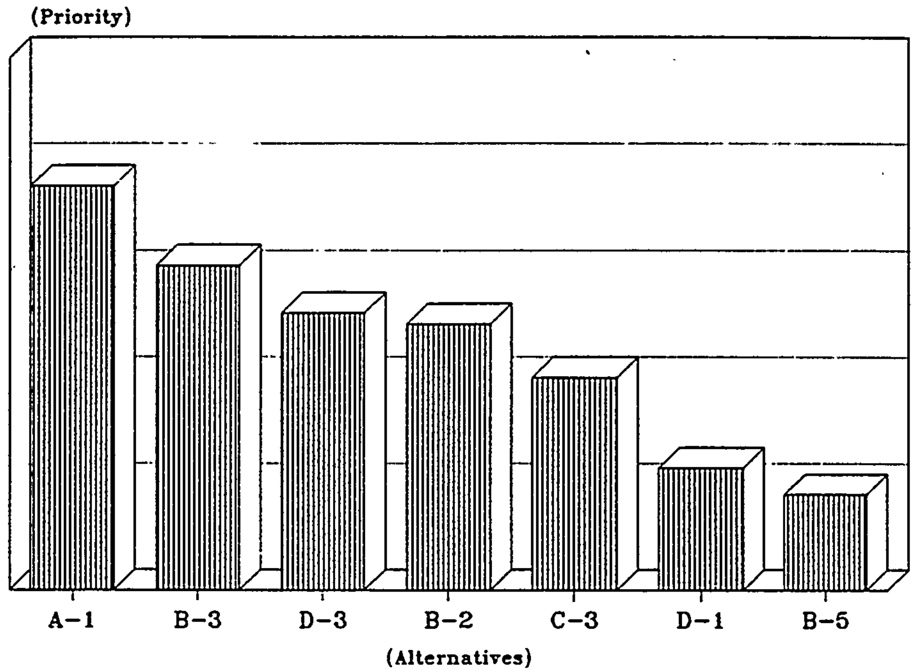

Figure 10. Ranking of Top Seven (7) Alternatives

All ranked alternatives could be engineered to function for waste disposal at the WIPP. The degree of desirability follows the descending ranking of that alternative from 1 to 16.

Alternative A-1, Shielded Package Emplaced in CH TRU Waste Stack, is ranked first in the evaluation. To build a comprehensive disposal system, a combination of A-1 complemented with B-3, Unshielded Package Emplaced in Horizontal Boreholes and/or D-3, New Package Emplaced in Horizontal Boreholes, would create a major improvement in the RH TRU waste disposal system at the WIPP.

The result of the evaluation is that A-1, Shielded Package Emplaced in CH TRU Waste Stack, ranked the best choice for the following reasons:

During the evaluation process, A-1 was ranked the best choice for the following reasons:

- Geotechnically, the alternative requires no new mining. The least impactive disposal process includes minimal mining or drilling. This alternative uses the same mined space as the CH TRU waste. Boreholes are no longer required.

- All of the support systems required to start up the RH TRU waste disposal facilities, e.g., RH High Bay, Hot Cell, HEPA Ventilation, RH machinery, are not needed.

- The alternative eliminates the need for technicians to operate RH TRU waste equipment because all waste is handled in one facility, using one set of procedures. All of the costs, personnel, procedures and training involved with a second disposal system are eliminated.

- The TRUPACT-II can be used for shipping this alternative. The time, funding, and difficulty of certifying the current TRUPACT-II to handle shielded waste is considerably less than starting with a new design.

- The alternative does not impact facility Performance Assessment because the waste packages will be interspersed within the unshielded CH TRU waste packages. There will be no waste packages emplaced into boreholes outside of the CH TRU waste disposal envelope. Once the non-TRU waste isotopes decay away, there is no difference in the wastes.

- The alternative causes only minor changes to WIPP technical documents. The only alternative that would cause less change to WIPP technical documents would be the current disposal system.

- The alternative incurs no cost to WIPP for new equipment because the waste can be emplaced with the CH TRU waste. Also, the costs associated with operating and maintaining a separate system for RH TRU waste disposal would be eliminated.

- The alternative is not affected by CH TRU waste throughput rate. If all waste is handled as CH TRU waste, there is sufficient equipment available to handle the additional drums or boxes of shielded waste. The original concerns with lost capacity caused by CH TRU waste arriving faster than RH TRU waste are eliminated.

- The alternative can be implemented with initial CH TRU waste receipt. The evaluation group believes very few resources are needed to implement this alternative at the time of CH TRU waste receipt, or closely thereafter.

- While the alternative reduces DOE's overall RH TRU waste inventory, it would not impact other alternatives for handling RH TRU waste at the WIPP. The evaluation group feels that while there is no single best answer for disposal of the entire inventory, this alternative provides a quick, economical, practical and safe solution for a large portion of the inventory for the near term. In addition, it has no negative impact on later alternatives for RH TRU waste disposal.

The disadvantages to this system over other alternatives are:

- RH TRU waste in shielded packages would be more likely to have surface dose rates closer to the upper limit of 200 mrem/hr than the average CH TRU waste package. This would be the major contributor to a potential for increased worker radiation exposure. Due to the relatively small RH TRU waste inventory compared to CH TRU, increases in exposure due to the handling of the additional "CH TRU waste" would be insignificant.

- Packaging efficiency is reduced because of the internal shielding volume. This inefficiency impacts the overall system because the actual waste volume shipped to WIPP would be less than 7,080 m^3 (250,000 ft^3). (It is assumed system-wide that the waste volume equals the gross package volume. Research indicates there is no written requirement for this widely accepted assumption.)

- Not all of the RH TRU waste inventory could be shipped to WIPP using this method because it becomes inefficient to repackage RH TRU waste with surface dose rates in excess of ~20 rem/hr in shielded packages.

- The weight of the packages is limited. Shielded drums decrease the volume of a TRUPACT-II or TRUPACT HalfPack can carry. The TRUPACT-II is limited to a 7,000 pound payload which might limit some shipments to two drums per TRUPACT.

Alternative B-3 was ranked as the second best choice for the following reasons:

- Geotechnically, horizontal boreholes are the least detrimental form of mining for the current disposal room configuration. Horizontal boreholes are the best method for breaching the bounds of a disposal room. Vertical emplacement has a detrimental affect on the stability of the disposal room. Trenches are the worst emplacement configuration from a geotechnical standpoint.

- Horizontal boreholes can be smaller in diameter than the current design. Increasing the number of boreholes in a disposal room is considered detrimental to room stability, i.e., boreholes closer than 8-foot centers, but longer boreholes are not. Using 55-gallon drums or shorter canisters, instead of 10-foot canisters, allows for small diameter horizontal boreholes.

- The emplacement machine (H.E.R.E.) can be reduced in length. The current machine is approximately 25 feet long when fully assembled. The remaining eight feet of space in a disposal room is needed to assemble the machine. The H.E.R.E. is designed to support canisters up to 11 feet long. If the machine was designed to handle waste in 3-foot long packages, it could be reduced to about 10 feet in length.

- Most of the current equipment can easily be modified to support this alternative. Because emplacement remains horizontal, much of the existing equipment can be modified and reused. The Facility Cask can be cut in half to become a shield valve for the borehole. The shielded valve would provide the capability to emplace multiple packages in the borehole without shield plugs in between. The 20- and 40-ton forklifts can be used to move the emplacement equipment. This would eliminate most of the moving parts of the current system.

- Equipment modifications may be less expensive than repairing the current equipment. The H.E.R.E. can be disassembled while leaving the hydraulic ram for use. Equipment such as the cask rotating device and overpack welding station will no longer be required. The cask loading room will not need modification.

- Smaller equipment could be less expensive allowing the use of multiple units. Multiple redundant units would reduce the potential for single point failures impacting the entire system and provide a means for an efficient preventative maintenance schedule. Shielding for these smaller units could be designed for the surface dose rates of the majority of the waste inventory, further reducing size and weight. Because the waste package is only 3 feet long vice 10 feet long, the Facility Cask can be a third as long. Hazardous waste handling systems are available for approximately $300,000 that could be used to handle 55-gallon drums of RH TRU waste. Several smaller equipment components could be used in a disposal room at one time.

- Eliminating usage of the Hot Cell during normal operations is possible and preferred with all options. By using the existing overhead crane in the RH High Bay, a cask-to-cask transfer can be performed. Lighter and shorter facility casks increases the feasibility of this concept. The Hot Cell could be used for off-normal event recovery where storage, overpacking or repacking is required prior to disposal. RH TRU waste modeling has shown that elimination of Hot Cell usage could increase the RH TRU waste throughput rate by as much as 50 percent.

- Components of major equipment and the number of disposal steps can be reduced. By using the cask-to-cask transfer in the RH High Bay, all of the process steps and equipment in the Hot Cell complex can be eliminated during normal operations.

- The handling of smaller equipment would make it easier to automate in the future.

- The potential radiation dose to workers can be kept very low. Historically, the RH TRU waste handling process causes smaller radiation exposure to workers compared to CH TRU waste handling. Because smaller RH TRU waste equipment could be made robotic, the radiation dose rate of workers could go to near zero.

- The alternative is least impactive to the generators because of the efficient packaging size. A survey of generator sites indicated all had the capability to handle 55-gallon drums. Only Los Alamos National Laboratory is currently handling the 10-foot canister. Personnel at the Hanford Site expressed an interest larger packaging because they anticipate disposing of some very large equipment.

The disadvantages to this system over other alternatives are:

- The system design and description documentation will require major revisions.

Conversely, use of the current system would require no major changes. Because the current system is inefficient, some modifications would be needed and thus, require some documentation changes.

- Eliminating the canister increases the potential for spill events during normal handling operations because drums are handled vs. drums sealed in a canister. However, the margin of safety established at the WIPP would not be compromised because DOT Type A 55-gallon drums are the basis of the FSAR.

- The system is more costly to operate and maintain than the CH TRU waste handling options, but is less costly than the design basis design.

9.0 RECOMMENDED RH TRU WASTE DISPOSAL ALTERNATIVES

Although the objective of this evaluation was to select two alternatives for the disposal of RH TRU waste at the WIPP, the number one alternative turned out to complement other RH TRU waste disposal alternatives fortifying the disposal potential for the WIPP repository. For this reason, a combination of alternatives are being recommended. Alternative A-1 is the alternative of choice resulting from this evaluation. This option is of importance due to its simplicity of implementation and operation by utilizing the CH TRU waste handling process and realizing cost avoidance as a result. Its limitation is that not all of the waste inventory currently identified can be disposed by this method. Approximately 30% of the currently reported RH TRU waste inventory could be disposed of at the WIPP because of the inventories anticipated dose rate and the limited shielding available in a 55-gallon drum size package. The resulting volumetric inefficiency of using a shielded

55-gallon package could interfere with the limited space for CH TRU waste in the WIPP repository.

It is recommended that WIPP initiate the A-1, Shielded Package Emplaced in CH TRU Waste Stack alternative. This alternative provides the greatest possibility of achieving scheduled waste receipt with the least cost and safety impacts to the WIPP. In addition, incorporate one of the next alternatives capable of disposing of the higher dose rate waste. That being either B-3, Unshielded Package Emplaced in Horizontal Boreholes or D-3, New Package Emplaced in Horizontal Boreholes or both. The result will be a disposal system that is capable of disposing of a larger quantity of RH TRU waste than either of the alternatives could realize on its own. For this reason a combination of recommendations is provided.

10.0 CONCLUSION

This study was undertaken to develop and recommend to the DOE RH TRU waste disposal alternatives for the WIPP. Issues associated with the current design basis RH TRU waste system and the means for optimizing the disposal process at the WIPP were determined. The alternatives described in this report are consistent with the current facility configuration and ensure operations are conducted in a technically sound, economical, compliant and safe manner. Also, these alternatives will support the DOE's National TRU Program.

With the support of a decision analysis computer software program, a WIPP evaluation group evaluated 16 RH TRU waste disposal alternatives. These alternatives were developed by considering the two basic components of the RH TRU waste disposal system: safe and technically acceptable emplacement configurations and the potential type of waste package to be disposed. By combining five emplacement configurations with four potential waste packages to be disposed, alternative systems were generated. Each alternative was collectively evaluated and rated against a weighted criterion that defined its effectiveness and feasibility of implementation at the WIPP. The members of the group considered all of the alternatives with respect to each criterion. The criteria included ES&H Risk, Operational Impact, Technical Viability, and Cost.

It is recommended that WIPP initiate the A-1, Shielded Package Emplaced in CH TRU Waste Stack alternative. This alternative provides the greatest possibility of achieving scheduled waste receipt with the least cost and safety impacts to the WIPP. In addition, incorporate one of the next alternatives capable of disposing of the higher dose rate waste. That being either alternative B-3, Unshielded Package Emplaced in Horizontal Boreholes or D-3, New Package Emplaced in Horizontal Boreholes or both. The result will be a disposal system that is capable of disposing of a larger quantity of RH TRU waste than either of the alternatives could realize on its own. Thus using the combination would also exceed the expectations for RH TRU waste disposal at the WIPP while maintaining all applicable laws and regulations. For this reason, a combination of recommendations is provided.

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ATTACHMENT A

RH TRU Waste Disposal Alternatives Descriptions and Evaluations

I. ALTERNATIVE (A-1)

Shielded package emplaced in CH TRU waste stack.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are shielded DOT Type A packages with less than a 200 mrem/hr surface dose rate. The waste packages would have the same dimensions as a 55-gallon drum or standard waste box used for CH TRU waste disposal.

Transportation Mode: The waste is shipped in either the current TRUPACT-II, proposed TRUPACT-II Half-pack or other shipping package.

Handling Mode: The packages are removed from the shipping container using an overhead crane, placed on a pallet and set on the Waste Hoist using a forklift (normal CH TRU waste handling procedure).

Underground RH TRU Waste Handling

Transporter: The packages are transported underground to the CH TRU waste stack using the CH TRU waste pallet, transporter, and forklift.

Emplaced Container: The package is a shielded package that fits in the CH TRU waste stack.

Handling Mode: The packages could be handled as CH TRU waste or similar to CH TRU waste.

Emplacement Configuration: Waste emplacement could be (1) in the CH TRU waste stack, (2) in the voids of the stack, (3) next to a bulkhead before the CH TRU waste is brought into the disposal room, (4) on top of the CH TRU waste stack, or (5) as a bulkhead at the entrance to the waste disposal room after the unshielded waste has been emplaced.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability,

- less support system requirements,
- less maintenance activity requirements,
- increases the ability of WIPP to process CH and RH TRU waste,
- proven technology,
- less costly with respect to current baseline system modifications, maintenance, and operations, and
- potentially increases the ability of the facility to prevent or mitigate the consequences of abnormal events that could impact the public or environment.

This alternative was rated "poor" for the following reason:

- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment.

Overall, this alternative was rated by the evaluation group as the number one choice of the 16 alternatives.

I. ALTERNATIVE (B-1)

Unshielded package emplaced in CH TRU waste stack.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A packages. The waste packages would have the same dimensions as a standard 55-gallon drum.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The packages are removed from the road cask and placed in shielded CH TRU waste package configurations in the Hot Cell, RH High Bay or a new facility (possibly underground).

Underground RH TRU Waste Handling

Transporter: The packages are transported underground to the CH TRU waste stack using the CH TRU waste pallet, transporter, and forklift.

Emplaced Container: The package is a shielded package that fits in the CH TRU waste stack.

Handling Mode: The packages could be handled as CH TRU waste or similar to CH TRU waste.

Emplacement Configuration: Waste emplacement could be (1) in the CH TRU waste stack, (2) in the voids of the stack, (3) next to a bulkhead before the CH TRU waste is brought into the disposal room, (4) on top of the CH TRU waste stack, or (5) as a bulkhead at the entrance to the waste disposal room after the unshielded waste has been emplaced.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability,
- packaging readily available for the generator site,

- packaging easily handled at the generator site,
- overall generator site implementation costs are low with respect to the current baseline system, and
- proven technology.

This alternative was rated "poor" for the following reasons:

- more costly with respect to current baseline system operations, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number 12 choice of the 16 alternatives.

I. ALTERNATIVE (B-2)

Unshielded package emplaced in vertical boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A packages. The waste packages would have the same dimensions as a standard 55-gallon drum.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The packages are removed from the road cask and placed in a facility cask in the Hot Cell, RH High Bay or a new facility (possibly underground). Direct placement of packages into multiple, smaller facility casks carried by forklifts or automated guided vehicles (bypassing the Hot Cell) could be done with either of two methods: (1) a drum could be hoisted up into a facility cask that is mated to the top of the shipping container (cask-to-cask transfer), or (2) a drum could be picked out of a shipping container using a shield bell and placed into a facility cask.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. If used, smaller facility casks could either be set directly on the Waste Hoist or held on transporters capable of transporting the casks to the disposal rooms. The cask is rotated or raised to allow the waste package to be lowered into a pre-drilled vertical borehole.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance or robotics are used during normal operations.

Emplacement Configuration: The emplacement is in pre-drilled boreholes located in the floors of the disposal areas.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,
- packaging readily available for the generator site,
- packaging easily handled at the generator site,
- overall generator site implementation costs are low with respect to the current baseline system,
- potentially increases the ability of the facility to prevent or mitigate the consequences of abnormal events that could impact the public or environment (FSAR), and
- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- more maintenance activity requirements, and
- more costly with respect to current baseline system maintenance.

Overall, this alternative was rated by the evaluation group as the number four choice of the 16 alternatives.

I. ALTERNATIVE (B-3)

Unshielded package emplaced in horizontal boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A packages. The waste packages would have the same dimensions as a standard 55-gallon drum.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The packages are removed from the road cask and placed into a facility cask in the Hot Cell, RH High Bay or a new facility (possibly underground). Direct placement of packages into multiple, smaller facility casks carried by forklifts or automated guided vehicles (bypassing the Hot Cell) could be done with either of two methods: (1) a drum could be hoisted up into a facility cask that is mated to the top of the shipping container (cask-to-cask transfer), or (2) a drum could be picked out of a shipping container using a shield bell and placed into a facility cask.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. If used, smaller facility casks could either be set directly on the Waste Hoist or held on transporters capable of transporting the casks to the disposal rooms. The cask is placed on an emplacement machine that pushes the waste into a pre-drilled horizontal borehole.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The packages are handled as RH TRU waste because distance, shielding or robotics are used during normal operations.

Emplacement Configuration: The waste packages are pushed into pre-drilled horizontal boreholes. If the waste package is a 55-gallon drum, 4 drums could be placed in a 17-foot borehole.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,
- packaging readily available for the generator site,
- packaging easily handled at the generator site,
- overall generator site implementation costs are low with respect to the current baseline system,
- potentially increases the ability of the facility to prevent or mitigate the consequences of abnormal events that could impact the public or environment (FSAR),
- potentially decreases worker radiation exposure with respect to current baseline projections, and
- potentially improves the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

This alternative was rated "poor" for the following reasons:

- more maintenance activity requirements,
- more costly with respect to current baseline system maintenance and operations, and
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR).

Overall, this alternative was rated by the evaluation group as the number two choice of the 16 alternatives.

I. ALTERNATIVE (B-4)

Unshielded package emplaced in trenches.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A packages. The waste packages would have the same dimensions as a standard 55-gallon drum.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or Hot Cell. Individual packages may be combined into a single package for more efficient handling.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. The facility cask is designed for easy removal of the waste packages from the cask to the trench.

Emplaced Container: The emplaced waste package is the same as received or a combination of packages in a single efficient emplacement package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance, or robotics is used during normal operations.

Emplacement Configuration: The waste packages are set in open trenches in the floors of the disposal areas. The trenches are covered to allow stacking of CH TRU waste in the disposal room.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,

This alternative was rated "poor" for the following reasons:

- decreases disposal room stability,
- more maintenance activity requirements,
- more costly with respect to current baseline system maintenance and operations,
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR),
- potentially increases worker radiation exposure with respect to current baseline projections, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (FSAR).

Overall, this alternative was rated by the evaluation group as the number 14 choice of the 16 alternatives.

I. ALTERNATIVE (B-5)

Unshielded package emplaced in new mined area.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A packages. The waste packages would have the same dimensions as a standard 55-gallon drum.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay, Hot Cell or a new facility (possibly underground). Individual packages may be combined into a single package for more efficient handling.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a specially designed facility cask.

Emplaced Container: The emplaced waste package is the same as received or a load efficient package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance, or robotics is used during normal operations.

Emplacement Configuration: The emplacement would be in a disposal room, area of the mine, or level of the mine specially designed and dedicated for RH TRU waste disposal. In an alcove or room configuration, blocks of concrete or salt could be placed between stacks of waste to provide shielding, if needed.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability,
- increases the ability of WIPP to process CH and RH waste,
- packaging readily available for the generator site,

- packaging easily handled at the generator site,
- overall generator site implementation costs are low with respect to the current baseline system,
- proven technology, and
- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- more support system requirements,
- more maintenance activity requirements,
- more costly with respect to current baseline system modifications, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number seven choice of the 16 alternatives.

I. ALTERNATIVE (C-1)

Canister emplaced in CH TRU waste stack.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are the baseline 10-foot long canisters.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay where the canister is transferred to a shielded caisson.

Underground RH TRU Waste Handling

Transporter: The caisson is transported underground to the CH TRU waste stack by forklift or specially designed transporter.

Emplaced Container: The emplaced waste package is the canister inside of a shielded caisson.

Handling Mode: The package is handled as CH TRU waste because of the shielding provided by the concrete caisson.

Emplacement Configuration: The caisson is placed in the CH TRU waste stack. This means that the shape of the caisson is compatible with the stack.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability, and
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR).

This alternative was rated "poor" for the following reasons:

- more costly with respect to current baseline system maintenance and operations,
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safey and health, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number 13 choice of the 16 alternatives.

I. ALTERNATIVE (C-2)

Canister emplaced in vertical boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are the baseline 10-foot long canisters.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or existing Hot Cell complex.

Underground RH TRU Waste Handling

Transporter: The canister is transported to the Underground in a facility cask designed for vertical emplacement.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The package is handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The canister is lowered into pre-drilled boreholes in the floor of the disposal areas. The current disposal rooms are mined to a taller height to accommodate the vertical emplacement operations.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR), and
- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- decreases disposal room stability,
- more maintenance activity requirements,
- more costly with respect to current baseline system maintenance, and
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safey and health.

Overall, this alternative was rated by the evaluation group as the number 11 choice of the 16 alternatives.

I. ALTERNATIVE (C-3)

Canister emplaced in horizontal boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are the baseline 10-foot long canisters.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or existing Hot Cell complex.

Underground RH TRU Waste Handling

Transporter: The canister is transported to the Underground in a facility cask designed for horizontal emplacement.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The package is handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The canister is pushed into pre-drilled boreholes in the walls of the disposal areas.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH waste,
- proven technology,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR),
- potentially decreases worker radiation exposure with respect to current baseline projections, and

- potentially improves the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

This alternative was rated "poor" for the following reasons:

- more maintenance activity requirements,
- more costly with respect to current baseline system maintenance and operations, and
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safey and health.

Overall, this alternative was rated by the evaluation group as the number five choice of the 16 alternatives.

I. ALTERNATIVE (C-4)

Canister emplaced in trenches.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are the baseline 10-foot long canisters.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or existing Hot Cell complex.

Underground RH TRU Waste Handling

Transporter: The canister is transported to the Underground in a facility cask designed for placing canisters in trenches.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The package is handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The canister is lowered into open trenches in the floor of the disposal areas. The trenches are then covered to allow CH TRU waste disposal operations.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reason:

- increases the ability of WIPP to process CH waste.

This alternative was rated "poor" for the following reasons:

- decreases disposal room stability,
- more maintenance activity requirements,

- more costly with respect to current baseline system maintenance and operations,
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safey and health,
- potentially increases worker radiation exposure with respect to current baseline projections, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number 15 choice of the 16 alternatives.

I. ALTERNATIVE (C-5)

Canister emplaced in new mined area.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are the baseline 10-foot canisters.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or existing Hot Cell complex.

Underground RH TRU Waste Handling

Transporter: The canister is transported to the Underground in a shielded facility cask.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The package is handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The canister is placed in rooms, alcoves or levels of the mine specifically designed for RH TRU waste canister disposal.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability,
- increases the ability of WIPP to process CH and RH waste,
- proven technology,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR), and

- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- more support system requirements,
- more maintenance activity requirements,
- more costly with respect to current baseline system maintenance and operations,
- more costly with respect to current baseline system modifications,
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safey and health, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number eight choice of the 16 alternatives.

I. ALTERNATIVE (D-1)

New package emplaced in CH TRU waste stack.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, shielded DOT Type A packages that are volume and/or disposal emplacement efficient.

Transportation Mode: The waste is shipped in either the current TRUPACT-II, proposed TRUPACT Half-pack or other shipping packaging.

Handling Mode: The packages are removed from the TRUPACT-II using an overhead crane, placed on a pallet and set on the Waste Hoist using a forklift.

Underground RH TRU Waste Handling

Transporter: The packages are transported underground to the CH TRU waste stack using the CH TRU waste pallet, transporter, and forklift.

Emplaced Container: The emplaced waste package is a shielded package that fits in the CH TRU waste stack.

Handling Mode: The packages could be handled as CH TRU waste or similar to CH TRU waste.

Emplacement Configuration: Waste emplacement could be (1) in the CH TRU waste stack, (2) in the voids of the stack, (3) next to a bulkhead before the CH TRU waste is brought into the disposal room, (4) on top of the CH TRU waste stack, or (5) as a bulkhead at the entrance to the waste room after the unshielded waste has been emplaced.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- improves disposal room stability,
- less support system requirements,
- less maintenance activity requirements,

- less costly with respect to current baseline system modifications and operations,
- less costly with respect to current baseline system modifications,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR), and
- potentially improves the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

This alternative was rated "poor" for the following reasons:

- packaging not readily available for the generator site,
- packaging not easily handled at the generator site,
- overall generator site implementation costs are high with respect to the current baseline system, and
- potentially increases worker radiation exposure with respect to current baseline projections.

Overall, this alternative was rated by the evaluation group as the number six choice of the 16 alternatives.

I. ALTERNATIVE (D-2)

New package emplaced in vertical boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A waste packages that are volume and/or disposal emplacement efficient.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The packages are removed from the road cask and placed in a facility cask in the Hot Cell or the RH High Bay.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. The cask is rotated or raised to allow the waste package to be lowered into a pre-drilled borehole.

Emplaced Container: The emplaced waste package is the same as received waste package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The emplacement is in boreholes pre-drilled on 8-foot centers in the floors of the disposal areas.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR), and

- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- decreases disposal room stability,
- more maintenance activity requirements,
- packaging not readily available for the generator site,
- packaging not easily handled at the generator site,
- overall generator site implementation costs are high with respect to the current baseline system, and
- more costly with respect to current baseline system maintenance.

Overall, this alternative was rated by the evaluation group as the number nine choice of the 16 alternatives.

I. ALTERNATIVE (D-3)

New package emplaced in horizontal boreholes.

II. DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A waste packages that are volume and/or disposal emplacement efficient.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The packages are removed from the road cask and placed into a facility cask in the Hot Cell or RH High Bay.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. The cask is placed on an emplacement machine which pushes the waste into a pre-drilled horizontal borehole.

Emplaced Container: The emplaced waste package is the same as the received waste package.

Handling Mode: The packages are handled as RH TRU waste because distance, shielding or robotics is used during normal operations.

Emplacement Configuration: Waste packages are pushed into pre-drilled horizontal boreholes. If the waste package is a 55-gallon drum, 4 drums could be placed in a 17-foot borehole.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reasons:

- increases the ability of WIPP to process CH and RH waste,
- potentially increases the ability of the facility to prevent or mitigate the consequence of abnormal events that could impact the public or environment (FSAR),

- potentially decreases worker radiation exposure with respect to current baseline projections, and
- potentially improves the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

This alternative was rated "poor" for the following reasons:

- more maintenance activity requirements,
- packaging not readily available for the generator site,
- packaging not easily handled at the generator site,
- overall generator site implementation costs are high with respect to the current baseline system,
- more costly with respect to current baseline system maintenance and operations, and
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR).

Overall, this alternative was rated by the evaluation group as the number three choice of the 16 alternatives.

I. ALTERNATIVE (D-4)

New package emplaced in trenches.

II. DETAILED DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A waste packages that are volume and/or disposal emplacement efficient.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging.

Handling Mode: The road cask is unloaded in the RH High Bay or Hot Cell. Individual packages may be combined in to a single package for more efficient handling.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a facility cask specially designed for the task. The facility cask is designed for easy removal of the waste packages from the cask to the trench.

Emplaced Container: The emplaced waste package is the same as received or a combination of packages in a single efficient emplacement package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance, or robotics is used during normal operations.

Emplacement Configuration: Waste packages are set in open trenches in the floors of the disposal areas. The trenches are covered to allow stacking of CH TRU waste in the room.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reason:

- increases the ability of WIPP to process CH waste.

This alternative was rated "poor" for the following reasons:

- decreases disposal room stability,
- more maintenance activity requirements,
- packaging not readily available for the generator site,
- packaging not easily handled at the generator site,
- overall generator site implementation costs are high with respect to the current baseline system,
- more costly with respect to current baseline system maintenance and operations,
- potentially increases the consequences of abnormal events at WIPP with respect to personnel safety and health (FSAR),
- potentially increases worker radiation exposure with respect to current baseline projections, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number 16 choice of the 16 alternatives.

I. ALTERNATIVE (D-5)

New package emplaced in new mined area.

II. DETAILED DESCRIPTION

Surface RH TRU Waste Handling

Container: The waste packages are small, unshielded DOT Type A waste packages that are volume and/or disposal emplacement efficient.

Transportation Mode: The waste is shipped in a NRC-certified Type B shielded packaging (Road Cask).

Handling Mode: The road cask is unloaded in the RH High Bay or Hot Cell. Individual packages may be combined in to a single package for more efficient handling.

Underground RH TRU Waste Handling

Transporter: The packages are transported to the Underground in a specially designed facility cask.

Emplaced Container: The emplaced waste package is the same received package or a load efficient package.

Handling Mode: The packages are handled as RH TRU waste because shielding, distance or robotics is used during normal operations.

Emplacement Configuration: The emplacement would be in a room, area of the mine, or level of the mine specially designed and dedicated to RH TRU waste disposal. In an alcove or room configuration, blocks of concrete or salt could be placed between stacks of wastes to provided shielding, if needed.

III. EVALUATION CONSIDERATIONS

This alternative was rated "good" for the following reason:

- increases disposal room stability,
- increases the ability of WIPP to process CH and RH waste, and

- potentially decreases worker radiation exposure with respect to current baseline projections.

This alternative was rated "poor" for the following reasons:

- more support system requirements,
- more maintenance activity requirements,
- packaging not readily available for the generator site,
- packaging not easily handled at the generator site,
- overall generator site implementation costs are high with respect to the current baseline system,
- more costly with respect to current baseline system maintenance and operations,
- more costly with respect to current baseline system modifications, and
- potentially degrades the performance objective for the WIPP disposal system to adequately isolate TRU waste from the accessible environment (40 CFR 191).

Overall, this alternative was rated by the evaluation group as the number 10 choice of the 16 alternatives.

ATTACHMENT B

RH TRU Waste Disposal Alternatives WIPP Evaluation Group

Name	Experience	Location
Brown, Michael	Operations/ Engineering	Westinghouse Electric Corporation Waste Isolation Division (WID) Carlsbad, New Mexico
Burrington, Tod	Engineering	Westinghouse Electric Corporation (WID)
Johnson, Jack	Regulatory Compliance	Westinghouse Electric Corporation (WID)
Kelley, Clint	Operations	Westinghouse Electric Corporation (WID)
Osetek, Dan	ES&H	Los Alamos Technical Associates, Inc. Albuquerque, New Mexico
Palanca, Rod	Operations/ Engineering	Westinghouse Electric Corporation (WID)
Porter, Larry	Operations	Westinghouse Electric Corporation (WID)
Rempe, Norbert	Geotechnical	Westinghouse Electric Corporation (WID)
Sanchez, Paul	Performance Assessment	Sandia National Laboratories Carlsbad, New Mexico
Uptergrove, Joe	Operations	Westinghouse Electric Corporation (WID)
Woolsey, Gerry	Operations	Westinghouse Electric Corporation (WID)