TECHNOLOGY NEEDS FOR REMEDIATION: HANFORD AND OTHER DOE SITES

D. C. Stapp

January 1993

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington

MA 0778

 

EXECUTIVE SUMMARY

Technologies are being developed by the U.S. Department of Energy (DOE) at the Idaho National Engineering Laboratory (INEL) under the Buried Waste Integrated Demonstration (BWID) program to facilitate remediation of DOE's buried and stored low-level radioactive, transuranic (TRU), and mixed radioactive and hazardous buried wastes. The purpose of this study, prepared by Pacific Northwest Laboratory (PNL),^(a) is to present buried waste technology needs that have been identified for DOE sites other than at INEL; particular emphasis has been given to the Hanford Site in southeastern Washington because of the large volumes of buried wastes found there. Identifying the waste remediation technology development needs associated with the wastes and the environmental conditions at these other sites will assist the BWID program in developing and enhancing technologies that will be needed for remediation throughout the DOE complex.

Low-level radioactive waste (LLW), transuranic waste (TRU), and mixed radioactive and hazardous wastes originated from four primary activities starting in the 1940s: weapons research and development, nuclear materials production and processing, weapons production, and warhead testing. As the radioactive and hazardous materials were generated, they were separated according to level of radioactivity and waste form. Wastes were then packaged into protective containers, transported, and disposed in the environment. A variety of containers and disposal methods have been used by the various facilities over the years. A major change in the management of these wastes occurred in 1970, when wastes classified as TRU began to be disposed so that they could be retrieved in the future; prior to 1970, TRU-bearing wastes were treated similarly to LLW.

Remediation plans will be designed for each specific site within the DOE complex. The following strategies reflect a generic approach that is consistent with the current regulatory environment:

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

- Transuranic and transuranic-mixed solid waste. Buried pre-1970 suspect TRU-contaminated waste will be retrieved for treatment along with post-1970 stored and newly generated TRU and TRU-mixed solid waste. The waste is treated to segregate the TRU and TRU-mixed fraction from materials in other waste groups. The TRU and TRU-mixed fractions are converted to a disposal form by simple stabilization and volume-reduction processes, repackaged, and transferred to a storage facility for ultimate shipment offsite to the Waste Isolation Pilot Plant (WIPP) in New Mexico.
- Low-level and hazardous solid waste. Buried waste will be retrieved for treatment with stored and newly generated materials as required by the site closure process. The mixed waste is converted to a disposal form using stabilization and volume-reduction process systems and is disposed of onsite in permitted near-surface disposal systems. Land Disposal Restriction (LDR) standards may require further treatment of some mixed wastes.
- Low-level solid waste. Buried waste will continue to be disposed of in near-surface trenches, which are closed in the same manner as landfills.

Major efforts to identify technology needs for remediating buried waste have been under way at Hanford since 1988. These efforts have resulted in identifying numerous technology development needs related to characterization, retrieval, treatment, and disposal. A prioritization effort conducted in 1990 ranked the top ten needs and identified various potential technical solutions. Similar efforts being conducted by DOE-Headquarters, BWID, and other DOE sites are producing similar lists; those that were obtained are summarized in this report. No attempt was made to determine whether these needs are being addressed by the BWID program, as this can be more effectively done by BWID staff.

In identifying the technology needs for Hanford and the other sites, several problems were consistently encountered:

- In many cases, planning has not progressed to the stage where detailed remediation plans have been developed. Not knowing exactly what needs to be done makes it difficult to assess the technologies that will be employed, and thus, the technology development needs.
- The absence of baseline technology plans that identify the investigation and cleanup technologies that would be used if the remediation had to be conducted today hamper the ability to assess the benefits that new technology could bring.

- The lack of detail on the needs that have been identified makes it difficult to determine their validity. Typically, the description is one sentence long, and it is not always clear who identified the need and whether the individual knew enough about the site conditions, the nature of the wastes, the difficulty in treating them, or the capabilities of available technologies.

These problems need to be resolved if a sound technology development program is to be developed.

The following are the primary recommendations resulting from this study:

1. The technology needs identified in this report should be reviewed by the sites to assess their validity and completeness.
2. The technology needs identified in this report should be reviewed by the BWID program staff knowledgeable in the various technical areas. A determination of the significance of site-specific wastes, disposal conditions, or environmental conditions across the complex should be made.
3. This report should be made available to current and potential BWID researchers so that they can gain a more complete picture of the DOE-wide buried waste problem. By being aware of the range of wastes, disposal methods, and environmental conditions, researchers may be able to broaden the applicability of their research with minimal cost and effort.

As sites get closer to actual remediation, additional technology needs, largely enhancements to current technologies, will be identified. Technology needs identification will therefore be an on-going process. A mechanism must be in place to facilitate this transfer of information to the BWID program. We recommend efforts be made by BWID staff to work with knowledgeable staff at each site on a regular basis.

ACKNOWLEDGMENTS

This work was performed by Pacific Northwest Laboratory (PNL) under the auspices of Westinghouse Hanford Company (WHC). The author wants to thank Owen Kruger (WHC) for his support and encouragement in completing this study. The author also wants to thank Greg Holter (PNL), the Buried Waste Integrated Demonstration (BWID) project manager for PNL, for his support and direction.

Others who contributed to the study include various colleagues from PNL: Peri Kaae, Sue Garrett, Garrick Louie, and Steve Short; the technical reviewers were: Jim Anderson (WHC), Ed Derr (Los Alamos National Laboratory), Robert Mason (Oak Ridge National Laboratory), and Pat McDuffie and Jerry Scott (both of PNL); Dave Payson and Sheila Bennett (both of PNL) provided the technical editing, and Rose Urbina (PNL) performed the text processing.

The author accepts full responsibility for the accuracy of the content of this report.

CONTENTS

EXECUTIVE SUMMARY	iii
ACKNOWLEDGMENTS	vii
1.0 INTRODUCTION	1.1
1.1 BACKGROUND	1.1
1.2 APPROACH	1.2
1.3 REMEDIATION STRATEGIES	1.4
1.4 ORGANIZATION OF THIS DOCUMENT	1.6
2.0 SITE-SPECIFIC DISPOSAL STRATEGIES	2.1
2.1 RADIOACTIVE WASTE DISPOSAL PROCESS	2.1
2.2 PACKAGING OF RADIOACTIVE AND HAZARDOUS WASTES	2.1
2.3 DISPOSAL DESIGNS	2.3
2.3.1 Trenches	2.6
2.3.2 Pits	2.9
2.3.3 Caissons	2.9
2.3.4 Shafts	2.9
2.3.5 Landfills	2.10
2.3.6 Ponds and Basins	2.11
2.3.7 Injection Wells	2.12
2.3.8 Cribs and Ditches	2.12
2.4 CONDITION OF BURIED WASTES COMPLEX-WIDE	2.12
3.0 BURIED WASTE TECHNOLOGY NEEDS	3.1
3.1 HANFORD	3.2
3.1.1 Technology Development Needs	3.2
3.1.2 Technology Improvement	3.4
3.1.3 Prioritizing Hanford Site Needs	3.6

3.2 OTHER DOE SITES	3.10
3.2.1 Savannah River Site	3.11
3.2.2 Los Alamos National Laboratory	3.12
3.2.3 Oak Ridge Reservation	3.15
3.2.4 Miscellaneous Sites	3.17
4.0 RECOMMENDATIONS	4.1
5.0 REFERENCES	5.1
APPENDIX A - SAVANNAH RIVER SITE	A.1
APPENDIX B - LOS ALAMOS NATIONAL LABORATORY	B.1
APPENDIX C - OAK RIDGE	C.1
APPENDIX D - HANFORD SITE.	D.1

FIGURES

1.1	DOE Facilities with Large Volumes of Buried Waste	1.2
1.2	The Generic Buried Waste Remediation Process	1.5
2.1	Generic Waste Management System for DOE Buried Waste	2.2
2.2	Solid Waste Burial Trench Design at the Hanford Site	2.7
2.3	Retrievable TRU Waste Asphalt Pad Storage Design at the Hanford Site	2.8
2.4	Savannah Rive Site Trench Configurations at the Old Radioactive Waste Facility and the New Radioactive Waste Facility	2.10
2.5	Solid Waste Burial Caissons Used at the Hanford Site	2.11
2.6	Crib Construction at the Hanford Site	2.13

TABLES

1.1	U.S. Department of Energy Facilities with Large Volumes of Buried Radioactive Waste	1.3
2.1	Container Types Used for Specific Waste Categories	2.4
2.2	Container Types Used Across DOE Complex	2.5
2.3	Disposal Features Used Across DOE Complex	2.6

1.0 INTRODUCTION

Technologies are being developed under the Buried Waste Integrated Demonstration (BWID) program to facilitate remediation of the U.S. Department of Energy's (DOE) buried and stored low-level radioactive, transuranic (TRU), and mixed radioactive and hazardous buried wastes. The BWID program is being coordinated by the Idaho National Engineering Laboratory (INEL) in southeastern Idaho, a DOE site that has large volumes of buried radioactive wastes. The program is currently focusing its efforts on the problems at INEL's Sub-surface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC). As specific technologies are successfully demonstrated, they will be available for transfer to applications at other DOE buried waste sites.

The purpose of this study is to present buried waste technology needs that have been identified for DOE sites other than INEL. Particular emphasis is given to the Hanford Site in southeastern Washington, because of the large volumes of wastes found there. Other sites emphasized include the Savannah River Site (SRS) in South Carolina, Los Alamos National Laboratory (LANL) in New Mexico, and the Oak Ridge Reservation (ORR) in Tennessee (Figure 1.1). Identifying the needs associated with the wastes and the environmental conditions at these other sites will assist the BWID program in developing and enhancing technologies that will be needed for site remediation throughout the DOE complex.

This document is a companion to DOE Complex Buried Waste Characterization Assessment, PNL-8390 (Kaae et al. 1993).

1.1 BACKGROUND

Beginning in the 1940s, the federal government began producing uranium materials and irradiating them in nuclear reactors to produce weapons. In all, 14 facilities in 13 states were constructed to perform some function related to nuclear weapons production. The activities conducted at major facilities that produced radioactive and hazardous waste and the disposition of those wastes are presented in Table 1.1.

FIGURE 1.1. DOE Facilities with Large Volumes of Buried Waste (size of the icon indicates relative volumes of buried wastes.)

The activities can be broken down into several major categories:

- weapons research and development
- nuclear materials production and processing
- warhead component production
- warhead testing.

While the bulk of wastes generated were related to major activities identified in Table 1.1, it is also true that many facilities conducted miscellaneous activities that also may have generated radioactive or hazardous wastes.

1.2 APPROACH

The primary objective of this study was to assemble site-specific technology needs identified at Hanford and other sites (not including INEL). A

TABLE 1.1. U.S. Department of Energy Facilities with Large Volumes of Buried Radioactive Wastes

<u>Type of Facility</u>	<u>Facility</u>	<u>Start Date</u>	<u>Waste Disposition</u>
Weapons Research and Development	Los Alamos National Laboratory	1945	Onsite
Nuclear Materials Production and Processing	Hanford Plant	1943	Onsite
	Savannah River Site	1952	Onsite
	Idaho National Engineering Laboratory	1954	Onsite
	Rocky Flats Plant	1954	INEL/Onsite
Weapons Production	Oak Ridge Reservation	1943	Onsite
	Nevada Test Site	1961	Onsite
Warhead Testing	Argonne-East	1943	Onsite
Other	Argonne-West	1955	INEL

secondary objective was to identify site conditions, waste characteristics, and disposal methods across the DOE complex that might impact the BWID technology development program. The approach taken to meet these objectives was as follows:

1. Identify the baseline technical approaches developed to date for remediating the buried wastes at Hanford and other DOE facilities with large volumes of low-level, TRU, or hazardous wastes.
2. Collect the following information for the major facilities:
 - the types of wastes that have been disposed of onsite
 - the waste management practices employed to dispose of the wastes

- environmental conditions that can impact the integrity of wastes or waste packages in the ground or that could impact retrieval.
3. Compare sites according to the categories in Step 2, focusing on those elements that could impact remediation strategies.
 4. Compile technology needs identified previously for sites other than INEL.

This report was prepared primarily for BWID staff, though an attempt has been made to provide a suitable amount of background information for readers who are not familiar with basic buried waste issues and assumptions. No attempt was made to compare technology needs identified in this study with the current or planned BWID program; such an effort was beyond the scope of this study.

1.3 REMEDATION STRATEGIES

The remediation process can be described as a series of generic stages (Figure 1.2). The preferred option for buried waste is in situ disposal because of the reduced risk to workers and the reduced costs that such an option can afford. Unfortunately, at most sites, there is uncertainty concerning the ability of in situ methods to adequately treat all wastes completely, so wastes will probably be retrieved, treated and disposed of either onsite or offsite.

Remediation plans will be designed for each specific site. The following strategies reflect a generic approach that is consistent with the current regulatory environment:

- Transuranic and Transuranic-Mixed Solid Waste. Buried, pre-1970 suspect TRU-contaminated waste is retrieved for treatment along with post-1970-stored and newly generated TRU and TRU-mixed solid waste. The waste is treated to segregate the TRU and TRU-mixed fraction from materials in other waste groups. The TRU and TRU-mixed fractions are converted to a disposal form by simple stabilization and volume-reduction processes, repackaged, and transferred to a storage facility for ultimate shipment offsite to WIPP in New Mexico.

R9203192.1

FIGURE 1.2. The Generic Buried Waste Remediation Process

- Low-Level Mixed Solid Waste. Buried waste is retrieved for treatment with stored and newly generated materials as required by the site closure process. The mixed waste is converted to a disposal form using stabilization and volume-reduction process systems and is disposed of onsite in permitted near-surface disposal systems. Land Disposal Restriction (LDR) standards may require further treatment of some mixed wastes.
- Low-Level Solid Waste. LLW is being considered in two or more categories, generally segregated by low activity and high activity. Higher activity LLW that includes the sorted suspect TRU waste with activities below 100 nCi/g will probably be stabilized and/or disposed of in a near-surface disposal facility with appropriate engineered barriers. Lower activity LLW will continue to be disposed of in near-surface trenches and closed in the same way as landfills.

While these options are not necessarily the only options for solid waste disposal complex-wide, they do summarize the approaches being taken for the bulk of DOE's solid waste.

1.4 ORGANIZATION OF THIS DOCUMENT

This document is organized as follows:

- Section 1.0 presents the goals and objectives of this study, relevant background information, and the approach taken to meet the goals and objectives.
- Section 2.0 describes the disposal methods employed at each facility and assesses the known and suspected conditions of the wastes today.
- Section 3.0 identifies the technology needs identified previously at Hanford and other sites (other than INEL), particularly as they relate to waste characteristics and environmental conditions.
- Section 4.0 provides recommendations to the BWID program for refining the technology needs throughout the DOE complex.
- Section 5.0 lists the references used in this study.

Additional supporting information is included in several appendixes.

2.0 SITE-SPECIFIC DISPOSAL STRATEGIES

Waste management across the DOE complex during the 1940s and 1950s was not coordinated, primarily because of the need for national security. Each facility developed its own strategies for dealing with the wastes that were generally based upon the environmental setting and engineering preferences at that facility. As a result, various approaches were taken, so that today DOE is faced with a variety of contexts from which to manage buried wastes.

The purpose of this section is to describe the various disposal strategies, as a precursor to assessing the potential impact of these strategies on remediation technologies that will ultimately be required for the individual sites. Greater detail regarding the dimensions and contents of specific features at each site is provided in Kaae and Holter (1993), the companion document to this study.

2.1 RADIOACTIVE WASTE DISPOSAL PROCESS

Although each of the facilities in the DOE complex differed in the types and volumes of wastes generated and the manner in which wastes were disposed, some generalities can be made as to the overall waste management system employed (Figure 2.1). The parts of the system are as follows:

1. Radioactive and hazardous materials were generated.
2. Wastes were separated according to level of radioactivity and waste form.
3. Wastes were packaged into protective containers.
4. Wastes were transported and disposed in the environment.

For this needs assessment, the focus is on the types of containers used and the methods for disposal.

2.2 PACKAGING OF RADIOACTIVE AND HAZARDOUS WASTES

Certain types of waste were routinely placed into specific forms of containers. For example, at Hanford, dry wastes such as soiled clothing, laboratory supplies, and tools were packed in cardboard, wood, or metal containers.

R9205152.2

FIGURE 2.1.1. Generic Waste Management System for DOE Buried Waste

Industrial waste, such as failed process equipment, was packaged in wood, fiberglass-reinforced plywood, or heavy metal containers, concrete boxes, or buried directly. Some items, primarily large items such as trucks or heavy equipment, were disposed individually, without packaging. Starting in 1970, TRU-bearing waste at Hanford was packaged either in sealed metal containers or fiberglass-reinforced plywood boxes.

At Los Alamos, much of the radioactive waste was placed in the disposal pits without rigid packaging. Large metal boxes were routinely used in the disposal of LLW. Bulk waste and packaged waste were placed in multiple layers in the pits with backfill (crushed tuff) between the layers. During the placement and backfilling processes, the bulk waste and backfill were compacted in situ. A primary benefit of this disposal method was that the void space was minimized and as a result subsidence of closed disposal pits has not posed a significant problem. Since 1970, TRU waste at Los Alamos has been packaged in sealed metal containers, with the exception of very large items that have been packaged in plywood boxes coated with fiberglass-reinforced polyester; most of the waste packages have been placed in retrievable storage on asphalt pads under plywood, plastic, and earthen covers.

The types of packaging used for different categories of waste are shown in Table 2.1. The types of packaging used at specific sites throughout the DOE complex are identified in Table 2.2. Many times, wastes were placed into multiple containers (i.e., containers within containers).

2.3 DISPOSAL DESIGNS

Various designs were used for disposing the containerized and uncontainerized wastes into the environment. Methods for disposing liquid low-level radioactive wastes are included because the technology required to remediate these soils will be similar to that required to remediate soils contaminated by breached solid waste containers. We are not including methods for disposal of high level liquid wastes because different technologies will be required.

TABLE 2.1. Container Types Used for Specific Waste Categories^(a)

	LLW	TRU	
		Pre-70	Post-70
Direct Burial	x	-	-
Plastic			
Bags	x	x	x
Buckets		x	x
Fiber			
Drums	-	x	x
Cardboard Boxes	x	x	-
Wood Boxes			
Plywood	-	x	x
With Fiberglass	-	x	x
Concrete			
Boxes	x	x	x
Casks	-	x	x
Culverts	-	-	x
Metal Drums			
Carbon Steel	x	x	x
Polyethylene Lined	-	x	x
Asphalt Coated	x	-	-
Asphalt Encased	x	-	-
Rigid Metal			x
Metal "Paint Cans"	-	x	x
Metal Boxes			
90 ft ³	x	x	x
45 ft ³	x	x	x
Other	x	x	x
Metal Cylinders			
Concrete Encased		x	x

(a) LLW (low-level radioactive waste), TRU (transuranic).

TABLE 2.2. Container Types Used Across DOE Complex^(a)

	<u>INEL</u>	<u>Hanford</u>	<u>SRS</u>	<u>LANL</u>	<u>ORR</u>
Plastic					
Bags	X	X	X	X	?
Boxes	X	-	-	-	-
Buckets	X	-	-	X	X
Fiber					
Drums	-	X	-	-	X
Cardboard Boxes	X	X	X	X	?
Wood Boxes					
Fiberboard	X	-	X	-	-
Plywood	-	X	-	X	X
With Fiberglass	-	X	-	X	-
Concrete					
Boxes	?	X	?	-	?
Casks	?	X	?	X	X
Culverts	?	X	X	-	-
Metal Drums					
Stainless Steel	X	X	-	-	X
Galvanized Steel	X	X	-	X	-
Carbon Steel	X	X	X	-	X
Polyethylene-Lined	X	X	-	X	X
Asphalt-Coated	?	?	-	X	-
Asphalt-Encased	?	?	-	X	-
Rigid Metal	-	-	X	-	-
Metal "Paint Cans"	X	X	X	X	X
Metal Boxes					
90 ft ³	-	-	X	?	?
45 ft ³	-	-	X	?	?
Other	X	X	X	?	?
Metal Cylinders					
Concrete Encased	-	-	-	X	-

(a) INEL (Idaho National Engineering Laboratory), SRS (Savannah River Site), LANL (Los Alamos National Laboratory), ORNL (Oak Ridge National Laboratory).

The major disposal designs used throughout the DOE complex are as follows:

- trenches
- pits
- caissons
- shafts
- landfills
- injection wells
- ponds and basins
- cribs and ditches.

The distribution of these disposal features across the DOE complex is shown in Table 2.3. The characteristics of the features and the methods used for storing and stabilizing the wastes in the features are discussed below.

TABLE 2.3. Disposal Features Used Across DOE Complex^(a)

	<u>INEL</u>	<u>Hanford</u>	<u>SRS</u>	<u>LANL</u>	<u>ORR</u>
Trenches	H	H	H	L	H
Pits	H	-	-	M	-
Caissons	-	M	-	-	-
Shafts	L	-	-	H	-
Landfills	-	L	-	M	-
Injection Wells	M	L	-	-	L
Ponds and Basins	M	H	H	M	M
Cribs	-	H	-	-	-

(a) Designations H (high), M (medium), and L (low) are used to indicate the relative numbers of these features at each facility.

2.3.1 Trenches

The trench concept was commonly applied for disposing solid low-level radioactive and TRU wastes, particularly "dry waste" such as soiled clothing, laboratory supplies, and tools packed in cardboard, wood or metal containers, and industrial waste such as items of failed process equipment packaged in heavy metal or concrete boxes. Trenches across the complex vary widely in terms of size and construction, as discussed in the following paragraphs.

The Hanford Site

At the Hanford Site dry waste v-shaped trenches for LLW were constructed, measuring from 1.5 to 9 m (5 to 29 ft) wide, 3.7 m (12 ft) deep, and often as long as 100 m (325 ft) (DOE 1975). Trenches used for industrial wastes were two to three times larger (Figure 2.2) than those for non-industrial waste. Hanford also used trenches 7.3 m (24 ft) wide at the bottom on 15.3 m (50 ft) centers. Several other configurations might have been used as well.

The trenches constructed for retrievable TRU waste beginning in the 1970s changed considerably from the former design, as shown in Figure 2.3; certain wastes unsuitable for asphalt pads continued to be placed in the earlier-style trench (DOE 1975). A review of the packaging and trenches used for contact-handled TRU waste at Hanford is presented in Anderson et al. (1990).

FIGURE 2.2. Solid Waste Burial Trench Design at the Hanford Site (DOE 1987)

Idaho National Engineering Laboratory

The excavated earthen trenches concept was employed at INEL beginning in 1952. The INEL trenches are unusual in that they were excavated to the basalt bedrock; at most sites, bedrock is not that close to the surface. Trenches ranged in length from 30.5 to 305 m (100 to 1000 ft), in width from 1.5 to 2.4 m (5 to 8 ft), and in depth from 3.7 to 4.9 m (12 to 16 ft) at centers (Geotech 1991).

FIGURE 2.3. Retrievable TRU Waste Asphalt Pad Storage Design at the Hanford Site (DOE 1987)

Savannah River Site

Trenches have been used for disposing buried wastes since 1952, but little information was found concerning the construction of the early excavated earthen trenches (WSRC 1989; Geotech 1991). A map provided in one document (WSRC 1991) shows the wide diversity in trench configurations, both at the old radioactive burial ground (643-G) and the present radioactive burial ground (643-7G).

Los Alamos National Laboratory

Few trenches were constructed at LANL. Those identified ranged in size from 9 m (30 ft) wide by 60 m (200 ft) long x 3 m (10 ft) deep to 13 m (40 ft) wide by 45 m (150 ft) long by 4 m (12 ft) deep (Los Alamos National Laboratory 1991). Trenches were excavated into welded and nonwelded tuff (Los Alamos Scientific Laboratory 1977).

Oak Ridge Reservation

Little information was located concerning the construction of trenches at ORR during the 1940s and 1950, although maps provided in Coobs and Gissel (1986) indicate that the trenches at Oak Ridge National Laboratory were approximately 30 m (100 ft) to 40 m (130 ft) long. High water tables have led to most of the wastes in these trenches becoming saturated.

Since 1970, trenches have not been typically used for TRU wastes, although TRU waste with high external gamma exposure rates (>200 mR/hr) is placed in sealed reinforced concrete casks and placed one across in trenches 3 m deep (10 ft), approximately 4 m (13 ft) wide, and 15 m (50 ft) long; most TRU waste is stored in buildings or outside storage areas. Similar sized trenches have also been used for LLW.

2.3.2 Pits

Pits with buried waste seem most often to refer to excavated features that are irregular in shape; the distinction between pits and trenches is not always clear or consistent. For example, the trenches at Savannah River (Figure 2.4) would likely be called pits at INEL and elsewhere, while the pits at Los Alamos would seem to qualify as trenches at Hanford or Savannah River.

The term "pits" is also used to refer to areas where wastes were burned (referred to as burn pits) and to areas where contaminated liquids were disposed (e.g., chemical pits). Both types are of interest here because they contain contaminated soils similar in nature to those found in the more typical buried waste features.

2.3.3 Caissons

Caissons are a disposal method unique to Hanford (Figure 2.5). Caissons were used for small items of TRU-bearing solid waste containing fission products capable of generating high dose-rate gamma emissions (DOE 1975). These wastes were packaged and shipped in shielded casks to the caissons, where the wastes were discharged into the unit. Additional wastes may have been disposed in caissons at times, although no inventory records were located. At least one type of caisson was designed for retrieval.

2.3.4 Shafts

Shafts provided an alternative to large excavated earthen trenches and pits, especially at Los Alamos National Laboratory. Hundreds of shafts, 2 to 8 feet in diameter, were drilled into the tuff at Los Alamos to depths as great as 60 feet (LANL 1990). Some shafts were lined with concrete, some with various metal sleeves, and some were unlined. Wastes tended to be segregated into different shafts, or at different depths within a shaft. Cement or other

FIGURE 2.4. Savannah River Site Trench Configurations at the Old Radioactive Waste Facility (643-G) and the New Radioactive Waste Facility (643-7G) (WSRC 1991)

material was often placed into shafts to cover wastes, and most shafts are capped with cement. Two or three overlapping shafts also were constructed to accommodate waste items with physical dimensions too large to fit in a single shaft.

2.3.5 Landfills

Landfills refer to confined areas where solid waste accumulated. In general, landfills designate areas used by a facility to dispose of its daily

FIGURE 2.5. Solid Waste Burial Caissons used at the Hanford Site (DOE 1975)

nonhazardous refuse; occasionally, landfills were created for special purposes such as construction debris resulting from a large construction project. Landfills are considered here because several landfills across the DOE complex have been identified, usually through historical records, to have received radioactive or hazardous wastes. Landfills contrast with most other waste features of concern here because they represent small quantities of radioactive or hazardous wastes within a large nonhazardous matrix. Locating and retrieving the waste, therefore, might pose different sets of problems than some of the other feature types.

2.3.6 Ponds and Basins

Pond and basins and other types of surface impoundments were used to store large volumes of low-level contaminated liquid waste. Over time, the water evaporated, resulting in contaminated soils.

2.3.7 Injection Wells

Injection wells are subsurface features designed for disposing liquids. At Los Alamos, cemented americium wastes at SWMU 21-016, MDT were disposed in sealed, metal-lined wells that are classified as "shafts" at that site. TRU sludges were pumped into these vertical pipes and allowed to solidify. These metal pipes, with the solidified sludges, have been removed and are currently in retrievable storage at the primary radioactive waste storage and disposal facility (TA-54, Area G). Eventually, these pipes will be cut into sections and shipped to WIPP for disposal.

At Oak Ridge, cemented liquids were injected into the fractured bedrock; in at least one case the cement did not set up, resulting in a contamination problem. Radioactive wastes injected into wells at INEL have contaminated the Snake River Aquifer.

2.3.8 Cribs and Ditches

Cribs and ditches represent linear excavations used for disposing liquid wastes. Cribs are engineered features, whereas ditches generally are less so. Cribs at Hanford were constructed by digging a ditch about 20 feet deep and 1400 feet long, backfilling it with rock and covering it with an impermeable membrane and soil. A pipe running the length of the crib was designed to distribute the liquid uniformly along the crib length (Figure 2.6). The released liquid permeates through the soil. The soil column between the bottom of the crib and the groundwater is 150 to 300 feet thick and contains up to 50% silts and sand, with some clay.

2.4 CONDITION OF BURIED WASTES COMPLEX-WIDE

For those containers disposed during the 1940s through the 1960s, the integrity of the containers is confirmed to be bad in some cases and suspected to be poor in other cases. Breached containers result in contaminated soil as well as commingled wastes.

Anderson et al. (1990) conducted an analysis of buried TRU waste container integrity. Using the results of container investigations from INEL, Savannah River, and the Hanford Site, the authors concluded the following:

FIGURE 2.6. Crib Construction at the Hanford Site (DOE 1975)

- Direct burial in soil will lead to container penetration and loss of structural integrity from corrosion in much less than 20 years.
- Corrosion rates of carbon steel drums covered with plastic sheeting were significantly slower than for drums without plastic sheeting; drums should last 20 years without breaching.
- Galvanized drums corrode slower than carbon steel drums.
- Plywood containers not covered with plastic will probably crumble in less than 20 years.
- The fiberboard-reinforced plywood and metal box containers should last, though no assessment of the structural integrity for lifting and transport could be made.

The authors noted that corrosion processes are quite variable, even in the same environment, and a wide degree of scatter in corrosion rates is typical.

In addition to corrosion of buried containers, subsidence in trenches is another significant issue. Subsidence, which in some cases is substantial, can increase the potential for breached containers and can produce large

voids. Voids are particularly worrisome because they can fill up with gases, resulting in a significant health and safety issue. Subsidence below any cap-type barriers can cause a loss of integrity and a funneling of surface waters through contaminated media.

Changes such as pressure buildup or waste decomposition within unbreached containers are considered likely but are not well understood at the present time.

3.0 BURIED WASTE TECHNOLOGY NEEDS

Because technology development under the BWID program is based primarily on the INEL-specific technology baseline, it is possible that the buried waste technology needs of other sites are not being addressed. For this reason, it is useful to consider the technology needs that have been identified at other sites so that BWID staff can determine whether any gaps exist in its technology development program.

Buried waste technology needs previously identified come from a variety of sources and were collected in a variety of ways. Most commonly, the needs were identified in a workshop setting, in which the objectives were to identify known or suspected needs; time usually did not permit full description, evaluation, or prioritization of the needs. Moreover, all sites have not been equally represented in these efforts.

The buried waste technology needs identified to date were gathered primarily from the following documents:

- Technology Needs Assessment Final Report (Grand Junction Projects Office, August 1991)
- "Validation of Consolidated Needs List for Characterization, Monitoring, and Sensor Technology." February 1992. Memorandum from Sally Mann (HQ) to Joe Cullen (SAN), Liz Bracken (RL), and Alice William (ID).
- "Solid Waste Planning Sessions" (compiled by B. C. Anderson and distributed April 1990). This input was collected during six half-day planning sessions, conducted by the Hanford Solid Waste Technology group and involving over 75 individuals from 10 different groups (e.g., Engineering, Technology Development, Safety, Operations).
- "Hanford Technical Needs Assessment and Prioritization Summary Report FY-90" draft document. Westinghouse Hanford Company, Richland, WA 99352.
- Hanford Site-Specific Science and Technology Plan, FY 1991 Edition, March 1992 (Draft). DOE Field Office, Richland, WA.

The technology needs that have been identified are presented below, first for Hanford, and then for the other sites; needs for INEL are not

included because they are well known by BWID staff. In presenting the technology needs, they have been grouped according to the stages identified in Figure 1.2. Where a need has been identified, we assume that the function can not be conducted by existing technology with acceptable levels of risk to human health and the environment or at reasonable cost; no attempt has been made to assess the risk or cost of not developing or enhancing existing technology.

3.1 HANFORD

The buried waste technology needs for Hanford are broken into two categories: development and improvement. Following the listing of technology needs are the preliminary results of a prioritization effort.

3.1.1 Technology Development Needs^(a)

Technology development needs are listed according to the following categories: characterization, waste retrieval, waste treatment, and disposal.

Characterization

- Develop in situ techniques to identify drum contents (TRU or not).
- Develop electrochemical sensors to detect hazardous chemical constituents (M).
- Characterize miscellaneous waste in various physical and chemical forms in various containers.
- Develop in situ methods to identify the condition of containers that are buried or stored.
- Develop remote means to characterize technologies for caissons.

Waste Retrieval

- Develop equipment/methods for retrieving trench wastes, including both contact-handled and remote-handled.

(a) The designations (H), (M), or (L) in this section represent needs identified during the 1990 effort coordinated by Carol Fow, formerly of PNL. The designations stand for high, medium, and low priority, respectively.

- Develop material handling methods for retrieving uncontained waste (H).
- Develop advanced remote retrieval technology (H).
 - increase weight carrying capability
 - reduce cross section
 - increase reach
 - improve control
 - improve man-machine interface
- Build a self-contained in situ retrieval/treatment/disposal facility (H).
- Determine methods to retrieve caissons intact, and remove and process the waste in WRAP facility.
- Develop remote-operation equipment/methods for cleaning out caissons and PUREX tunnels.

Waste Treatment

- Select baseline waste forms for each waste type.
- Develop improved waste forms (H).
- Develop methods to treat sections within a trench containing TRU.
- Develop treatment technologies for destroying hazardous components in mixed wastes, thus allowing disposal of the rest as radioactive waste.
- Develop technology to treat mixed waste (H).
- Develop treatment technologies for improved performance waste forms (i.e., reduced transport of constituents from wastes).
- Develop alternatives to incineration (H).
- Develop incineration technology for solid waste (H).

Disposal

- Develop methods to control subsidence of trenches and reduce leaching of waste to groundwater.
- Develop advanced barrier concepts to reduce costs and risk (H).
- Develop techniques for mixed waste disposal.
- Develop disposal concepts for improved confinement.

3.1.2 Technology Improvement^(a)

Technology improvement needs are listed according to the following categories: characterization, waste retrieval, waste treatment, treatment in place, and disposal.

Characterization

- Develop improved analytical chemistry technology/methods (H).
- Develop improved technology/methods for sampling heterogeneous materials (H).
- Develop improved on-line/field sampling/analysis/monitoring technologies (H).
 - field techniques for classifying TRU and mixed waste
 - improve sensitivity of explosive gas measurement
- Extend life of electronics (activators, sensors, etc.) (M).

Waste Retrieval

- Improve excavation technology (H).
- Improve technology/methods for determining integrity of containers (H).
- Develop techniques to determine integrity of containers after retrieval.
- Develop methods to vent old containers.
- Develop equipment/methods to over-pack damaged or questionable containers.
- Develop general handling equipment/methods for all types of containers that may be encountered.
- Improve waste drying technology (L).
- Improve size reduction technology (H).
- Improve technology/methods to contain waste during retrieval, RI/FS work, etc., (H).

(a) As in the previous section, the designations (H), (M), or (L) represent needs that stand for high, medium, and low priority, respectively.

- Improve methods of packaging and transporting solid waste (H).
- Improve methods to decontaminate equipment to reclassify for disposal, repair, or re-use (H).

Waste Treatment

- Improve technology/methods to stabilize contaminated disposal sites with large void volumes (M).
- Improve technology/methods to segregate hazardous constituents from radioactive wastes (H).
- Provide compaction and/or shredder facilities for mixed waste.
- Obtain casks for transporting treated waste to disposal site (e.g., WIPP).
- Develop new trench back-filling techniques that ensure regulatory suitability.
- Develop new or improved technology for waste disposal packaging to support new disposal concepts (e.g., square drums).
- Improve technology/methods to verify treatment process performance (M)
 - validate waste form leach rates
 - validate waste package barrier performance
 - verify that waste form meets disposal criteria.
- Reduce hydrogen release during treatment and disposal (M).
- Interim stabilization
 - cryogenics
 - in situ vitrification
 - grout injection

Treatment In-Place

- Improve technology for stabilizing site (M).
- Improve technology for immobilizing contaminants in-place (H).
 - in situ microwave
 - in situ vitrification (electrode development, off-gas treatment, glass formulation)
 - in situ grouting (mixing, off-gas)
 - bioremediation
 - cryogenics.

- Improve technology for detoxifying contaminants (H)
 - destroy organics (in situ heating, bioremediation)
 - destroy nitrates (bioremediation)
- Electrokinetics

Disposal

- Improve contaminated soil treatment and disposal (H)
 - surface barriers to control infiltration of water; plant, animal, and human intrusion; and wind and water erosion
 - subsurface barriers to control leaching of contaminants, and advective and diffusive flow of infiltrating waters using slurry walls, sheet piling, grout injection, sorbent barriers, in situ vitrification, and cryogenic barriers
 - solidification and fixation of contaminants through sorption, pozzolanic agents, and micro-encapsulation
 - physical and chemical treatment using soil washing/flushing, solvent leaching, and lime neutralization
 - biological treatment using cultured micro-organisms and surface bioreclamation
 - thermal treatment using incineration, pyrolysis, and in situ vitrification
 - excavation using conventional mining industry techniques with approval.
 - electrokinetics/electroosmosis using contaminant migration under electrolytic cell action.
- Improve barrier design (H).

3.1.3 Prioritizing Hanford Site Needs

A workshop held at Hanford in 1990 prioritized the technology needs for the solid waste mission^(a) according to the following six criteria:

- size of problem
- imminent health risk
- Tri-Party Agreement milestones
- cost/risk benefit

(a) "Hanford Technical Needs Assessment and Prioritization Summary Report FY-90" draft document. Westinghouse Hanford Company, Richland, WA 99352. A Hanford solid waste needs is currently being coordinated by Linda Fassbender of Pacific Northwest Laboratory; when the results of the current effort are available, they may supplant the prioritization provided in this document.

- applicability
- regulatory acceptance.

The top ten technology needs were ranked as follows:

1. Operational Need: Provide a method for remediating contaminated soil sites

Technology Need: Develop, demonstrate, test, and evaluate containment, removal, and treatment technologies for contaminated soils using physical, chemical, biological, thermal, and other suitable techniques.

Potential Technical Solutions:

- Surface barriers to control infiltration of water; plant animal, and human intrusion; and wind and water erosion
- Subsurface barriers to control leaching of contaminants, and advective and diffusive flow of infiltrating waters using slurry walls, sheet piling, grout injection, sorbent barriers, in situ vitrification, and cryogenic barriers
- Solidification and fixation of contaminants through sorption, pozzolanic agents, and micro-encapsulation
- Physical and chemical treatment using soil washing/flushing, solvent leaching, and lime neutralization
- Biological treatment using cultured micro-organisms and surface bioreclamation
- Thermal treatment using incineration, pyrolysis, and in situ vitrification
- Excavation using conventional mining industry techniques with appropriate modifications.

2. Operational Need: Provide techniques for controlling subsidence of solid waste burial trenches and reduce the leachability of solid wastes.

Technology Need: Develop, demonstrate, test, and evaluate methods for providing chemical isolation and physical stability at solid waste disposal sites through containment and treatment technologies.

Potential Technical Solutions:

- Dynamic consolidation and grout compaction
- Surface and subsurface barriers including cryogenic barriers, slurry walls, grout curtains, sorbent barriers, hydrologic barriers, and in situ vitrification.

3. Operational Need: Ensure control of airborne contamination during retrieval operations.

Technology Need: Develop, demonstrate, test, and evaluate methods for controlling personnel, equipment, and environmental contamination during retrieval operations.

Potential Technical Solutions:

- Portable "green houses"
- Inflatable or fixed structures
- Fixing agents to minimize dispersal
- In situ vitrification to fix contaminants in a grout matrix.
- Grouting to fix contaminants in a solid grout matrix
- Enhanced HEPA filtration systems (high-efficiency metal-fiber filters) and pressure differentials.

4. Operational Need: Ensure long-term confinement of buried solid wastes.

Technology Need: Develop, demonstrate, test, and evaluate methods for ensuring long-term confinement of buried solid wastes by controlling water infiltration; plant animal and human intrusion; wind and water erosion.

Potential Technical Solutions:

- Surface and subsurface barriers including multilayered earthen barriers, slurry walls, grout curtains, and sorbent barriers
- In situ vitrification to encapsulate waste materials in a low leachability glass matrix
- In situ grouting to encapsulate waste materials in a low leachability grout matrix.

5. Operational Need: Ensure safe transport of retrieved materials to their place of treatment.

Technology Need: Develop, demonstrate, test, and evaluate methods for packaging and shipping retrieved solid wastes.

Potential Technical Solutions:

- Acquire, adapt, modify existing regulations and containers to comply with Department of Transportation regulations
- Interface with the high-level waste repository program to acquire, adapt, and modify packaging and shipping systems
- Develop portable in-field sorting methods to minimize unnecessary handling of wastes.

6. Operational Need: Ensure that the waste form is in a low leachability configuration.

Technology Need: Develop, demonstrate, test, and evaluate methods for transforming the wastes into low leachability products or otherwise isolate the wastes from leaching mechanisms.

Potential Technical Solutions:

- In situ vitrification to encapsulate wastes in a low leachability glass matrix
- In situ grouting to encapsulate wastes in a low leachability grout matrix
- Surface and subsurface barriers including multilayered earthen barriers, grout curtains, slurry walls, sorbent barriers, cryogenic barriers, and hydrologic barriers.

7. Operational Need: Provide in situ sensors to demonstrate long-term performance of in situ isolation and stabilization efforts.

Technology Need: Develop, demonstrate, test, and evaluate in situ sensors to provide on-line, real-time monitoring of the effectiveness of remediation actions in isolating and stabilizing solid waste disposal sites.

Potential Technical Solutions:

- Use biosensors to evaluate contaminant migration through plant uptake and/or stress.
- Use soil gas monitoring to evaluate volatile organic contaminants.
- Suction lysimetry for moisture migration.
- Self-diagnosing sensors (SMART).

8. Operational Need: Provide capability to determine the nature of box and drum contents.

Technology Need: Develop, demonstrate, test, and evaluate methods for nondestructively interrogating burial boxes and drums to determine if they contain such things as compressed gas cylinders, free liquids, flammable or explosive materials.

Potential Technical Solutions:

- Use fiberoptic techniques to detect the presence of organic contaminants and determine the physical nature of the contained materials.
- Use biosensors to evaluate the presence of organic and other contaminants by monitoring plant uptake and/or plant stress.
- Use gamma ray, x-ray, and other types of tomography to interrogate waste package contents.

- Use neutron interrogation to screen TRU from non-TRU materials.
- Use conventional geophysical surveying methods including ground-penetrating radar, resistivity, electromagnetic induction and others.

9. Operational Need: Provide container venting systems to avoid the buildup of potentially explosive gases.

Technology Need: Develop, demonstrate, test, and evaluate methods for mitigating gas buildup within waste containers by controlled venting to the atmosphere.

Potential Technical Solutions:

- Use non-sparking container piercing devices connected to analyzers.
- Acquire and adapt techniques from the hazardous waste management industry.
- Novel applications of pressure relief valves or porous filter adapters.

10. Operational Need: Provide methods for retrieving TRU burial grounds and caissons.

Technology Need: Develop, demonstrate, test, and evaluate methods for remote retrieval of TRU contaminated materials while providing airborne contamination control.

Potential Technical Solutions:

- Adapt conventional construction and decommissioning methods.
- Use in situ vitrification to encapsulate materials in a stable glass matrix.
- Use in situ grouting to encapsulate materials in a stable grout matrix.
- Use portable "green houses," inflatable and fixed structures, and enhanced HEPA filtration systems to control airborne contaminants.
- Use portable in-field sorting techniques.

3.2 OTHER DOE SITES

The majority of buried waste technology needs for other DOE sites were compiled from the Technology Needs Assessment prepared by Geotech (1991) and

the EM-50 effort described in the memorandum from Sally Mann.^(a) Site-specific technology needs identification and prioritization efforts similar to those at Hanford have likely been conducted over the last few years, and there are probably a number of unpublished internal documents related to these efforts. The level of effort utilized for this report was limited to reviewing the above documents and the waste characteristics and general site conditions for each site in an attempt to note site-specific conditions that could impact the technology requirement for remediation.

The following review of technology needs focuses on the following DOE sites with large quantities of buried waste: the Savannah River Site, Los Alamos National Laboratory, and the Oak Ridge Reservation. Brief reviews of other DOE sites are also provided. Needs identified for INEL are not addressed in this report as they form the basis for the BWID program.

3.2.1 Savannah River Site

The Savannah River Site, located in South Carolina, is a nuclear materials production site.

Environmental Setting. The site is humid, the climate temperate, and rainfall plentiful compared with the western DOE sites. The area is underlain by a wedge of seaward-dipping unconsolidated and semi-consolidated sediments. Of particular geohydrologic significance are three major confining beds that retard the vertical movement of groundwater. Groundwater occurs at relatively shallow depths; the sediments are saturated with groundwater beginning at a depth of 12 m (Jaegge et al. 1987).

Buried Wastes. This site has large volumes of contaminated soils from numerous seepage basins (Appendix A). Old radioactive waste burial grounds (643-G) received low-level contaminated wastes that included shielding material, contaminated equipment, construction debris, incidental waste from production operations, mercury from pumps and offsite shipments--all placed in

(a) Department of Energy Memorandum dated February 6, 1992. "Validation of Consolidated Needs List for Characterization, Monitoring, and Sensor Technology," from Sally Mann to Joe Cullen (SAN), Liz Bracken (RL), and Alice Williams (ID).

excavated earthen trenches (WSRC 1989). Geotech (1991) reported that the carbon-14 on resin may require retrieval; if it breaks down, carbon-14 will probably be released and retrieval of the resin would be necessary.

Technology Needs

Geotech (1991) noted that the major technological concern is the stability, integrity, moisture content, and maintenance of capped units. Most other needs were high-level (e.g., "need for field analytical capabilities") or programmatic in nature (e.g., "need to transfer technologies from other industries"). The following technology needs were identified by the EM-50 effort:

- DQO identification and data planning (all areas).
- Non-invasive subsurface mapping and characterization (all areas).
- Non-invasive method for mapping the continuity of clay layers (aquitards) in the subsurface (all areas).
- Evaluation of inventory and flux of contaminants in fractured basalt (all areas).

3.2.2 Los Alamos National Laboratory

Los Alamos National Laboratory, located in Los Alamos, New Mexico, is a nuclear weapons research and development facility.

Environmental Setting. Los Alamos is located in a semi-arid area, at high elevation, with a topography marked by mesas and canyons. Soil type on the mesas is tuff. Average rainfall is 45 cm (18 in.). The evapotranspiration rate exceeds the precipitation rate; although rain tends to come in torrential downpours, the ground dries quickly and the moisture does not significantly penetrate the undisturbed tuff. Depth to the aquifer on the mesas, where the majority of wastes are found, is 100 to 190 m (350 to 620 ft). At TA-54, Area G, which has been the primary radioactive waste disposal area since 1957, the depth to the aquifer is 900 to 1000 ft. Winds exceeding 60 mph are common in spring.

Buried Wastes. Many disposal units at Los Alamos contain exploded ordnance, explosives, uranium, plutonium, PCB, and organics (Appendix B). Most of the volume of waste and nearly all of routine waste (especially radioactive waste) has been placed in pits. Los Alamos, however, is different from

other DOE sites in its reliance on shafts as a disposal strategy for unique or high-activity waste items and wastes requiring handling or isolation (Geotech 1991; LANL 1990).

Technology Needs

The fact that much waste at Los Alamos is found in shafts often as deep as 20 m (66 ft), some of which are entombed in concrete, invites speculation that technology development may be required to characterize and retrieve these wastes. The shafts, however, are not identified in the Geotech (1991) or EM-50 effort as troublesome. The prevalence of explosives and pyrophorics do appear to cause technological concern. Wastes generated by a research and development facility may also add an area of concern because of the potentially unique characteristics. In general, planning for remediation of waste disposal sites at Los Alamos has not progressed to the detailed planning stage; however, due to the environmental setting, closure of the sites without waste retrieval is under consideration. Los Alamos expects to begin retrieval operations for legacy TRU waste--stored in drums and fiberglass-reinforced, polyester-coated, plywood boxes under plastic, plywood, and earthen covers--in approximately two years. Technology needs for this operation currently are being identified.

The Geotech document (1991) identified the following needs:

- Satisfactory containment methods using caps and subsurface barriers.
- Waste segregation methods.
- Treatment of high explosives by in situ bioremediation processes.
- Non-invasive characterization techniques.
- Directional and dry drilling techniques.

Additional technology needs identified by the EM-50 effort include the following:

- Better definition of boundaries of disposal area (MDA).
- Non-invasive characterization techniques (all areas).

- Non-intrusive characterization techniques for material disposal areas (all areas).
- Low-level field screening for wide variety of metals, explosives, organics, etc.

Technology needs for the retrieval of legacy TRU waste at Los Alamos include the following items:

- Techniques for remotely assessing the conditions of containers in storage.
- Methods for identifying releases of hazardous waste constituents and radioactive components within the storage facilities.
- Monitoring methods for distinguishing releases attributable to the current storage facility from releases attributable to the older disposal pits (early 1960s) under the storage facilities.
- Equipment for drum venting and head space sampling, including confinement of potential deflagrations.
- Characterization methods for RCRA-regulated components in TRU waste.
- Definition of sampling methods for highly variable and unique waste matrices, including a definition of "acceptable".
- Drum handling equipment for safely retrieving drums of unknown structural integrity from a multi-level, densely-packaged storage array.
- Methods for complying with RCRA inspection requirements while minimizing storage space and worker radiation exposure.
- Methods to control releases (radioactive, VOCs, semi-VOCs, and other hazardous components) during retrieval operations.
- Methods for waste retrieval when the container has failed.
- Assay methods to segregate LLW from TRU waste, especially for unique waste matrices.
- Final definition of WIPP Waste Acceptance Criteria and Waste Analysis Plan requirements.
- Methods for sorting and treating TRU waste to ensure acceptance at WIPP.

Other technology needs for general radioactive waste include the following:

- Methods for in situ characterization of waste for hazardous waste and radioactive components.
- Methods for in situ treatment of waste, especially for components subject to land disposal restrictions.
- Methods for in situ vitrification of waste.
- Methods for in situ waste sampling.
- Methods for waste minimization.
- Methods for treatment of mixed low-level and TRU waste.
- Treatment facilities for mixed waste.
- Disposal facilities for mixed waste.
- Methods for enhanced environmental surveillance.
- Methods for characterization of soil gases, both radioactive and hazardous waste components.
- Methods for in situ treatment of soil gases.
- Concise definition of regulatory requirements for legacy waste and waste disposal areas.
- A "below regulatory concern" (BRC) level for radioactive components in the waste.

3.2.3 Oak Ridge Reservation

The Oak Ridge Reservation, located in Oak Ridge, Tennessee, was originally dedicated to the production of fissile materials for national defense. This subsection summarizes the available information on Oak Ridge National Laboratory (ORNL), formerly known as X-10, the former uranium processing facility at site K-25, and the former nuclear weapons facility at site Y-12.

Environmental Setting. Oak Ridge is located in a humid and temperate zone, with annual precipitation averaging 136 cm (53.5 in.). Groundwater is shallow and soils are silty with considerable amounts of clay present; pH ranges from 4.5 to 5.7. Weathered zones in areas underlain by limestone (SWSAs 1, 2, 3) are thin (less than 3 m [10 ft]). Areas are underlain by the Conasauga Group (shales and limestone); depth of weathering is related to topography (SWSA 4--1.2 to 4.9 m; SWSA 5--from 1 to 12 m; SWSA 6--1.5 to

12 m). For SWSA-6, the structure of the weathered bedrock commonly extends to within 30 cm of the surface, thereby providing pathways for transporting water quickly during precipitation events (Davis et al. 1986).

Buried Wastes. Oak Ridge wastes date back to 1944, with the earlier wastes deposited in trenches in the Bethel Valley, a practice that was found to be environmentally unsound. Subsequent burial occurred in the Merton Valley, which was a better site but which still posed problems. Between 1955 and 1963, a large volume of waste (1 M ft^3) from various offsite facilities was buried at Oak Ridge (Coobs and Gissel 1986). Additional information on buried wastes at Oak Ridge can be found in Appendix C.

Technology Needs. Geotech (1991) noted that "The combination of nearly all of Oak Ridge's contamination in the form of mixed wastes and an annual rainfall of 50 to 55 inches significantly complicates the environmental restoration of the site." The following specific needs were identified by Geotech:

- Non-invasive subsurface characterization and mapping.
- Improved field analytical activities.
- Improved methods for locating historical disposal areas.
- Improved methods to measure mercury in sediments.

The following technology needs were identified by the EM-50 effort:

- Better sampling strategy/identification of DQOs (OU3).
- Method to measure Hg in sediment (X10-1).
- Method to identify burn pits (K25-B1).
- Locate solvent disposal pits (K25-B1).
- Minimal to non-invasive means to identify buried waste (X10-3).
- Hydropunch drilling technique for high clay soils (K25-B1).
- Lower detection limits for sampling equipment (X10-1).
- Rapid techniques to determine when remediation of soils can be finished (rapid lab analysis) (X10-2).

- Walkover technologies for chemical and rad-contaminated soils (X10-2).
- Better field screening for remediation in buried sediments (X10-4).
- Probe for radioactive waste (X10-3).
- Gamma/beta probe for sediments (X10-3).

3.2.4 Miscellaneous Sites

Rocky Flats

The Rocky Flats Plant, located outside Denver, Colorado, was primarily focused on fabricating plutonium triggers used as detonating devices in nuclear bombs. The majority of wastes were shipped to INEL, though significant quantities still remain at Rocky Flats. Plutonium-contaminated soils and wastes are common.

Concerning technology needs, Geotech (1991) reported that during one cleanup effort in the 1960s, high winds spread the contamination to adjacent areas, indicating the need to consider high winds at Rocky Flats and other sites where winds are prevalent. Other needs identified by Geotech were:

- Real-time analytical equipment that has regulatory approval for faster turnaround times and reduced costs.
- Better, faster, and cheaper laboratory analyses.
- Improved methods to define the subsurface geology and geohydrologic framework.
- High-precision instrumentation to analyze radionuclides and organics at low concentrations.

The following technology needs were identified by the EM-50 effort:

- Sampling protocols for the sampling of windblown plutonium- and americium-contaminated soil (AU).
- Instrumentation/sensors for geophysics (OU-2B).
- Ability to drill and sample without disturbing the media (all areas).

- Ability to analyze trace levels of organics, metals, and radiological contaminants in the field; short-turnaround times needed (all areas)
- High-precision field and lab instruments for very low concentration of RAD organics (all areas).
- Real-time monitoring devices (all areas).
- Measure low levels of plutonium in soils and lake sediments; new sampling method needed for disturbed soils (OU3).
- Remote methods for in situ determination of waste category--TRU or non-TRU (OU3).
- In situ metal and radionuclide measurements (OU3).
- In situ organic characterization measurements (OU3).

Sandia National Laboratory

Sandia National Laboratory, located in Albuquerque, New Mexico, conducts nuclear weapons development and engineering. The Geotech document (1991) reports that chemical landfills present the greatest degree of contamination at Sandia. The following technology needs were identified by the EM-50 effort:

- Subsurface characterization (all areas).
- Definition/delineation of trenches, pits, buried drums (TA2).
- Directional drilling techniques for soils/ground water to identify migration without interfering with the source.
- Dry drilling techniques for soils/ground water to identify migrations without interfering with the source.
- In-field hydrocarbon analysis.

Argonne National Laboratory-East

- Non-invasive identification of contents of numerous concrete casks believed buried in the 319 Area (East-6).
- Non-invasive identification of geological features and contaminant plumes below landfill (East-5).

Fernald Environmental Management Program

- Non-destructive location of buried drums and waste is needed (OU2).
- Better sampling strategy/identification of DQOs (OU3).
- Soil washing - vitrification.

Nevada Test Site

- Agreed-upon methodology for radionuclide analysis (all areas).
- Well casing that will stand up in "tectonically active" area for indefinite future.
- Physical and chemical characterization technique for verifying soil cleanup.
- Soil washing - vitrification.

4.0 RECOMMENDATIONS

In identifying the technology needs for Hanford and the other sites, several problems were consistently encountered:

- In many cases, planning has not progressed to the stage where detailed remediation plans have been developed. Not knowing exactly what needs to be done makes it difficult to assess technologies that will be employed.
- The absence of baseline technology plans (i.e., plans that identify the investigation and cleanup technologies that would be used if the remediation had to be conducted today) hamper the ability to assess the benefits that new technology could bring.
- The lack of detail concerning the needs that have been identified makes it difficult to determine the validity of the need. Typically the description is one sentence long, and it is not always clear who identified the need and whether or not the individual knew enough about the site conditions, the nature of the wastes, the degree of cleanup required, or the capabilities of available technologies.

These problems must be addressed if a sound technology development program is to be developed.

Following are recommendations for enhancing the technology development for buried wastes.

1. The technology needs identified in this report should be reviewed by the sites to assess the validity of the need, to add needs, and to prioritize the needs to the extent possible. We therefore recommend that those parties responsible for remediating buried wastes across the DOE complex be sent copies of this report and asked to update the sections that relate to their particular facilities. An annual revision to this document to incorporate changes is also recommended, since new needs will continue to be identified as each facility gets closer to actual remediation.
2. The technology needs identified in this report should be reviewed by the BWID program staff knowledgeable in the various technical areas to determine if there are site-specific wastes, disposal conditions, or environmental conditions that are not being addressed but need to be included in the BWID program. If not being addressed, the needs must be evaluated as for validity, the ability of existing technology to meet the need, and the potential that technology can be developed in time to meet the need.

3. This document should be made available to current and potential BWID researchers so that they can gain a more complete picture of the buried waste problem throughout the DOE complex. At present, research is being conducted at several sites on various pieces of the problem. Some may focus only on particular problems at specific sites. By being aware of the range of wastes, disposal methods, and environmental conditions, researchers may be able to broaden the applicability of their research with minimal cost and effort (e.g., testing a process on soil types representative of two sites rather than just one).
4. It would also benefit personnel at other sites if they had a better understanding of the BWID program in general. Currently, one can gain a limited understanding by reviewing the numerous technology task plans (TTPs) that comprise the program. However, the level of detail in the TTPs often is not sufficient to promote a full understanding of the technical work that is conducted. A visit to the various sites by the BWID program technical staff to describe the current and planned activities would allow the transfer of information in both directions.

A further benefit of this two-way information transfer would be potential reduction in overlapping technology development efforts. Currently within the DOE system, technology development is conducted both at the site and the national levels (BWID is an example of the latter). Regular interaction among all parties can prevent overlap. The BWID program should fund complex-wide meetings to identify technology needs and to ensure effective communication among the sites. This funding should address the meeting, travel, and other costs of the attendees.

5. Technology development for buried wastes could also be strengthened by an active "lessons learned" program. Coordination with individuals involved in retrieval actions in projects such as the remediation of the 618-9 Burial Ground at Hanford (DOE 1991) and Weldon Spring Quarry in Missouri (Steffen and Ferguson 1991), as well as private industry, is imperative.

Identifying technology needs is a two-way street. It is difficult to assess one's needs not knowing exactly what work needs to be done. While some of the sites have a general strategy for remediating buried wastes and baseline technology plans, it is difficult to anticipate the potential perturbations that may arise once detailed technology plans and cost analyses are prepared. As sites get closer to actual remediation, additional technology needs, largely enhancements to current technologies, will be identified; a

mechanism should be in place to facilitate this transfer of information to the BWID program. We recommend efforts be made by BWID staff to work with knowledgeable staff at each site on a regular basis.

5.0 REFERENCES

Anderson, B. C., Anderson, J. D., Demiter, J. A., Duncan, D. R., and D. C. McCann. 1990. Contact-Handled Transuranic Waste Characterization Based on Existing Records. WHC-EP-0225, Westinghouse Hanford Company, Richland, Washington.

Chem-Nuclear Geotech, Inc. (Geotech). August 1991. Technology Needs Assessment Final Report. DOE/ID/12584-92 Vol. 1, DOE Field Office, Grand Junction, Colorado.

Coobs, J. H., and J. R. Gissel. October 1986. History of Disposal of Radioactive Wastes into the Ground at Oak Ridge National Laboratory. ORNL/TM-10269, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Davis, E. C., D. S. Marshall, R. G. Stansfield, and R. B. Dreier. March 1986. ORNL Solid Waste Storage Area 6 Trench Photos and Geologic Descriptions: July 1984 Through September 1985. ORNL/TM-9874, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Kaae, P. S., G. M. Holter, and S. M. K. Garrett. 1993. DOE Complex Buried Waste Characterization Assessment PNL-8390, Pacific Northwest Laboratory, Richland, Washington.

Kostelnik, K. M. 1991. Buried Waste Integrated Demonstration Plan. EGG-WTD-9870, Revision 1, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Los Alamos National Laboratory (LANL). 1990. Solid Waste Management Units Report. LAUR 90-3400, Volumes I to IV, LANL, Los Alamos, New Mexico.

Los Alamos Scientific Laboratory (LANL). 1977. History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes. LA-6848-MS, Volume 1. Los Alamos, New Mexico.

Steffen, D. E., and R. D. Ferguson. March/April 1991. "Remedial Action Program for the Weldon Spring Quarry." Hazardous Materials Chemistry.

U.S. Department of Energy (DOE). 1987. Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes. Final Environmental Impact Statement. DOE/EIS-0113, 5 Volumes. DOE, Washington, D.C.

U.S. Department of Energy (DOE). 1991. Engineering Evaluation of the 618-9 Burial Ground Expedited Response Action. DOE/RL-91-38, DOE Field Office, Richland, Washington.

Westinghouse Savannah River Company (WSRC). 1989. Waste Management Units - Savannah River Site (Volumes 1 and 2), WSRC-RP-89-898, WSRC, Aiken, South Carolina.

Westinghouse Savannah River Company (WSRC). 1991. Savannah River Site's Site Specific Plan. WSRC-RP-91-596, WSRC, Aiken, South Carolina.

APPENDIX A

SAVANNAH RIVER SITE

APPENDIX A

SAVANNAH RIVER SITE

From WSRC 1989 Report

<u>Site</u>	<u>Location/Use</u>	<u>Comment/Description</u>
904-41G, 42G, 43G	F-Area Seepage Basins	This site received liquid wastes containing low-level radioactivity and chemicals from the chemical separation facilities in the 200-Area. Excavated earthen basins; 1955-1988. 41G: 27m x 84m, 1.5M gal 42G: 27m x 161m, 3M gal 43G: 94m x 219m, 15.8M gal.
904-44G 904-45G 904-56G	H-Area Seepage Basins	The site received liquid wastes containing low-level radioactivity and chemicals from the chemical separation facilities in the 200-Area. 44G: 27m x 73 m, 1.1M gal; 1955-1988 45G: 36m x 140m, 2.8M gal; 1955-1988 46G: 3.8E +04M ² ; 1962-1988.
904-46G	H-Area Seepage Basin	The site received liquid wastes containing low-level radioactivity and chemicals from the chemical separation facilities in the 200-Area. Excavated earthen basin, 480 ft x 350 ft, 9.5M gal; 1955-1962.
643-G	Old Radioactive Waste Burial Ground	The site received radioactively (low-level) contaminated wastes that included protective clothing and lead shielding material, contaminated equipment, construction debris, incidental waste from production operations, mercury from pumps and offsite shipments. 76 acres (46M cu. ft). Excavated earthen trenches; 1952-1974.
643-7G	Present Radioactive Waste Burial Ground	This site receives radioactively (low-level) contaminated wastes that include protective clothing, contaminated equipment, construction debris, and

		incidental waste from production operations. 61 acres; approx 15M cu. ft at 100% land use efficiency. Excavated earthen trenches and concrete storage pads; 1974-present.
643-28G	Mixed Waste Management Facility	The site received radioactively (low-level contaminated wastes that included protective clothing, lead shielding material, contaminated equipment, construction debris, and incidental waste from production operations. 58 acres; 40.6M cu. ft at 100% land use efficiency. Excavated earthen trenches; 1972-1986.
904-53G1 904-53G2 904-54G 904-55G	Seepage Basins/Bldgs.	129' x 62' x 6'; 214K gal; 1954-1982 129' x 129' x 6'; 1M gal; 1954-1982 175' x 125' x 9'; 1.6M gal; 1958-1982 300' x 150' x 11'; 4.3M gal; 1960-1982 These basins received low-level radioactive liquid waste (less than 100 d/m/ml alpha and 50 d/m/ml Beta Gamma) generated in laboratories in Bldgs. 773-A and 735-A. The basins have not received waste since October 1982. Excavated earthen pits.
904-91G	Ford Bldg Seepage Basin	This site received wastewater with low levels of radioactive contamination and trace amounts of oil and grease. Excavated earthen-diked basin. Top: 24 x 12m; Bottom: 18 x 6m; Depth: 3m. (600m ³).
281-3F 281-3H	F-Area Retention Basin H-Area Retention Basin	37m x 61m x 2m (4.7E + 06L); 1955-1973. 37m x 61m x 2m (4.7E + 06L); 1955-1973. Potential low levels of radioactivity from segregated and recirculated cooling water from the F- and H-Area process buildings (221-F and 221-H) and evaporation condensate from the F- and H-Area high-level liquid waste tank farm. Excavated earthen basins.
281-8F 281-8H	F-Area Retention Basin H-Area Retention Basin	151,000 ft ² ; 1973-present 123,000 ft ² ; 1973-present Potential low levels of radioactivity from segregated and recirculated cooling water from the F- and H-Area Chemical Separations Buildings. Also tank

farm stormwater runoff. Excavated earthen basins lined with polymers.

643-1G Bingham Pump Outage Pits This site received piping and associated construction debris associated with a pump changeout. The solid waste placed in the pit had very low levels of radioactive surface contamination. Excavated earthen pits; 1957 and 1958. From 76m x 5m x 4m to 159m x 8m x 4m. 643-1G, 2G, 3G, 4G, 8G, 9G, 10G.

904 Reactor Seepage Basins This site received wastewater containing low levels of radioactive contamination. 14 basins, use varying between 1957 and present, size varying between 40m x 14m x 3m to 120m x 11m x 2m (904-103G, 104G, 57G to 68G). Excavated earthen dike.

904-88G K-Area Containment Basin This site contained wastewater with low levels of radioactive contamination; 1965 to present. Excavated earthen dike. 170m x 188m.

From Geotech 1991 Report

SRO LLWDF1 The Low Level Waste Disposal Facility is composed of old, new, and mixed waste burial grounds. 175 acres, 10 to 20 feet deep. Contaminants include Hg, C14 on resin, TRU, organics, LLW, Ag, Pb, Cd, waste oil, solvent rags, H3 in crucibles. Waste disposal in a number of trenches, some in boxes, some uncontained. Concentration up to very high locally (total 19E06 curies). Inventory records are not good for old burial grounds but are fairly complete for the other two; the records identify what is buried, though not exactly where. Burial grounds are a source of groundwater contamination. TRU waste in old burial grounds must be retrieved for shipment to WIPP. Criticality is an issue for retrieval and characterization. Closure of old burials may be required before WIPP will be ready to receive waste. Possible alternative for permanent solution is capping. Problems have been identified

associated with maintaining cap integrity, stability of wastes, and routine maintenance. A question also exists as to whether C-14 on resin will require retrieval. If resin breaks down, release of C-14 is highly probable, and would necessitate retrieval of the resin. Currently attempting to evaluate the behavior of the resin. This is one of the high priority units. Solvent tanks are also present as buried waste.

SRO

SL2

This sanitary landfill is 52 acres in size, with trenches 10- to 17-ft deep. Contaminants include TCE, PCE, H3, benzene, RA226, and methane. There are large concentrations of methane due to decomposition of waste; groundwater may intersect trenches. Methane concentration is 50% by volume in some soil gas samples; groundwater contamination above DWS for all contaminants. Landfill may contain some hydrocarbon-contaminated soil. Solvent rags were buried along with non-hazardous waste (paper, plastic, construction debris, carcasses). Problems in cap design for closure due to subsidence are likely as waste decays.

APPENDIX B

LOS ALAMOS NATIONAL LABORATORY

APPENDIX B

LOS ALAMOS NATIONAL LABORATORY

(from LANL 1990)

Shafts

21-016	MDA T	Disposal	62 shafts, 15' to 68' deep and 4' to 8' in diameter; cemented batch americium wastes were pumped down the shafts. The shafts were sprayed with heated roofing asphalt prior to emplacing the cemented mixture. Used for TRU cement paste disposal, 1968-1983.
35-001	MDA W	Disposal	2 vertical tubes (120') used to dispose of liquid sodium coolant from the decommissioned LAMPRE reactor. Stainless steel tubes in carbon steel sleeves. 5' above ground entombed in concrete. 500 to 650 lbs of sodium and NaK w/ Pu-239 and traces of fission products. 1970s.
49-001	MDA AB	Test/Disposal	6 areas, containing 3' to 6' diam holes, 31' to 108' deep. Remains of 35 hydronuclear and nine related types of experiments. Configurations place in bottom, exploded, and filled. U-235, U-238, PU, fission products, Beryllium, large quantities of lead, aluminum, steel, iron, cables, rock debris; pipes; equipment, steel boxes. 1959-1961.
50-009	MDA C	Disposal	107, various diameters and depths. Many lined with corrugated metal. Plutonium-contaminated sodium loops from TA-35. 1948-1969
54-004	MDA H	Shaft	9, 6' diam, 60' deep. Intended for non-radioactive waste, but parts with depleted uranium were included and possibly some TRU. Also tritium, beryllium, lithium, He-contaminated. 1-8 pre-1980, capped with soil; 9 pre- and post 1980.

54-006	MDA L	Landfill	34, 3' to 8' diam x 60' deep; wastes segregated into organics, inorganics, oils, acids, bases, and reactive metals, capped with concrete. 1975-1985.
54-005	MDA J	Landfill	2 shafts, post 1980. Equipment possibly contaminated with HE, asbestos, and possibly hazardous and LLW.
54-014	Rad	Pit/Shaft	33, 1' diam, x 18' deep (concrete); contain hot cell waste and trash; Mostly post 1980.
54-019	MDA G	Shafts	91, 1 to 6' diam, 25 to 60' deep; many of unknown size, most unlined, some cement-lined; shafts separated by 7.5'; .5' of crushed tuff between layers, capped with 3' of cement. Cell trash, solvents, animal tissue, fuel elements, waste contaminated with tritium, U-235, U-238, Pu-239, Cs-137, Ba-140, beryllium and other radionuclides, and a wide variety of other radioactive and mixed waste forms [pre-1980].
54-029	MDA G	Shafts	Same type as 54-019, but used after 1980. Hot cell waste, animal tissue, fuel elements, control rods, uranium chips and turnings, spallation products, low and high level tritium, reactor parts, PCB oil, and a wide variety of other radioactive, hazardous, and mixed waste forms.

Trenches

36-001	MDA AA	Disposal	3 maybe 4 trenches. One measures 30' x 200' x 10' deep. ? to 1989. Waste consists of potentially HE-contaminated combustibles, such as cables and broken wooden tables. Small quantities depleted uranium may adhere to combustibles and be in ash. A new facility was built in area in 1990.
39-001	MDA Y	Test/disposal	2, 8 to 10' wide, 1960s. 2, 20' x 150' x 12' deep. Pre-1980 (MDA Y) 2, 150' x 40' x 10' deep. Post-1980; Earlier trenches contain U, Pb, mercury, and possibly solvents, chemicals, beryllium, and PCB-containing oil. MDA Y and adjacent received wastes from TA-39 firing sites, laboratories, and offices; U, Pb, mercury, chemical, and oil (maybe PCBs).

54-014	Rad	Storage	<p>A, 263' x 13' x 6' deep (backfilled) 120 casks</p> <p>B, 219' x 13' x 6' deep (backfilled) 100 casks</p> <p>C, 219' x 13' x 8' deep (backfilled) 100 casks</p> <p>D, 60' x 13' x 6' (est); all four trenches contain retrievable heat source Pu-238 TRU waste. Each trench holds a single layer of concrete casks, each containing 2 30-gal drums. 1974 - present.</p>
--------	-----	---------	---

Pits

6-007	MDA F	Disposal	Several pits ranging from 40' x 70' to 2' x 2' x 4'. Wastes probably include experimental pieces, small quantities of radio-nuclides, and possibly unexploded HE material.
8-006	MDA Q	Disposal	Landfill, believed to be 30' x 32'. The wastes consist of gun barrels, projectiles, casings. Some HE and U residues may be associated.
9-013	MDA M	Disposal	Surface disposal site, 3 acres in size. Wastes include construction debris, land-clearing debris, asbestos, and laboratory waste. A number of discarded gun barrels, chemical bottles, and paint cans buried in 1950s. Laboratory waste may contaminated with chemical, explosives, and uranium.
11-009	MDA S	Test/disposal	Landfill, 10' x 10'. Twelve different types of HE were buried in cylinders in a soil matrix for this experiment to determine the decomposition rate of buried HE material. 1965-present.
16-018	MDA P	Disposal	Landfill, 7 acres in size. Wastes consist of HE-contaminated building debris containing barium, lead, and chemicals, and maybe radioactive waste. 1940s to 1985.
16-019	MDA R	Disposal	Landfill, 2 acres in size. Waste consists of HE burn residues, possibly containing barium. During early years, uranium and lead were suspected to have been used. 1940s.

21-015	MDA B	Disposal	6-acre area; one landfill pit or several small ones. Also slit trenches (2' wide x 4' deep x 40' long). Wastes consist primarily of solids w/ various radioactive contaminants such as PU, polonium, U, Am, curium, and actinium. At least one contaminated truck is buried. Slit trenches include old bottles of organics, perchlorates, ethers, solvents. 1945-1948.
33-001	MDA E	Test/Disposal	Pit 1: 15' x 75' x 6-7' deep Pit 2: 15' x 45' x 6-7' deep Pit 3: 5' diameter Pit 4: 15' x 100' x 6-7' deep. Wastes consist primarily of low-level radioactive (uranium) contaminated equipment, and test and shot debris possibly containing beryllium. 1949-1956.
35-002	MDA X	Disposal	Steel-lined reactor pit built to hold LAPRE-II reactor. Also subsurface fuel reservoir. Fuel removed and area covered with soil and asphalt. 1968 to present.
50-009	MDA C	Disposal	Pits 1 to 4: 186 m x 12.2 m in area [rad] Pit 5: 215 m x 34 m x 6 m deep [rad] Pit 6: 154 m x 31 m x 7 m deep [rad]. Pit 7: 55 m x 8 m x 4 m deep [chemical] Rad waste included building debris from TA-1 and 10, routine contaminated trash, sludge from waste treatment plants, and depleted uranium chips. Chem was included a variety of chemicals, pyrophoric metals, hydrides and powders, sealed vessels containing sodium potassium alloys or compressed gasses, and equipment. All pre-1980.
54-006	MDA L	Disposal	1 200'x 12'x 12'; all wastes from 1964-1974
54-005	MDA J	Disposal	4 pits, pre- and post-1980. Equipment possibly contaminated with HE, asbestos, and possibly hazardous and LLW.
54-017	MDA G	Disposal	19 disposal pits (main radioactive waste disposal site for LANL. Pit volumes range from 1,400 cu. yds to 57,000 cu. yds. Includes wing tanks, dryboxes, building debris, sludge drums, lab waste, hot dirt, d&d waste, filter plenums, uranium, and other waste forms. Pre-1980.

54-018	MDA G	Disposal	11 disposal pits. Similar to 54-017, except post-1980. Wastes include reactor control rods, wing tanks, d&d waste, lab waste, building debris, PCBs, asbestos, glove boxes, and other waste forms.
--------	-------	----------	--

Storage Pits

54-014	Rad	Storage	SP 9, 30' x 400 x 20' deep; 55 gal drums and fiberglass crates w/ retrievable TRU; 1974-?. Mixed waste also.
--------	-----	---------	--

Surface Impoundments

21-016	MDA T	Disposal	4 adsorption beds, 120' x 20' x 4' deep. Received 14M gal of plutonium processing waste which included 10, 500 gal of effluent containing highly concentrated ammonium citrate. 1954-1952.
--------	-------	----------	--

21-017	MDT U	Disposal	2 adsorption beds, 20' x 100' x 4' to 13' deep. Used for subsurface disposal of contaminated liquid wastes from DP East, 1948 to 1968, including radionuclides (polonium, actinium), and possibly organics and possibly oils containing beryllium and PCBs.
--------	-------	----------	---

21-018	MDA V	Disposal	3 "adsorption beds" or seepage pits used for disposal of radionuclide-contaminated wastewater from the laundry operations from 1945 to 1961 (barium-140, strontium-90, PU-239, Pu-240, tritium, and probably U). 1 acre in size.
--------	-------	----------	--

54-006	MDA L	Disposal	3, 20' x 10' x 10'; used to dispose of bulk quantities of treated aqueous waste. Water evaporated and left a salt cake in bottom. When salt cake reached 1 yd from top, pit backfilled. Pre- and post-1980.
--------	-------	----------	---

Miscellaneous

33-003	MDA D	Test/disposal	2 underground concrete chambers each associated with a 6' x 8' x 46' shaft shored with 2' x 12' timbers. The octagonal chambers measured 16' x 18' by 11' high and 18' x 18' x 16' high. Used for testing involving detonation of explosives. Residue may contain beryllium and lead. 1948 and 1952.
--------	-------	---------------	--

APPENDIX C

OAK RIDGE

APPENDIX C

OAK RIDGE

(from Geotech 1991)

Shallow land burial has been used at Oak Ridge to dispose of solid low-level radioactive waste since 1943. From 1955 to 1963, the solid waste storage areas were designated as the Southern Regional Burial Ground. During this period, about 1M ft^3 of material from various offsite facilities were buried at SWSA 4 and 5. Six SWSAs have been used since 1944 (Coobs and Gissel 1986).

SWSA 1 and 2. Bethel Valley. 1944 to 1946. Waste materials placed in unlined trenches and covered with 60 cm (2 ft) of soil. Two burial grounds cover about 2 hectares (5.0 acres). No records of the amount or type of radionuclides. After closure, most of waste in SWSA 2 was removed and buried in SWSA 3. Stainless steel drums containing liquid plutonium waste were removed intact, but black iron drums had deteriorated such that the surrounding earth had to be removed for burial.

SWSA 3. Bethel Valley. 1946 to 1951. Operated in the same manner as SWSAs 1 & 2, except that numerous items were stored aboveground. About 2.8 hectares (7 acres) were used. Area underlain with rock, making excavation difficult. No information available about content, though investigation of radioactive release from burial ground have been published (Stueber 1981).

SWSA 4. Melton Valley. 1951 to 1959. A 1951 study showed Melton Valley preferable to Bethel Valley for radioactive waste disposal because the former is underlain by relatively impervious shale. But the site chosen turned out to have a shallow water table in some parts. NAS concluded in 1976 site was unacceptable.

Pits and Trenches. Near SWSA 4. 1951 to 1965. pits and trenches for disposal of intermediate level waste (ILW). 160 M liters (42 M gal) of waste containing more than one million curies of mixed fission products were disposed (SR-90, Cs-137, RU-106).

SWSA 5. 1959 to 1973, though part continues to be used for retrievable storage of TRU wastes. 13.4 hectares (33 acres). Problems related to high water table.

SWSA 6. 1973 to present [1986]. 27.5 hectares (68 acres). Used for routine burial of low-activity-level solid radioactive wastes. Problems related to high water table, particularly during late winter-early spring rains. [Coobs and Gissel 1986]

APPENDIX D

HANFORD SITE

APPENDIX D

HANFORD SITE

(from Waste Management Operations EIS 1975)

CRIBS, PONDS, DITCHES

200 Area

177 cribs, 30 surface ponds and ditches (360 acres for 1.3×10^{11} gal of water and condensates)

Crib Construction

A crib is constructed by digging a ditch about 20 feet deep and 1400 feet long, backfilling with rock and covering with an impermeable membrane and soil. A pipe running the length of the crib is designed to distribute the liquid uniformly along the crib length (Figure II.1-50). The released liquid permeates through the soil. The soil column between the bottom of the crib and the groundwater is 150 to 300 feet thick and contains up to 50% silts and sand, having some clay content. [lengthy discussion P. II.1-50 to 51.]

SOLID RADIOACTIVE WASTE BURIAL GROUNDS

200 Area

19 sites (155 acres). "Dry Waste" (soiled clothing, laboratory supplies, tools, etc., packed in cardboard, wood or metal containers) and industrial waste (primarily items of failed process equipment packaged in heavy metal or concrete boxes). TRU-bearing waste has been packaged in sealed metal containers and segregated in the burial trenches since May 1, 1970. Prior to 1968, all waste was from 200 Area operating facilities. Since 1968, waste from 300 Area sent to 200 Area.

Since Dec 1973, waste from 100 Area reactor operations sent to 200 Area. Also small volumes from offsite.

Burial grounds are listed and shown on map in Appendix II.1-C, Part 2.

300 Area

Radioactive Solid Waste--No active facilities in the 300 Area. All goes to the 200 areas (p. II.1-55).

Retired Solid Waste Storage Facilities--Approximately 7.5×10^5 ft³ of solid waste containing approximately 10 Ci of uranium contamination have been placed in the 300 Area burial sites since fuel fabrication began at Hanford. Thorium-contaminated waste is less than 0.5 Ci and is segregated from uranium (i.e., a different trench). Most of the 300 Area contaminated waste is in a matrix of bonding materials on fabrication components, scrap material and equipment as surface contamination.

Of the total solid waste, approximately 90,000 ft³ are surface-contaminated metallic, concrete, and asphalt materials. The remaining approximately 6.6×10^5 ft³ occupy approximately 1×10^5 ft³ of underground space. The volume reduction occurs as a result of the weight of the solid waste and the soil overburden.

The burial sites are listed in Appendix II.1-E, Part 2, along with the size, date of deactivity, general description of the contents and the depth of groundwater. Figure II.1-64 shows their location (p. II.1-55).

Trench Construction

Solid radioactive waste buried in the ground is considered to be in long-term storage, except for TRU after April 30, 1970 (p. II.1-48).

Large items of solid waste, such as failed equipment from locations where the presence of TRU can be safely ruled out, are packaged in concrete boxes and buried in industrial waste burial trenches. Small items of failed equipment and trash-type contaminated waste, from locations where TRU can be ruled out, are packaged in cardboard cartons, wood boxes, or steel or fiber drums and buried in the so-called "dry waste" trenches (see schematic).

The various waste containers used provide containment of non-TRU contamination and minimize radiation exposure to personnel during temporary storage, handling, shipment, and burial operations. Once buried, no reliability is placed on the containers for confinement or retrievability of these materials. Although burial of the waste containers by backfilling the trench is normally

done at the close of the day's receipt of solid waste, waste trenches are immediately backfilled whenever the dose rate at the edge of the trench reaches 100 mR/hr. Solid waste is normally covered with 10 to 20 feet of earth to prevent uptake of radionuclides by plant life or disturbance by burrowing animals. An exception, waste contained in concrete boxes or small drums, may have a minimum dirt cover of 4 feet provided that radiation levels at grade are less than 1 mR/hr. Periodic routine surveillance of filled burial trenches is provided to assure that the burial grounds are maintained to meet existing standards.

Solid waste, containing or suspected of containing TRU buried after April 30, 1970, is packaged and buried in compliance with ERDAM-0511. This directive states that "such wastes shall be segregated from other solid wastes and shall be packaged and buried so that they can be readily retrievable, as contamination-free packages, within an interim period of 20 years."

Formerly, the waste was packaged in iron drums and iron or concrete boxes and buried in special trenches. Subsequent evaluation of iron drums directly buried in Hanford soils indicated that failures could occur in less than 20 years and retrieval, as contamination-free packages, might not be possible. Two alternates to direct burial were implemented on a test basis, either of which will protect the containers from direct contact with the soil and will permit ease of retrieval.

A prototype concrete V-trench was built and filled with TRU-bearing waste drums, as shown in Figure II.1-55. A metal cover and several feet of earth cover isolate the drums from the environment. This alternate provides protection of the drums from the soil and allows sampling of the storage trench atmosphere for radioactive materials and combustible gases, either of which would indicate drum failure.

Currently, a simpler alternate, pad storage, is being tested. The TRU-bearing solid waste is segregated as combustible and non-combustible at the point of origin and placed in labeled drums. The segregated waste drums are placed on the storage pad in a stack of four drums high; each layer of drums is separated by plywood treated with a fire retardant. When drums are stacked to a volume of 24 feet by 24 feet by 12 feet, the stack will be covered with

plywood and plastic-reinforced nylon sheeting prior to covering with 4 feet of earth. Capability for sampling the storage atmosphere is also provided (Figure II.1-56).

Small items of TRU-bearing solid waste, containing fission products capable of generating high dose rate gamma emissions, are packaged and shipped in shielded casks. This waste is discharged from the casks to the caissons, as shown in Figure II.1-57, and the caissons can be retrieved.

Some of the Purex processing equipment is so large and becomes so contaminated in service, that its transport to a burial ground would require abnormally high exposure of operating personnel. Such equipment is placed on flatcars and pushed into the solid waste storage tunnels appended to the Purex Plant (Figure II.1-58).

Currently, two methods for reducing the volume of solid waste are being practiced. Some waste from the laboratories and from the 234-5-Z Building plutonium-finishing operation is compacted prior to storage to provide a volume reduction of approximately four to one (pp. II.1-48-50).

Hanford 200 East Area
Dry Radioactive Waste Burial Grounds
(from Waste Management Operations EIS 1975, Table II.1-C-17)

<u>Number</u>	<u>Burial Ground Description</u>	<u>Status</u>
218-E-1	Dry Waste Burial Grounds	1 Inactive
218-E-2	Industrial Burial Grounds	2 Inactive
218-E-2A	Regulated Equipment Storage Site	2A Inactive
218-E-4	Minor Construction Burial Grounds	4 Active
218-E-5	Industrial Burial Grounds	5 Inactive
218-E-5A	Industrial Burial Grounds	5A Inactive
218-E-7	Vault (behind 222-B)	Inactive
218-E-8	Construction Waste Burial Grounds	Inactive
218-E-9	Regulated Equipment Storage Site	Active
218-E-10	Industrial Waste Burial Grounds	Active
218-E-12A	Dry Waste Burial Grounds (North)	12 Active
218-E-12B	Dry Waste Burial Grounds (South)	12B Active
218-E-13	Solid Waste Disposal Site (Contaminated Concrete)	Inactive
218-E-14	Failed Equipment Disposal Tunnel (Purex)	1 Inactive
218-E-15	Failed Equipment Disposal Tunnel (Purex)	2 Active

Hanford 200 West Area
Dry Radioactive Waste Burial Grounds
(from Waste Management Operations EIS 1975, Table II.1-C-17)

<u>Number</u>	<u>Burial Ground Description</u>	<u>Status</u>
218-W-1	Dry Waste Burial Grounds	1 Inactive
218-W-1A	Industrial Burial Grounds	1 Inactive
218-W-2	Dry Waste Burial Grounds	2 Inactive
218-W-2A	Industrial Burial Grounds	2 Active
218-W-3	Dry Waste Burial Grounds	3 Inactive
218-W-3A	Dry Waste Burial Grounds	3A Active
218-W-4A	Dry Waste Burial Grounds	4A Inactive
218-W-4B	Dry Waste Burial Grounds	4B Active
218-W-4C	Dry Waste Burial Grounds	4C Active
218-W-7	Vault South of 222-S	Inactive
218-W-8	Vault South of 222-T	Inactive
218-W-9	Dry Waste Burial Grounds	Inactive
218-W-11	Regulated Equipment Storage Site	Active

Volume Estimates in Table II.1-C-24, p. II.1-C-68

Hanford 300 Area
Storage and Disposal Sites
 (from Waste Management Operations EIS 1975, Table II.1-E-1)

<u>Site</u>	<u>Acres</u>	<u>Description</u>	<u>End Year</u>	<u>Depth to Water (ft)</u>
1	1.1	200' trenches, 15' x 8' deep on N-S axis, some 20' x 15' deep on E-W axis. Covered w/ 4' layer w/ 4' layer of clean dirt, and marked in 1961. Markers 3-61-51 to 3-61-90	1956	41
2	1.7+	Pits 150' x 51' x 15' deep. Covered w/ clean soil and marked in 1961. Markers 3-61-1 to 3-61-50. Contains uranium-contaminated equipment and material.	1961	41
3	1.3+	An expansion to the west of No. 2 w/ similar contents and deactivation procedures	1961	41
4	2.9+	Elongated pits containing uranium contaminated miscellaneous materials from 300 Area manufacturing facilities. Filled & covered w/ clean dirt. Marked in 1961 w/ markers 3-61-137 to 3-61-189.	1961	33
5	1.2+	Elongated pits to 15' deep containing uranium contaminated trash. Covered, filled w/ 4' of clean dirt. Marked in 1962, 3-62-1 to 3-62-38	1962	38

DISTRIBUTION

<u>No. of Copies</u>		<u>No. of Copies</u>	
<u>OFFSITE</u>		10	<u>Westinghouse Hanford Company</u>
12	DOE/Office of Scientific and Technical Information		J. D. Anderson N3-11 O. L. Kruger H5-33 P. H. Jacobsen H2-58 J. C. Womack L0-18
10	K. M. Kostelnik EG&G Idaho Idaho National Engineering Laboratory Idaho Falls, ID 83415		Environmental Data Management Center (6) H4-22
		31	<u>Pacific Northwest Laboratory</u>
	B. D. Helton Westinghouse Company Savannah River Site Aiken, SC 29808		S. Q. Bennett K7-90 L. L. Fassbender K6-61 S. M. Garrett K6-61 G. M. Holter (2) K7-97 P. S. Kaae K6-61 J. F. Keller L6-13 D. K. Kreid K1-22 G. W. McNair K7-90 D. R. Payson K7-90 M. E. Peterson P7-41 W. A. Ross P7-41 J. L. Scott P7-39 D. C. Stapp (10) K7-97 D. L. Stiles K6-61 R. C. Walling K7-97
2	Los Alamos National Laboratory Los Alamos, NM 87545 ATTN: E. Derr, J595 R. Vocke, K481		Publishing Coordination Technical Report Files (5)
2	Oak Ridge National Laboratory P.O. Box 2008, Bldg 3047 Oak Ridge, TN 37831-6023 ATTN: R. Forgy R. Mason		
<u>ONSITE</u>			
	<u>DOE Richland Field Office</u>		
	D. E. Trader A5-90		

END

DATE
FILMED

5 / 24 / 93